

Climate Mitigation through Ecosystems: The Role of the Kilombero Valley Flood Plain in Biomass and Carbon Sequestration in Tanzania

Adili Y Zella*

Department of Economics, Faculty of Leadership and Management Sciences, The Mwalimu Nyerere Memorial Academy, Tanzania

Submission: May 14, 2025; Published: May 29, 2025

*Corresponding author: Adili Y. Zella, Department of Economics, Faculty of Leadership and Management Sciences, The Mwalimu Nyerere Memorial Academy, P.O Box 9193, Dar es Salaam, Tanzania

Abstract

Land use and land cover (LULC) changes are pivotal drivers of biomass stock and carbon sequestration, playing a critical role in global climate mitigation efforts. This study investigates the biomass stock and carbon sequestration potential of Tanzania's Kilombero Valley Flood Plain (KVFP), an ecologically significant region, in 2020. Using moderate-resolution Landsat imagery and a random forest (RF) algorithm for land classification, combined with spatial analysis in ArcGIS, biomass and carbon stocks were estimated based on models from Tanzania's National Forest Resources Monitoring and Assessment (NAFORMA). The analysis reveals a total biomass stock of 14.7 billion tonnes in KVFP, corresponding to 6.8 billion tonnes of carbon and 24.9 billion tonnes of CO₂ sequestration. This sequestration equates to an economic valuation of approximately US\$ 99.4 billion in the global carbon market. Forest ecosystems contributed the largest share, accounting for 92.3% of the biomass, followed by agriculture (2.9%), bushland (2.7%), and grassland (1.9%). Wetlands stored a minimal 0.1% of the biomass, while bare land, settlement, and water areas showed negligible contributions. Aboveground biomass represented 71.6% of the total stock, followed by belowground biomass (22.3%) and deadwood biomass (6.1%). These findings underscore the critical role of KVFP in carbon sequestration and its economic potential within climate mitigation frameworks. The study advocates for sustainable land use practices and the integration of climate resilience into land management policies to protect natural resources and combat climate change. Urgent policy interventions are needed to safeguard the KVFP's ecological and economic value, aligning with broader global efforts to address climate change.

Keywords: Land uses; Biomass; Carbon; Carbon dioxide; Kilombero valley floodplain

Abbreviations: LULC: Land Use and Land Cover; KVFP: Kilombero Valley Flood Plain; RF: Random Forest; NAFORMA: National Forest Resources Monitoring and Assessment; AGB: Above Ground Biomass; BGB: Below Ground Biomass; DW: Dead Wood; IPCC: Intergovernmental Panel on Climate Change

Introduction

Background of the study

Climate change is a significant global challenge of the 21st century, affecting ecosystems, biodiversity, and human livelihoods extensively. The main cause of this crisis is the rising concentration of greenhouse gases (GHGs) in the atmosphere, especially carbon dioxide (CO₂), which stems from human activities including deforestation, industrial emissions, and changes in land use IPCC [1]. These activities interfere with the Earth's carbon cycle, resulting in the buildup of heat-trapping gases that exacerbate global warming. The Intergovernmental Panel on Climate Change IPCC [2] asserts that immediate measures are necessary to decrease carbon emissions and improve carbon sequestration

to alleviate the negative impacts of climate change. Terrestrial ecosystems, such as forests, wetlands, and grasslands, are essential in mitigating climate change. These ecosystems function as natural carbon sinks, sequestering and storing carbon via photosynthesis and various biological processes FAO [3]. Forests sequester about 45% of annual anthropogenic CO₂ emissions, underscoring their importance in global climate mitigation efforts IPCC [2]. The degradation and loss of these ecosystems, caused by deforestation and unsustainable land-use practices, have converted them from carbon sinks to sources of emissions, thereby worsening the climate crisis Kulindwa et al. [4].

Land-use changes in Tanzania, including deforestation and agricultural expansion, significantly contribute to the nation's

carbon emissions. Tanzania's annual CO₂ emissions are estimated at approximately 126 million tons, with deforestation contributing 78 million tons and forest degradation contributing 48 million tons FAO [3]. The emissions highlight the essential requirement for sustainable land management practices that reconcile economic development with environmental conservation. The Kilombero Valley Flood Plain (KVFP) in southeastern Tanzania represents a landscape of considerable ecological importance within the country. Covering an area of 30,500km², it is noted for its significant biodiversity, vast wetlands, and essential ecosystem services such as water regulation, biodiversity conservation, and carbon sequestration Leemhuis et al. [5]. Designated as a Ramsar Site in 2002, the KVFP hosts a diverse range of flora and fauna, with many species endemic to the region Starkey et al. [6]. The wetlands and adjacent woodlands are essential for biomass storage and carbon sequestration, serving as a critical element of Tanzania's natural climate mitigation strategies.

The KVFP, while ecologically significant, is confronted with considerable threats from human activities, including agricultural intensification, deforestation, and population growth. In the last thirty years, land-use and land-cover changes (LULCC) have resulted in significant biomass depletion and a reduction in carbon sequestration potential in the valley Msofe et al. [7]. The degradation of wetlands and forests has disrupted the region's hydrological balance and reduced its capacity to support biodiversity. The challenges require an immediate assessment of biomass loss, quantification of related carbon emissions, and the development of sustainable management strategies for the KVFP.

Motivation of the study

This study is motivated by the increasing necessity to tackle the interconnected issues of climate change and ecosystem degradation in Tanzania. The KVFP serves as an essential natural resource, providing a platform to examine the role of ecosystems in climate mitigation and their support for local livelihoods. With the global emphasis on carbon emission reduction growing, it is essential to comprehend the role of ecologically significant areas such as the KVFP in carbon sequestration IPCC [2]. The study is motivated by the insufficient data regarding the biomass and carbon dynamics of the KVFP. The valley is acknowledged for its ecological significance; however, research on biomass depletion and associated carbon emissions from land use and land cover change (LULCC) remains limited. This study seeks to address the existing knowledge gap, thereby establishing a foundation for informed decision-making and the formulation of sustainable land management policies in the region Msofe et al. [8]. Furthermore, quantifying the economic costs associated with carbon emissions from the KVFP will enhance awareness among policymakers and stakeholders regarding the financial and ecological consequences of ecosystem degradation.

This study is driven by the necessity to synchronize local and national land-use practices with international climate objectives. Tanzania, a developing nation, experiences significant

adverse effects from climate change, such as extreme weather events, food insecurity, and biodiversity loss Fordham et al. [9]. Improving the function of ecosystems such as the KVFP in carbon sequestration may assist the nation in fulfilling its obligations under the Paris Agreement and other global climate frameworks. This study aims to enhance the global discourse on nature-based solutions for climate mitigation. The results of the KVFP may provide a framework for other regions encountering analogous challenges, illustrating the potential of sustainable land-use practices to alleviate climate change while enhancing biodiversity and benefiting local communities. This study emphasizes the ecological, economic, and cultural importance of the KVFP to motivate efforts for the protection and restoration of essential ecosystems in Tanzania and beyond.

Methodology

Study area

The Kilombero Valley floodplain (KVFP) in southeastern Tanzania, covering approximately 30,500km², is situated between the Udzungwa escarpment and the Mahenge Highlands as indicated in Figure 1. It is divided into three districts: Kilombero, Ulanga, and Malinyi, and is characterized by the Kilombero River, which supports the largest freshwater wetland in Africa below 300 meters above sea level Wilson et al. [10]. This wetland, recognized as a Ramsar site in 2002, is vital for biodiversity, serving as a habitat for numerous endemic species and wildlife corridors Msofe et al. [7]. The KVFP experiences a sub-humid tropical climate with annual rainfall between 1200 to 1400 mm, although mountainous areas can receive up to 2100 mm Wilson et al. [10]. The valley has two rainy seasons and a mean temperature ranging from 24 °C in the valley to 17 °C in higher altitudes. The geology of the area consists of sedimentary basin infillings, creating a seasonal alluvial floodplain dominated by flavanols. Vegetation varies, with riverbanks featuring *Hyparrhenia spp.* and *Phragmites mauritianus*, while grasslands are home to Guinea grass and various tree species Starkey et al. [6].

Socioeconomically, the KVFP is heavily reliant on agriculture, with about 80% of the rural population engaged in subsistence and small-scale farming. Key crops include rice, maize, sugarcane, cocoa, and bananas, contributing significantly to the local and national economies, accounting for 25% of Tanzania's GDP URT [11]; Wilson et al. [10]. Currently, rice and sugarcane dominate land use, reflecting the valley's agricultural significance.

Data used and methods

This study utilized Landsat-8 imagery from 2020 to generate land use/land cover (LULC) datasets through supervised classification using the random forest algorithm. The classification, performed with ArcGIS Desktop 10.2, identified eight LULC types: forest, bushland, grassland, agriculture, urban area, bare soil, water, and wetland. An accuracy assessment showed an overall accuracy of 86.7% and a kappa coefficient of 0.82, validating the classification results and linking each LULC type to its respective biome as indicated in Table 1.

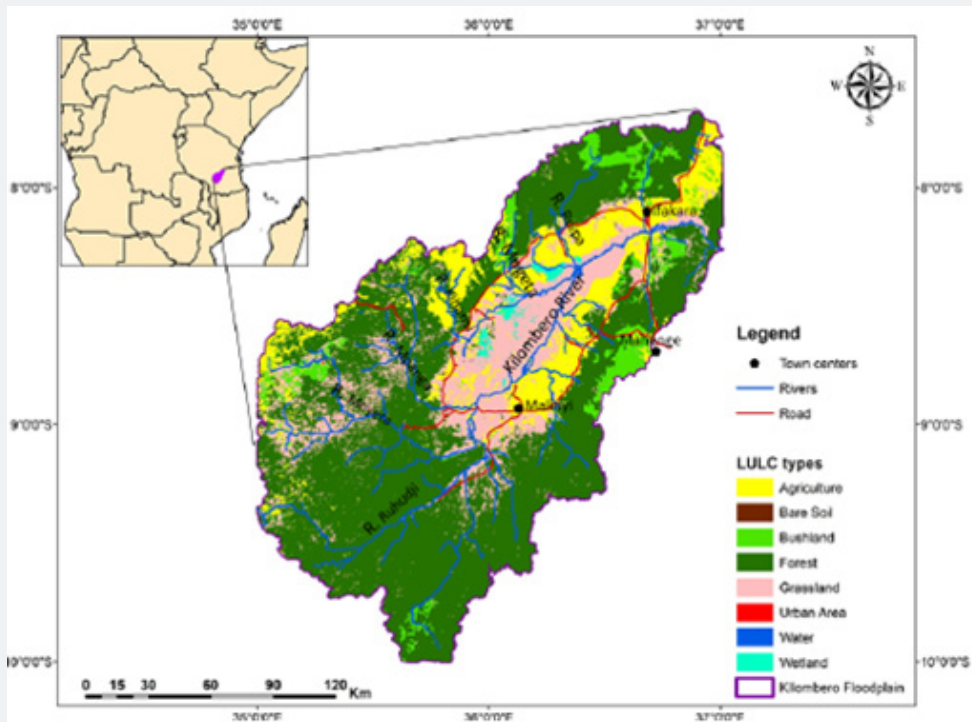


Figure 1: Map of the study area adopted from Msofe et al. [17].

Table 1: Land use and land cover (LULC) (10^3 ha) types.

LULC Type	AG	BRL	BS	FT	GL	ST	WTR	WTL
Area (ha)	484.2	0.7	246	1641.5	642.5	3.8	3	26.1

G = Agriculture, BRL = Bare land, BS = Bushland, FT = Forest, GL = Grassland, ST = Settlement, WTR = Water, WTL = Wetland.

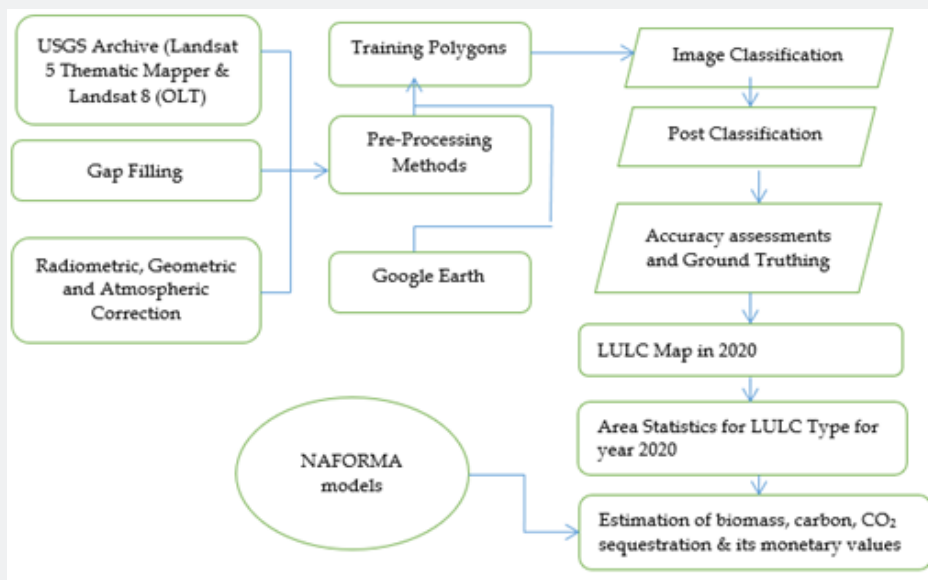


Figure 2: Flowchart of the methodological approach for this study.

Figure 2 below shows the flow chart of the methodological approach used in this study for the estimation of the biomass and carbon stocks for the year 2020 and the computation of changes between studies periods.

Data analysis

Biomass stock of Kilombero valley flood plain:

Tanzania forest Carbon can be estimated in three pools namely AGB (above ground biomass), BGB (below ground biomass) and DW (dead wood) URT [12]. BGB was estimated as a fraction of AGB. AGB and BGB were estimated as follows:

a) AGB (tonnes/ha) = Tree stem volume (m³/ha) * wood density/1000; and

b) BGB (tonnes/ha) = AGB * 0.25 (as default), or root to shoot ratios.

URT (2015) uses conversion factors into programmed NAFORMA analysis system by tree species or species groups to provide standards in each terrestrial ecosystem of Tanzania. Dead wood (DW) biomass is estimated from the volume computed using Smalian formula multiplied by wood density of 619kg/m³ Chidumayo [13] cited by URT [12]; URT [12]; through NAFORMA reveals the dead wood Biomass of Tanzania (Table 2) is relatively low since most dead wood in accessible areas is collected as fuelwood. As woodlands are generally more accessible than forests, collection of dead wood for fuelwood from these areas is easier. The relatively high volume of dead wood in water / wetlands are difficult to access and decay slowly and because they are wet and therefore unattractive for fuelwood as shown in Table 2.

Table 2: Living tree stem wood and deadwood biomass (t/ha).

Primary Vegetation Type	AG	BRL	BS	FT	GL	ST	WTR	WTL
AGB	5.9	2.9	11	59.5	2.9	2.9	4.6	4.6
BGB	2.1	1.1	4.4	18.2	1.1	1.1	1.7	1.7
DWB	0.9	0.2	0.7	4.9	0.4	0.2	1.3	1.3
Total	8.9	4.2	16.1	82.6	4.4	4.2	7.6	7.6

AG = Agriculture, BRL = Bare land, BS = Bushland, FT = Forest, GL = Grassland, ST = Settlement, WTR = Water, WTL = Wetland.

Table 3: Living tree stem wood and deadwood carbon (t/ha).

Primary Vegetation Type	AG	BRL	BS	FT	GL	ST	WTR	WTL
AGC	2.8	1.4	5.2	28	1.4	1.4	2.2	2.2
BGC	1	0.5	2.1	8.6	0.5	0.5	0.8	0.8
DWC	0.4	0.1	0.3	2.3	0.2	0.1	0.6	0.6
Total	4.2	2	7.6	38.8	2	2	3.6	3.6

Table 4: Living tree stem wood and deadwood carbon dioxide (t/ha) sequestration.

Primary Vegetation Type	AG	BRL	BS	FT	GL	ST	WTR	WTL
AGCO ₂	10.2	5	19	102.6	5	5	7.9	7.9
BGCO ₂	3.6	1.9	7.6	31.4	1.9	1.9	2.9	2.9
DWCO ₂	1.6	0.4	1.3	8.4	0.6	0.4	2.3	2.3
Total	15.4	7.3	27.8	142.4	7.5	7.3	13.1	13.1

Table 5: Living tree stem wood and deadwood economic potential (US\$ /ha).

Primary Vegetation Type	AG	BRL	BS	FT	GL	ST	WTR	WTL
AGCO ₂	40.7	20	75.9	410.5	20	20	31.7	31.7
BGCO ₂	14.5	7.6	30.4	125.6	7.6	7.6	11.7	11.7
DWCO ₂	6.3	1.5	5	33.6	2.4	1.5	9	9
Total	61.5	29.1	111.3	569.7	30	29.1	52.5	52.5

Table 6: Living tree stem wood and deadwood biomass (10⁵ tons) stock of KVFP.

LULC	AG	BRL	BS	FT	GL	ST	WTR	WTL	Total
AGB	2,856.80	2	2,706.00	97,669.30	1,863.30	11	13.8	120.1	105,242.2
BGB	1,016.80	0.8	1,082.40	29,875.30	706.8	4.2	5.1	44.4	32,735.70
DWB	435.8	0.1	172.2	8043.4	257	0.8	3.9	33.9	8,947.10
Total	4,309.40	2.9	3,960.60	135,587.9	2,827.00	16	22.8	198.4	146,924.9
%Age	2.9	0	2.7	92.3	1.9	0	0	0.1	100

AG = Agriculture, BRL = Bare land, BS = Bushland, FT = Forest, GL = Grassland, ST = Settlement, WTR = Water, WTL = Wetland

Table 7: Living tree stem wood and dead wood carbon (10⁵ tons) stock

LULC	AG	BRL	BS	FT	GL	ST	WTR	WTL	Total
AGB	1,342.70	1	1,271.80	45,904.50	0.5	5.2	6.5	56.4	48,588.60
BGB	477.9	0.4	508.7	14,041.40	0.5	2	2.4	20.9	15,054.10
DWB	204.8	0.1	80.9	3,780.40	0.5	0.4	1.8	15.9	4,084.80
Total	2,025.40	1.4	1,861.50	63,726.30	1.4	7.5	10.7	93.2	67,727.40
%Age	2.9	0	2.7	92.3	1.9	0	0	0.1	100

Table 8: Carbon dioxide (10⁵ tons) sequestration in KVFP.

LULC	AG	BRL	BS	FT	GL	ST	WTR	WTL	Total
AGB	4,927.70	3.5	4,667.60	168,469.7	3.7	19	23.8	207.1	178,322.0
BGB	1,753.90	1.3	1,867.00	51,531.90	3.7	7.2	8.8	76.5	55,250.40
DWB	751.7	0.2	297	13,874.00	3.7	1.3	6.7	58.5	14,993.20
Total	7,433.20	5.1	6,831.60	233,875.6	11	27.5	39.3	342.2	248,565.5
%Age	2.9	0	2.7	92.3	1.9	0	0	0.1	100

Table 9: Economic potential (10⁵ US\$) of KVFP.

LULC	AG	BRL	BS	FT	GL	ST	WTR	WTL	Total
AGB	19,710.60	14	18,670.30	673,878.8	14.7	76	95.2	828.4	713,288.0
BGB	7,015.70	5.3	7,468.10	206,127.6	14.7	28.8	35.2	306.1	221,001.6
DWB	3,006.70	1	1,188.10	55,495.90	14.7	5.2	26.9	234.1	59,972.60
Total	29,733.00	20.3	27,326.60	935,502.3	44	110.1	157.3	1,368.60	994,262.2
%Age	2.9	0	2.7	92.3	1.9	0	0	0.1	100

Carbon stock of Kilombero valley flood plain

According to URT [12]; carbon in terrestrial ecosystems of Tanzania can be computed as follows:

$$\text{Carbon (tonnes/ha)} = \text{Biomass} * 0.47.$$

Living tree stem wood (AGC + BGC) and dead wood carbon (DWC) (t/ha) by primary vegetation type are illustrated in Table 3.

Carbon dioxide sequestration in KVFP

Estimating the carbon dioxide (CO₂) sequestered in KVFP involves converting total carbon stock into CO₂ equivalents,

crucial for understanding its climate mitigation role. The Intergovernmental Panel on Climate Change (IPCC) provides guidelines for this conversion, using a factor of 3.67, representing the molecular weight ratio of CO₂ to carbon (IPCC, 2006 & 2023). The formula is:

$$\text{CO}_2 \text{ (tonnes)} = \text{Carbon (tonnes)} * 3.67$$

Applying this to the estimated carbon stocks of living and dead biomass in KVFP gives the CO₂ sequestration potential as indicated in Table 4:

$$\text{Total CO}_2 \text{ (tonnes)} = \text{AGCO}_2 \text{ (tonnes)} + \text{BGCO}_2 \text{ (tonnes)} + \text{DWCO}_2 \text{ (tonnes)}$$

Economic potential of KVFP resulted from carbon dioxide sequestration

The study adopted from Jenkins [14], and Lobora et al. [15] emphasized that, the standard carbon market is US\$ 4 per ton if REDD+ is implemented; this was used to estimate economic potential of carbon sequestered in Kilombero Valley floodplain as shown in Table 5.

Results and Discussion

Biomass stock of Kilombero valley flood plain

The Kilombero Valley Flood Plain (KVFP) exhibits a substantial biomass stock, primarily driven by forest ecosystems, which accounted for 92.3% of the total biomass, estimated at 14.7 billion tonnes in 2020 as indicated in Table 6. Forests, with a biomass of 13.6 billion tonnes, serve as crucial carbon reservoirs, essential for climate mitigation and ecosystem services. Other land-use types, including agriculture (2.9%), bushland (2.7%), and grassland (1.9%), contributed significantly less, while wetlands contributed a mere 0.1% due to limited aboveground vegetation Leemhuis et al. [5]. Biomass distribution reveals that aboveground biomass (AGB) constitutes 71.6% of the total, highlighting the importance of tree canopies in carbon storage FAO [3]. Belowground biomass (BGB) accounts for 22.3%, emphasizing the role of root systems in carbon sequestration and soil stabilization Msofe et al. [7].

Deadwood biomass, at 6.1%, is limited by high fuelwood demand in the area URT [12]. Forests are pivotal for carbon sequestration and biodiversity, yet they face threats from deforestation and land-use changes driven by agriculture and logging Chidumayo & Gumbo [12]. While agriculture, bushland, and grassland contribute 7.5% to biomass, sustainable practices can enhance their carbon storage potential Zhu et al. [16]. Wetlands, despite low biomass contributions, are vital for biodiversity and soil organic carbon storage Muro et al. [17]. The findings underscore the necessity for policies focused on forest conservation, sustainable land management, and wetland protection to enhance carbon sequestration and ecosystem resilience in KVFP. These strategies are crucial for maintaining the region's climate mitigation role and supporting biodiversity FAO [3]; Leemhuis et al. [5].

Carbon stock of Kilombero valley flood plain

The Kilombero Valley Flood Plain (KVFP) is a vital ecosystem for climate mitigation, with a total carbon stock estimated at 6.8 billion tonnes in 2020 as summarized in Table 7, predominantly stored in forests. Forests account for 92.3% of this total, approximately 6.4 billion tonnes, highlighting their unparalleled capacity for carbon storage in Tanzania. Other land-use types contribute modestly, with agriculture at 2.9%, bushland at 2.7%, and grassland at 1.9%. Wetlands, despite their ecological importance, contribute only 0.1% due to limited aboveground vegetation Msofe et al. [7]; URT [12]. The carbon stock distribution

reveals that aboveground carbon (AGC) constitutes 71.6% of the total, attributed to extensive tree canopies. Belowground carbon (BGC) accounts for 22.3%, emphasizing the role of soil-root interactions, while deadwood carbon (DWC) contributes 6.1%, limited by the collection of dead wood for fuel FAO [3]. The high carbon stock in forests underscores their role as significant carbon sinks, crucial for mitigating anthropogenic greenhouse gas emissions. However, threats from deforestation and agricultural expansion jeopardize these stocks, necessitating protective measures Chidumayo & Gumbo [12].

While agriculture, bushland, and grassland contribute less to carbon stocks, they hold potential for enhanced storage through sustainable practices like agroforestry Zhu et al. [16]. Wetlands, despite their minimal contribution, are essential for soil organic carbon sequestration and water regulation, necessitating their protection Muro et al. [17]. The findings advocate for targeted policies to protect and enhance KVFP's carbon stocks, emphasizing forest conservation, sustainable agricultural practices, and wetland restoration. Such initiatives are crucial for maintaining carbon sequestration potential and supporting climate goals FAO [3]. Overall, safeguarding KVFP's ecosystems is imperative for climate regulation and biodiversity.

Carbon dioxide sequestration in Kilombero valley flood plain

The Kilombero Valley Flood Plain (KVFP) serves as a significant carbon dioxide (CO₂) sequestration ecosystem, with an estimated total of 24.9 billion tonnes of CO₂ sequestered in 2020 as indicated in Table 7. Forests, which cover the majority of the area, accounted for 92.3% of this total, equating to 23.4 billion tonnes, highlighting their essential role as carbon sinks URT [12]; FAO [3]. Other land-use categories, including agriculture (2.9%), bushland (2.7%), and grassland (1.9%), contributed smaller amounts, while wetlands contributed only 0.1% due to limited aboveground biomass Leemhuis et al. [5]. The distribution of CO₂ sequestration revealed that aboveground carbon (AGC) sequestration represented 71.6% of the total, emphasizing the importance of tree canopies in carbon absorption. Belowground carbon (BGC) made up 22.3%, while deadwood carbon (DWC) accounted for 6.1%, affected by local fuelwood collection practices URT [12].

Forests are crucial not only for CO₂ sequestration but also for biodiversity conservation. However, they face threats from deforestation and unsustainable land use, necessitating protective measures to maintain their carbon storage capacity Chidumayo & Gumbo [12]. Other land-use types, while contributing less, can enhance their sequestration potential through sustainable practices like agroforestry and conservation farming Zhu et al. [16]. The findings call for targeted conservation and sustainable land management policies to bolster CO₂ sequestration in KVFP. Prioritizing forest conservation, promoting sustainable agricultural practices, and restoring wetlands are essential strategies for enhancing carbon storage and supporting

biodiversity FAO [3]; URT [12]. Ultimately, protecting KVFP's ecosystems is vital for achieving global climate change mitigation goals.

Economic potential of Kilombero valley flood plain

The Kilombero Valley Flood Plain (KVFP) holds significant economic potential for carbon dioxide (CO₂) sequestration as indicated in Table 8, estimated at approximately US\$ 99.4 billion based on a carbon market price of US\$ 4 per tonne, as per REDD+ guidelines Jenkins [14]; Lobora et al. [15]. Forests dominate this valuation, contributing 92.3% (around US\$ 91.8 billion) due to their extensive coverage and high biomass density, essential for climate mitigation and carbon offset projects FAO [3]. Other land uses, such as agriculture (2.9%), bushland (2.7%), and grassland (1.9%), play lesser roles but highlight the importance of sustainable land management practices to enhance carbon sequestration Zhu et al. [16]. Wetlands, while contributing only 0.1% (US\$ 100 million), are vital for soil organic carbon storage and water regulation, despite their limited biomass Leemhuis et al. [5].

The economic potential is also analysed across carbon pools: aboveground carbon (71.6%, US\$ 71.2 billion), belowground carbon (22.3%, US\$ 22.2 billion), and deadwood carbon (6.1%, US\$ 6.06 billion) (Table 9). The high demand for fuelwood limits deadwood accumulation, affecting its contribution URT [12]. To harness this potential, policies promoting reforestation, afforestation, and sustainable forest management are crucial Chidumayo & Gumbo [12]. Enhancing carbon sequestration in agricultural and grassland areas through practices like agroforestry can support local livelihoods while increasing carbon storage. Integrating KVFP into carbon offset programs like REDD+ can generate revenue for conservation and community development, fostering a balance between climate mitigation and economic growth Jenkins [14]. Thus, targeted conservation and sustainable management are essential for maximizing KVFP's economic and ecological contributions to Tanzania's sustainability [18].

Conclusion and Recommendations

Conclusion

The Kilombero Valley Flood Plain (KVFP) is a valuable natural resource that can help reduce greenhouse gas emissions and keep ecosystems healthy. It also has the ability to store biomass, sequester carbon, and generate revenue through international carbon markets. The study found that forests are quite dominant in the landscape, making up 92.3% of carbon stocks and biomass, and they also play a big role in sequestering carbon dioxide (CO₂). Approximately 24.9 billion tonnes of CO₂ were sequestered by KVFP in 2020, which is worth around US\$99.4 billion. These results highlight the importance of KVFP in reducing the effects of climate change and in providing other essential ecosystem services, including as regulating water flow, protecting biodiversity, and

bolstering local economies. But land-use changes, including as deforestation, agricultural growth, and wetland degradation, are putting more and more pressure on the KVFP. Environmental sustainability, carbon sequestration capacity, and economic worth are all jeopardized by these actions. Forests must be specifically protected and restored because of their importance in biomass and carbon sequestration. Sustainable land management approaches also present an opportunity to utilise the underutilised potential of agricultural areas, bushlands, grasslands, and wetlands. In order to take advantage of KVFP's economic potential while protecting its ecological services, this study stresses the importance of incorporating it into national and international climate policies like REDD+. The KVFP can set an example for how to balance sustainable development with climate mitigation by aligning with Tanzania's national climate goals and global commitments under the Paris Agreement.

Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the role of KVFP in climate mitigation and ecosystem sustainability.

References

1. IPCC (2021) Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
2. IPCC (2022) Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
3. FAO (2022) Global forest resources assessment 2022: Main report. Food and Agriculture Organization of the United Nations.
4. Kulindwa K, Sosovele H, Lokina R (2016) Environment and sustainable development: A guide for higher education in Tanzania. Dar es Salaam University Press.
5. Leemhuis C, Thonfeld F, Näschen K, Steinbach S, Muro J, et al. (2017) Sustainability in the water-energy-food nexus: Agricultural intensification and ecosystem services in the Kilombero floodplain, Tanzania. *Journal of Environmental Management* 196: 476-489.
6. Starkey M, Topp-Jørgensen E, Brown K (2002) Biodiversity in Tanzania: A comprehensive study. *Journal of East African Natural Resources* 56(3): 121-135.
7. Msofe N, Sheng L, Lyimo J (2020) Land use change dynamics and their effects on forest ecosystems and agriculture in Tanzania. *Scientific Reports* 10(1): 22128.
8. Msofe N, Sheng L, Lyimo J (2019) Analysis of land use and land cover change dynamics and its implications on food production. *Environmental Development* 29: 32-46.
9. Fordham DA, Brook BW, Moritz C, Nogués-Bravo D (2013) Better forecasts of range dynamics using genetic data. *Trends in Ecology & Evolution* 28(8): 436-443.
10. Wilson JR, Lyimo J, Shayo D (2018) Climatic variability and its effects on agricultural productivity in the Kilombero Valley. *African Journal of Environmental Science and Technology* 12(5): 235-249.

11. United Republic of Tanzania (URT) (2010) National strategy for growth and reduction of poverty II (NSGRP II). Ministry of Finance and Economic Affairs.
12. United Republic of Tanzania (URT) (2015) National forest resources monitoring and assessment (NAFORMA): Main report. Ministry of Natural Resources and Tourism, Tanzania Forest Services Agency.
13. Chidumayo EN, Gumbo DJ (2013) The environmental impacts of charcoal production in tropical ecosystems of the world: A synthesis. *Energy for Sustainable Development* 17(2): 86-94.
14. Jenkins WA (2014) Valuing ecosystem services: A new approach to forest management. *Forest Policy and Economics* 38: 68-73.
15. Lobora AL, Mduma SA, Foley C, Durant SM (2017) The status of Tanzania's carnivore populations and the prospects for their conservation. *Journal of Biodiversity and Endangered Species* 5(2): 1-7.
16. Zhu L, Sun L, Li Z (2022) Biomass carbon stocks in agricultural landscapes: A global perspective. *Environmental Science and Policy* 131: 22-31.
17. Muro J, Diekkrüger B, Thonfeld F (2017) Integrated hydrological modeling of Kilombero Valley Floodplain (Tanzania) using SWAT, MODFLOW and a GIS-based coupling procedure. *Hydrology Research* 48(2): 417-435.
18. Mshandete A, Mwalyego B (2022) Revisiting Nyerere's conservation legacy for modern climate strategies. *Tanzanian Journal of Climate Research* 7(1): 15-28.



This work is licensed under Creative Commons Attribution 4.0 License
DOI: [10.19080/ECO.A.2025.05.555654](https://doi.org/10.19080/ECO.A.2025.05.555654)

**Your next submission with Juniper Publishers
will reach you the below assets**

- Quality Editorial service
- Swift Peer Review
- Reprints availability
- E-prints Service
- Manuscript Podcast for convenient understanding
- Global attainment for your research
- Manuscript accessibility in different formats
(Pdf, E-pub, Full Text, Audio)
- Unceasing customer service

Track the below URL for one-step submission

<https://juniperpublishers.com/online-submission.php>