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Original Article

Sacred Forest Addressing Climate Action Through Emission Mitigation in the North Pare Mountains, Tanzania

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Carbon Stock, Sacred Forest, Carbon Sequestration, Spiritual Sacred Forests, Traditional Sacred Forests.

ABSTRACT

Forest carbon storage is among the indicators of climate change mitigation potential and achievement of Sustainable Development Goals by forests. Understanding the potential of sacred forests to store carbon is important in determining their significance in emission mitigation and contribution to climate action goals within the SDG framework. Assessing the carbon storage potential of these culturally managed forests is critical for understanding their role in emission reduction and climate action within the SDG framework. There has been minimal effort in understanding the role of sacred forests in climate change mitigation in Tanzania. This study aimed to assess the extent to which the spiritual and traditional training sacred forests, comparing spiritually sacred forests with traditional training forests of North Pare Mountains address climate action and SDGs through carbon capture. Measurement were done in 23 plots of 20 m x 40 m (0.08 ha) placed along randomly established transects within five sacred forests. The inter-plot and inter-transect distances were 200 m and 400 m, respectively. All tree in each plot with DBH ≥ 5 cm were identified and measured for Diameter at Breast Height (DBH). A linear allometric model $B = \beta_o \times DBH^{\beta_o}$ was used to estimate tree biomass and carbon estimated as 50% of the biomass. A total of 134 species were identified in all forests. The average carbon density was 211.6 t C ha^{-1} (776.6 t CO_2-eq ha^{-1}). Seven (7) of 134 species enumerated contributed more than 60% of the carbon stock. *Macaranga kilimandscharica*, occurring across Kiwia, Mangio, and Motingi sacred forests contributed the highest carbon density, followed by *Xymalos monospora, Manilkara densiflora, Albizia schimperiana, Newtonia buchanannii, Tabernaemontana pachysiphon*, *Syzygium guineense*, and *Albizia gummifera*. Apparently, traditionally managed sacred forests in the North Pare Mountains have high potential for carbon storage conservation of which enhances climate change mitigation and the attainment of the Sustainable Development Goal 13, among others. This index is useful for evaluating sacred forests' conservation efforts and their contribution to sustainable development goals.

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INTRODUCTION

Globally, forest resource areas are usually protected by laws and regulations. In Tanzania, particularly in the North Pare Mountains, several, especially those densely populated encompassed traditionally conserved forests i.e. sacred forests protected through spiritual beliefs and cultural norms, varying among different ethnic groups (Chandrakanth *et al.*, 2004; Parthasarathy *et al.*, 2008; Pala *et al.*, 2013; Parthasarathy & Babu, 2020). They are completely shielded from human disturbances with bylaws developed by local communities (Claudia, 2008; Uyeda *et al.*, 2014). These sacred forests serve as productive terrestrial ecosystems that provide various ecosystem services supporting human well-being (Costanza *et al.*, 2017) including their role in climate change mitigation through carbon capture (Nabuurs *et al.*, 2007; Pala *et al.*, 2013; Vikrant & Pala, 2019).

Such forests are also important in addressing some of the sustainable development goals such as SDG 13 on Climate Action which emphasizes the urgent need to combat climate change and its impacts while supporting life on land (SDG 15) since they restore natural ecosystems at various levels from global carbon sequestration to maintaining suitable habitats for wildlife. However, forests have played a significant role by providing wild foods (SDG 2) and serving as habitats for pollinators which guarantee ecosystem resilience and increasing resilience against future climate shocks leading to zero hunger outcomes. Furthermore, the forest's impact extends to ensuring clean water and sanitation services (SDG 6) by acting as natural shields guarding water sources. Communities surrounding conserved forest areas directly benefit from employment opportunities created sustainably via eco-tourism activities. These activities thereby serve both economic functionalities of poverty reduction while meeting SDG goals such as sustainable livelihoods promotion. One of the key strategies for achieving this goal is through the preservation and sustainable management of forests (FAO, 2018).

Forests, including sacred forests, play a crucial role in climate change mitigation by capturing and storing carbon dioxide, and reducing greenhouse gas emissions (Munishi, 2001, Munishi & Shear, 2004, IPCC, 2018, Munishi *et al.*, 2010). However, the process of land clearing and fragmentation, driven by anthropogenic activities, poses a significant threat to ecosystem services and carbon storage in forest ecosystems (Guo & Gifford, 2002; Jackson *et al.*, 2002; Levy *et al.*, 2004). Reports on Reducing Emissions from Deforestation and Forest Degradation (REDD+) highlight the decline in carbon stock due to unsustainable logging practices for fuel wood, timber, and charcoal production (Berghöfer & Schneider, 2015). Additionally, the assimilation of modernization and unpredictable management practices has resulted in the deterioration of many sacred forests (Parthasarathy & Babu, 2020).

This study was conducted in five sacred forests, namely Kiwia, Mangio, Motingi, Rigilia, and Mbale, with approximate areas of 4 ha, 2 ha, 2 ha, 0.5 ha, and 4 ha, respectively (Ylhäisi, 2004). These forests were divided into two categories, Spiritual sacred forests which are totally prohibited and it is used for spiritual and ritual ceremonies, and Traditional training sacred forests (Profane forests) which are primarily used for traditional training purposes such as initiating men

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into adulthood (Ylhäisi, 2006). It is worth noting that approximately 77% of these sacred forests are found in fertile soils at an altitude ranging from 1200 to 1400 m (Ylhäisi, 2004). Although few studies have been conducted on sacred forests in the North Pare Mountains, previous research has mainly focused on traditional forest protection, nature conservation, and tree symbolism (Mwihomeke *et al.*, 1998; Sheridan, 2009; Hellermann, 2016). However, the climate services through carbon capture and storage of these North Pare Mountain sacred forests have not been adequately documented.

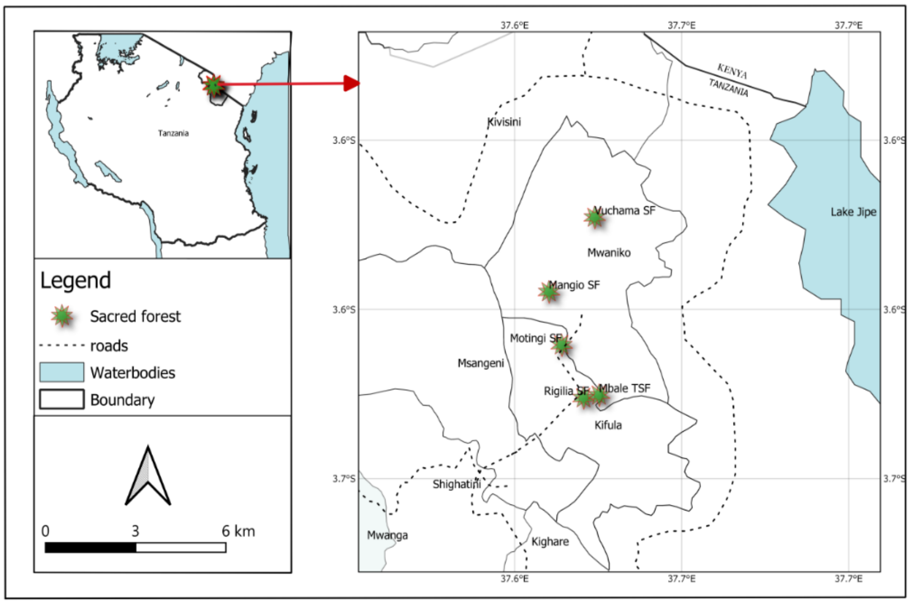
Given their small size and protection under traditional systems, it is crucial to quantify the current and future capacity of these sacred forests to mitigate carbon emissions and contribute to climate change mitigation. This study aims to estimate the average above-ground biomass (AGB) and carbon stock in the sacred forests of the North Pare Mountains, compare the carbon density between spiritually sacred forests and traditional training sacred forests, and test the hypothesis that spiritually sacred forests store higher carbon than traditional training forests. It will also evaluate the species' contributions to carbon density in these forests, assess their potential for mitigating carbon emissions, and explore their relevance to Sustainable Development Goal 13 (Climate Action). The findings of this research will provide valuable insights for conservation practitioners, decision-makers, and the government, aiding in conservation planning efforts to effectively preserve these sacred forests (Mwihomeke *et al.*, 1998; Sheridan, 2009; Hellermann, 2016).

MATERIALS AND METHOD

Description of the Study Area

The study was conducted in the North Pare Mountains located in Mwanga District, Kilimanjaro Region, and 35 km south-south-east of Mount Kilimanjaro within 3.555° to 3.645° S, and 37.665° to 37.710° E (Fig. 1). It is a geological part of the Eastern Arc Mountains which represent the northernmost tip of the range in Tanzania. The area is inhabited by Gweno, Pare, and Chagga tribes who are traditionally agro-pastoralists with few zero-grazing livestock management regimes. Rainfall ranges between 800 – 1250 mm per annum with a mist effect at higher altitudes (Heckmann, 2014; Hellermann, 2016). The dry season extends between June and October and the wet season occurs from March to June, while temperatures vary from 25 °C max (March) to 16 °C min (July).

Figure 1: A map showing the location of the sacred forests (indicated with a star symbol) in North Pare Mountain, Tanzania.



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Data collection

Five sacred forests namely Kiwia, Mangio, Motingi, Rigilia, and Mbale were purposefully selected to represent forest areas considered sacred forests. Data were collected from 23 plots measuring 20 m x 40 m (0.08ha) subdivided into eight 10m x 10m subplots. The plots were positioned along randomly established transects within each forest. The distance between transects and plots was 400 m and 200 m respectively. Sacred forests with an area of less than 1 hectare were considered a single plot. All trees with a Diameter at Breast Height (DBH) ≥10cm were measured with the main plot. Trees with DBH ≥2.5 cm <10 cm were measured within the subplots. All trees were recorded and identified by their scientific and vernacular names with the aid of botanists and local forest caretakers.

Data analysis

The linear allometric model for tropical rainforests as developed by Masota *et al.*, (2014), $B = \beta_0 \times DBH^{\beta 1}$ was used to calculate the biomass for each tree whereby B is biomass (Kg), β_0, and β1 are 0.9635 and 1.9440 which represent the constant and the coefficient of the independent variable (DBH) respectively. Tree biomass was aggregated to plot biomass and converted to per-hectare values by division by plot size. The aboveground carbon stock was computed by multiplication of the biomass by 0.5 (50%) (Ravindranath *et al.*, 1997; Munishi and Shear, 2004; Shirima *et al.*, 2011). Since the number of plots sampled differed in each sacred forest, we performed a linear mixed model (LMM) to assess the mean difference in carbon stock per forest by randomizing the plots. The statistical significance of differences in carbon stock between forests was determined using p-values, with a significance level set at $\alpha = 0.05$. The role of the forests in addressing the sustainable development goals was assessed by scanning through literature and identifying those SDGs with direct or indirect relations with CC adaptation and or mitigation.

RESULTS

Carbon density across the five sacred forests

Table 1 and Figure 2 present the estimated carbon density for the different forests which range from 518.5 t C ha^{-1} (1,902.8 t CO_2-eq ha^{-1}) in the Kiwia forest to 68.8 t C ha^{-1} (252.4 t CO_2-eq ha^{-1}) in Mbale sacred forest with an average carbon density of 211.6 t C ha^{-1} (776.65 t CO_2-eq ha^{-1}). The carbon density differed significantly across the different forests. Kiwia forest had the highest carbon density of 518.5 t C ha^{-1} (1,902.8 t CO_2-eq ha^{-1}), followed by Mangio with 238.1 t C ha^{-1} (873.8 t CO_2-eq ha^{-1}), Motingi 151.6 t C ha^{-1} (556.4 t CO_2-eq ha^{-1}), Rigilia with 81.1 t C ha^{-1} (297.5 t CO_2-eq ha^{-1}) and Mbale 68.8 t C ha^{-1} (252.4 t CO_2-eq ha^{-1}). Seven out of the 134 plant species contributed more than 60% of the carbon stock. *Macaranga kilimandscharica* which is dominant in Kiwia sacred forest but occurs across Mangio and Motingi contributed the highest carbon density, followed by *Xymalos monospora*, *Manilkara densiflora*, *Albizia schimperiana*, *Newtonia buchanannii*, *Tabernaemontana pachysiphon*, *Syzygium guineense* and *Albizia gummifera* (Table 2). Linear Mixed Model analysis shows that Mangio sacred forest had significantly higher carbon density than all the other forests (LMM, F = 2.03, DF =4, CI = 0.68 - 3.39)

Table 1: Carbon Stock of five Sacred Forests in Ugweno ward, North Pare Mountains, Tanzania

Forest	Mean Biomass (t/ha)	Mean Carbon Stock (t C ha^{-1})	Mean Carbon Dioxide –eq. (t CO_2 ha^{-1})
Kiwia	1037.0	518.5	1902.8
Mangio	476.2	238.1	873.8
Motingi	303.2	151.6	556.4
Rigilia	162.1	81.1	297.5
Mbale	137.6	68.8	252.4
Mean	**423.2**	**211.6**	**776.6**

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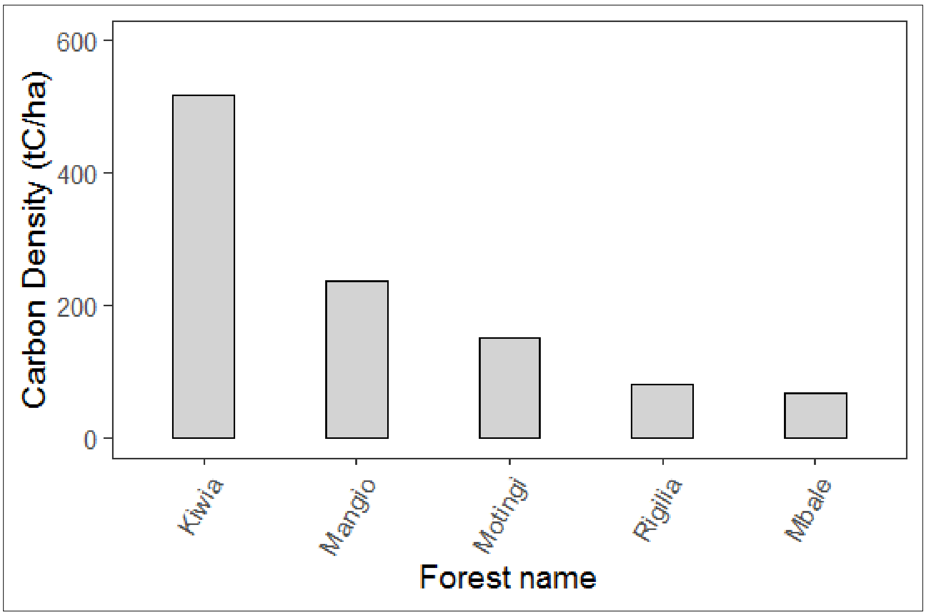
Figure 2: Carbon density among the five sacred forests in the North Pare Mountain, Tanzania.



Individual Species Contribution to Carbon Stocks

The top-ranking species which contributes more than 4% of biomass and carbon in these sacred forests were *Macaranga kilimandscharica* occurring in Kiwia, Mangio, and Motingi; but more dominant in Kiwia sacred forest contributing 122.5 t C ha^{-1} (449.6 t CO_2-eq ha^{-1}). Others were *Xymalos monospora* contributing 106.4 t C ha^{-1} (390.5 t CO_2-eq ha^{-1}); distributed across all sacred forests except Mbale followed by *Manilkara densifolia* 104.9 t C ha^{-1} (385.0 t CO_2-eq ha^{-1}) occurring in Mangio only, *Albizia schimperiana* contributing 104.1 t C ha^{-1} (382.0 t CO_2-eq ha^{-1}) distributed across all the sacred forests; *Newtonia buchananii* contributing 88.6 t C ha^{-1} (325.2 t CO_2-eq ha^{-1}) distributed in all forests except Mbale, *Tabernaemontana pachysiphon* contributing 71.0 t C ha^{-1} (260.6 t CO_2-eq ha^{-1}) distributed across all sacred forests and *Syzygium guineense* contributing 51.7 t C ha^{-1} (189.7 t CO_2-eq ha^{-1}) occurring in all forests except Mbale (Table2).

Table 2: Species that contributed more than 4% of the Carbon Stock in the Five Sacred Forests in the North Pare Mountains, Tanzania

Scientific name	Kiwia	Mangio	Mbale	Motingi	Rigilia	Total C (t Cha^{-1})	Contribution %
Macaranga kilimandscharica	118.6	0.9		3.0		122.5	11.6
Xymalos monospora	99.7	0.6		6.2		106.4	10.1
Manilkara densiflora		104.9				104.9	9.9
Albizia schimperiana	60.9	3.2	7.8	17.2	15.2	104.1	9.8
Newtonia buchanannii	30.0	54.2		3.0	1.4	88.6	8.4
Tabernaemontana pachysiphon	62.1	0.3	6.5	1.6	0.5	71.0	6.7
Syzygium guineense	40.9	3.1		6.4	1.3	51.7	4.9

Comparison of Carbon Stock between Spiritual and Training Sacred Forests

The carbon density in the spiritual forests; Kiwia, Mangio, Motingi and Rigilia was 989.1 t C ha^{-1} (3629.9 t CO_2-eq ha^{-1}) and the traditional training forest; Mbale was 68.8 t C ha^{-1} (252.4 t CO_2-eq ha^{-1}). There was no significant difference in carbon stock between spiritual and training sacred forests (LMM, t = -0.007, 95% CI = -1.84 – 1.82). Mangio has a higher average carbon density compared to other forests, these was due to the presence of big trees with large diameters. However, when comparing the two forest statuses (i.e. Spiritual and training forest) the forest used for traditional training (Mbale) was higher than the sacred forests used for spiritual purposes (Figure 3) which may imply similar forest structure and vegetation types.

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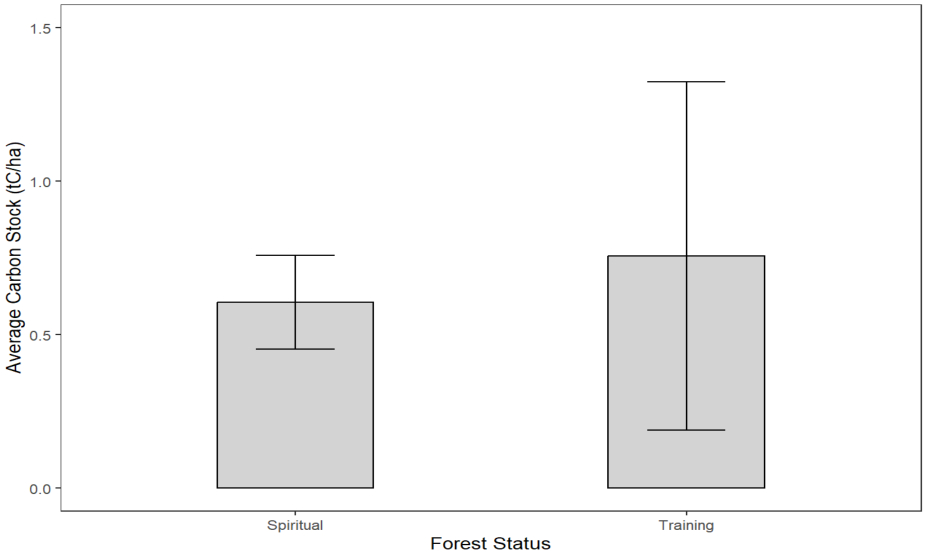
Figure 3: Carbon density in spiritual and traditional training sacred forests of the North Pare Mountain, Tanzania. The training forests have higher though insignificant carbon density. Arrows represent confidence intervals.



Sacred forests and their carbon storage potential are strongly related to some of the SDGs especially SDG 13, which focuses on climate action with the goal to minimize greenhouse gas emissions while to mitigate and adapt climate change. Sustainable Development Goal 13 urges to take action to combat climate change and its impacts thus playing a critical role in reducing climate change impacts and transitioning to a more sustainable future by advocating actions that reduce emissions and maintain/increase carbon density in existing carbon stocks. Through climate change mitigation it concurrently emphasizes and supports biodiversity conservation (SDG 15) and provides other ecosystem services such as food (SDG 2) and clean water and sanitation (SDG 6). Therefore, these acknowledge the significance of increasing carbon density via forest conservation and adopting sustainable practices.

DISCUSSION

Despite their size there is substantial carbon storage potential across the sacred forests. The amount of carbon stored did vary between sacred forests used for spiritual purposes and those used for traditional training. Contrary to expectations, the data from the study indicate that traditional training forests tend to have higher carbon stocks than their spiritual counterparts. The study found that seven woody species out of 134 were responsible for about 60% of the carbon stored in all sacred forests.

Our results align closely with those studies conducted in the same study district by Wisner *et al.*, (2012) who report a mean carbon stock of 426 t C ha^{-1}. Other studies provide similar evidence for the difference in carbon stock between sacred woods (Sharma *et al.*, 2019; Biradar and Channabasappa, 2021) which showed that the ability of large forests to store a significant quantity of carbon stock per area varied. This is caused by the forest's protected status as well as the presence of large trees, which store more carbon. However, research turned out those small-sized sacred forests appeared to store more carbon stock than large-sized sacred forests when the sampling areas were controlled for both sizes. Our research indicates that small sacred forests need to be preserved because anthropogenic activities make them more vulnerable to extinction given their small size and fragmentation.

This study identified plant species that contributed more than 60 per cent of carbon stock in the North Pare Mountain sacred forests. These woody species include *Macaranga kilimandscharica*, *Xymalos monospora*, *Manilkara densiflora*, *Albizia schimperiana*, *Newtonia buchanannii*, *Tabernaemontana pachysiphon*, *Syzygium guineense*, and *Albizia gummifera;* the results are in line with that of Heckman, (2011). These species have high carbon stock due to their high density and large stem diameter. These observations are supported by other studies (Munishi & Shear, 2004; Munishi *et al.,* 2004, Munishi *et al.,* 2010; Slik *et al.,* 2013; Mauya & Madundo, 2021).

The study found similarities in carbon density between forests used for traditional training (profane) and those used for spiritual activities. These are the results of more conservation efforts placed and fear of deity for the communities living adjacent to the forests. This implies that local communities protect both forests equally. Some studies acknowledge the utilization of sacred forests for spiritual purposes and traditional training thus enhancing their conservation (Chandrakanth *et al.,* 2004; Parthasarathy *et al.,* 2008; Pala *et al.,* 2013; Parthasarathy & Babu, 2020; Mgumia & Oba, 2003).

Climate change is a main challenge for societies and the environment and forests have been integral to this challenge. Sacred forests are key to implementing the SDG 13 (Climate action) through emission mitigation and this climate change mitigation and adaptation. Like any other forest ecosystem, sacred forests, which have cultural and ecological importance, contribute to carbon conservation by functioning as carbon sinks and storing considerable amounts of carbon dioxide (Munishi & Shear 2004, Munishi *et al.,* 2010; Bhakat & Sen, 2021). Several reports show that the loss of different types of forests can contribute to global annual CO_2 emissions substantially irrespective of their sizes (Zarin *et al.,* 2016). In addition, these forests also play a crucial role by protecting humans and the environment from being exposed to climate change impacts by providing food to emphasize zero hunger (SDG 2), water availability (SDG 6) and protection from floods (Osman-Elasha *et al.,* 2009). The forests also act as a refuge for biodiversity in the face of environmental change (SDG 15). Sustainable Development Goal 13 focuses on climate action and stresses lowering greenhouse gas emissions, strengthening resilience, and mobilizing resources for climate action. By preserving sacred forests, community-based forest management contributes to conserving carbon stocks, reducing greenhouse gas emissions and mitigating climate change by promoting sustainability and resilience in the face of climate change actions (Maru *et al.,* 2023).

CONCLUSION

The sacred forests have high potential for climate change mitigation through carbon capture and storage, the conservation of which is of paramount importance. Due to augmented conservation efforts made by communities out of religious conviction, these sacred forests have substantial potential to store carbon and provide other ecosystem services. Community management of the sacred forests also has high potential for addressing some of the SDGs especially related to ecosystem services provisioning and climate change mitigation. It is critical to recognize the efforts made by the community to preserve the small sacred forest as a source of regional biodiversity and climate change mitigation as they continue towards this environmentally important pathway. More studies on the range of traditional forest management strategies that have been employed to satisfy livelihoods while enhancing climate change mitigation and biodiversity conservation are imperative.

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Conflict of interest

All authors agreed on the publication of this paper, and have no conflicts of interest.

Author Contribution Statement

Elisante A. Kimambo, Pantaleo K. Munishi, Sayuni B. Mariki and Halima Kilungu participated in the study. Elisante Kimambo collected data in the field and developed the first draft of the manuscript as the lead author of this paper. Pantaleo K. Munishi Sayuni B. Mariki and Halima Kilungu participated in designing the study, supervising fieldwork and data analysis, manuscript writing and reviewing.

REFERENCES

Berghöfer, A., & Schneider, A. (2015). *Indicators for managing ecosystem services – Options and examples public management.* ValuES Project Report. Helmholtz Zentrum für Umweltforschung (UFZ) GmbH, Leipzig, and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany 49 pp.

Bhakat, R. K., & Sen, A. (2021). Aboveground biomass and carbon stock in the largest sacred grove of Manipur, Northeast India. *Journal of Forestry Research, 32*(1), 251–261. https://doi.org/10.1007/s11676-017-0439-y

Biradar, P. I., & Channabasappa, K. S. (2021). Assessment of biomass and carbon sequestration potential of sacred Kaans in Soraba taluk of Central Western Ghats, Karnataka. *The Pharma Innovation Journal, 10*, 801–806.

Chandrakanth, M. G., Bhat, M. G., & Accavva, M. S. (2004). Socio-economic changes and sacred groves in South India: Protecting a community-based resource management institution. *Natural Resources Forum, 28*, 102–111.

Claudia, S. (2008). *The role of indigenous peoples in biodiversity conservation: The natural but often forgotten partners.* Report to World Bank, Washington, DC.

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, 28, 1–16.

Food and Agriculture Organization of the United Nations. (2018). *The state of the world's forests 2018: Forests and the 2030 agenda for sustainable development.* https://doi.org/10.4060/I9535EN

Guo, L. B., & Gifford, R. M. (2002). Soil carbon stocks and land use change: A meta-analysis. *Global Change Biology* 8: 345–360.

Heckmann, M. (2011). *Soil erosion history and past human land use in the North Pare Mountains: A geo-archaeological study of slope deposits in NE Tanzania* (Doctoral dissertation). University of York. (333 pp.)

Hellermann, P. (2016). Sacred forests in conservation: The cultural and ecological roles of sacred groves in sub-Saharan Africa. *Journal of Environmental Management, 55*(3), 245– 256. https://doi.org/10.1016/j.jenvman.2016.03.012

Intergovernmental Panel on Climate Change. (2018). *Global warming of 1.5° C: Special report.*

Jackson, R. B., Banner, J. L., Jobbágy, E. G., Pockman, W. T., & Wall, D. H. (2002). Ecosystem carbon loss with woody plant invasion of grasslands. *Journal of Nature,* 418: 623–626.

Levy, P. E., Friend, A. D., White, A., & Cannell, M. G. R. (2004). The influence of land use change on global-scale fluxes of carbon from terrestrial ecosystems. *Journal of Climate Change*, 67: 185–209.

Article DOI : https://doi.org/10.37284/ajccrs.4.1.2668

Maru, Y., Gebrekirstos, A., & Haile, G. (2023). Indigenous sacred forests as a tool for climate change mitigation: Lessons from Gedeo community, Southern Ethiopia. *Journal of Sustainable Forestry,* 42(3): 260–287.

Masota, A. M., Zahabu, E., Malimbwi, R. E., Bollandsas, O. M., & Eid, T. H. (2014). Volume model for single trees in tropical rainforests in Tanzania. *Journal of Energy and Natural Resources*, 3(5): 66–76.

Mauya, E. W., & Madundo, S. (2021). Aboveground biomass and carbon stock of Usambara tropical rainforests in Tanzania. *Tanzania Journal of Forestry and Nature Conservation*, *90*(2), 63–82.

Mgumia, F. H., & Oba, G. (2003). Potential role of sacred groves in biodiversity conservation in Tanzania. *Journal of Environmental Conservation,* 30: 259–265.

Munishi, P. K. T., & Shear, T. H. (2004). Carbon storage in Afro-Montane rainforests of the Eastern Arc Mountains of Tanzania: Their net contribution to atmospheric carbon. *Journal of Tropical Forest Science,* 16: 78–93.

Munishi, P. K. T., Maliondo, S. M., Temu, R. P. C., & Msanya, B. (2004). The potential of Afromontane rain forests to mitigate carbon emissions in Tanzania. *Journal of Tanzania Association of Foresters* (TAF, 10), 14–25.

Munishi, P. K. T., Mringi, S., Shirima, D. D., & Linda, S. K. (2010). The role of the Miombo woodlands of the Southern Highlands of Tanzania as carbon sinks. *Journal of Ecology and the Natural Environment*, 2(12): 261–269.

Mwihomeke, S. T., Msangi, T. H., Mabula, C. K., Ylhäisi, J., & Mndeme, K. C. H. (1998). Traditionally protected forests and nature conservation in the North Pare Mountains and Handeni District, Tanzania. *Journal of East African Natural History,* 87(1): 279–290.

Nabuurs, G.J., O. Masera, K., Andrasko, P., Benitez-Ponce, R., Boer, M., Dutschke, E., Elsiddig, J., Ford-Robertson, P., Frumhoff, T., Karjalainen, O., Krankina, W.A., Kurz, M., Matsumoto, W., Oyhantcabal, N. H., Ravindranath, M.J., Sanz Sanchez, X. and Zhang, A. (2007). Forestry. In B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, & L. A. Meyer (Eds.), *Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.Osman-Elasha, B., Parrotta, J., Adger, N., Brockhaus, M., Colfer, C. J. P., Sohngen, B., and Robledo, C. (2009). Future socio-economic impacts and vulnerabilities. *IUFRO World Series, 22*: 101-122.

Osman-Elasha, B., Parrotta, J., Adger, N., Brockhaus, M., Colfer, C. J. P., Sohngen, B., & Robledo, C. (2009). Future socio-economic impacts and vulnerabilities. *IUFRO World Series,* 22: 101–122.

Pala, N. A., Negi, A. K., Vikrant, K. K., Gokhale, Y., & Todaria, N. P. (2013). Carbon storage in sacred groves: A study from Chanderbadni sacred grove in Garhwal Himalaya, Uttarakhand, India. *Journal of Biodiversity and Ecological Sciences*, 3(2): 75–79.

Parthasarathy, N., & Babu, K. N. (2020). Sacred groves: Potential for biodiversity and bio-resource management. *Journal of Tropical Conservation Science,* 13: 865–880.

Parthasarathy, N., Selwin, M. A., & Udayakumar, M. (2008). Tropical dry evergreen forest of peninsular India: Ecology and conservation significance. *Journal of Tropical Conservation Science,* 1(2): 89–110.

Ravindranath, N. H., Somashekhar, B. S., & Gadgil, M. (1997). Carbon flow in Indian forests. *Climatic Change, 35*(3): 297–320.

Sharma, S., Tiwari, A., Sheikh, M. A., & Kumar, B. (2019). Carbon stock in Kaner Jhir sacred grove and non-sacred grove of Gwalior, MP. *Journal of Emerging Technologies and Innovative Research,* 6(3): 598–605.

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Sheridan, M. E. (2009). Traditional sacred forests as a strategy for conserving biodiversity in East Africa. *Journal of Biodiversity and Conservation*, 18(10): 2641–2655.

Shirima, D. D., Munishi, P. K. T., Lewis, S. L., Burgess, N. D., Marshall, A. R., Balmford, A., & Zahabu, E. M. (2011). Carbon storage, structure and composition of miombo woodlands in Tanzania's Eastern Arc Mountains. *African Journal of Ecology*, *49*(3), 332–342.

Slik, J. F., Paoli, G., McGuire, K., Amaral, I., Barroso, J., Bastian, M., Blanc, L., Bongers, F., & Clark, C. (2013). Large trees drive forest aboveground biomass variation in moist lowland forests across the tropics. *Global Ecology and Biogeography*, *22*(12), 1261–1271.

Uyeda, L. T., Iskandara, E., Purbatrapsila, A., Pamungkas, J., Wirsing, A., & Kyes, R. C. (2014). The role of traditional beliefs in the conservation of herpetofauna in Banten, Indonesia. *Fauna and Flora International, Oryx*, *48*(4): 1–6.

Vikrant, K., & Pala, N. A. (2019). Carbon storage in sacred groves: A study from Chanderbadni sacred grove in Uttarakhand, India. *Journal of Biodiversity and Ecological Sciences*, *3*(1): 1–3.

Wisner, B., Mascarehas, A., Bwenge, C., Smucker, T., Wargui, E., Weiner, D., & Munishi, P. (2012). Let them eat (maize) cake: Climate change discourse, misinformation and land grabbing in Tanzania. In *International Conference on Global Land Grabbing II, Cornell University*.

Ylhäisi, J. (2004). Indigenous forests fragmentation and the significance of ethnic forests for conservation in the North Pare, the Eastern Arc Mountains, Tanzania. *International Journal of Geography* 182 (2): 109-132.

Ylhäisi, J., (2006). *Traditional Protected Forests and Sacred Forests of Zigua and Gweno Ethnic Groups in Tanzania* (PhD thesis). Department of Geography, University of Helsinki, Finland.

Zarin, D. J., Harris, N. L., Baccini, A., Aksenov, D., Hansen, M. C., Azevedo-Ramos, C., and Tyukavina, A. (2016). Can carbon emissions from tropical deforestation drop by 50% in 5 years? *Global change biology*, 22(4): 1336-1347.