Unlocking nature-based solutions through carbon markets in Kenya

TECHNICAL REPORT

David Landholm
Felipe Bravo
Ivan Palmegiani
Charlotte Streck
Lydia Omuko-Jung
Gabriela Martinez de la Hoz
Szymon Mikolajczyk

18 October 2022

CLIMATE FOCUS

Acknowledgments

This technical report is one in a series produced by Climate Focus and the Food and Land Use Coalition (FOLU). Since September 2021, Climate Focus and FOLU have been collaborating on a research project around financing strategies for terrestrial nature-based solutions (NbS) at a country and global level. The ultimate objective of the project is to enable public and private decision-makers to prioritize and deploy activities and investments that will unlock the potential of NbS for climate mitigation, adaptation, resilience, biodiversity and beyond. Our current report series includes the publication of country-based assessments in Kenya & Colombia, as well as global analyses focused on the voluntary carbon market. For more information about the project, please see below.

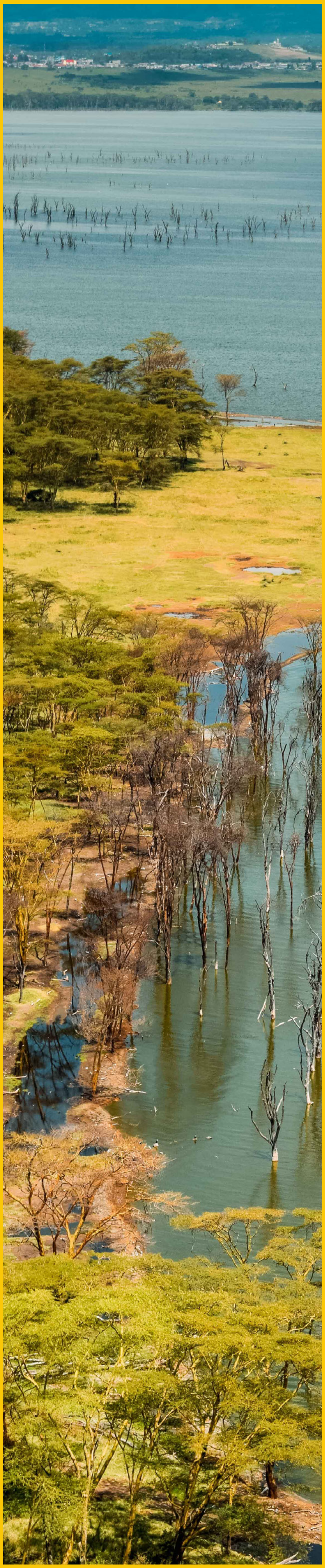
This report has received generous support from the Quadrature Climate Foundation.

Quadrature Climate Foundation

It has been produced in partnership with SYSTEMIQ.

SYSTEMIQ
Talia Smith
Scarlett Benson
Mitch Groves
Abel Hemmelder
Natasha Mawdsley
Alessandro Passaro
Alex Andreoli

Climate Focus would like to thank Stefanie Roe (WWF) for contributing time and energy to provide input on the model.



Acronyms

A/R Afforestation and Reforestation

AD Avoided Deforestation

AFOLU Agriculture, Forests and Other Land Use

AG Agriculture

BAU Business-as-usual

CEMP Cost Effective Mitigation Potential

FAO Food and Agriculture Organization

GHG Greenhouse Gas

IAM Integrated Assessment Model

IDEAM Instituto de Hidrología, Meteorología y Estudios Ambientales

IFM Improved Forest Management

MACC Marginal Abatement Cost Curves

MRV Measuring, Reporting and Verification

NBS Nature-Based Solutions

NDC Nationally Determined Contribution

PA Protected Areas

UNFCCC United Nations Framework Convention on Climate Change

VCM Voluntary Carbon Market

VCS Verified Carbon Standard

WL Wetlands

Introduction

An effective and efficient transition to low-carbon economies will be required over the next three decades to achieve the goals of the Paris Agreement and avoid the worst impacts of a changing climate. In addition to cutting greenhouse gas (GHG) emissions in half each decade, the global economy must also make significant investments in carbon removals to have a high probability of limiting warming to 1.5°C or 2°C by 2100.[1]

Nature-based solutions (NbS) – actions that protect and enhance carbon stored in natural ecosystems and reduce GHG emissions – are essential climate strategies, yet only receive a fraction of global finance. Although the global climate mitigation potential of terrestrial NbS has been estimated at 9-14 $GtCO_2e\ yr^{-1}$ [2,3] only 3% of public climate mitigation funding is allocated to NbS, compared to 38% to renewable energies alone.[4] At best, the current level of funding for forest protection, restoration, and enhancement only reaches 5% of the estimated total needed to align with the Paris Agreement's 1.5°C targets,[5] indicating a drastic shortfall in climate finance for forests.

Considering the lack of financing for mitigation in the land sector, it is important that countries like Kenya use climate finance strategically to maximize adaptation and mitigation benefits. Tapping into nature's mitigation potential is particularly relevant for countries that depend on NbS to meet their Nationally Determined Contributions (NDC) under the Paris Agreement. According to Kenya's updated NDC, the Agriculture and LULUCF[6] sectors accounted for 40% and 38%, respectively, of their total emissions – 93.7 $MtCO_2e$ in 2015.[7] Most of the emissions from the Agriculture sector arise from livestock enteric fermentation, manure left on pastures and agricultural soils, and fe rtilizer application.

Carbon markets provide an opportunity for Kenya to channel finance into sustainable land use. Carbon investments have significantly gained momentum over the last two years, largely driven by companies relying on carbon markets to realize their mitigation commitments or to offset a portion of their emissions.[8,9] Indeed, although there is a lot of uncertainty, some estimates of carbon market demand reach 3-9.5 $GtCO_2e$ by 2050.[10] However, it is unclear whether NbS supply

---

1 This decarbonization roadmap translates to reducing global CO_2 emissions to 20 Gt $CO_2\ yr^{-1}$ by 2030, 10 Gt $CO_2\ yr^{-1}$ by 2030 and 5 Gt $CO_2\ yr^{-1}$ by 2050. Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., & Schellnhuber, H. J. (2017). A roadmap for rapid decarbonization. Science, 355(6331), 1269–1271.

2 Roe, S., Streck, C., Beach, R., Busch, J., Chapman, M., Daioglou, V., et al. (2021). Land-based measures to mitigate climate change: Potential and feasibility by country. Global Change Biology, 27(23), 6025–6058.

3 To illustrate the scale of these numbers: the Climate Action Tracker estimated China's 2021 GHG emissions to be at 14.1 $GtCO_2e$, and the International Energy Agency estimated global transport emissions for 2019 at 8.5 $GtCO_2e$. Tracking Transport 2021. (2021). IEA. Retrieved July 26, 2022, from https://www.iea.org/reports/tracking-transport-2021.

4 Buchner, B., Baysa Naran, & de Aragão Fernandes, P. (2022). Global Landscape of Climate Finance 2021. Climate Policy Initiative (CPI). Retrieved August 1, 2022, from https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2021/.

5 NYDF Assessment Partners. (2021). Taking stock of national climate action for forests. Retrieved August 1, 2022, from https://forestdeclaration.org/resources/taking-stock-of-national-climate-action-for-forests/.

6 Land Use, Land Use Change, and Forestry.

7 Kenya Ministry of Environment and Forestry. (2020). Kenya's Updated Nationally Determined Contribution (NDC). Retrieved October 11, 2022 from https://unfccc.int/sites/default/files/NDC/2022-06/Kenya's%20First%20%20NDC%20(updated%20version).pdf.

8 Verra - Data and Insights VCS Quarterly Update on Q1/2020. (2020). Verra. Retrieved August 1, 2022, from https://verra.org/datainsights/april-2020/.

9 Since 2017, carbon credits' issuance grew from 49 to 300 $MtCO_2e$ in 2021, amounting to a market value of 748 billion in the first eight months of 202. More than 53% of these credits derive from NbS projects, of which 72% comes from developing countries. Donofrio, S., Maguire, P., Zwick, S., & Merry, W. (2020). Voluntary Carbon and the Post-Pandemic Recovery: A Special Climate Week NYC 2020 Installment of Ecosystem Marketplace's State of Voluntary Carbon Markets 2020 Report. Retrieved from https://wecprotects.org/wp-content/uploads/2020/11/EM-Voluntary-Carbon-and-Post-Pandemic-Recovery-2020.pdf.; Verra - Data and Insights VCS Quarterly Update on Q4/2021. (2022). Verra. Retrieved August 1, 2022, from https://verra.org/datainsights/data-and-insights-january-2022/.

10 Trove Research (2021). Future Demand, Supply and Prices for Voluntary Carbon Credits. Retrieved June 1, 202, from https://trove-research.com/wp-content/uploads/2021/06/Trove-Research-Carbon-Credit-Demand-Supply-and-Prices-1-June-2021.pdf.

will manage to deliver these amounts when considering the land sector's widespread investment barriers.

The mitigation potential of the carbon market activity pipeline in Kenya, which covers a wide range of NbS, is currently unknown. Studies tend to focus on global demand, cover a limited set of NbS, and typically disregard supply constraints other than price. In reality, carbon market investments face barriers across multiple dimensions that go beyond price , such as challenges related to land tenure, the country's political environment, or its attractiveness to foreign investments. Furthermore, there is a lack of spatially explicit information on where the mitigation potential for different NbS activities can be found, which represents an information barrier for both project developers and decision makers.

This technical report addresses these important knowledge gaps and examines the role that carbon markets may play in the short and mid-term in Kenya with regards to unlocking NbS mitigation potential. Specifically, the objectives of this report are fourfold:

1. to model what is the projected NbS mitigation potential supply of carbon markets in Kenya over the 2021-2050 period;
2. to better understand the role that different feasibility barriers may play in relation to unlocking carbon markets' full mitigation potential;
3. to spatially identify the areas where the mitigation potential is concentrated in Kenya across subnational units (i.e. at a county level); and
4. to determine what share of NbS potential is currently unlocked by carbon markets.

This report forms part of a series of technical country-specific reports.[11] The methodological approach piloted in these countries will be applied analogously at a higher scale in a forthcoming global study to understand better how much NbS mitigation potential can be supplied from carbon markets.

Methodological approach

To address the research gaps outlined above, we have developed a country-level model that explores how much mitigation potential can be unlocked by the NbS activities of Avoided Deforestation (AD), Afforestation/Reforestation (AR), Agriculture (AG)[12], the conservation and restoration of Wetlands (WL), and Improved Forest Management (IFM), through the assessment of both economic and other country-specific constraints (Figure 1). Specifically, the model accounts for:

1. the mitigation potentials of the five activities in Kenya[13] and a wide range of carbon market price scenarios over time,

[11] As of September 2022, the first country report has been released for Colombia.

[12] The "Agriculture" activity includes mitigation potential from activities that reduce emissions and/or remove CO_2 from the atmosphere and store it in the soil and biomass. Specifically, the following activities are considered: Enteric fermentation, manure management, improved rice production, nutrient management, soil carbon sequestration on grasslands, soil carbon sequestration on croplands, agroforestry, and biochar.

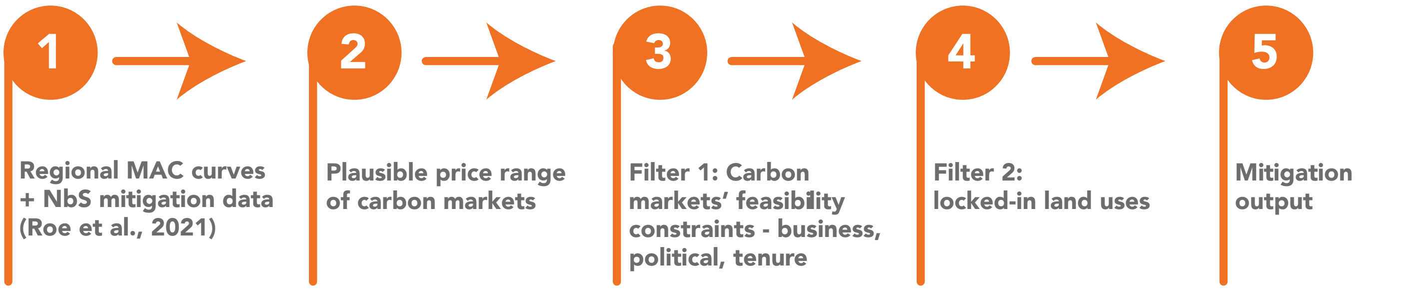
[13] Roe, S., Streck, C., Beach, R., Busch, J., Chapman, M., Daioglou, V., et al. (2021). Land-based measures to mitigate climate change: Potential and feasibility by country. Global Change Biology, 27(23), 6025–6058.

2. the feasibility barriers to implementation of these measures, related to ease of doing business, land tenure, and political factors, and

3. the on-the-ground restrictions posed by previously existing land uses (hereafter referred to as "locked-in land uses"). Specifically, we consider economic land concessions[14] and extractive industries, such as mining, oil and gas concessions.[15] The country level estimates obtained through the model are further disaggregated at the county level based on secondary, spatially-explicit data. These are used to determine the higher-priority areas for carbon market uptake in Kenya.

A visual overview of the methodology can be found in **Figure 1**, while a detailed description of the model and approach can be found in the **Annex** (Methodology).

Figure 1: Schematic overview of the methodology applied to obtain the Nature-Based Solutions (NbS) mitigation potential from carbon markets in Kenya.



Results and discussion

Under current constraints, carbon markets in Kenya hold the potential to unlock 27.7 – 46.4% of their modelled mitigation potential over three decades (0.31 – 0.52 GtCO_2e of 1.12 GtCO_2e available after 30 years) (**Figure 2**). Carbon markets could unlock up to 4.0-5.9 MtCO_2e yr^{-1} in 2023, 9.0-15.8 MtCO_2e yr^{-1} by 2030 and reach 16.2-25.1 MtCO_2e $yr^{-1}$by 2050. This represents only 11-16% (37.4 MtCO_2e yr^{-1}) by 2023 and 43-67% by 2050 of their available mitigation potential.

After accounting for the different constraints (price, implementation feasibility, and spatial location), the modeled available mitigation potential for all three scenarios is much lower than Roe et al. (2021)'s cost-effective mitigation potential (yellow dashed line in Figure 2). As shown in **Figure 2**, there is a steep increase in carbon-market driven mitigation potential in the first half of the 2020 decade, followed by a second period where its growth continues following a more moderate trajectory. These broad dynamics are determined mainly by the regional Marginal Abatement Cost Curves (MACC), which reflect decreasing amounts of mitigation unlocked as prices increase beyond a certain threshold (an example is shown for the agriculture activity in **Figure 5**, **Annex**).

[14] Source: Land Matrix public database on land deals [https://landmatrix.org/]

[15] For other country reports, we also considered the inclusion of protected areas. However, in Kenya there are currently carbon projects being developed in these areas. Furthermore, we found no strong evidence of project development being restricted in these areas in the future.

In terms of activities, Agriculture dominates the carbon markets in Kenya, with 61% of the total potential, followed by Avoided Deforestation (19%), Afforestation/Reforestation (11%), Improved Forest Management (7%), and the conservation and restoration of Wetlands (3%) (**Figure 3**).

Figure 2: Carbon markets' mitigation potential for Nature-Based Solutions (NbS) measures in Kenya (Avoided Deforestation, Agriculture, Afforestation/Reforestation, Improved Forest Management, and the conservation and restoration of Wetlands) for three price scenarios (high, medium, low). Phased cost-effective mitigation potential (CEMP) over the 2020-2050 period is shown for reference.[16]

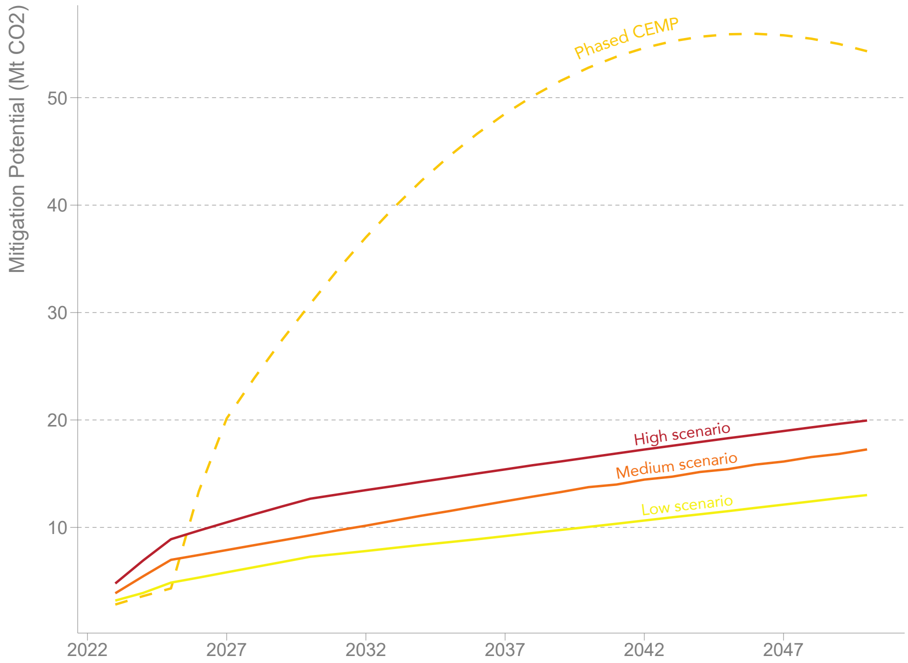
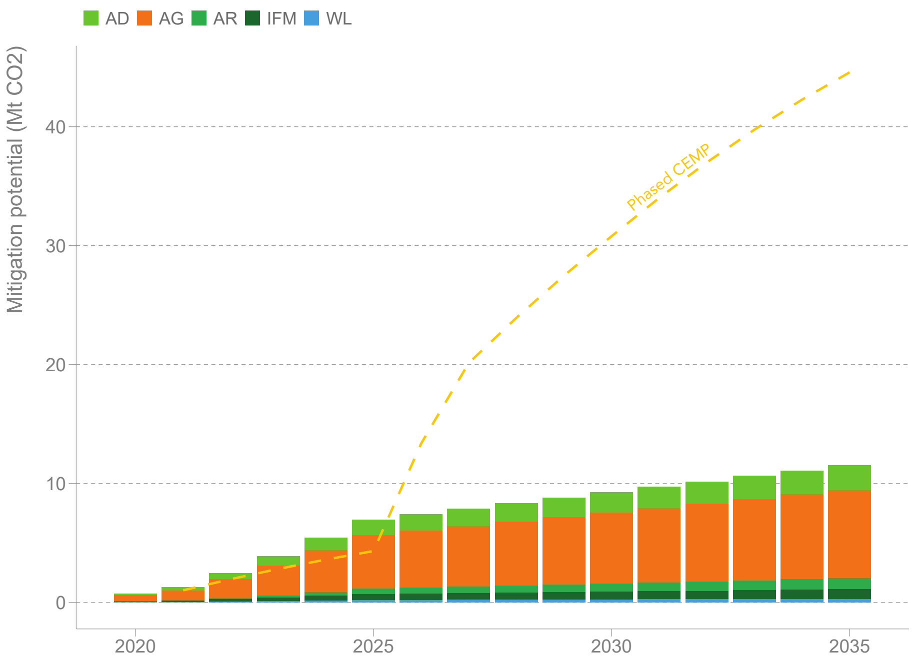


Figure 3: Carbon markets' mitigation potential by Nature-based Solutions in Kenya (Avoided Deforestation, Agriculture, Afforestation/Reforestation, Improved Forest Management, and the conservation and restoration of Wetlands) for a medium-price scenario. Average cost-effective mitigation potential over the 2022-2050 period is shown for reference.[17]



[16] Roe et al., 2021

[17] Roe et al., 2021

Our model estimates the available carbon market potential for Agriculture in Kenya to reach 7.03 $MtCO_2e\ yr^{-1}$ by 2030 under the medium price scenario of USD 40 per tonne (low-high range, 5.52-9.57 $MtCO_2e\ yr^{-1}$).[18] At a country scale, Roe et al. (2021) disaggregates the mitigation potential across agricultural activities as follows: soil carbon sequestration in grasslands (39.0%), Agroforestry (25.5%), soil carbon sequestration in croplands (21.7%), biochar (10.2%), enteric fermentation (2.7%), and nutrient management (0.8%). Manure management and improved rice production both represent <0.1% of its potential.

Using a combination of secondary datasets, and after filtering out locked-in land uses, we estimate the potential for Agriculture to be most relevant for the counties of Turkana, Marsabit and Narok, with 7.9%, 6.6%, and 6.1% of the potential, respectively (see **Figure 4** and **Table 2** in the **Annex**). In all the three counties, and aligned with the agricultural potential breakdown presented above, pastoralism or livestock husbandry is the main agricultural activity, suggesting the highest potential lies in grassland restoration.[19] With the exception of Narok County, crop-farming is done at a small scale in these three counties due to the counties' aridity.

Carbon markets' mitigation potential for Avoided Deforestation in Kenya reaches 2.27 $MtCO_2e\ yr^{-1}$ by 2030 under the medium price scenario (1.83-2.94 $MtCO_2e\ yr^{-1}$). Kenya has only between 5.7[20]-7.2%[21] of forest cover left, which limits the countries Avoided Deforestation potential. The potential for this activity is most relevant for the counties of Garissa, Lamu, and Narok with 11.3%, 11.3%, and 10.6%, respectively (see **Figure 4**).

Finally, the carbon market potential for Afforestation/Reforestation in Kenya increases to 1.04 $MtCO_2e\ yr^{-1}$ by 2030 under the medium price scenario (0.72-1.73 $MtCO_2e\ yr^{-1}$). The potential for this activity is most relevant for the counties of Lamu, Kitui, and Kwale with 19.1%, 14.8%, and 12.4%, respectively (see **Figure 4**).

Accounting for all three activities, the county of Kitui shows the highest mitigation potential with 7.4%, followed by Lamu, Garissa, and Narok (6.9%, 6.9%, and 5.3%, respectively). Kitui's potential could be because of its features: 20% of the land in the county is in Kenya's largest protected area, Tsavo East National Park, with the area in Kitui being under threat due to extensive charcoal production. Land tenure issues are less of a risk in this area, as the land is publicly owned and under the management of the wildlife authority. Another 50% of the land area in the county is arable agricultural land where small-scale agriculture is practiced by majority of farmers.

We find that the overlap of locked-in land uses (economic concessions, oil and gas concessions, and mining concessions) with the spatial distribution of carbon market potential is a minor issue in Kenya. Specifically, only 1.3% of the Agriculture mitigation potential overlaps with other land uses. The overlap affects even less strongly the Afforestation/Reforestation and Avoided Deforestation potential (0.9% and 0.3%, respectively).

---

[18] Our model shows Agriculture as the activity with most potential; however, important technical measuring, reporting and verification (MRV) barriers need to be overcome for carbon markets to leverage its full potential. A lot of effort is currently placed on solving this barrier, but the outcome is yet unclear.

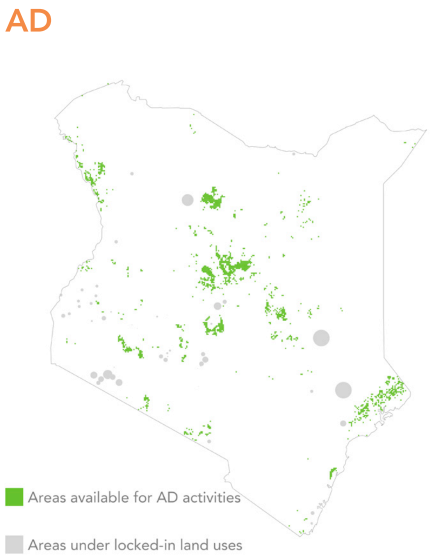
[19] See County Integrated Development Plans (CIDP): AHADI - The Agile and Harmonized Assistance for Devolved Institutions, USAID, & UKAid. (n.d.). County Integrated Development Plan (CIDP), The County Governance Toolkit. Retrieved October 17, 2022, from https://countytoolkit.devolution.go.ke/process/planning/county-integrated-development-plan-cidp.

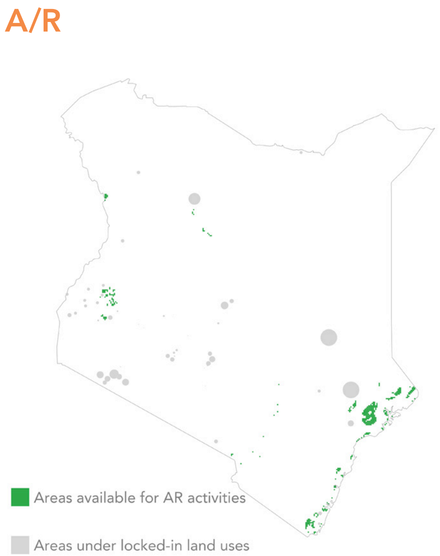
[20] Global Forest Watch. (n.d.). Kenya Deforestation Rates & Statistics. Retrieved October 17, 2022, from https://www.globalforestwatch.org/dashboards/country/KEN.

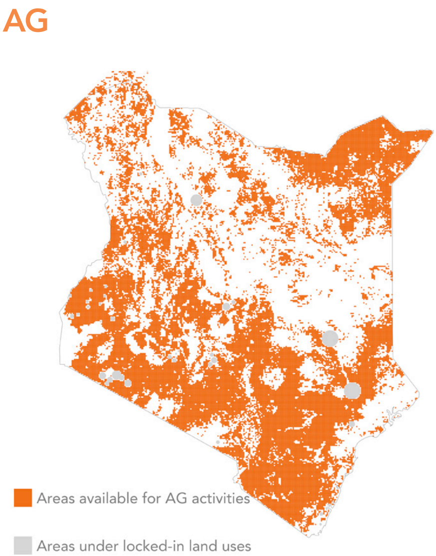
[21] Kenya Forest Service. (n.d.). 2022 Data and Background materials. Retrieved October 17, 2022, from http://www.kenyaforestservice.org/index.php/background/.

We lack spatially explicit secondary data on mitigation potential for Improved Forest Management and Wetland activities, which constitute 9.5% of NbS potential in Kenya. For these activities we provide model results at the country level only and do not further disaggregate them by county. For Improved Forest Management, we assume a similar distribution of locked-in land uses as for Avoided Deforestation; hence, the same percentage of restriction is applied for this activity at the country scale. We assume an average distribution of locked-in areas for Wetlands from the other three activities.

Figure 4: Distribution of mitigation potential in Kenya for Avoided Deforestation[22], Afforestation/Reforestation[23], and Agriculture.[24] Locked-in land uses such as mining, oil and gas concessions have been removed from the original datasets. The difference between the initial potential and final potential, after accounting for these areas removed, is recorded, and provides the second feasibility filter (%) that is applied to our country-level model estimates. The Table 2 in the Annex presents the disaggregated potential by counties.







Currently, the VCM is unlocking just over 6.6% of the available mitigation potential simulated by our model in Kenya.[25] For Agriculture, there are only three projects currently registered in the voluntary carbon markets. These have, on average, unlocked 2,2% of the annual mitigation potential available from this activity (i.e., 0.18 out of 8.33 $MtCO_2e\ yr^{-1}$) (**Table 1**). The three registered Avoided Deforestation projects have, on average, unlocked 43.9% of the annual mitigation potential suggested by our model (i.e., 1.17 out of 2.67 $MtCO_2e\ yr^{-1}$). Lastly, the eight registered Afforestation/Reforestation projects, have unlocked, on average, 8.3% of the annual available mitigation potential suggested by our model for this activity (i.e., 0.11 out of 1.33 $MtCO_2e\ yr^{-1}$).

[22] Koh, L. P., Zeng, Y., Sarira, T. V., & Siman, K. (2021). Carbon prospecting in tropical forests for climate change mitigation. Nature Communications, 12(1), 1–9.

[23] Cook-Patton, S. C., Leavitt, S. M., Gibbs, D., Harris, N. L., Lister, K., Anderson-Teixeira, K. J., et al. (2020). Mapping carbon accumulation potential from global natural forest regrowth. Nature, 585(7826), 545–550. Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., et al. (2017). Natural climate solutions. Proceedings of the National Academy of Sciences, 114(44), 11645–11650.

[24] FAO. (2022). Global soil organic carbon sequestration potential map (GSOCseq v1.1). Retrieved October 11, 2022, from http://www.fao.org/documents/card/en/c/cb2642en.

[25] For context, in a forthcoming report that examines all countries with VCM projects, we find that VCM currently unlocks about 1% of NbS mitigation potential globally from the five activities examined.

Table 1: Breakdown of Nature-based Solutions mitigation potential and mitigation delivered by the carbon markets per activity. The average annual emission reductions are calculated by averaging the verified emissions reductions of different monitoring periods for each project. Data is through September 2022.

Activity type	Roe et. al. CEMP ($MtCO_2e\ yr^{-1}$)	CEMP ($MtCO_2e\ yr^{-1}$) (model output, after filters)[26]	Average annual ERs delivered by VCM ($MtCO_2e\ yr^{-1}$)[27]	% of CEMP unlocked by VCM[28]
Agriculture (AG)	**21.94**	**8.33**	**0.18**	**2.2%**
Avoided Deforestation (AD)	**6.21**	**2.67**	**1.17**	**43.9%**
Afforestation/Reforestation (AR)	**5.65**	**1.33**	**0.11**	**8.3%**
Improved Forest Management (IFM)	**2.66**	**1.00**	**-**	**0.0%**
Wetlands (WL)	**0.89**	**0.33**	**-**	**0.0%**
Total	**37.36**	**13.67**	**1.46**	**10.7%**

Despite its potential, we find a disproportionately low number of Agriculture projects in Kenya. For instance, although the mitigation potential available for Avoided Deforestation represents approximately one-third of that for Agriculture (i.e., 2.67 and 8.33 $MtCO_2e\ yr^{-1}$, respectively), both activities currently count only three registered projects. This is even clearer when considering that, even though the mitigation potential of Agriculture is more than six times that of Afforestation/Reforestation, the latter has eight registered projects in contrast to three of the former. One of the Agriculture projects, the Nothern Kenya Grassland Project, focusses on carbon capture in grasslands by improving the grazing practices for pastroral communities in the nothern savannas and grasslands, including in Marsabit county.[29] The other Agriculture project[30] is on cropland, supporting sustainable land management in the Western part of the country where small-scale agriculture is prevalent. Lastly, the third Agriculture project is "Sustainable agroforestry based dairy value chain in Mount Elgon", a livelihood improvement project being implemented within the Mount Elgon catchment areas of Bungoma and Tran Nzoia counties.[31]

Although Agriculture represents the activity with largest potential, in practice numerous barriers hinder the proliferation of agriculture carbon projects.[32] These barriers are not specific to Kenya but affect the development of agriculture projects generally. A major constraint is the need for cost-effective methods for measurement, reporting, and verification (MRV) of soil organic carbon stock changes from agriculture projects.[33] Moreover, permanence issues also represent a source of uncertainty regarding unlocking carbon projects in agriculture. Although questions of

[26] This is calculated by dividing the mitigation potential per activity type obtained with the medium scenario of our model for the period 2021-2050, divided by the length of the period (i.e., 30 years). The model's underlying methodology can be found in the Annex of this document.

[27] The average ERs delivered by the VCM are calculated based on the total emission reductions, as reported by the VCS database. For each activity type, we calculate the Average Annual ERs by adding up the total issuances and dividing them by the period in which the projects in each category have been active.

[28] Average annual ERs delivered by VCM divided by CEMP (model output, after filters).

[29] The Northern Kenya Carbon Project. (n.d.). Northern Rangelands Trust. Retrieved October 17, 2022, from https://www.nrt-kenya.org/carbon-project.

[30] Kenya Agricultural Carbon Project - P107798. (2017). World Bank. Retrieved October 17, 2022, from https://projects.worldbank.org/en/projects-operations/project-detail/P107798.

[31] Sustainable agroforestry based dairy value chain in Mount Elgon (n.d.). Retrieved October 17, 2022, fom https://registry.goldstandard.org/projects/details/1809

[32] Wongpiyabovorn, O., Plastina, A., & Crespi, J. M. (2022). Challenges to voluntary Ag carbon markets. Applied Economic Perspectives and Policy. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1002/aepp.13254.

[33] Villegas, D., Bastidas, M., Matiz-Rubio, Ruden, A., Rao, Hyman, et. al. (2021). Soil carbon stocks in tropical pasture systems in Colombia's Orinoquía region: supporting readiness for climate finance - CCAFS Info Note. Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/116231/2021%20Info%20Note%20SOC_WB_HSJ_Final_Nov_22.pdf.

permanence affect most removal activity categories, it is particularly challenging in the context of agriculture, where practices can change quickly on an annual basis. Similarly, there are specific additionality concerns to this project type, since not all carbon standards require farmers to change practices to comply with additionality requirements. Some just require that practices in the field be different from common practices in the area, even if the same practices have been implemented for many years in the field under consideration.[34] Finally, the development of standards for this activity is comparably recent in relation to very established methodologies for REDD+ or Afforestation/Reforestation activities.[35]

There are also barriers specific to Kenya that could additionally hinder agriculture carbon projects. The bulk of the mitigation potential is in counties where nomadic pastoralism is practiced, and land tenure is an issue. The majority of the land where pastoralism occurs is communally used and not registered nor titled.[36] Unregistered community lands are held by the county governments in trust for the communities, which adds an additional layer of complexity for project development on community land. Furthermore, although the grazing practices could be sustainable, the nomadic nature of the pastoral communities makes it challenging to quantify and monitor their activities. In other counties where crop-farming is prevalent, the activities are done by small-holder farmers who in many cases lack titles or legally recognized rights to land.

Despite existing challenges, the alignment of three different factors offers a positive mid-term outlook for Agriculture projects. First, over the next few years these technical barriers are expected to be overcome, as maturing technological advancements provide information on how soil responds to a myriad of practices in different regions, and therefore models may reduce uncertainty and bring down the costs associated to MRV.[37] Secondly, this category presents a diversified set of project designs and activities that can both reduce emissions and sequester carbon.[38] Agriculture projects are of interest to a wide range of actors, including a large number of non-governmental organizations that are ready to work with local communities. Finally, there is a lot of political momentum targeting emissions reductions and removals in the agricultural sector. To illustrate, as part of the 26th session of the conference of the Parties to the UNFCCC in Glasgow, at least five declarations were made that mention wide emission reductions and removals from the agricultural sector.[39] This interest is translating as well into concrete policy measures, e.g. EU's incipient Carbon Farming initiative[40], some of which could rely on carbon markets, and which could rapidly extend to other geographies. In Kenya, there are ongoing efforts to secure land tenure rights of communities and to formally register community land rights, which could address the land tenure issues.[41]

---

[34] Wongpiyabovorn, O. et al. (2022).

[35] Taskforce on Scaling Voluntary Carbon Markets - Final Report. (2021). Retrieved October 11, 2022, from https://www.iif.com/tsvcm.

[36] For instance, only 2% of the land in Marsabit is registered. This is way below the national average which is 39.4 % of land-owners with titles. Republic of Kenya, & County Government of Marsabit. (n.d.). Second County Integrated Development Plan 2018-2022. Retrieved from https://cog.go.ke/cog-reports/category/106-county-integrated-development-plans-2018-2022?download=313:marsabit-county-integrated-development-plan-2018-2022.

[37] European Commission, Directorate-General for Climate Action, Radley, G., & Keenleyside, C. (2021). Technical guidance handbook: setting up and implementing result based carbon farming mechanisms in the EU. Retrieved October 11, 2022, from https://data.europa.eu/doi/10.2834/12087.

[38] Roe, S. et al. (2021). Land-based measures to mitigate climate change: Potential and feasibility by country. Global Change Biology, 27, 6025– 6058.

[39] The Glasgow Leaders' Declaration on Forests and Land Use, the Glasgow Food and Climate Declaration, the Agriculture Innovation Mission for Climate pledge, the Policy Action Agenda for a Just Transition to Sustainable Food and Agriculture, and, finally, the methane pledge, where over 100 countries agreed to reduce methane emissions to 30% of 2020 levels by 2030, which has implications for the livestock sector.

[40] European Commission et al. (2021).

[41] There is an increased land demarcation and adjudication efforts currently ongoing, resulting to titles being issued. In addition, the government of Kenya enacted Community Land Act in 2016 to govern management of community land and community lands are currently undergoing formal registration as required by the Act.

While the potential for Afforestation/Reforestation projects is much smaller than for Agriculture, there is a clear political will to support restoration efforts. Kenya's Constitution demands a minimum of 10% forest cover and in 2019 the Government set a goal to achieve the constitutional target by 2022.[42] While the Government has missed that target, it welcomes investments into carbon sequestration activities. With the Green Belt Movement founded by the late Nobel Prize Winner Wangari Maathai[43] and the TIST community forest initiative,[44] Kenya has a track record and potential to scale community-driven reforestation. Agroforestry systems that combine community forestry with climate-smart agricultural practices can combine various mitigation strategies in Kenyan landscapes.

Conclusions

The results presented here indicate that carbon markets can play an important role in supplying mitigation potential in Kenya, but they are not a silver bullet. Our results suggest that it is important to remove barriers for investors and project developers to leverage carbon market's NbS mitigation potential fully. However, even when measures are taken to facilitate carbon market investments, markets alone are insufficient to fully deliver Kenya's NbS mitigation potential. As a result, it is important to leverage other financial instruments in parallel.

This study exemplifies the risks of approaching the supply of NbS mitigation potential from a price-centric perspective alone. Supply studies should attempt to capture, on the one hand, the different political, economic, social, and legal barriers which limit the leverage of NbS mitigation potential via carbon markets. On the other hand, it is important to capture spatial restrictions in the form of locked-in land uses, which outline the areas that are not accessible to carbon markets. The latter restrictions were relatively minor for Kenya, but have been found to be very important for other countries.[45] The methodological approach presented in this report is a first endeavor to reflect more realistically the on-the-ground limitations faced nowadays by project developers.

Finally, additional investments are needed to produce high-quality local data. An enhanced understanding of local restrictions may be obtained through spatially explicit data on different types of land ownership (private, public, community, etc.). These data are not yet available for Kenya, but would greatly improve our understanding of carbon market limitations on the ground.

[42] Republic of Kenya, Ministry of Energy and Forestry. (2019). National strategy for achieving and maintaining over 10% tree cover by 2022. Retrieved October 17, 2022, from http://www.environment.go.ke/wp-content/uploads/2019/08/Strategy-for-10-Tree-Cover-23-5-19-FINAL.pdf.

[43] The Green Belt Movement. (2022). Retrieved October 17, 2022, from http://www.greenbeltmovement.org/.

[44] The International Small Group and Tree Planting Program. (n.d.). TIST Farmers Program. Retrieved October 17, 2022, from https://program.tist.org/kenya.

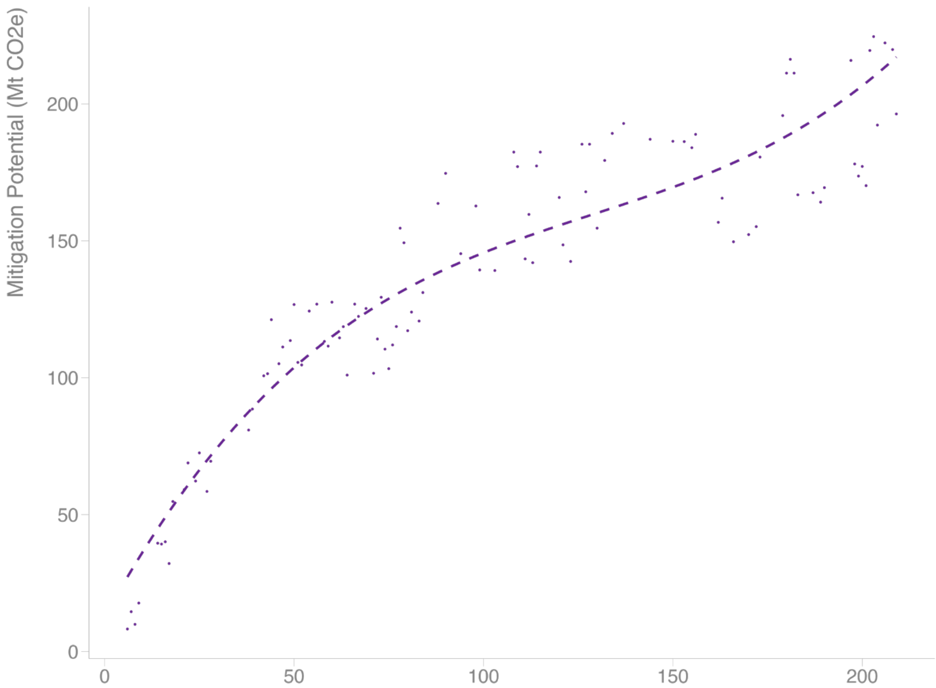
[45] Streck, C., Martinez, G., Landholm, D., Bravo, F., Castro, J. P., Cote, L., et al. (2022). Unlocking nature-based solutions through carbon markets in Colombia. Climate Focus. Retrieved October 11, 2022, from https://climatefocus.com/publications/unlocking-naturebasedsolutions-through-carbon-markets-in-colombia/.

Annex

Methodology

To estimate how much mitigation potential can be unlocked by carbon markets, we combined unpublished IPCC regional Marginal Abatement Cost Curves (MACC), produced by MESSAGE-GLOBIOM, an integrated assessment model (IAM), with the latest country data on Nature-based Solutions (NbS) mitigation potential from Roe et al. (2021). This paper provides available mitigation estimates ("cost-effective mitigation") for 20 different NbS (USD100/tCO_2e). For each of the five considered activities (Avoided Deforestation, Afforestation/Reforestation, Agriculture[46], the conservation and restoration of Wetlands, and Improved Forest Management), we fitted a function to the MACC output of MESSAGE-GLOBIOM model. The output of this model provides how much mitigation is unlocked for different prices (see example of Agriculture for Africa in Figure 5). We used the shape of the regional MACC and apply it to the Roe et al. (2021)'s country-level mitigation data estimate (USD100/tCO_2e) to extract how much can be unlocked at lower prices.

Figure 5: Example of a fitted function for a Marginal Abatement Cost Curve (MACC) based on MESSAGE-GLOBIOM's integrated assessment model (IAM). This particular curve refers to the Agriculture activity for Africa.

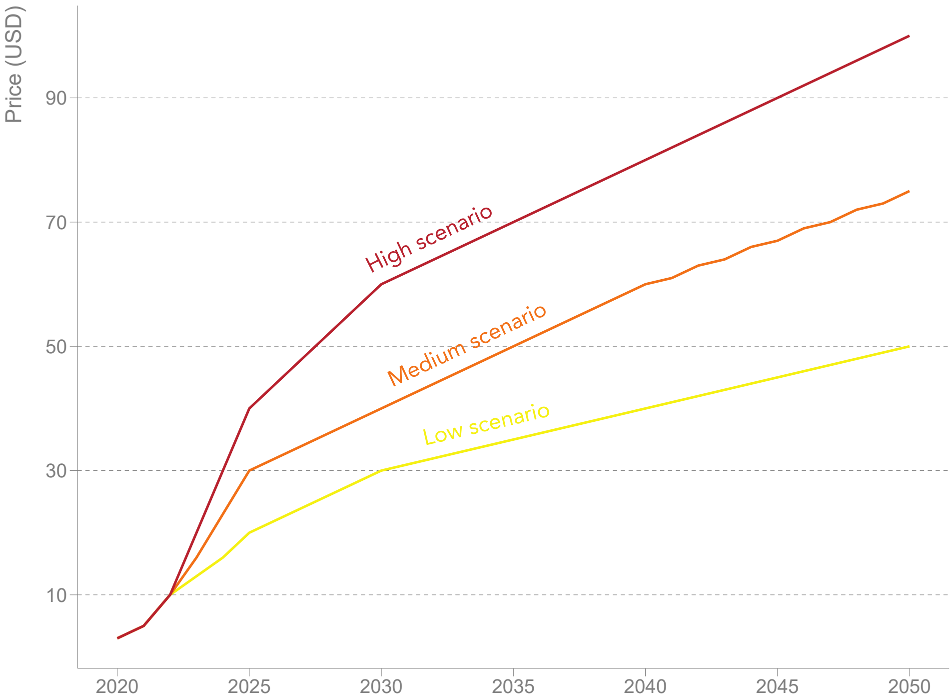


Next, we considered a wide range of price scenarios (**Figure 6**). Given the long timeframe considered (until 2050), a simple and transparent scenario-based approach is preferred over modeling specific price forecasts, which is particularly complex in the very uncertain carbon market environment. Combining these wide price projection ranges with the information above, we obtained a first estimate of how much mitigation potential can be unlocked in Kenya for each of the five activities, which considers both available NbS mitigation potential and possible price scenarios.

---

[46] The Agriculture activity includes mitigation potential from activities that reduce emissions and/or remove CO_2 from the atmosphere and store it in the soil and biomass.

Figure 6: Price projections considered (low, medium, high).



Filter 1: Feasibility factors

In practice, the implementation of NbS projects does not solely consider costs, but numerous other, typically ignored, dimensions act as barriers for the uptake of projects. Political, institutional, social, and technological dimensions are also important. We found that there is a significantly positive correlation between Roe et al. (2021)'s NbS country feasibility scores, which includes many of these dimensions, and project uptake[47] across all countries engaged in VCM.

We develop a tailored feasibility scoring system that reflects three distinct carbon market investment and implementation barriers. Specifically, we use the business and investment freedom indexes from the Heritage Foundations as a proxy of "ease of doing business", reflecting the need for countries to remove barriers to external investments. In addition, we consider the same political feasibility factors used in Roe et al. (2021). Political feasibility includes World Bank indicators of Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Finally, for land tenure security we used the International Property Rights Index.[48]

We combined the three parameters described above (i.e., ease of doing business, political and land tenure) to calculate the feasibility score for each of the 214 countries in the dataset and year.[49] We used historic data from 2013 to 2020 to estimate how feasibility factors may evolve in the future. For this purpose, we divided the countries into 43 groups of 5 to 6 countries, calculated the feasibility factors for each country and year and then average the yearly score among countries in each group. We then sorted the country groups according to their average score in 2013 and

47 We measured project uptake as project*years, i.e., the number of VCM NBS projects a given country times the number of years each project has been running.

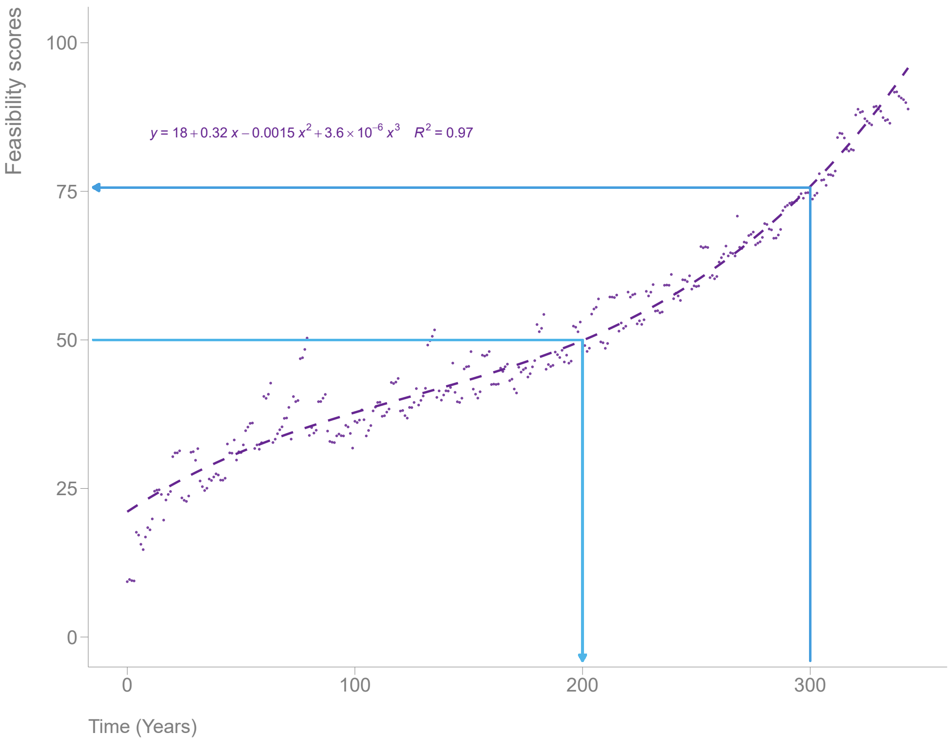
48 Property Rights Alliance. (2021). International Property Rights Index. Retrieved October 11, 2022, from http://www.internationalpropertyrightsindex.org

49 Individual feasibility scores are first normalized (0-100), then averaged across the three variables to obtain a final feasibility score.

values in each group according to year. We obtain a sequence of 344 scores (i.e. 43 groups by 8 years per group), indexed from 0 to 343.

Figure 7 **displays how the average feasibility scores of these groups (y axis) change over time (x axis), i.e. the 344 data points.** Based on historic data, as observed, feasibility scores are expected to gradually increase over time, albeit at different rates, depending on where a country starts on the development pathway curve.

Figure 7: Modelled evolution of feasibility scores over time. Y axis represents feasibility scores, x axis years. Green lines (with arrows) highlight the process: we have the initial feasibility score for Kenya (53), obtain the initial time value (x axis); then we return x+30 years to the equation to obtain the feasibility factor in 2050 (60).



To obtain the feasibility score in 2050 for an individual country, we proceed as follows along the fitted function shown in Figure 7: we consider the starting feasibility score of the country at present day (2020), e.g. Kenya (53), and derive the corresponding time index on the x axis. We then obtain the final feasibility score as the y value corresponding to x+30, which for Kenya is 60. Kenya therefore experiences a growth of 12.4% in their feasibility score over this time period.

The final step is to transform the calculated feasibility scores into percentage values, which are used as filters to reduce the mitigation potential of each country. This was done by assigning scores from 0 to 100 to each country for every year (i.e., the lowest scoring country receives 0 and the highest 100). Under this assumption the top scoring feasibility country (100%) has no barriers, and no mitigation potential is discounted in the model. In contrast, the worst scoring country receives 0%, i.e. no mitigation is unlocked in this country due to high barriers.

In the case of Kenya, the feasibility filter goes from 53.1% in 2020 to 67,8 % in 2050. This means 46.9% and 32.2% are discounted from Kenya's NbS mitigation potential in 2020 and 2050, respectively.

Filter 2: Spatially explicit mitigation potential maps

In a final step, we consider areas where it is very difficult to develop carbon market projects, due to existing on-the-ground limitations. We refer to these as "locked-in land uses". For Kenya, the following activities are considered: economic concessions[50], ongoing and planned mining activities[51], as well as the extraction of oil and gas.[52] The location, size and productivity of extractive sites serve as proxies for the portions of terrain covered by locked-in land uses. Overall, our approach holds the underlying assumption that investors and project developers will prefer to invest in areas that are not used by or committed to extractive industries.

We use existing spatially explicit maps on mitigation potential per activity for Avoided Deforestation, Afforestation/Reforestation, and Agriculture, and estimate what percentage of the potential falls within these locked-in areas. This percentage is then applied to the country-level model output to provide a conservative estimate on what is realistically available for NbS mitigation via carbon markets. The final maps are also used to highlight where the potential for different activities lies in Kenya (**Figure 4**).

For Avoided Deforestation, data is obtained directly from Koh et al. (2021). These authors address key VCS criteria, including additionality, to model and map investible forest carbon across the tropics; for Afforestation/Reforestation potential we consider carbon accumulation potential from natural forest regrowth in reforestable areas. We use data from Cook-Patton et al. (2020), filtered to include only reforestable areas as defined by Griscom et al. (2017). This map is not specific to carbon markets, but presents overall potential for the activity. Finally, for Agriculture potential we use the recently released Global Soil Sequestration Potential (GSOCseq) Map (FAO, 2022): we use scenario 3 and compared it to the business as usual (BAU) scenario. Using a more pessimistic scenario (e.g., scenario 1) would reduce slightly the values presented in the map but does not affect the distribution of where the potential is. Similar to Afforestation/Reforestation, this map is not specific to carbon markets, but presents the overall distribution potential for the activity.

All three potential maps are then processed to account for locked-in land uses where leveraging carbon markets is deemed difficult. This provides not only a final map of where the activity may be developed, but also the second feasibility filter (%) that is applied to the country model. After accounting for economic, feasibility, and land tenure barriers, the model then accounts for locked-in land uses by applying a percentage reduction that is informed by these spatially explicit maps.

---

[50] Land Matrix: Public database on land deals (n.d.). Retrieved October 11, 2022, from https://landmatrix.org/.

[51] Mines footprints provided in Maus et al. (2021) were used to identify the for the location of active mining projects. Further, we calculate the ratio between mine footprints and the respective mining concessions as provided on Global Forest Watch, to estimate the size of concessions where the mine footprint is known but not the respective concession area. Maus, V., Giljum, S., Gutschlhofer, J., da Silva, D. M., Probst, M., Gass, S. L. B., et al. (2020). Global-scale mining polygons (Version 1) [Data set]. PANGAEA. Retrieved October 11, 2022, from https://doi.pangaea.de/10.1594/PANGAEA.910894. Global Forest Watch. (n.d.). "Mining concessions." Retrieved from www.globalforestwatch.org.

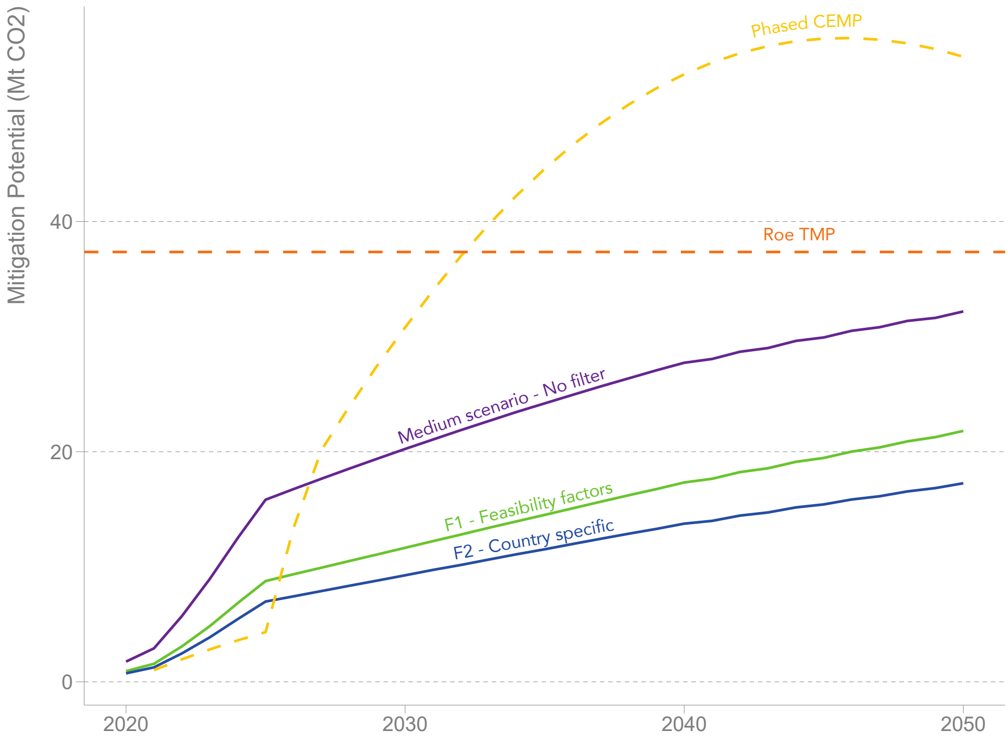
[52] Data on location and production of extraction facilities are provided by the Global Energy Monitor. Production of each facility is used to estimate the size of the respective land concession. Global Energy Monitor. (n.d.). Retrieved October 11, 2022, from https://globalenergymonitor.org/.

Table 2: Breakdown of NBS mitigation potential by county for AD, AR, AG, and total.

County	AD (%)	AR (%)	AG (%)	Total (%)
Kitui	1,0%	14,8%	5,9%	7,4%
Lamu	11,3%	19,1%	0,5%	6,9%
Garissa	11,3%	7,4%	5,4%	6,9%
Narok	10,6%	0,0%	6,1%	5,3%
Turkana	1,4%	0,5%	7,9%	4,9%
Tana River	2,0%	3,7%	5,9%	4,7%
Kwale	2,3%	12,4%	1,4%	4,4%
Kilifi	7,3%	7,6%	2,1%	4,3%
Marsabit	1,1%	0,2%	6,6%	4,1%
Kajiado	0,9%	1,8%	5,4%	3,8%
Nandi	1,7%	11,3%	1,1%	3,8%
Wajir	0,0%	0,0%	5,9%	3,4%
Taita Taveta	0,4%	3,6%	4,0%	3,3%
Makueni	0,9%	6,0%	1,9%	2,7%
Samburu	4,9%	1,6%	2,6%	2,7%
Baringo	4,9%	0,8%	2,6%	2,5%
Nakuru	3,6%	0,0%	2,9%	2,3%
Laikipia	1,8%	0,0%	3,4%	2,3%
West Pokot	3,1%	0,2%	2,4%	1,9%
Mandera	0,0%	0,0%	3,2%	1,9%
Meru	2,3%	0,7%	1,7%	1,5%
Kakamega	1,0%	3,0%	1,0%	1,5%
Isiolo	0,0%	0,1%	2,4%	1,4%
Keiyo-Marakwet	4,7%	0,1%	1,0%	1,4%
Uasin Gishu	0,9%	1,5%	1,4%	1,3%
Nyeri	4,3%	0,0%	0,9%	1,2%
Bomet	3,0%	0,0%	1,0%	1,1%
Nyandarua	1,7%	0,0%	1,4%	1,1%
Machakos	0,1%	0,1%	1,8%	1,1%
Homa Bay	2,3%	0,1%	0,8%	0,9%
Bungoma	1,6%	0,0%	1,0%	0,8%
Trans Nzoia	1,9%	0,0%	0,7%	0,7%
Tharaka	0,7%	1,0%	0,5%	0,7%
Kisumu	0,0%	0,7%	0,7%	0,6%
Migori	0,3%	0,0%	0,9%	0,6%
Embu	0,5%	0,3%	0,7%	0,6%
Kiambu	0,7%	0,0%	0,8%	0,6%
Kericho	0,7%	0,0%	0,7%	0,5%

Siaya	0,1%	0,0%	0,8%	0,5%
Murang'a	0,6%	0,0%	0,6%	0,5%
Kisii	0,6%	0,0%	0,4%	0,3%
Busia	0,1%	0,0%	0,5%	0,3%
Kirinyaga	0,7%	0,0%	0,3%	0,3%
Nyamira	0,5%	0,0%	0,3%	0,3%
Vihiga	0,0%	0,3%	0,2%	0,2%
Mombasa	0,0%	0,7%	0,0%	0,2%
Nairobi	0,0%	0,0%	0,2%	0,1%

Figure 8: Visual description of methodological process displaying a medium price scenario (orange). After considering feasibility and locked-in land use constraints the mitigation available is represented by the grey and yellow lines, respectively.



Limitations

Forecasting carbon markets' potential over a long timeframe for a varied set of NbS is fraught with challenges that reflects on some limitations of our analysis.

First, the defined price trajectories, the used MACCs, and the filters (feasibility and locked in land uses) do not capture some additional activity-specific constraints. For instance, our model shows Agriculture as the activity with most potential; however, important technical barriers related to measuring , reporting and verification (MRV) need to be overcome for carbon markets to leverage Agriculture's full potential. A lot of effort is currently placed on solving these barriers, but the outcome is still unclear.[53] It is also unclear how future changes in carbon market standard rules will affect these estimates. If countries seriously address their deforestation, the Avoided Deforestation project activity may eventually flatten over time, as already occurred for renewable energy projects. These activities are no longer considered additional to countries' business-as-usual policies and therefore, have been excluded by some carbon market standards (except for Least Developed Countries).

Secondly, our model uses regional MACCs derived from IAMs for 5 different NbS activities. The model takes the shape of the regional MACC and applies it to the country-specific mitigation potential presented by Roe et al. (2021), i.e. the cost-effective mitigation potential unlocked at USD100/tCO_2e. Although this approach is not expected to deviate substantially from an approach that gathers country-level costs, the accuracy can certainly be improved in the future by using local data.

Thirdly, the estimation of the portion of area occupied by locked-in land uses is unlikely to perfectly match the shape and size of mining, oil and gas concessions in the country. As spatially explicit information becomes available on these land uses, the accuracy of the model outputs can be improved. However, at a country scale, this is expected to be a minor source of uncertainty.

Finally, carbon market prices will evolve over time as a function of supply and demand. Regarding the latter, however, there are still a lot of uncertainties regarding how many companies will go beyond net-zero targets. The volume of credits generated by neutrality claims may be even larger than target-year net-zero claims. Hence, until this becomes clearer the uncertainty around demand will be very large over a 30-year forecasting period. Here, we preferred to lay a wide range of price scenarios to gauge the effect under different scenarios. What is expected at the moment is that demand will quickly outpace supply, and therefore addressing country supply barriers is urgently needed.

[53] European Commission, Directorate-General for Climate Action, Radley, G., & Keenleyside, C. (2021). Technical guidance handbook: setting up and implementing result based carbon farming mechanisms in the EU. Retrieved October 11, 2022, from https://data.europa.eu/doi/10.2834/12087.

Climate Focus is an independent expert in international and national climate law, policies, project design and finance. We have been pioneering carbon markets ever since their inception. We aim to find a creative and unique solution for every single client, ranging from the development of policies to protect the rainforest to structuring greenhouse gas mitigation projects in the energy sector. Our advice is rooted in a profound knowledge of climate change policies, emission trading schemes and project development.

Climate Focus has offices in Amsterdam, Rotterdam, Washington DC, Berlin, and Bogotá. Our core team is complemented by a broad network of in-country and specialized partners.

CONTACT US

GLOBAL HEAD OFFICE
AMSTERDAM, THE NETHERLANDS
Climate Focus, B.V.
Van Diemenstraat 170
1013CP Amsterdam,
The Netherlands
T +31 20 262 10 30

ROTTERDAM, THE NETHERLANDS
Het Industriegebouw
Goudsesingel 52-214
3011 KD Rotterdam
The Netherlands
T +31 20 262 10 30

WASHINGTON, DC, USA
Climate Focus North America, Inc.
1701 Rhode Island Ave NW
Washington, DC 20036, USA
T +1 202 540 22 73

BERLIN, GERMANY
Climate Focus Berlin GmbH
Schwedter Str. 253
10119 Berlin, Germany
T +49 30 24637919

BOGOTÁ, COLOMBIA
Carrera 14 #89-48, 305
Bogotá, Colombia
T +57 1 322 73 54