DISCUSSION STARTER

MAY 2025

The potential of carbon credits in incentivizing sustainable agricultural development

Lessons from Southern and Eastern Africa

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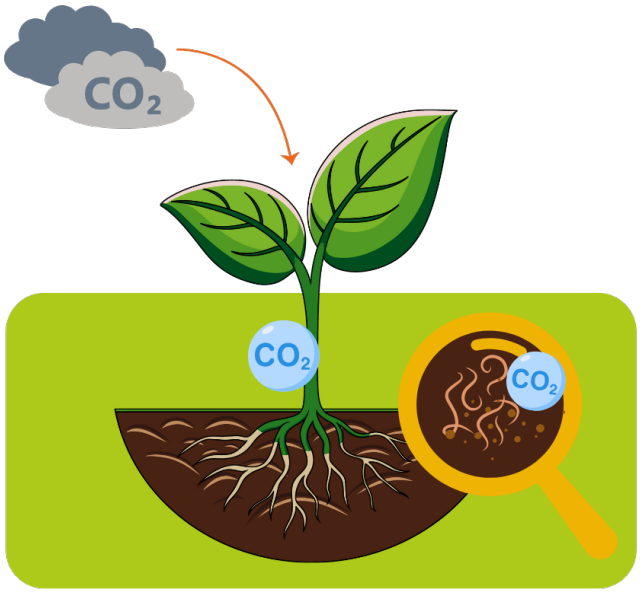
Introduction

Carbon farming improves the rate of carbon sequestration in soils and plants, which reduces atmospheric carbon dioxide. Higher levels of soil carbon can increase soil health, boost yields, and enhance farmer resilience. However, there are multiple challenges limiting the adoption of carbon farming by smallholder farmers, including high uptake costs. The potential revenue from selling carbon credits can provide the necessary incentives to overcome those challenges. However, carbon markets are characterized as uncertain, complex, and volatile, especially because of challenges in monitoring, reporting and verifying (MRV) carbon sequestered.

Despite these challenges, with the support from specialized intermediary institutions, the development sector has embraced carbon credits as a new funding mechanism for their projects, as well as for supporting farmers' adoption of sustainable agricultural practices. Lessons from projects in Southern and Eastern Africa show the benefits of working with specialized intermediary institutions dealing with MRV, how to overcome land tenure restrictions, the need to manage farmers' expectations on profits and the timing of payments, the potential cost-effectiveness of carbon credits as an incentive mechanism, and, finally, the significance of longer-term benefits from increased soil health.

Carbon farming: reducing emissions and increasing yields

One approach to tackling the challenges of agricultural emissions, climate adaptation and food insecurity is carbon farming. Carbon farming is the adoption of practices that increase carbon sequestration, i.e. "improve the rate at which CO2 is removed from the atmosphere and transformed into plant material and/or soil organic matter" (Schilling et al., 2023, p. 1). Such practices include agroforestry, silvopastoral systems, use of organic fertilizers, nutrient management, intercropping, crop rotation, use of biochar, reduced/no tillage, terracing, mulching, and rehabilitating degraded lands (Anuga et al., 2020; Sharma et al., 2021; Saikanth et al., 2023; Schilling et al., 2023). Given its reliance on natural processes, the success of each carbon farming practice depends on contextual factors such as soil type and climate (Saikanth et al., 2023).



Carbon farming has demonstrated the potential to not only remove carbon from the atmosphere, but also to improve soil health, biodiversity, water quality, and farm productivity (Sharma et al., 2021; Saikanth et al., 2023). With soils holding 81% of the world's terrestrial carbon stock, maintaining high soil carbon is vital for the climate and to ensure the soil's capacity to retain water and nutrients as well as to preserve its biotic habitat (World Bank, 2012). Healthier soils increase the quality and quantity of crop yields (World Bank, 2012; Sharma et al., 2021). Consequently, carbon farming can enhance farmers' food security, income, and resilience (Saikanth et al., 2023, Tang et al., 2020).

However, transitioning to carbon farming faces several barriers, particularly amongst smallholder farmers. One of the most significant challenges is the initial expenditures to uptake the new farming practices (World Bank, 2012; Sharma et al., 2021; Saikanth et al., 2023; Matekele et al., 2025). The appropriate carbon farming practice varies based on context, so do implementing costs. However, these costs include, for example, investments in materials, labor, and training (Saikanth et al., 2023). Additionally, the likelihood that smallholder farmers will obtain financial assistance from banks or other institutions is low (Sharma et al., 2021). Other challenges to adopting carbon farming include the nonavailability of certain inputs in local markets, a lack of access to information on carbon farming practices, insufficient capacity to implement new techniques, and incompatibility with traditional practices (World Bank, 2012; Sharma et al., 2021; Matekele et al., 2025).

Incentives for carbon farming adoption

Carbon markets allow for trading of carbon credits, which are units representing one metric ton of carbon dioxide (Jois & Thimmaiah, 2023). They have been established to encourage companies, organizations and countries to fulfill commitments to reducing greenhouse gas (GHG) emissions (Michaelowa et al., 2019). These markets facilitate leveraging private capital to scale climate action (Schilling et al., 2023). Since 2002, more than 4.3 billion tons of carbon dioxide emissions have been either removed, reduced or avoided due to carbon markets (see table 1) (Lokuge et al., 2022). The revenue from selling carbon credits provides an incentive for farmers to adopt carbon farming since it can help break the financial barriers farmers face when transitioning to carbon farming (Schilling et al., 2023; Lokuge et al., 2022).

Table 1. Types of actions that contribute to the overall mitigation of global carbon emissions

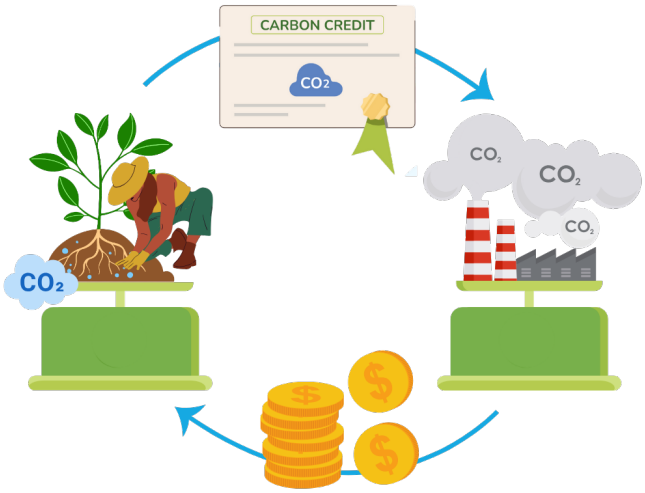
Removal	Reduction	Avoidance
Actions that extract carbon dioxide from the atmosphere and sequester it for extended periods. E.g. increasing soil carbon.	Actions that decrease emissions compared to prior practices. E.g. microdosing of fertiliser applications rather than blanket application.	Actions that prevent potential carbon-emitting activities from occurring. E.g. avoided deforestation through intensification of agriculture rather than extensification.

There are two types of carbon markets: the compliance market and the voluntary market (Michaelowa et al., 2019). In the compliance market, stakeholders are legally bound to comply with emission reduction targets set by governments or international institutions, such as the targets set under the Nationally Determined Contributions (NDCs) (Lokuge et al., 2022). It is typically set up as a cap and trade scheme, where stakeholders receive allowances based on their industry sector (Zhang et al., 2024; Lovell, 2010). These allowances stipulate the amounts of carbon dioxide they are permitted to emit. If they emit more than allowed, stakeholders must either pay fines to the regulating institution or buy carbon credits from others that succeeded in keeping their emissions within the set limit (Michaelowa et al., 2019). The European Union Emissions Trading System, the California Global Warming Solutions Act, and the Chinese National Emission Trading System are the largest compliance carbon markets (CarbonCredits.com, n.d.). In Southern and Eastern Africa, South Africa developed a tax-based carbon compliance mechanism in 2019 (SARS, 2024).

In the voluntary market, stakeholders are not legally required to limit their carbon emissions but are motivated by corporate and individual social responsibility (Michaelowa et al., 2019). In 2020, half of the total carbon credits issued were under voluntary markets (Lokuge et al., 2022).* The voluntary market is led by voluntary carbon registries which set the standards for issuing carbon credits and provide a platform for trading them (Michaelowa et al., 2019). These registries are usually privately owned and have led to innovations and improvements in the way the removal, reduction, or avoidance of carbon emissions is measured and verified. The largest registry is Verra's Verified Carbon Standard (VCS) (Verra, n.d.A). Countries can also engage in the voluntary market. For example, Rwanda established the National Carbon Market Framework in 2023 aiming to scale Rwandan stakeholders' participation in the voluntary market (Rwanda Ministry of Environment, n.d.).

In 2022, agriculture started being recognized as a sector in the voluntary market and it accounted for 1.3 percent of all carbon credits issued that year (Schilling et al., 2023), the majority of them coming from manure and methane projects (Lokuge et al., 2022). In the global architecture for emissions reductions, a common category is Agriculture,Forestry and Other Land Use' (AFOLU).

Within this type of market, carbon offsets are the units representing one metric ton of carbon dioxide emission that has either been removed, reduced or avoided from the atmosphere (Lovell, 2010). However, the terms carbon offset and carbon credit are commonly used interchangeably. In this paper, we use 'carbon credit' to refer to units sold in both the compliance and voluntary markets.



Apart from agriculture projects, AFOLU also includes the Reduced Emissions from Deforestation and forest Degradation (REDD) subcategory. REDD encourages stakeholders to protect and avoid destroying forests (Pearce, 2022). In 2022, AFOLU projects accounted for 42% of all credits issued in voluntary carbon markets, with the REDD subcategory comprising 59,5% of that share (Schilling et al., 2023).

The uncertainty of carbon markets

Carbon markets are often criticized for their uncertainty as prices are volatile and issuing a carbon credit does not guarantee its sale (Lokuge et al., 2022; Schilling et al., 2023; Alshatri & Hussain, 2023). In the voluntary market, a carbon credit is issued when it is formally registered (EcoTree, 2024). Once it is sold, the buyer must retire the credit by claiming it as a contribution to its offset targets. In this way, it cannot be sold again, which ensures transparency and avoids double-counting (see table 2). As of April 2025, 2,16 billion carbon credits have been issued in the voluntary carbon market (CarbonPlan.org, 2025). Out of those, 1,17 billion of them were sold and retired. Therefore, 54,16% of all carbon credits issued have been sold and retired. A similar ratio is observed for agriculture where 6,52 million credits have been issued and 3,28 million retired, while for REDD 537 million credits have been issued and 304 million retired.

The revenue generated by selling carbon credits could serve as an incentive for stakeholders to choose to change their practices, but prices and income would need to be sufficiently attractive to the sellers (Tang et al., 2020). Governments and international institutions are responsible for regulating carbon credit prices in compliance markets which fluctuate based on changes to countries' emission

targets (Michaelowa et al., 2019). In voluntary markets, prices mostly fluctuate based on supply and demand (Tang et al., 2020). However, in both market types, prices also fluctuate based on sector, type of project that led to the credit, and on quality of the credit.

The quality of a carbon credit is determined by three main factors: (a) environmental integrity, (b) linkage to other environmental and/or societal benefits, and (c) monitoring, reporting, and verification (MRV) standards. Environmental integrity relates to the legitimacy of the credit, ensuring that emissions are in fact decreasing and not increasing (Michaelowa et al., 2019). The price of carbon credits depends on how well the project performs in terms of six different components of environmental integrity (see table 2). In addition, when carbon projects contribute to other environmental and societal benefits, such as improvement in biodiversity, water quality, food security, or farmer livelihoods, it can result in higher prices for the carbon credit (Schilling et al., 2023). Finally, stakeholders have developed different MRV standards to prove the validity of their carbon credits (Petropoulos et al., 2025). The more a standard is recognized as robust, the higher the price of credits. For example, carbon credits issued through Verra can be sold for higher prices since the registry is known for having a robust methodology (Michaelowa et al., 2019).

Table 2. Components of environmental integrity

Components	Definition
Baseline setting	Refers to the amount of emissions that would most likely occur in the absence of a carbon market. The assumption is that the carbon market encourages changes in activities to remove, reduce, or avoid emissions, which means that the emissions scenario will be different than the baseline (Michaelowa et al., 2019).
Additionality	Ensures that GHG emission reductions in a project have only taken place because of the carbon market. This means that activities that are implemented because they are required by law or to make a profit, are not considered additional. This includes the reduction of emissions that would naturally happen without a project (Michaelowa et al., 2019). For example, if farmers are applying manure to soils because they always have done it, then they cannot claim carbon credits since there is no additionality.
Leakage	Refers to the failure to account for the indirect increase of GHG emissions outside of the project's recognized boundaries. Lack of consideration for a project's unintended effects might lead to the overestimation of GHG emission reduction (Filewod & McCarney, 2023). For example, if farmers add crop residues to a field to improve soils, but collect those crop residues from other fields that then have less organic matter additions, then this is classified as leakage.
Permanence	Refers to the condition of emission reduction being permanent. When carbon is stored, there are significant risks that it will be later emitted due to changes in practices or other causes, e.g. fires or shifting from no-till to tilling. That is why carbon credit registries either issue temporary or reversible credits, or already discount a percentage of the credits because they expect some reversals (Michaelowa et al., 2019).
Avoidance of double counting	Refers to the scenario in which 1) the same emission is issued as a carbon credit more than once, 2) different parties claim the same credit, or 3) different parties use the same credit to offset their emissions. To manage these risks, carbon credits are registered with a unique serial number that allows for traceability and accountability (Michaelowa et al., 2019).
Overall mitigation in global emissions (OMGE)	Ensures that trading carbon credits is reducing the total amount of global GHG emissions, and not just reallocating them. This means that buying carbon credits should not discourage stakeholders from putting efforts into reducing their own emissions (Michaelowa et al., 2019).

MRV: the most significant challenge

Apart from affecting the price of carbon credits, the accuracy of carbon sequestration measurement is crucial for the effectiveness of carbon markets (Petropoulos et al., 2025; Okoli & Birkenberg, 2024). Poor monitoring, reporting and verification (MRV) might lead to the issuing of carbon credits that do not represent the stated emissions reduction (Schilling et al., 2023). This can result in undermining trust in, and reducing the legitimacy of, the market, which can lead to a collapse of the incentive structure created to encourage stakeholders to reduce emissions (Schilling et al., 2023; Lokuge et al., 2022; Sharma et al., 2021). MRV approaches have often been mistrusted and criticized for being inconsistent or even manipulated (Anuga et al., 2020; Chung et al., 2024). Although with time, MRV has improved in accuracy, comparability, and affordability, it still poses the most significant challenge to issuing carbon credits (World Bank, 2012; Sharma et al., 2021; Chung et al., 2024).

Given the scale of carbon market operations, both private and public intermediary institutions have emerged that support farmers with information about carbon farming and conduct MRV activities. These institutions also lead the process of issuing and selling carbon credits (Schilling et al., 2023). For example, Tanzania has a National Carbon Monitoring Centre that allows the country to coordinate MRV and centrally manage that data (NCMC, n.d.). These institutions are crucial in ensuring smallholder access to the carbon market, although their services can be costly (Schilling et al., 2023; Okoli & Birkenberg, 2024). Their costs include developing baselines, predicting outcomes, monitoring compliance over large areas over long periods, annual certification, and administering the payments from carbon revenue (Schilling et al., 2023).

Conducting MRV requires specific activities, such as selecting land to monitor carbon changes, developing measurement protocols, estimating a baseline, measuring changes, and scaling results to the entire project area (World Bank, 2012). Approaches for measuring the level of organic carbon in soils can make use of different types of analysis as well as vary in data collection procedures, sample size, and frequency (Okoli & Birkenberg, 2024). These approaches involve soil sampling or be based on inferences derived from proxy variables, such as through remote sensing and activity modelling. The most significant challenge faced in direct soil sampling relates to spatial variation and the costs of collection and analysis, which is why assessments through inferences can enhance reliability by covering larger areas (Petropoulos et al., 2025). However, even though more time and labor intensive, direct soil samples are more precise and accurate (World Bank, 2012). Therefore, robust international carbon registries are increasingly incorporating soil sampling into their issuing criteria (Schilling et al., 2023).

Soil samples are mostly analyzed in laboratories, but there are also methods to do analysis in the field (World Bank, 2012). For example, soil spectroscopy, with data collected from handheld field scanners or remote sensing imagery, shows an optimal cost-accuracy performance (Okoli & Birkenberg, 2024). Field data collection with scanners can be conducted by smallholder farmer who are trained by extension services, thus ensuring capacity building, community participation, and project sustainability. However, the level of standardisation in the use of these methods is limited and high quality control protocols are necessary to ensure comparability and approval by carbon certification standards.

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Carbon farming projects in Southern and Eastern Africa

Multiple projects have been established in Southern and Eastern Africa in which farmers are encouraged to adopt carbon farming. These projects commonly involve a partnership between multiple stakeholders, with clear roles. Generally, NGOs use their networks with local communities and extension services to enable the dissemination of knowledge on carbon farming. Intermediary institutions often assist in creating MRV systems as well as in issuing and selling carbon credits. Organizations that fund these projects, such as governmental institutions, international organizations, and large companies, commit to buying the carbon credits issued.

The Kenya Agricultural Carbon Project (KACP) was one of the first projects to adopt a carbon farming model. It has reached around 30,000 smallholder farmers, covering more than 20,000 hectares of land in the Nyanza and Western provinces, and has sequestered more than 180,000 tonnes of carbon dioxide from the atmosphere since 2009 (Vi Agroforestry, 2019). The project was set up by Vi Agroforestry, the World Bank's BioCarbon Fund, and UNIQUE. Vi Agroforestry is the lead of the project and trains existing extension services on carbon practices, which then pass on the knowledge to smallholder farmers (Vi Agroforestry, n.d.A). The World Bank's BioCarbon Fund committed to buy carbon credits issued from the project until 2017 (BioCarbon Fund, n.d.). This provided the project, and the farmers, with a guarantee of revenue for the first years. Since the KACP is meant to last until 2029, it has advanced to selling carbon credits to a larger group of buyers (Vi Agroforestry, n.d.B). UNIQUE supported the development of the Sustainable Agricultural Land Management (SALM) methodology, which defines the practices that smallholder farmers implement and also the MRV system that allows for carbon credits to be issued under Verra's VCS (Verra, 2011).

The SALM methodology was an innovative approach for smallholder carbon farming projects (Schilling et al., 2023). The methodology entails monitoring carbon soil in relation to factors such as change in farming practices, soil type, and climate. This allows activity data to be compared to a baseline and used in the MRV system. The SALM methodology also includes participating smallholder farmers in the process, which strengthens the sustainability of the project (Tennigkeit et al., 2013). In 2023, the SALM methodology was being used or planned for in seven other African projects (Schilling et al., 2023). That same year, Verra inactivated the methodology to review and align it with new developments in the field. Verra's 2020 Methodology for Improved Agricultural Land Management serves as a potential replacement for SALM. It includes direct soil sampling assessments, as studies show that soil analysis is more accurate than assessments through activity data inferences (World Bank, 2012). The Grassland Restoration and Stewardship in South Africa Project has applied to issue carbon credits under this new methodology while the Agricarbon program in the same country is already registered under it (Verra, n.d.B).

Similar to KACP, and with the support from the World Bank's BioCarbon Fund and the Global Environment Facility, the Zambian Ministry of Green Economy created the Jurisdictional Sustainable Landscape Program (BioCarbon Fund, 2023). Established in 2024, the governmental program is meant to create incentives for the adoption of

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holistic integrated land-use and climate smart agriculture practices that lead to carbon sequestration, improve the health of ecosystems, and create new income streams for farmers. They aim to reach 150,000 farmers and 311,000 hectares of land by 2029 with the assistance of extension officers who are trained to teach communities how to implement carbon farming. Their MRV system combines climate, soil, and land management data to compare the amount of carbon in the soil with the amount measured in the baseline generated from data from 2009-2018. The World Bank, Global Environment Facility, and the BioCarbon Fund have committed to financing the program. The revenue from carbon credits will be distributed to farmers through a benefit sharing plan.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is implementing carbon farming projects in Ethiopia and Kenya. In Ethiopia, GiZ is working on a carbon farming project under their CompensAction program (CompensAction, n.d.). The project activities entail designing a carbon farming scheme and MRV mechanism, registering and verifying carbon credits in Verra's VCS, and distributing the revenue back to farmers. In Kenya, GIZ opted to establish a social enterprise, the Soil-Carbon Certification Services (SCCS), that serves as an intermediary institution and ensures that extension services and farmers can have continuous access to funding for training on carbon farming (First Climate, 2023). First Climate is financially supporting SCCS that has yet to issue its first carbon credit.

The private sector has also created programs that support farmers in transitioning to carbon farming and selling carbon credits. In South Africa, the company Anthesis Group created the Agricarbon program under Verra's VCS in 2021 (Anthesis, n.d.). The company provides farmers with a financing mechanism allowing them to overcome the initial barriers of adopting carbon farming. "These funds help offset short-term yield fluctuations and invest in advanced farming equipment and technology", thereby ensuring income security to farmers when taking the risks necessary to implement carbon farming (Anthesis, n.d). The company later assists farmers in quantifying and verifying carbon credits to be sold.

Similarly, Rabobank, a Dutch food and agri-bank, has an affiliated organization that supports farmers to practice agroforestry and exchange sequestered carbon for their Carbon Removal Units (CRUs) (Acorn, n.d.A). Agroforestry CRUs for the Organic Restoration of Nature (Acorn) has projects around the world, including in Tanzania, Kenya, Zambia, Uganda, and Rwanda (Acorn, n.d.B). In this model, carbon credits are not issued or sold in the existing compliance or voluntary carbon markets, but instead, Acorn has created their own carbon unit and certification standards. They use a satellite monitoring system as MRV for the CRU's and demand that farmers maintain planted trees for at least 25 years (Treek, 2024). This is an example of how carbon markets have inspired the private sector to create results-based granting mechanisms.

BOX 1: Blurred lines - REDD, agriculture and conservation projects

When it comes to interventions on livestock management, some NGOs support indigenous communities to transition into rotational grazing practices which boosts soil biomass, fertility, and carbon storage (Khalil et al., 2019). These projects do not engage with smallholder farmers individually but with communities that live in areas designated for conservation. Still, carbon credits issued under these initiatives are categorised under REDD and AFOLU credits.

In 2010, the Northern Rangeland Trust (NRT) established the Northern Kenya Rangeland Carbon Project, considered "the world's largest soil carbon removal project" as it spans across 1.9 million hectares (NRT Kenya, n.d.). It is certified by Verra and aims to sequester 50 million tons of carbon dioxide over the course of 30 years. Partnering with 14 member conservancies, NRT trains local communities on rotational livestock grazing practices to restore their grasslands. The almost 5 million US dollar revenue generated until 2022 from selling carbon credits serves as an incentive for communities to enhance their conservation efforts (Northern Kenya Rangelands Carbon Project, n.d.). However, the project is criticized for reasons of environmental integrity, MRV methodologies, breaking long-standing traditional grazing and pastoral practices, militarization of conservancies, control over the use of carbon credit revenue distributed, and disrespect to communities' indigenous rights (Survival International, 2023). In January 2025, Kenya's Environmental and Land Court ruled that two of the largest conservancy members of NRT were established unconstitutionally (Wandati & Kiplagat, 2025).

Similarly, conservation projects by Soils for the Future Tanzania and The Nature Conservancy in Tanzania are criticized for infringements on Maasai rights, restriction of their traditional practices, limited community participation, and risk of land dispossession (MISA, 2025, Lang, 2025). The projects are also accused of having poor environmental integrity, exacerbating land conflicts and community tensions, and threatening "the cultural heritage, livelihoods, and food security of Maasai pastoralists" (Lang, 2025). A lesson learned from these projects is that REDD projects must consider the protection of indigenous communities' rights from the inception phase. As a response to these critiques, the social enterprise Carbon Tanzania designs and implements conservation projects that revolve around local communities' rights and knowledge (Carbon Tanzania, n.d.).

Especially in the case of REDD projects, achieving carbon credit issuance and certification does not automatically indicate strong environmental integrity as the validity of REDD methodologies is constantly debated (Survival International, 2023). It is argued that there has been a systematic overestimation of carbon sequestered through avoided deforestation (Schilling et al., 2023). Carbon Tanzania argues that it is not only important to measure soil organic carbon levels, but also to compare these levels with a baseline that demonstrates the improvement rate due to a change in practice (Pearce, 2022). The debate around environmental integrity is an important contributing factor to the overall mistrust of carbon markets, largely influencing stakeholders' confidence in the effectiveness of carbon credits in mitigating GHG emissions (Sharma et al., 2021; Schilling et al., 2023). Therefore, it is crucial that REDD projects address this by improving their MRV (Mukama et al., 2011; Ochieng et al., 2016; Schilling et al., 2023).

Lessons learned from Southern and Eastern Africa

The challenges faced by the carbon farming projects discussed above have resulted in relevant lessons.

1. **The challenges of MRV and assessing changes in soil organic carbon levels are significant.** In GIZ's project in Ethiopia, the expectation is that only 30% of sequestered carbon will be qualified to be sold as carbon credits (CompensAction, n.d.). Due to complexity and volatility of carbon markets, partnering with intermediary institutions provides access to strong support and knowledge when conducting MRV as well as when issuing and selling carbon credits (Schilling et al., 2023). The Global Resilience Partnership and the Food Security for Peace and Nutrition Africa have created a carbon financing initiative that facilitates the scaling of MRV systems in Kenya and Tanzania (Global Resilience Partnership, n.d.). Another option is to establish social enterprises that become an intermediary institution, just as GIZ implemented in Kenya (First Climate, 2023). The establishment of social enterprises in local communities can also positively impact local skills, knowledge, entrepreneurial techniques, engagement, trust, and incomes (Matekele et al., 2025).

2. **Land tenure can be a challenge.** Experiences from KACP and Acorn demonstrate that the poorest and smallest-scale farmers are excluded from the carbon market because most carbon credit registries demand land tenure for carbon issuance (Schilling et al., 2023). Acorn only allows for farmers to participate if 1) they officially own land, 2) if that land expands to at least half an acre, and 3) if they have local residency (Treek, 2024). This excludes renters or informal land owners from the Acorn initiative. On the other hand, KACP recognized that most farmers in their project area registered their land with the government but did not process a title deed since that required payments (Vi Agroforestry, n.d.B). To not exclude these farmers, KACP acknowledges tenure of land owned through family ties, after confirmation by village elders and community members. This ensured that women and youth farmers in particular could participate in the project.

3. **Carbon revenues can be insufficient to cover costs.** In general, the projects show that revenue from carbon credits can increase communities' incomes, allowing them to accumulate wealth and achieve better living standards (Matekele et al., 2025; Schilling et al., 2023). However, the instability of carbon prices, the high costs to monitor carbon sequestration, and high costs to adopt carbon farming mean that selling carbon credits may not be cost-effective for farmers (Tang et al., 2020; Lokuge et al., 2022; Alshatri & Hussain, 2023). The low price of carbon credits in voluntary carbon markets often does not cover the costs associated with adopting carbon farming, resulting in some projects where farmers only managed to recover 5–25% of their costs (Schilling et al., 2023). This is why GIZ's project in Ethiopia opted for setting a minimum price per carbon credit to ensure the credits generate the necessary incentives for farmers

to change their farming practices (CompensAction, n.d.). However, it remains to be seen how they will ensure a stable price. In addition, efforts to decrease implementation and transaction costs need to be made, allowing farmers to generate more income (Schilling et al., 2023). In KACP, 60% of the revenue goes to participating farmers and 40% to the implementation of the project itself (Vi Agroforestry, 2019). In Acorn, 80% of the revenue from selling CRU's goes to the farmers (Acorn, n.d.A). In general, farmer expectations around revenues need to be managed.

4. **Timelines can be challenging.** A lesson from the KACP and GIZ projects relates to the timeline of issuing and selling carbon credits, receiving revenues, and distributing these back to farmers. After three years, GIZ has yet to issue their first carbon credit (First Climate, 2023), whereas KACP's first carbon credit issuance was in 2014, almost five years after the start of the project (Muriuki, 2014). It is important to manage farmers' expectations regarding the time needed to earn extra income from carbon credits.

5. **Upfront costs of transitioning to carbon farming are high.** Acorn explains that farmers should expect a loss of income from changing their agricultural practices in the first two to three years (Treek, 2024). Smallholder farmers generally lack the financial resources to start investing in carbon farming, which is why government support at start-up is recommended (World Bank, 2012; Schilling et al., 2023). It is estimated that by 2030 African governments need to invest up to 20 billion US dollars to enable farmers to implement carbon farming (World Bank, 2012). This support includes investments in research, seeds and seedlings, input subsidies, payment for ecosystem services (PES), extension services and more.

6. **There is a lack of recognition of the co-benefits of carbon farming.** Overall, the economic benefits of carbon farming are underestimated given the co-benefits it provides, such as improvements in soil health, farm productivity, and crop yields (Lokuge et al., 2022; Sharma et al., 2021; Saikanth et al., 2023; World Bank, 2012). Carbon farming can increase yields and reduce production costs in the long run, making farming more profitable. This is why owning instead of renting land can serve as an incentive for farmers to engage in carbon farming (World Bank, 2012). The increased income resulting from such improvements is usually overlooked (Tang et al., 2020; Schilling et al., 2023). In KACP, the BioCarbon Fund states that there was a 20% income increase from yield improvement, which is more significant than the revenue farmers earned from carbon credits (Tennigkeit et al., 2013). Therefore, it is crucial to promote these co-benefits of carbon farming to better manage farmers' expectations when adopting the practices and selling carbon credits (Lokuge et al., 2022; Tang et al., 2020)

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"Overall, the economic benefits of carbon farming are underestimated given the co-benefits it provides, such as improvements in soil health, farm productivity, and crop yields."