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Decarbonising Africa's Agriculture and Forestry: Synergies and Trade-offs for Sub-Saharan Africa

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Abstract

Decarbonisation as a climate mitigation strategy is gaining much traction lately due to the heightening climate variabilities and risks. While decarbonisation is essential across all sectors to have a meaningful transition towards net-zero emissions by the mid-twenty-first century, agriculture and forestry are critical areas in Sub-Saharan Africa (SSA).

Noting that over 70 percent of forest loss in SSA is linked to agricultural expansion, the two sectors are examined jointly because an activity in one sector implicates the other. The journey towards decarbonising Africa's agriculture and forestry faces several challenges; it also presents opportunities to exploit natural resources and conserve and develop green projects that promote sustainable development. On the contrary, the climate adaptation component has been given more emphasis in most of the development and policy frameworks in SSA than the attention the mitigation component receives. Thus, this paper analyses the greenhouse gas emission sources in the agriculture and forestry sectors while interrogating some of the challenges barring their decarbonisation and considers potential trade-offs in SSA. Policy integration, more robust governance and multi-sectoral collaboration are discussed throughout the paper as some enablers of decarbonisation.

1.0 Introduction

The race towards net-zero emissions by 2050 is picking momentum across the globe. The IPCC's 2018 special report on Global Warming of 1.5°C indicates that urgent and comprehensive actions need to be adopted in order

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to limit warming to 1.5°C.[1] In particular, transformation in the land, energy, transportation, buildings, and industrial operations is a fundamental vehicle towards reducing emissions escaping into the atmosphere. Accordingly, reaching the net-zero emission mark by the mid-21st century mandates that the net human-induced emissions worldwide must reduce by 45 percent by 2030 from the 2010 levels.[2] This means efforts to decarbonise by all sectors and persons in all the geographical locations are deemed necessary even though some countries and regions contribute an insignificant amount of emissions. Africa, for instance, is estimated to contribute less than four percent of the total global greenhouse gas (GHG) emissions compared to China at 23 percent and the United States of America at 19 percent.[3] In the context of this paper, decarbonising refers to removal or reduction (mitigation) of all GHG emissions.

Of interest in this paper is exploring opportunities and challenges in decarbonising the agriculture and forestry sectors in Sub-Saharan Africa (SSA). These two crucial areas influence the region's social, economic, political, and ecological standings. The agriculture sector in SSA is estimated to contribute an average of about 15 percent of the gross domestic product; however, it varies per country, ranging from 3 to 50 percent.[4] Agriculture serves a direct and indirect need in the region, to both rural and urban populations. It is a source of employment, income, and food to the majority of the residents; for example, to 70 percent of the people in Southern Africa.[5]

1 IPCC. 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. *World Meteorological Organization, Geneva, Switzerland, 32 pp. https://www.ipcc.ch/sr15/*

2 Ibid

3 Czechowski, Aditi, Surie. 2020. CDP Africa Report Benchmarking Progress Towards Climate Safe Cities, States, And Regions. CDP. Retrieved on 9th feb *https://www.cdp.net/en/research/global-reports/africa-report*

4 OECD. 2016. OECD-FAO Agricultural Outlook 2016-2025: Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade. *OECD/FAO. https://doi.org/10.1787/agr_outlook-2016-5-en*

5 SADC. 2021. Agriculture and Food Security. *Southern African Development Community*.

Agriculture is the cornerstone of food security, a matter that many countries in SSA are struggling to meet. Population increase, intensifying climate variability and impacts, changing lifestyles, economic constraints and policy inadequacies has stretched the agriculture sector to the point of not meeting the immediate urgent needs of the population. In response, agricultural expansion has been activated, most of which has led to clearing the forests to create more room for farming and livestock rearing. The repercussion of this reflex action is deforestation and forest degradation, destruction of vital carbon sinks resulting in increased accumulation of carbon emissions in the atmosphere.[6] Notably, agriculture is not the only agent of forest destruction; logging, commercial wood harvesting, timber harvesting, urbanisation, need for settlement and infrastructural space are other drivers.

Similarly, despite the integral social and economic functions of agricultural operations, they contribute to GHGs responsible for global warming. In most cases, the latter is overlooked, yet, climate change which is a consequence of increased emissions, devastates the agriculture sector due to uncertain occurrences such as droughts, floods, pest invasions, livestock and crop diseases, water scarcity, and erratic rainfall. Notably, adaptation to climate change in SSA has been emphasised and prioritised in most policies, institutional and programmatic frameworks giving mitigation a low priority.[7] In that regard, this paper analyses some of the synergies and trade-offs in decarbonising agriculture and forestry sectors in SSA as an avenue to climate change mitigation.

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https://www.sadc.int/themes/agriculture-food-security/#:~:text=The%20agriculture%20sector%20is%20of,for%20food%2C%20income%20and%20employment.

6 Smith Peter, Bustamante Mercedes. 2014. *Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, USA. *https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter11.pdf*

7 Ciplet, David, J. Timmons Roberts, and Mizan Khan. 2013. The Politics of International Climate Adaptation Funding: Justice and Divisions in the Greenhouse. *Global Environmental Politics* 13, 1: 49–68. *https://doi.org/10.1162/GLEP_a_00153*

2.0 Emission Perspective from the Agriculture and Forestry in SSA

2.1 Agriculture sector

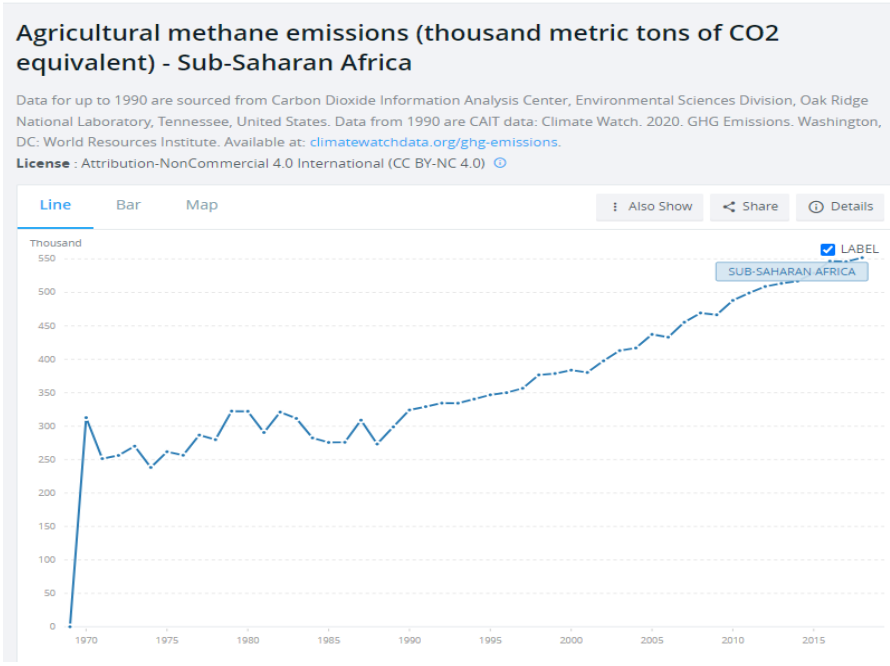
Agriculture is responsible for carbon dioxide and non-carbon emissions.[8] Non-carbon emissions include methane and nitrous oxide from crop farming and livestock keeping. On the other hand, carbon emissions are associated with the conversion of the natural lands into crop and livestock production zones. Forests are the majority of the natural ecosystems affected. On a global scale, FAOSTAT's 2018 estimations of methane and nitrous oxide from crop and livestock farming were about 5.3 gigatons of carbon equivalent.[9] Out of the estimations, only a third were from crop production and the rest from livestock farming. This high proportion of emissions from livestock production is linked to enteric fermentation that produces methane gas. Similarly, animal manure, either secreted by the livestock or applied in farmlands, is responsible for nitrous oxide. In principle, when the livestock increase in a given area, it is expected that the amounts of manure and enteric fermentation will be higher, translating to increased GHGs in the atmosphere. SSA's emission trend for specific GHGs has been upward, mirroring the total continental emissions presented by different sources.

For example, from 2000 to 2018, Africa's emissions rose by six percent of the total global agricultural emissions.[10] Also, agricultural methane emissions for SSA rose from 1969 to 2018 with a steady increase during the 1990-2018 period, as shown in figure 1. It should be noted that while the total methane contribution is showing an upward trajectory, the contrary is the case for some countries like Mauritius, Seychelles, Sao Tome and Principe, and Equatorial Guinea, whose curves have been stagnating or dropping.[11] A similar trend (see figure 2) is manifested in SSA's agricultural

8 FAO. 2020. Emissions due to agriculture. Global, regional and country trends 2000–2018. *FAOSTAT Analytical Brief 18*.
https://www.fao.org/3/cb3808en/cb3808en.pdf
9 Ibid
10 Ibid
11 World Bank. 2022. Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent) - Sub-Saharan Africa.

nitrous oxide emissions with some countries such as Lesotho and Cabo Verde showing a declining trend.

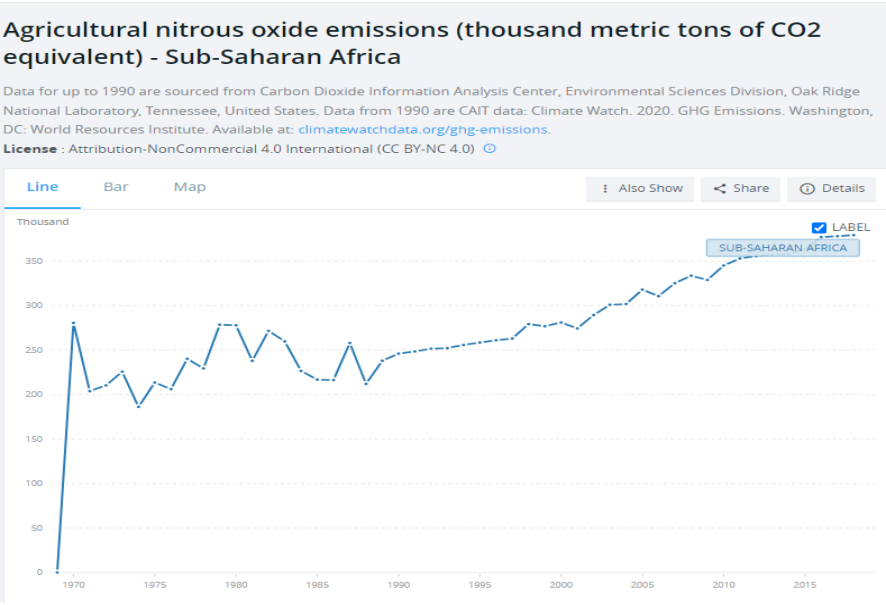
Figure 1: Agricultural methane emissions (thousand metric tons of CO2 equivalent) - Sub-Saharan Africa



Source: World Bank: generated on 11/02/2022

Figure 2: Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent) - Sub-Saharan Africa

https://data.worldbank.org/indicator/EN.ATM.NOXE.AG.KT.CE?end=2018&locations=ZG&start=1969&view=chart



Source: World Bank: generated on 11/02/2022

While SSA countries have almost similar agricultural practices, country-specific socio-economic and ecological systems influence the quantity of GHG emissions produced. Technological usage in crop farming and livestock production, population size, fertiliser use and type, crop variety, and livestock breeds are a few of the variables that influence the upward, downward, or flattening trends of emissions curves.[12] Essentially, the use of synthetic fertiliser which is a common practice in most African communities is one of the drivers of greenhouse gases. Because of land degradation and poor soil fertility, the majority of the farmers, whether smallholder or large scale, tend to use large amounts of artificial fertilisers to increase crop yields to meet the needs of the growing population.[13] With climate variability intensifying, it is expected that adaptation and risk mitigation measures in the agriculture sector will be adopted.

12 Tongwane, Mphethe, Thandile Mdlambuzi, Mokhele Moeletsi, Mitsuru Tsubo, Vuyo Mliswa, and Lunga Grootboom. 2016. Greenhouse gas emissions from different crop production and management practices in South Africa. *Environmental Development*, *19*, 23–35. *https://doi.org/10.1016/j.envdev.2016.06.004*
13 Ibid

Conversion of land into agricultural zones is an important driver of emission upsurge, although the actual amount of GHGs associated with land-use change cannot be ascertained.[14]

2.2 Emission perspective from forestry

Forests play a fundamental role in carbon sequestration while at the same time it can be a carbon source. Accordingly, forests are considered a carbon source when the amount of carbon it releases into the atmosphere is higher than the amount it sequesters.[15] That is, when the net balance of carbon emissions linked to forests is positive, it is considered a carbon source, however, when the net balance is negative, it is carbon sequestration.[16] Several questions and debates have been floated as to whether forests are actually a carbon sink or carbon source. This question will remain active unless proper carbon quantifications are done to establish a net value on a contextual basis. Nonetheless, deforestation, agricultural expansion, fires, and development activities are some land-use changes that reduce forests' size, limiting their ability to perform the crucial functions of absorbing carbon. For instance, forests and other land uses are approximated to inject 11 percent of carbon dioxide into the atmosphere based on a 2010 global emission estimate.[17] Deforestation accounts for the highest amount of carbon emissions linked to forests. World Resources Institute, using granular information, estimated the global carbon emitted into the atmosphere by forests as a result of deforestation to be about 8.1 million metric tons

14 African Development Bank. 2020. Drivers of Greenhouse Gas emissions in Africa: Focus on agriculture, forestry and other land use. *AfDB. https://blogs.afdb.org/climate-change-africa/drivers-greenhouse-gas-emissions-africa-focus-agriculture-forestry-and-other*

15 NASA. 2021. NASA Study Finds Tropical Forests' Ability to Absorb Carbon Dioxide Is Waning. *NASA's Jet Propulsion Laboratory. https://www.jpl.nasa.gov/news/nasa-study-finds-tropical-forests-ability-to-absorb-carbon-dioxide-is-waning*

16 UNECA. N.d. Carbon Sinks and Sequestration. *United Nations Economic Commission for Europe*. https://unece.org/forests/carbon-sinks-and-sequestration

17 IPCC. 2014. AR5 Climate Change 2014: Mitigation of Climate Change. The Working Group III contribution to the IPCC's Fifth Assessment Report (AR5). *https://www.ipcc.ch/report/ar5/wg3/*

annually.[18] More studies show that deforestation and peatland degradation are responsible for 12 percent of the global greenhouse gas emissions.[19]

Zooming in to the African continent, it is argued, Africa hosts 17 percent of the world's forests with Congo basin hosting over 50 percent of Africa's biodiversity.[20] In the SSA region, forests have been decreasing at an alarming rate from the late-20th century to the present day. The total forest land area in SSA is estimated to have reduced from 33 percent in 1990 to 26.3 percent in 2020.[21] It can be concluded that the decline in the forested land translates to increased GHGs accumulating in the atmosphere when all other factors are held constant. Forest loss in SSA is driven not only by demand for forest products but also by fundamental activities such as farming, which injects greenhouse gases into the atmosphere and realistically cannot be avoided. For example, cocoa farming which is a valuable export crop in West Africa, has left a huge deforestation footprint in Ghana and Cote d'Ivoire with a relatively minimal impact in Cameroon.[22] The fact that forests are two-edged in regional and global emissions control, high impact synergies are necessary.

18 Harris Nancy and Gibbs David. 2021. Forests Absorb Twice As Much Carbon As They Emit Each Year. *World Resources Institute*. *https://www.wri.org/insights/forests-absorb-twice-much-carbon-they-emit-each-year*

19 Ox-fam. 2021. Tightening the Net: Net zero climate targets – implications for land and food equity. OXFAM Briefing Paper. *https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621205/bp-net-zero-land-food-equity-030821-en.pdf*

20 AWF. 2015. Get the Scoop on Deforestation in Africa. African Wildlife Foundation. https://www.awf.org/blog/get-scoop-deforestation-africa

21 World Bank. 2022b. Forest area (% of land area) - Sub-Saharan Africa. *https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=ZG*

22 Hoare Alison, King Richard & Airey Sam. 2017. Cocoa trade, climate change and deforestation. Resource Trade Earth. *https://resourcetrade.earth/publications/cocoa-trade-climate-change-and-deforestation#Forests*

2.3 Framing the implications of greenhouse gas emissions on agriculture and forestry

Climate change is consequential of increased greenhouse gases in the atmosphere. As outlined above, the agriculture and forestry sectors in SSA contribute to the global share of emissions in varying proportions. At the same time, carbon emissions destabilise the normal functioning of the two industries leading to cross-cutting implications whose magnitude is significantly high in Africa. Uncertainties occasioned by intensifying climate events in SSA is creating a complex environment for the agriculture sector to meet its supposed primary function of curbing food insecurity, exterminating hunger, and improving livelihoods.[23]

Rainfall variability- temporal and areal- is a result of climate change, an event that is already jeopardising farming activities in SSA given that over 95 percent of agriculture is rain-fed.[24] This implies that food security will not be assured. Although some individuals have resorted to irrigating farms and practicing greenhouse farming as well as integrating the climate-smart agriculture concept, water scarcity and inconsistent humidity patterns is another challenge.[25] Equally, increased atmospheric temperature is likely to complicate the germination and performance of crops and reproduction and growth of livestock. In the recent past, prolonged droughts, higher frequency of floods and famine have been registered in many parts of SSA Africa, a phenomenon that directly impacts fishing, crop, and livestock production.[26]

23 OECD. 2016. OECD-FAO Agricultural Outlook 2016-2025: Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade. OECD/FAO. https://doi.org/10.1787/agr_outlook-2016-5-en

24 Abrams, Len, et al. 2018. Unlocking the potential of enhanced rainfed agriculture. *Stockholm Resilience Centre, Report no. 39*. Stockholm University. https://siwi.org/wp-content/uploads/2018/12/Unlocking-the-potential-of-rainfed-agriculture-2018-FINAL.pdf

25 Abou Zaki, et al. 2018. "An Index-Based Approach to Assess the Water Availability for Irrigated Agriculture in Sub-Saharan Africa" *Water* 10, no. 7: 896. https://doi.org/10.3390/w10070896

26 IMF. 2020. Chapter 2: Adapting to Climate Change in Sub-Saharan Africa. *International monetary Cooperation.*
https://www.imf.org//media/Files/Publications/REO/AFR/2020/April/English/ch2.ashx

The implications are felt far and wide, although communities in marginalised areas mostly in drier areas and climate-dependent are more susceptible. The Sahelian region, for instance, has experienced pronounced climate change effects in terms of droughts, water shortage, and erratic rainfall.[27] The expected outcome is food shortage and shrinkage of natural resources affecting the swelling population estimated at a 2.8 percent growth rate annually.[28] Similarly, countries like Kenya and Ethiopia have lost livestock, pasture lands and crops due to climate-induced episodes like famine, floods, and prolonged-droughts.

When looking at the climate effects in forests and forestry, often, the focus is on the functional attributes of the forests. Climate change increases the risks of droughts and wildfires that may destroy a forest entirely, leading to carbon storage reduction, animal habitats destruction, and biodiversity loss.[29] Forests are water catchment areas; once ruined, the effects trickle down to all entities in an ecosystem loop. Rainfall variability and prolonged drought limit the growth of new trees and vegetation, leaving the soil bare and potentially loose. Bare soils are prone to erosion and floods; such an ecosystem loses its role as a flood shed.

Also, Africa's forests are home to several plant and animal species, modification of their habitats combined with heat stress due to rising temperatures could trigger migration or deaths of some animals.[30] In some

27 Schraven Benjamin et al. 2020. Climate change impacts on human (im-) mobility in Sub-Saharan Africa: Recent trends and options for policy responses. *GIZ. https://www.adaptationcommunity.net/wp-content/uploads/2020/07/GIZ_Climate-impacts-on-human-mobility-Africa.pdf*

28 Shepard Dan. 2019. Global warming: severe consequences for Africa. *United Nations Africa Renewal, 2018-2019*. *https://www.un.org/africarenewal/magazine/december-2018-march-2019/global-warming-severe-consequences-africa*

29 Nunes Leonel, et al. 2021. The Impact of Climate Change on Forest Development: A Sustainable Approach to Management Models Applied to Mediterranean-Type Climate Regions. *Plants*, *11*(1), 69; https://doi.org/10.3390/plants11010069

30 Sonwa Denis. 2018. Forest and Climate Change Response in Africa. Proceedings of the ASC – TUFS 'Kickoff' Symposium, Tokyo University of Foreign Studies. https://www.cifor.org/knowledge/publication/6903/

instances, the animals will be forced to adapt to the changes. In communities that rely on forests for spiritual intervention and herbal medication, their socio-cultural and economic activities may be threatened. In Kenya, for instance, the supply of some medicinal plants is thought to have declined due to changing environmental conditions such as rainfall and temperature variability.[31] Researchers worry some plants may go extinct. It is important to note that human activities such as logging, fuelwood harvesting, and agricultural expansion are exacerbating the decline.

3.0 Challenges in decarbonising agriculture and forestry in Sub Saharan Africa

Decarbonising the agriculture and forestry sectors in SSA is an uphill task due to financial, governance, attitudes, forest dependence, and technological advancement. This section will explore some of the challenges evident across different countries and economic regions in SSA.

3.1 Dependence on forests, forest products and deforestation

Forests serve the needs of Sub-Saharan Africa's people in varying degrees. While it is not possible to give an exact account on the degree of dependence, World Bank approximates about 1.6 billion people dependent on forests globally, where 350 million living close to or within dense forests derive their livelihood from it.[32] However, the figures are not specific to persons falling under indigenous community category. In Central Africa alone, forest people are estimated to be between 33-60 million.[33] The Ogiek of Kenya and the pygmies of Uganda and Cameroon are some of the many forest people still existing in SSA whose livelihoods are almost entirely defined by the richness of forests. According to a high-level report from a panel of experts

31 Gafna Jeff Dikko, et al. 2021. Medicinal service supply by wild plants in Samburu, Kenya: Comparisons among medicinal plant assemblages. *Global Ecology and Conservation*, 30, e01749.
https://doi.org/10.1016/j.gecco.2021.e01749

32 World bank. 2021. Forests and Terrestrial Ecosystems (Landscapes). *https://www.worldbank.org/en/topic/forests#1*

33 Chao Sophie. 2021. Forest Peoples: Numbers across the world. *Forest Peoples Programme*.
https://www.forestpeoples.org/sites/fpp/files/publication/2012/05/forest-peoples-numbers-across-world-final_0.pdf

on sustainable forestry for food security and nutrition, the contribution of forests and trees is summed up into; provision of bio-energy for cooking, direct source of food, economic and livelihood source, and supply of ecosystem services such as for agriculture.[34] The close dependence on forests for income and subsistence is not only an African problem but a global matter challenging the possibility of decarbonising the forestry sector. It is particularly hard given that about 59 percent of the SSA population reside in rural areas.[35]

As Sub-Saharan Africa's population continues to balloon with a projection of 2.1 billion by 2050, agriculture which averagely accounts for 15 percent of the region's GDP, will inevitably have to expand.[36] This expansion puts a lot of pressure on forests and trees, leading to deforestations. This scenario presents a state of dilemma for many communities and governments in SSA at a time when climate variability is intensifying, and food insecurity is persistent. The scenario raises the following questions: - will SSA countries limit agricultural expansion to safeguard forests as carbon sinks? Will decarbonisation be prioritised at the expense of economic development and food security?

Wood is an essential commodity in SSA where 90 percent of it is utilised as an energy source in the form of charcoal and firewood, constituting 70 percent of heating and cooking energy needs.[37] As stated above, SSA's population is rising, indicating that energy demands will go up, putting a strain on the remaining forests, potentially posing a severe ecological challenge. Demand for charcoal, in particular, has been going up, although

34 FAO. 2017. Sustainable Forestry for Food Security and Nutrition. A Report by the High-Level Panel of Experts on Food Security and Nutrition. *HLPE Report 11*. http://www.fao.org/cfs/cfs-hlpe

35 World bank. 2022. Rural population (% of total population) - Sub-Saharan Africa. *https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=ZG*

36 OECD. 2016. OECD-FAO Agricultural Outlook 2016-2025: Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade. OECD/FAO. https://doi.org/10.1787/agr_outlook-2016-5-en

37 FAO 2021. Conference: Sustainable Woodfuel Value Chains in Africa: Governance, Social, Economic and Ecological Dimensions. *FAO Africa.* https://www.fao.org/africa/events/detail-events/es/c/1445092/

the consumption and production vary per country based on the population sizes, connection to the national grid, and availability of alternative cooking methods. In the Congo forest basin, deforestation trends demonstrate an upward trend, same as charcoal production.[38] Arguably, the rising trend is not surprising as the population in the Congo basin region is growing. For example, the Democratic Republic of Congo (DRC) was the largest charcoal producer in the region, estimated at 71 percent in 2007 compared to Cameroon at 21 percent. [39] Nonetheless, the figures were directly proportional to each country's population, an indication that population increase is a threat to forests and forestry products. Only 9 percent of DRC's population can access electricity, leaving the rest to source fuel for domestic and small-scale businesses from firewood and charcoal.[40] This trend is worrisome to the sustainability of the Congo forest and its ability to satisfy the ecosystem services and carbon mitigation functions. Thus, solving the problem calls for energy transition, primarily cooking and heating. The choice of cooking and heating energy sources depend on availability, accessibility, cost-effectiveness, and sustainability where wood fuel happens to fulfil most of these factors in many households in developing nations.[41]

3.2 Financial Investment and constraint

Decarbonising agriculture and forestry sectors take different angles; the most important aspect is energy transition. Transitioning to renewable energy sources in agriculture is fundamental, although the developing nations, including the SSA region, are financially challenged due to competing

38 Behrendt Hannah, Megevand Carole & Sander Klas. 2013. Deforestation Trends in the Congo Basin Reconciling Economic Growth and Forest Protection. *Working Paper 5 | Wood-based Biomass Energy, World Bank*.https://documents1.worldbank.org/curated/en/642861468005138886/pdf/779400NWP0P1160ort0FINAL0web00may13.pdf

39 Ibid

40 Cibemba Angel. 2021. How the Charcoal Industry Threatens DRC's Forests. World Resources Institute. https://www.wri.org/insights/how-charcoal-industry-threatens-drcs-forests

41 Malla Sunil and Timilsina R Govinda. 2014. Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries: A review. *World Bank, Policy Research Working Paper 6903*. https://cleancooking.org/binary-data/RESOURCE/file/000/000/376-1.pdf

priorities to meet, in particular, social and economic needs.[42] Given that about 600 million people in SSA have no access to electricity, it is likely that energy demands for agriculture will primarily come from carbonised sources.[43] Nonetheless, efforts have been made to introduce off-grid solar energy sources to support farming operations in different countries although cost constraints seem to impede the progress. For instance, a 2019 report by the World Bank, International Finance Corporate and Lighting Global assessed the possibility of leveraging solar energy use in SSA and demonstrated the viability of uptake in different agricultural departments; however, the cost estimates are high for an ordinary smallholder farmer.[44]

The report underscores that the scale of uptake of solar-powered machineries is not the same in all countries, defined by the agricultural value and market chains of each country. Comparing uptake of solar-powered irrigation pumps in three countries, uptake is advancing in Kenya; uptake is limited, although the solar pumps are available in Zimbabwe and Cote d'Ivoire has a low uptake.[45]

Lack of tailored funds towards the adoption of renewable energy sources in agri-food systems is also a challenge that inhibits the possibility of decarbonising the agriculture sector in Africa.[46] Even with external funds, the socio-economic status of SSA countries influence the local and country-level transitional capacity. Decarbonising the forestry sector, for instance,

42 IFAD. 2020. Renewable Energy for Smallholder Agriculture (RESA). *International Fund for Agricultural Development*. https://www.ifad.org/documents/38714170/41937394/resa.pdf/715e1a75-35df-bafc-f491-7effde867517

43 World Bank. 2019. (Em)powering Farmers in Africa: Small-scale Solar Lights a Path for Agricultural and Economic Impact. *https://www.worldbank.org/en/news/feature/2019/12/05/small-scale-solar-for-agricultural-and-economic-impact*

44 IFC. 2019. The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa. *International Finance Corporation*. *https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf*

45 Ibid

46 IRENA and FAO. 2021. Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. *IRENA and FAO, Abu Dhabi and Rome*. https://doi.org/10.4060/cb7433en

lies within the financial investment in improving the cooking energy sources at the household, commercial and industrial scopes, including ensuring accessibility, reliability, and cost-effectiveness.[47] As expensive as it may be to transition, operating at a business as usual scenario, harvesting and exploitation of forest products exacerbate deforestation. The cost of reversing deforestation is hefty, knowing that trees take longer to mature, tending and managing them needs money and expertise; cleaning the air of carbon accumulated due to deforestation is expectedly higher, and the ripple effect is cross-cutting.

Other financial constraints are associated with the acquisition of organic fertilisers. Generally, access to and use of fertilisers in most African countries is low because of high prices.[48] A working paper by the Food and Agriculture Organisation of the United Nations specifies financial challenges as one of the main inhibitors to fertiliser use in SSA by citing high administrative and transportation cost and lack of favourable credit facilities.[49] In addition, a report on fertiliser production and consumption in Africa notes the monetary constraint in fertiliser access and usage in Africa, arguing that the fertiliser industry is capital intensive. Still, many financial institutions have a low presence in the grassroots areas.[50] Even with rural presence, the report says, most banking and credit financing systems have high-interest rates and that market information is often lacking. Although some countries have introduced fertiliser subsidies to ease access and

47 NewClimate Institute. 2021. The Kenyan Cooking Sector - Opportunities for Climate Action and Sustainable Development: GHG mitigation potential, health benefits and wider sustainable development impacts. *International Climate Initiative*. http://www.ambitiontoaction.net/outputs

48 Bationo Andre, et al. 2012. *Lessons learned from Long-term Soil Fertility Management Experiments in Africa*. Springer Science & Business Media

49 Druilhe Zoé and Barreiro-Hurlé, Jesús. 2012. Fertilizer subsidies in sub-Saharan Africa. ESA Working paper No. 12-04. Rome, FAO. *https://www.fao.org/3/ap077e/ap077e.pdf*

50 UNECA, AFDB and African Union. 2018. Promotion of Fertilizer Production, Cross-Border Trade and Consumption in Africa. *https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Study__sponsored_by_UNECA___AFFM__on_promotion_of_fertilizer_production__cross-border_trade_and_consumption_in_Africa.pdf*

affordability by all farmers, it is unsustainable and season-based.[51] It is crucial to note that organic fertiliser alone cannot counter Africa's fertiliser shortage to the extent of satisfying increasing agricultural intensification in a climate insecure region with already degraded soils. Thus, organic and inorganic fertilisers are considered not as substitutes but complementary of each, presenting an opportunity for integrated soil fertility management.[52] This reality opens a window for decarbonising the fertiliser industry in itself; however, it poses several issues around sustainability, cost, and technological capacity. Are countries within SSA ready to commit? Does SSA have the financial muscle?

3.3 Limited Awareness and inadequate technical capacity

With the knowledge that decarbonising agriculture and forestry stem across different socio-economic sectors, building the capacities of all stakeholders from bottom-up and top-down in equal measures should not be overlooked. However, awareness among the small-scale farmers on the existence of renewable energy technologies intended to ease agricultural operations and the merits of adopting these technologies in improving overall production and addressing food security is still low in SSA.[53] Accordingly, the use of solar-powered irrigation systems is likely to increase farmer's revenues by more than 15 percent per hectare and reduce operational costs by about 50 percent per hectare in Senegal compared to using diesel-powered systems.[54]

While the cost of installing or acquiring such as solar-powered farm inputs may be relatively high for many smallholder farmers, in the long-term, it is cost-efficient and generates tremendous benefits in agriculture, health, water and education.[55] With about 40 percent of Africa's population residing in

51 Druilhe Zoé and Barreiro-Hurlé, Jesús. 2012. Fertilizer subsidies in sub-Saharan Africa. ESA Working paper No. 12-04. Rome, FAO. https://www.fao.org/3/ap077e/ap077e.pdf
52 Ibid
53 IRENA and FAO. 2021. Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. *IRENA and FAO, Abu Dhabi and Rome*. https://doi.org/10.4060/cb7433en
54 Ibid
55 IRENA. 2015. Africa 2030: Roadmap for a Renewable Energy Future. *IRENA, Abu Dhabi*. www.irena.org/remap

the rural areas where most of the agricultural production and forests area and the potential for off-grid energy sources is high, enhancing awareness should be a priority to improve the possibility of reducing emissions. This is possible with the presence of local or intermediate personnel with technical knowhow to operate, maintain and repair, for instance, the solar-powered irrigation pumps or milking systems.[56] In cases where the renewable energy materials are imported and the instructional manual is in a different language; individuals and retailers tend to shy away, where spare parts and repair services are not locally available.[57] Awareness also means knowing what is good and bad and which technology to invest in so as to break even economically and reduce chances of producing more emissions.

Awareness creation goes beyond availing information to providing different options for citizens to make energy choices and decisions on a need-basis and economic situation, case in point being the cooking and heating options. While more emphasis is on electrification, instituting forest policies and regulations, and demonstrating adverse implications of deforestation, often, adequate information and services on feasible alternative cooking energy options are not emphasised enough in SSA.[58] Yet, this is an area that could help reduce over-reliance on wood fuel, eventually saving forests and increasing carbon sinks. Biogas production, which could fulfil the lighting and cooking energy needs of many SSA rural households, has not been fully exploited, yet most rural households own at least a cow. The lack of information and technical skills to exploit the biogas potential could be a reason for low uptake. Nonetheless, debates have emerged around the 'greenness' of biogas production; despite this, studies show that it is possible to achieve a negative carbon footprint with proper implementation of

56 IRENA and FAO. 2021. Renewable energy for agri-food systems – Towards the Sustainable Development Goals and the Paris agreement. *IRENA and FAO, Abu Dhabi and Rome*. https://doi.org/10.4060/cb7433en
57 Ibid
58 IRENA. 2015. Africa 2030: Roadmap for a Renewable Energy Future. *IRENA, Abu Dhabi*. www.irena.org/remap

combined pathway.[59] This necessitates increased information dissemination at the rural areas to capacitate the residents exploit biogas in ways that are environmentally friendly and sustainable. Ideally, most biogas installations in Africa are family-sized meant for domestic needs; the bulk of firewood harvesting and charcoal production is in the rural areas.[60]

3.4 Inadequacies in Policies and Institutional frameworks (policy prioritisation)

Policies are integral given the high dependence on forests and farming to meet livelihood needs. Weak and fragmented policies potentially hinder the possibility of achieving net-zero emissions targets by each country. The East African Community recognises that policy constraints such as; weak institutional frameworks, poor governance, inadequate legal procedures; limited access to resources and lower public participation are the forces behind poor performance in the agriculture sector.[61] Countries within SSA are at different stages of economic development. The policies and legal frameworks designed are more often a reflection of the socio-political and economic positions at a given time. One commonality is that agriculture and forest policies are not mainstreamed into the entire development spectrum.

The fact that each country has several overlapping ministries and departments representing interlinking areas such as environment, climate, agriculture, wildlife, energy and forestry is the genesis of policy fragmentation that can hamper decarbonisation processes. The problem of competing policies and institutional tools is evident at the sub-regional level. For example, the Economic Community of West Africa Agricultural Policy (ECOWAP) which was instituted in 2005 to address food security, nutrition

59 EBA. 2020. The contribution of the biogas and biomethane industries to medium-term greenhouse gas reduction targets and climateneutrality by 2050. *European Biogas Association*. *https://www.europeanbiogas.eu/wp-content/uploads/2020/04/20200419-Background-paper_final.pdf*

60 Kemausuor Francis, Adaramola Muyiwa S and Morken John. 2018. A Review of Commercial Biogas Systems and Lessons for Africa. *Energies, 11, 2984*. http://dx.doi.org/10.3390/en11112984

61 EAC. N.d. Constraints and challenges of the EAC Agriculture sector. *https://www.eac.int/agriculture/constraints-and-challenges*

and agricultural development, including trade regime in West Africa, faced facing a myriad of challenges that include competing priorities from other frameworks and fragmented coordination weakening the implementation of regulatory and sectoral strategies.[62] Without seamless coordination and agreeing policies across the sub-regional countries, collaborative decarbonising strategies will be nearly impossible.

Following the Paris Climate Agreement, several African countries have submitted their first and updated Nationally Determined Contributions (NDCs); however, their emission targets, mitigation and adaptation strategies vary. For example, Kenya's updated NDC, submitted in December 2020, a framework outlining the climate adaptation and mitigation priorities for the period 2020-2030, gives more emphasis on adaptation strategies than mitigation in the agriculture sector.[63] Although the document (Kenya's Updated NDC) mentions several mitigation activities that could ultimately lower greenhouse gases from the agriculture sector, such as efficient livestock management system through the climate-smart agriculture strategy, specific actions and estimates are not indicated. Nonetheless, Kenya's Climate Smart Agriculture strategy 2017-2026 frames practical approaches for emission mitigation in crop production and livestock farming.[64] On the other hand, Nigeria's updated NDC, submitted in July 2021, presents agriculture, forestry and land use as emission mitigation priority areas and outlines the specific actions and targets for each area.[65] In principle, the mitigation priorities of Nigeria and Kenya differ because of reasons such as demographic, social and economic standings, which in turn influence the policy angle and proposed national emission abatement targets.

62 Crola, Jean Denis. 2015. Ecowap: A Fragmented Policy. *Oxfam International*. *https://policy-practice.oxfam.org/resources/ecowap-a-fragmented-policy-development-partners-and-regional-institutions-shoul-582075/*
63 Kenya's Updated nationally Determined Contribution (NDC). 2020. *https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx*
64 Kenya Climate Smart Agriculture Strategy 2017-2026. *https://www.adaptation-undp.org/sites/default/files/resources/kenya_climate_smart_agriculture_strategy.pdf*
65 Nigeria's Updated Nationally Determined Contribution (NDC). 2021. *https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=NGA*

By virtue of the NDCs, it seems that despite working towards a common goal of emissions mitigation, the implementation of regional-binding policies is still at an infancy stage. Besides the fragmentation is the existence of several poorly formulated policies and regulations characterised by missing links with policies in other relevant sectors such as land, energy, trade and commerce.[66] Transforming the agriculture or forestry sector, which includes decarbonisation require consistent policies and regulations with constancy in implementation, an aspect that could be impeded by factors mentioned above.[67]

3.5 Knowledge-Attitude-behaviour gap in low-carbon emissions

The knowledge-attitude-behaviour gap in understanding human perceptions and actions in fostering sustainability and low-carbon emissions is gaining much attention in recent decades. Putting knowledge-attitude-behaviour gap into the emission context, individuals, governments, policy-makers and private sector actors with the data, information, knowledge and capability to shift towards carbon-neutral activities; they manifest positive attitudes towards reducing GHG emissions, but they do not act accordingly.[68]

Looking at the climate-agriculture-forestry-policy nexus in SSA, it is known that climate change occasioned by increasing greenhouse gases released into the atmosphere has adverse impacts on food security and cause desertification, which has led to the formulation of policies and response strategies. Despite this knowledge, techniques and guidelines, little effort is put into action.[69]

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66 Hollinger Frank and Staatz John. 2015. Agricultural Growth in West Africa: Market and policy drivers. *African Development Bank and UNFAO. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Agricultural_Growth_in_West_Africa_-_Market_and_policy_drivers_-_OSAN.pdf*

67 Ibid

68 Wyss, Annika M., Daria Knoch, and Sebastian Berger. 2022. When and How Pro-Environmental Attitudes Turn into Behavior: The Role of Costs, Benefits, and Self-Control. *Journal of Environmental Psychology* 79:101748. https://doi.org/10.1016/j.jenvp.2021.101748.

69 Averchenkova Alina, Gannon Kate and Patrick Curran. 2019. Governance of climate change policy: A case study of South Africa. Grantham Research Institute on Climate Change and the Environment and the Centre for Climate Change

Similarly, exploitation and consumption patterns of forest products indicate knowledge-attitude-behaviour gap. It is common knowledge that over-exploitation of forests and harvesting of trees for wood fuel or timber will result in deforestation and loss of vital carbon sinks, and that controlled exploitation is fundamental, but, often, the latter is ignored.[70] Also, the value of traditional knowledge systems in forest protection and governance go unnoticed and policing, legal and institutional frameworks are not implemented accordingly. This is despite the understanding that they limit consumption and unnecessary development and infrastructural projects that otherwise undermine the functionality of an ecosystem in most of Africa's forests. In this regard, it is argued that the developmental and environmental budding of forests in Africa is responsible for a significant part of the carbon emissions.[71] The same applies to the intensive use of artificial fertilisers to supplement soil fertility loss and increase crop yields among smallholder and large-scale farmers. To a large extent, it is known to many in SSA that synthetic fertilisers are a source of greenhouse gases; if not well applied, they can pump massive emissions into the atmosphere. Research shows the use of organic fertilisers improves soil fertility by reducing nutrient leaching and increasing crop production.[72] Even with existing data and knowledge on the significance of traditional farming practices, limited use of organic manure is apparent. Thus, the knowledge-attitude-behaviour gap should be narrowed as quickly as possible as operating on a business-as-usual scenario provides an enabling environment for more emissions from agriculture and forestry sectors, hence, undermining SSA's decarbonisation prospects.[73]

Economics and Policy. *https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2019/06/GRI_Governance-of-climate-change-policy_SA-case-study_policy-report_40pp.pdf*

70 UNEP. 2015. Growing a green economy in Africa: why forests matter. *UN-REDD Programme*. http://www.unep.org/publications

71 UNEP. 2015. Growing a green economy in Africa: why forests matter. *UN-REDD Programme*. http://www.unep.org/publications

72 Martey, Edward. 2018. Welfare effect of organic fertilizer use in Ghana. *Heliyon* vol. 4,10 e00844. 9 https://dx.doi.org/10.1016%2Fj.heliyon.2018.e00844

73 UNEP. 2015. Growing a green economy in Africa: why forests matter. *UN-REDD Programme*. http://www.unep.org/publications

4.0 Trade-offs

Marching towards low emission comes with requisites that compel individuals, policy-makers, and government leaders to make tough choices. Trade-offs are inevitable in decarbonising forestry and agriculture if countries and the world at large are motivated to attain net-zero emissions or keep warming below 1.5 degrees Celsius. Thus, decarbonising the two sectors presents opportunities in SSA. This paper supplies various scenarios such as: transformation in livestock production, crop production strategies and interventions, forest establishment, protection and management, shift to renewable energy technologies and multi-sectoral collaboration as some areas to explore in a quest to reduce greenhouse gas emissions associated with forests and agriculture. The policy, legal frameworks and guidelines elements are introduced at different stages of the discussion.

4.1 Forest Establishment, Protection and Management

Forests as a climate mitigation strategy have been adopted widely in SSA through initiatives at the grassroots and national level led by individuals, civil society organisations, private companies, non-governmental and governmental organisations. Ethiopia, through its generational green legacy initiative, planted over 350 million tree seedlings in 2019 on a single day in the pursuit to increase the country's forest cover and mitigate climate change impacts.[74] Similarly, in 2019, Kenya launched a tree planting initiative targeting two billion trees by 2022 to meet the national tree cover target of 10 percent as per the 2010 constitution.[75] Kenya's approach takes different shapes and sizes at ministerial and county government levels. While tree planting has been lauded as an easier way of mitigating emissions, debates have emerged, not only on the sidelines but on mainstreams. For instance, a study that estimated the potential for global tree restoration in carbon sequestration concluded that it was indeed an efficient roadmap to reducing

74 UNEP. 2019. Ethiopia plants over 350 million trees in a day, setting new world record. *https://www.unep.org/news-and-stories/story/ethiopia-plants-over-350-million-trees-day-setting-new-world-record*

75 KNA. 2019. Government Plans to Plant 2 Billion Seedlings By 2022. *https://www.kenyanews.go.ke/government-plans-to-plant-2-billion-seedlings-by-2022/*

emissions.[76] The study, however, warns that urgent action is needed lest the globe loses about 223 million hectares of the potential canopy by the mid-twenty-first century. On the other hand, NASA's scientists at Jet propulsion laboratory, while agreeing that forest restoration is significant in mitigating climate change, they hold that tree planting by itself cannot be a subsidiary for lowering fossil-driven emissions.[77] NASA's Jet Propulsion Laboratory proposes the need to reduce human-induced emissions.[78]

As discussed earlier, the forest area in SSA has been steadily declining from 1990 to 2020 from 33 to 20 percent; hence, planting trees suffices as a much-needed solution to increase the forest cover to the levels stipulated under each country's constitution.[79] Viability and efficiency of reforestation linger around the following four pointers: how it is done, after-care plans, where they are planted, and the tree type. Therefore, intentional reforestation and afforestation are necessary, keeping in mind that forests are double-edged; trees emit carbon at the same time sequesters.[80] Africa's landscapes are diverse, from savannah grasslands, woodlands, rainforest to tropical forests; hence, there is no one-fits-all strategy on forest establishment and management.

Ensuring the existing forests satisfy the natural and human needs, working regulatory and management procedures are essential. With the majority of the population in the region depending on forests either directly or indirectly, it is vital to institute and streamline forest policies and synchronising with

76 Bastin, Jean-Francois, et al. 2019. The Global Tree Restoration Potential. *Science*, vol. 365, no. 6448, pp. 76–79. *DOI.org (Crossref), https://doi.org/10.1126/science.aax0848.*

77 Buis Alan. 2019. Examining the Viability of Planting Trees to Help Mitigate Climate Change. NASA's Jet Propulsion Laboratory. *https://climate.nasa.gov/news/2927/examining-the-viability-of-planting-trees-to-help-mitigate-climate-change/*

78 Ibid

79 World Bank. 2022b. Forest area (% of land area) - Sub-Saharan Africa. *https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=ZG*

80 UNECA. N.d. Carbon Sinks and Sequestration. *United Nations Economic Commission for Europe*. *https://unece.org/forests/carbon-sinks-and-sequestration*

the agriculture and energy policies and frameworks.[81] Agricultural expansion and wood fuel harvesting are primary drivers of deforestation and forest degradation, where, farming extension is blamed for about 70 percent of forest loss in SSA.[82] Therefore, stringent measures are necessary to caution against illegal activities, ration tree harvesting, and limit agriculture expansion to allow forests perform their duties, without which pose adverse implications on human, biodiversity, and ecosystems. It is a reality that humans cannot survive without trees and forests, but humanity can co-exist with nature in sustainable ways, even better when conditions are drawn.

Forests are at the centre of growing a green economy in Africa, not only for the carbon capture but it is the source of many resources and that it defines the socio-economic livelihoods of the larger population.[83] Thus, increasing and safeguarding forests comes at the expense of energy transition, limiting agricultural expansion, channelling more funds for conservation and prohibiting new developments and settlements in forest lands. It also means governments have to provide enabling environments for diversified income sources for the forest-depend individuals such as charcoal businesses, logging, and timber harvesting. As a starting point, enhancing resource efficiency is an avenue to reduce pressure on forests.[84]

4.2 Improving Livestock Production

Looking at the updated NDCs, not all SSA countries have outlined the greenhouse gas mitigation potential from the livestock production sector, yet, it is an area that offers several opportunities to bring down the overall continental emission contribution. Notwithstanding, countries like Nigeria, Rwanda, South Sudan, and Kenya have outlined in their updated NDCs their intention and planned actions to lessen emissions from livestock production through a number of measures such as improved feeding and breeding under

81 Hogarth James, et al. 2015. Report: Low-carbon development in sub-Saharan Africa: 20 cross-sector transitions. *Overseas Development Institute*. ISSN: 2052-7209. *https://cdn.odi.org/media/documents/9878.pdf*
82 Ibid
83 UNEP. 2015. Growing a green economy in Africa: why forests matter. *UN-REDD Programme*. *https://wedocs.unep.org/handle/20.500.11822/9775*
84 Ibid

short, medium, or long-term scenarios.[85] Kenya has emphasised efficient livestock production systems. At the same time, South Sudan recognises poor quality animal feeds as the source of emissions. The underlying issue is reducing methane emissions from enteric fermentation. It is important to realise that it is unclear whether traditional, crossbreeds or hybrid livestock breeds emit more methane than the others; however, it is clear that behavioural, physiological and feeding characteristics influence the methane gas produced.[86] While it might be a hurdle developing common livestock improvement interventions across the SSA, individual countries have the opportunity to develop workable strategies in close consultation with the farmers and research institutions while referring to success cases from neighbouring countries. Because livestock husbandry is a cultural identity to some communities, such as the Maasai of Kenya and Tanzania and Karamoja of Uganda, it might take several interventions to adjust their long-standing livelihood sources. However, government ministries will have to introduce an integrated climate-smart livestock production system that incorporates the traditional livestock practices in part intending to modify and valorise gradually.[87] This approach needs financial investment, technical expertise, training, research, and applicable policies and governance structures.

4.3 Improving Crop Production Techniques

Crop production is at the core of SSA's development beyond food security. This means it is an area where decarbonisation needs to be explored at length but with caution. What is evident is the low prioritisation of emission mitigation from crop production as compared to the adaptation strategies, as seen in, for instance, the updated NDCs from most of the SSA countries.[88]

85 UNFCCC. 2022. NDC registry. *https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx*

86 Fraser, Mariecia, et al. 2014. Traditional vs modern: role of breed type in determining enteric methane emissions from cattle grazing as part of contrasting grassland-based systems. *PloS one* vol. 9,9 e107861. *https://dx.doi.org/10.1371%2Fjournal.pone.0107861*

87 Hogarth James, et al. 2015. Report: Low-carbon development in sub-Saharan Africa: 20 cross-sector transitions. *Overseas Development Institute*. ISSN: 2052-7209. *https://cdn.odi.org/media/documents/9878.pdf*

88 UNFCCC. 2022. NDC registry. *https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx*

Emissions from crop production come from different sources, from land preparation to post-harvest processing, transportation and distribution. While there seems to be a wide window for decarbonisation, there will be a no one-size-fits-all approach due to the cultural, socio-economic, political, and ecological dynamics surrounding food systems in SSA countries. As discussed earlier, agricultural expansion (includes other forms of agriculture) is attributed to about 70 percent of forests lost in SSA.[89] What this means is the urgent need to minimise agricultural activities in existing forests and designated forest lands. This proposition cannot happen without effectively enforced stringent forest policies, consultative and integrated land-use planning, and trained personnel to safeguard the forests.[90]

Increasing crop yield per hectare is preferable instead of opening up new areas. However, this raises concerns as it could motivate the use of artificial fertilisers intensively to compensate for the already degraded soils causing more deleterious effects.[91] A 2-year experimental research to establish the effects of substituting chemical fertilisers with organic manure concluded that with the right quantity, organic manure did enrich not only the soils but also increased crop yields and reduced leaching of nitrogen.[92] Drawing from this research, there is a potential for promoting a low-emission crop production through the promotion of organic fertilisers. This means investing in research and ensuring farmers, especially smallholders that form the majority in SSA, can easily access and afford organic fertilisers. It also means supplying improved crop seeds that are drought resistant and designing policies that cap fertiliser prices, lowering the cost of organic fertiliser at the expense of chemical fertilisers. Similarly, directing resources

89 Hogarth James, et al. 2015. Report: Low-carbon development in sub-Saharan Africa: 20 cross-sector transitions. *Overseas Development Institute*. ISSN: 2052-7209. *https://cdn.odi.org/media/documents/9878.pdf*
90 Ibid.
91 Geng Yuhui, et al. 2019. Effects of equal chemical fertilizer substitutions with organic manure on yield, dry matter, and nitrogen uptake of spring maize and soil nitrogen distribution. *PloS one* vol. 14,7 e0219512. *https://dx.doi.org/10.1371%2Fjournal.pone.0219512*
92Ibid

towards training and improving the capacities of farmers, in particular those in the rural areas, on composting and on the proportions of animal manure per seed and variety in relation to climate variability and humidity. Other opportunities in reducing emissions from crop production is the implementation of climate-smart agricultural technologies such as agroforestry and conservation farming.[93] By conservation farming, I refer to reduced or no-tillage, intercropping, contour farming and terracing and halting shifting cultivation and slash and burn methods.[94]

4.4 Expand of Agroforestry Systems Over Conventional Farming

It is argued that agroforestry has a higher potential to sequester carbon compared to conventional farming systems.[95] Agroforestry, which is the art of growing trees and crops in the same piece of land, is common in SSA and many other developing countries, allowing smallholder farmers to produce food crops while nurturing trees in their small lands. Research estimates that East African smallholder agroforestry farming systems can sequester carbon of about 66 megagrams per hectare over 20 years.[96] More studies show that there is a significant increase in carbon sequestration in the conversion of agriculture to agroforestry and that it induces a positive effect on soil organic matter. [97] The essence of agroforestry is offsetting carbon that could otherwise accumulate in the atmosphere when conventional agriculture is being practiced. Due to the land tenure systems and increasing land fragmentation in many SSA countries, agroforestry suffices as an

93 Hogarth James, et al. 2015. Report: Low-carbon development in sub-Saharan Africa: 20 cross-sector transitions. *Overseas Development Institute*. ISSN: 2052-7209. *https://cdn.odi.org/media/documents/9878.pdf*
94 FAO. 2022. Conservation Agriculture.
https://www.fao.org/3/cb8350en/cb8350en.pdf
95 Cole Stephani. 2018. Importance of agroforestry systems in carbon sequestration. *CABI, Forest and Science database*
96 Thangata, P. H., and P. E. Hildebrand. 2012. Carbon Stock and Sequestration Potential of Agroforestry Systems in Smallholder Agroecosystems of Sub-Saharan Africa: Mechanisms for 'Reducing Emissions from Deforestation and Forest Degradation' (REDD+). *Agriculture, Ecosystems & Environment*, vol. 158, Sept. 2012, pp. 172–83. *DOI.org (Crossref)*, https://doi.org/10.1016/j.agee.2012.06.007
97 De Stefano, Andrea, and Michael G. Jacobson. 2017. Soil Carbon Sequestration in Agroforestry Systems: A Meta-Analysis." *Agroforestry Systems*. https://doi.org/10.1007/s10457-017-0147-9.

agricultural system that motivates tree growing without pressuring farmers to abandon or reduce their farming activities. Practicing agroforestry is not only a conservation measure but influences a change in land tenure systems to promote land ownership and reduce gender disparities in owning land across SSA.[98]

4.5 Contextualise and Implement REDD+

REDD+ (Reducing emissions from deforestation and forest degradation), which was first introduced in 2005 during the 11th Conference of Parties in Montreal through to the conclusion of negotiations in Bonn in 2015, is an approach SSA countries should capitalise on to safeguard their forests while mitigating carbon emissions.[99] So far, more than twenty African countries, most of which are in SSA have submitted their REDD+ strategies.[100]

REDD+ works based on national strategies or action plans to reduce deforestation and forest destruction; hence, countries estimate the value of their forests in terms of ecosystem services and carbon sequestration potential. Ideally, REDD+ is a whole-rounded emission mitigation strategy that promotes gender considerations, stakeholder consultation and participation, forest governance and land tenure matters during the development and implementation of national strategy.[101] Therefore, in SSA, where a significant portion of the population depends on forests directly or indirectly to meet their most basic needs, REDD+, if well implemented, allows local communities and indigenous people to make decisions that promote sustainable exploitation of forests and provide a level grounds for offsetting carbon emissions. Given that REDD+ operates on a voluntary

98 Benjamin Emmanuel, et al. 2021. Interaction between Agroforestry and Women's Land Tenure Security in Sub-Saharan Africa: A Matrilocal Perspective. *Forest Policy and Economics* 133: 102617. https://doi.org/10.1016/j.forpol.2021.102617.
99 AFDB and CIF. 2016. REDD+ in Africa: Context, challenges and next steps of REDD+ mechanisms in the continent. *AfDB Knowledge Series*. *https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/REDD_in_Africa__Context__challenges_and_next_steps_of_REDD__mechanisms_in_the_continent.pdf*
100 UNFCCC. 2022. REDD+. *https://redd.unfccc.int/*
101 Ibid

carbon markets basis, it motivates eco-friendly forestry activities that enhance human livelihoods and incentivises habitual changes that could otherwise degrade forests and increase carbon emissions.[102] The diverse and unique benefits generated from sustainable use and management of forests such as cultural heritage preservation, conservation of biodiversity and animal habitats will be enhanced through the carbon finance which supports carbon offsetting activities consequently augmenting social and economic conditions of a given community.

Despite the promising positive indicators of REDD+, it is facing political, legal, technical and socio-economic challenges in Africa.[103] Limited consultation with local and indigenous communities whose livelihoods entirely depend on forests and inadequate provision of information to facilitate sound decision making are some evident challenges in countries like Kenya.[104] Fragmented forest laws and policies and weak enforcement is also another obstacle likely to thwart the successful implementation of REDD+.[105]

4.6 Renewable Energy Technologies and Improved Energy Mix

Energy consumption is at the centre of decarbonising the forestry and agriculture sectors in SSA. Over two-thirds of households in Africa depend

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102 IFC. 2016. REDD Market Overview. *International Finance Corporation. https://www.ifc.org/wps/wcm/connect/50d40b6d-d088-4c75-8777 5c3761835f8a/FINAL+REDD+Market+Factsheet+10-17.pdf?MOD=AJPERES&CVID=lxS1-4R*

103 AFDB and CIF. 2016. REDD+ in Africa: Context, challenges and next steps of REDD+ mechanisms in the continent. *AfDB Knowledge Series. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/REDD_in_Africa__Context__challenges_and_next_steps_of_REDD__mechanisms_in_the_continent.pdf*

104 IUCN. 2016. Widening Informed Stakeholder Engagement In REDD+ Engaging Indigenous Peoples in Kenya's National REDD+ Strategy. *IUCN/EAWLS WISE REDD+. https://www.iucn.org/sites/dev/files/content/documents/8-policy_brief_indigenous_people_and_redd_in_kenya.pdf*

105 Korwin Sebastien. 2016. REDD+ and Corruption Risks for Africa's Forests: Case Studies from Cameroon, Ghana, Zambia and Zimbabwe. *Transparency International.* ISBN: 978-3-96076-030-6. *https://transparency.eu/wp-content/uploads/2016/10/REDD-CRA-Synthesis-Report_FINAL-TI-EU.pdf*

on wood fuel for cooking and heating; wood fuel constitutes half of the total energy consumption in more than twenty countries in SSA.[106] This trend is expected to increase to cater to the growing population and the 9 out of 10 Africans that have no access to electricity but rely on biomass leading to the destruction of more carbon sinks.[107] In addition, burning biomass emits black carbon, which is not only a greenhouse gas but has detrimental implications on human health.[108] Similarly, as discussed in the previous sections, the agricultural sector consumes a lot of energy at different stages of its operations. Therefore, decarbonisation efforts present an opportunity for SSA countries to consider transitioning from fossil fuels to renewable energies. Energy transition is quite cumbersome and expensive to many countries in SSA that lack the technology and expertise to harness wind, solar or geothermal power.

To ensure sustainable agricultural production and increase carbon sinks, African countries will have no choice but to shift their current energy sources and dynamize the energy mix. This means pumping resources to purchase and install renewable energy technologies such as wind and solar power plants and to develop the skills and capacities as well as boost the projects of early-stage innovators.[109] On the other hand, effective energy-agriculture-forest policies that are mainstreamed and complementary of each are

106 Bailis Rob, et al. 2017. Incentivizing sustainable wood energy in sub-Saharan Africa a way forward for policy-makers. FAO.
*https://www.fao.org/documents/card/en/c/39ec4bfa-e593-4a0e-8db5-*ccdd13c86a47/

107 Sulaiman, Chindo, et al. 2017. Wood Fuel Consumption, Institutional Quality, and Forest Degradation in Sub-Saharan Africa: Evidence from a Dynamic Panel Framework. *Ecological Indicators*, vol. 74, pp. 414–19. *DOI.org (Crossref), https://doi.org/10.1016/j.ecolind.2016.11.045.*

108 World Bank. 2011. Wood-Based Biomass Energy Development for Sub-Saharan Africa: Issues and Approaches. Energy Sector Management Assistance Program (ESMAP*). World Bank.*
https://openknowledge.worldbank.org/handle/10986/26149 License: CC BY 3.0 IGO

109 IFC. 2019. The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa. *International Finance Corporation*. *https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf*

necessary, given that it is a challenge that has already been identified in SSA as promoting continued reliance on wood fuel and destruction of forests.[110]

Thus, it is an apt moment for African governments and policy-makers to intentionally realign the policies to accommodate the decarbonisation component in their short, medium and long-term energy transition and diversification strategies. Crucial to note is that decarbonisation and energy transition bear cost implications that individual countries have to foot.

4.7 Multi-Sectoral Partnerships and Policy Integration

The urgency of climate action cannot be addressed from a siloed angle; multi-sectoral collaboration at local, national, and regional levels is integral to achieving long-term, and sustainable solutions. [111] Decarbonising agriculture and forestry require huge investments, monetary and non-monetary capital, where co-financing is prudent to ensure effectiveness and swift action. [112] This is possible by mainstreaming climate change interventions into different development sectors in each country. In fact, the regional economic communities should be an entry point into establishing and strengthening multi-sectoral and stakeholder collaboration in instituting GHG mitigation approaches. So far, all regional economic communities within SSA have agricultural policies, strategies and frameworks towards food security and climate adaptation and mitigation. More emphasis should go towards national and sub-national multisector collaboration so as to easily

110 Bailis Rob, et al. 2017. Incentivizing sustainable wood energy in sub-Saharan Africa a way forward for policy-makers. FAO.
https://www.fao.org/documents/card/en/c/39ec4bfa-e593-4a0e-8db5-ccdd13c86a47/

111 World Bank. 2018. Accelerating Climate Resilient and Low Carbon Development: The Africa Climate Business Plan – Third Implementation Progress Report and Forward Look. *World Bank, Washington DC. https://openknowledge.worldbank.org/bitstream/handle/10986/30932/WBG_Africa_Low_Carbon.pdf?sequence=4*

112 IPCC. 2014. *Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
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mainstream climate policies and contextualise decarbonisation while enhancing resilience capacity in as much as the regional partnerships are significant.[113]

Through multi-sectoral collaboration, it is straightforward (although paradoxical sometimes) to integrate policies considering that agriculture and forest policies are strongly interrelated.[114] IPCC contends that policy interactions can be synergistic or conflicting and proposes a need for adequate forestry and agriculture policies to promote innovativeness and strengthen carbon mitigation actions at national and international levels.[115] The World Bank, on the other hand, identifies knowledge gaps and recommends profound systemic shifts that entrench mitigation measures into sectoral and multi-sectoral frameworks.[116] Thus, SSA countries can tap into private-public partnerships in mainstreaming agriculture-forestry climate policies to enable decarbonisation investments from grassroots levels to the national and regional arenas.

5.0 Conclusion

In light of this paper's analysis, decarbonising Africa's agriculture and forestry is fundamental and critical towards mitigating climate impacts and ensuring sustainable development in SSA. Decarbonising the two sectors is not the only solution to reach a net-zero emission target. Trade-offs are

113 World Bank. 2018. Accelerating Climate Resilient and Low Carbon Development: The Africa Climate Business Plan – Third Implementation Progress Report and Forward Look. *World Bank, Washington DC. https://openknowledge.worldbank.org/bitstream/handle/10986/30932/WBG_Africa_Low_Carbon.pdf?sequence=4*

114 IPCC. 2014. *Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
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115 Ibid

116 World Bank. 2018. Accelerating Climate Resilient and Low Carbon Development: The Africa Climate Business Plan – Third Implementation Progress Report and Forward Look. *World Bank, Washington DC. https://openknowledge.worldbank.org/bitstream/handle/10986/30932/WBG_Africa_Low_Carbon.pdf?sequence=4*

inevitable; for example, low-emission agriculture comes with cost liabilities that individual countries have to foot. Increasing forest cover and composition for carbon sequestration also involves limiting developmental activities. However, the resultant effect is positive change with a long-term implication on biological, human livelihood, global temperatures, and landscapes. Arriving at the positive outcome requires a dynamic mix of interventions; integrated policies and regulations, energy transition, expertise, science, data, multi-sectoral collaboration, and integrated land-use planning. Deducing from EAC's acknowledgement that policy constraint is a huge problem in agricultural performance, mainstreaming forestry-agriculture-energy climate policies is essential, without which decarbonisation may be a challenge.

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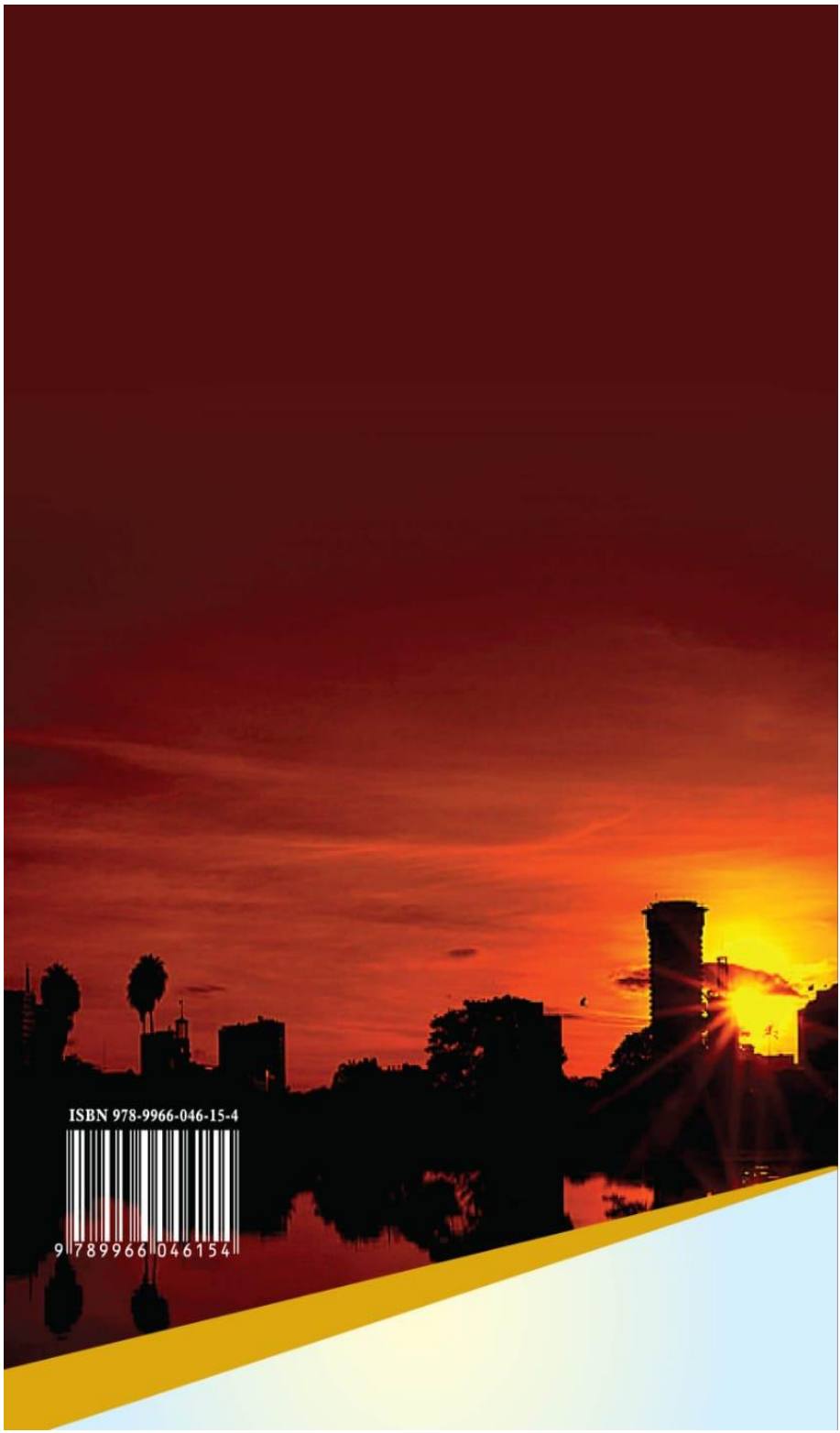

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