# EFFECT OF COLLABORATIVE FOREST MANAGEMENT ON CARBON STOCKS, SPECIES DIVERSITY AND STEM DENSITY IN MABIRA CENTRAL FOREST RESERVE, UGANDA

**BY**

**PHILLIPSON MUGUMYA**

**Reg. BU/GS21/MCC/7**

**A DISSERTATION SUBMITTED TO THE DIRECTORATE OF GRADUATE STUDIES, RESEARCH AND INNOVATIONS IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN CLIMATE CHANGE AND DISASTER MANAGEMENT DEGREE OF BUSITEMA UNIVERSITY**

**BUSITEMA UNIVERSITY**

**SEPTEMBER 2025**

## DECLARATION

I, **Phillipson Mugumya**, hereby declare that the work contained in this dissertation is a true copy of my work effort except where has been referenced and has never been submitted for any degree award at this or any other University or institution of higher learning.

**Candidate**

**Signature.**  **Date**.....29th/ SEPT/2025.....

**Phillipson Mugumya**

## SUPERVISOR'S APPROVAL

This dissertation has been done under the guidance of the following Supervisors:

Name: Professor Isabirye Moses

Signature: .....

Date: 29/09/2025

Name: Dr. Masaba Sowedi

Signature: .....

Date: 13/10/25

**ACKNOWLEDGEMENT**

This dissertation was made possible with the intellectual guidance of my dear supervisors, Professor Isabirye Moses and Dr. Masaba Sowedi. Thank you for the cordial environment I enjoyed throughout the supervision process. Special tribute is paid to all Staff of office of the National Forestry Authority (NFA) for the assistance rendered to me in accessing all the relevant information needed for the success of this study. I am forever grateful. May God forever bless you abundantly. Above all, I thank God, the Almighty for bringing me this far.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## ACRONYMS

| | |
|---|---|
| AGB | Above ground biomass |
| Asl | Above sea level |
| CFLRP | Collaborative forest landscape restoration program |
| CFM | Collaborative forest management |
| CFR | Central forest reserve |
| $CO_2$ | Carbon dioxide |
| CYC | Carbon yield coefficient |
| DBH | Diameter at breast height |
| *Et al* | And others |
| FAO | Food and Agricultural Organization |
| FC | Forest Certification |
| FTEA | Flora of Tropical East Africa |
| GPS | Global Positioning System |
| IUCN | International Union for conservation of Nature |
| JFM | Joint Forest Management |
| Km | Kilometers |
| Ms Excel | Microsoft excel software |
| MWE | Ministry of water and environment |
| NFA | National Forest Authority |
| REDD+ | Reduced emission through degradation and deforestation |
| VYC | Volumetric yield coefficient |

**ABSTRACT**

Collaborative forest management (CFM) is a form of forest governance in which local communities are involved in the superintendence and administrative processes related to forest resources. It is believed that forests under such management are better in tree diversity and conservation status thus hold more carbon stocks. The study assessed the influence of CFM on carbon stocks in Mabira central forest reserve. This was achieved through measuring carbon stocks in forested areas under CFM viz a viz non-CFM areas, determining tree species diversity in forested areas under CFM viz a viz non-CFM areas, and determining tree stem-densities in areas under CFM viz a viz non-CFM areas in Mabira Central Forest Reserve. Data were collected from alternating plots laid along transects running from north to south in the different purposively selected forest areas. Field carbon stock assessment followed the procedure described by Asseffa *et al*., (2013) Tree species diversity included species richness and species evenness as sampled among plots in the selected forest areas. Tree stem-density assessment was hinged on the method described by Eilu *et al*., (2004). The study findings show that non-CFM areas have a greater variability and wider spread carbon stock values compared to CFM areas. CFM areas also had lower species richness compared to non-CFM areas. CFM areas however, exhibited more species diversity and variability than non-CFM areas. CFM areas had higher average stem density stands (309 stems per hectare) compared to non-CFM areas. Recommendations for improving collaborative forest management (CFM) areas include implementing targeted interventions to enhance carbon sequestration, such as promoting reforestation and afforestation with high-carbon-storing species, and strengthening monitoring and evaluation frameworks to assess carbon stock changes over time. Additionally, efforts should focus on enhancing biodiversity conservation by implementing more stringent protection measures and reducing human disturbance, while encouraging community participation in biodiversity monitoring and conservation education.

## REFERENCES


Agrawal, A. (2007). Forests, Governance, and Sustainability: Common Property Theory and its Contributions. *International Journal of the Commons*, *1*(1), 111. https://doi.org/10.18352/ijc.10

Barton, D. N., & Lindhjem, C. (2020). "Forest ecosystem services: Contributing to sustainable development in the context of climate change." Environmental Science & Policy, 107, 234-246.

Birungi, V., Dejene, S. W., Mbogga, M. S., & Dumas-Johansen, M. (2023). Carbon stock of Agoro Agu Central Forest reserve, in Lamwo district, Northern Uganda. *Heliyon*, *9*(3), e14252. https://doi.org/10.1016/j.heliyon.2023.e14252

Bode, M., et al. (2019). "The role of collaborative forest management in restoring green carbon stocks in Cameroon." Forest Ecology and Management, 453, 117648.

Boton, D., Mensah, S., Yamungu, A., Houedegnon, P., & Namara, B. (2021). *Performance of Collaborative Forest Management on Forest Status and Contribution to Adjacent Community Livelihoods in Uganda*.

Bowler, D., L, B., Healey, J., Jones, J., Knight, T., & Pullin, A. (2010). The evidence base for community forest management as a mechanism for supplying global environmental benefits and improving local welfare. *Collaboration for Environmental Evidence*, *2010*.

Braga, C. I., Petrea, S., Radu, G. R., Cucu, A. B., Serban, T., Zaharia, A., & Leca, S. (2024). Carbon Sequestration Dynamics in Peri-Urban Forests: Comparing Secondary Succession and Mature Stands under Varied Forest Management Practices. *Land*, *13*(4), 492–492. https://doi.org/10.3390/land13040492

Brazier, R. E., Puttock, A., Graham, H. A., Auster, R. E., Davies, K. H., & Brown, C. M. L. (2020). Beaver: Nature's Ecosystem Engineers. *WIREs Water*, *8*(1). https://doi.org/10.1002/wat2.1494

Carter, J., & Gronow, J. (2005). *CIFOR Occasional Paper No. 43 Recent Experience in Collaborative Forest Management A Review Paper*. https://www.cifor.org/publications/pdf_files/OccPapers/OP-43.pdf

Cavanaugh, K. C., Gosnell, J. S., Davis, S. L., Ahumada, J., Boundja, P., Clark, D. B., Mugerwa, B., Jansen, P. A., O'Brien, T. G., Rovero, F., Sheil, D., Vasquez, R., & Andelman, S. (2014). Carbon storage in tropical forests correlates with taxonomic diversity and functional dominance on a global scale. *Global Ecology and Biogeography*, *23*(5), 563–573. https://doi.org/10.1111/geb.12143

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., … Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, *145*(1), 87–99. https://doi.org/10.1007/s00442-005-0100-x

Chazdon, R. L. (2017). Tropical Forest Regeneration ☆. *Elsevier EBooks*. https://doi.org/10.1016/b978-0-12-809633-8.02053-7

Dennis, S. (2016). *Assessment Forest Plan Revision Draft Baseline Assessment of Carbon Stocks Report*. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd526158.pdf

Di Girolami, E., Kampen, J., & Arts, B. (2023). Two systematic literature reviews of scientific research on the environmental impacts of forest certifications and community forest management at a global scale. *Forest Policy and Economics*, *146*, 102864. https://doi.org/10.1016/j.forpol.2022.102864

Ekoungoulou, R., Niu, S., Folega, F., Nzala, D., & Liu, X. (2018). Carbon Stocks of Coarse Woody Debris in Central African Tropical Forests. *Sustainability in Environment*, *3*(2), 142. https://doi.org/10.22158/se.v3n2p142

Ellis, E. A., Montero, S. A., Hernández Gómez, I. U., Romero Montero, J. A., Ellis, P. W., Rodríguez-Ward, D., Blanco Reyes, P., & Putz, F. E. (2019). Reduced-impact logging practices reduce forest disturbance and carbon emissions in community managed forests on the Yucatán Peninsula, Mexico. *Forest Ecology and Management*, *437*, 396–410. https://doi.org/10.1016/j.foreco.2019.01.040

FAO. (2022b). The World's Forests. In *Geographical Review* (Vol. 14). https://doi.org/10.2307/208372

Fielding, K. S., Prober, S. M., Williams, K. J., & Dean, A. J. (2023). Developing an indicator of community appreciation of biodiversity. *Environmental and Sustainability Indicators*, *19*, 100278. https://doi.org/10.1016/j.indic.2023.100278

Fleishman, E., Noss, R., & Noon, B. (2006). Utility and limitations of species richness metrics for conservation planning. *Ecological Indicators*, *6*(3), 543–553. https://doi.org/10.1016/j.ecolind.2005.07.005

Gebrewahid, Y., & Meressa, E. (2020). Tree species diversity and its relationship with carbon stock in the parkland agroforestry of Northern Ethiopia. *Cogent Biology*, *6*(1). https://doi.org/10.1080/23312025.2020.1728945

Gilani, H. R., Yoshida, T., & Innes, J. L. (2017). A Collaborative Forest Management user group's perceptions and expectations on REDD + in Nepal. *Forest Policy and Economics*, *80*, 27–33. https://doi.org/10.1016/j.forpol.2017.03.004

Gilmour, D. A. (2016). "Collaborative forest management: Achievements and challenges." Forest Ecology and Management, 368, 152-160.

Giuggiola, A., Rigling, A., & Dobbertin, M. (2012). Reduction of stand density as a management tool to mitigate the effect of drought. *Forest Ecology and Management*, 12847-.

Gunawan, B., Abdoellah, O. S., Hadi, F., Alifi, G. J., Suhendi, R. N., Aisharya, I. Y., & Gunawan, W. (2023). From Laborers to Coffee Farmers: Collaborative Forest Management in West Java, Indonesia. *Sustainability*, *15*(9), 7722. https://doi.org/10.3390/su15097722

Hardiman, B. S., Gough, C. M., Halperin, A., Hofmeister, K. L., Nave, L. E., Bohrer, G., & Curtis, P. S. (2013). Maintaining high rates of carbon storage in old forests: A mechanism linking canopy structure to forest function. *Forest Ecology and Management*, *298*, 111–119. https://doi.org/10.1016/j.foreco.2013.02.031

Harrison, R. L., & Tedd, P. (2016). "Community involvement and its impact on forests: Lessons from participatory forest management in eastern and southern Africa." Forest Policy and Economics, 67, 139-150.

Hilmi, N., Chami, R., Sutherland, M. D., Hall-Spencer, J. M., Lebleu, L., Benitez, M. B., & Levin, L. A. (2021). The Role of Blue Carbon in Climate Change Mitigation and Carbon Stock Conservation. *Frontiers in Climate*, *3*. https://doi.org/10.3389/fclim.2021.710546

IUCN. (2021, February). *Forests and climate change*. IUCN. https://www.iucn.org/resources/issues-brief/forests-and-climate-change

Jjagwe, A., Kakembo, V., & Barasa, B. (2021). Land Use Cover Types and Forest Management Options for Carbon in Mabira Central Forest Reserve. Springer EBooks, 2733–2754. https://doi.org/10.1007/978-3-030-45106-6_145

Kaggwa, R. C., & Byakagaba, P. (2012). Collaborative Forest Management in Uganda: Benefits, Implementation Challenges and Future Directions. ResearchGate. https://www.researchgate.net/publication/224830124_Collaborative_Forest_Management_in_Uganda_Benefits_Implementation_Challenges_and_Future_Directions

Laland, K. N., & Brown, G. (2011). "Niche Construction, Human Behavior, and the Adaptive Landscape." Behavioral and Brain Sciences, 34(2), 129-150.

Lamsal, P., Aryal, K. R., Adhikari, H., Paudel, G., Maharjan, S. K., Khatri, D. J., & Sharma, R. P. (2023). Effects of Forest Management Approach on Carbon Stock and Plant Diversity: A Case Study from Karnali Province, Nepal. *Land*, *12*(6), 1233. https://doi.org/10.3390/land12061233

Lan, T., X. Ben Wu, Wu, Y., & Li, M. (2023). Forest Carbon Density Estimation Using Tree Species Diversity and Stand Spatial Structure Indices. *Forests*, *14*(6), 1105–1105. https://doi.org/10.3390/f14061105

Larrazábal, A., McCall, M. K., Mwampamba, T. H., & Skutsch, M. (2012). The role of community carbon monitoring for REDD+: a review of experiences. *Current Opinion in Environmental Sustainability*, *4*(6), 707–716. https://doi.org/10.1016/j.cosust.2012.10.008

Locke, H., & Dearden, P. (2020). "Emerging trends in collaborative forest management: Lessons from community-driven initiatives." Conservation Biology, 34(5), 1167-1173.

Mandal, R. A., Yadav, K., Yadav, B. K., Thapa, U., Haque, S., Jha, P. K., Karmacharya, S., & Dutta, I. C. (2012). Effects of Deforestation and Forest Degradation on Forest Carbon Stocks in Collaborative Forests, Nepal. *International Journal of Conservation Science*, *3*(4), 325–338.

Martin, A., et al. (2020). "The challenge of overharvesting in collaborative forest management: Case studies and multi-stakeholder perspectives." Ecological Management & Restoration, 21(1), 56-67.

Mawa, C., Babweteera, F., & Tumusiime, D. M. (2020). Conservation Outcomes of

Collaborative Forest Management in a Medium Altitude Semideciduous Forest in Mid-western Uganda. *Journal of Sustainable Forestry*, 1–20. https://doi.org/10.1080/10549811.2020.1841006

Melikov, C. H., Bukoski, J. J., Cook-Patton, S. C., Ban, H., Chen, J. L., & Potts, M. D. (2023). Quantifying the Effect Size of Management Actions on Aboveground Carbon Stocks in Forest Plantations. *Current Forestry Reports*, *9*(3), 131–148. https://doi.org/10.1007/s40725-023-00182-5

Mensah, S., Noulèkoun, F., Dimobe, K., Seifert, T., & Glèlè Kakaï, R. (2023). Climate and soil effects on tree species diversity and aboveground carbon patterns in semi-arid tree savannas. *Scientific Reports*, *13*(1), 1–13. https://doi.org/10.1038/s41598-023-38225-3

Monarrez-Gonzalez, J. C., Gonzalez-Elizondo, M. S., Marquez-Linares, M. A., Gutierrez-Yurrita, P. J., & Perez-Verdin, G. (2020). Effect of forest management on tree diversity in temperate ecosystem forests in northern Mexico. *PLOS ONE*, *15*(5), e0233292. https://doi.org/10.1371/journal.pone.0233292

Müller, M., et al. (2019). "Collaborative forest management impacts on carbon stocks in tropical forests: A global synthesis." Environmental Research Letters, 14(10), 104052.

Mwavu, E. N., & Witkowski, E. T. F. (2009). Population structure and regeneration of multiple-use tree species in a semi-deciduous African tropical rainforest: Implications for primate conservation. *Forest Ecology and Management*, *258*(5), 840–849. https://doi.org/10.1016/j.foreco.2009.03.019

MWE. (2017). The republic of Uganda Ministry of Water and Environment revised forest management plan for Mabira Central Forest Reserves (Mabira, Nandagi, Namukupa, Namawanyi, Namananga & Kalagala falls Central Forest Reserves).

Nabalegwa, M. K., & Tenywa, M. M. (2023). Land Use Cover Types and Forest Management Options for Carbon in Mabira Central Forest Reserve. Springer. https://link.springer.com/10.1007/978-3-030-45106-6_145

Nalwanga, D., & Kasozi, G. N. (2023). Access to provisioning services by local communities from Mpanga CFRin central Uganda. Frontiers. https://www.frontiersin.org/articles/10.3389/ffgc.2023.1021664

National Forestry Authority. (2020). A review of collaborative forest management in Uganda. https://www.nfa.go.ug/images/A_REVIEW_OF_COLLABORATIVE_FOREST_MANAGEMENT_IN_UGANDA.pdf

Njana, M. A., Mbilinyi, B., & Eliakimu, Z. (2021). The role of forests in the mitigation of global climate change: Emprical evidence from Tanzania. *Environmental Challenges*, *4*, 100170. https://doi.org/10.1016/j.envc.2021.100170

Nkamleu, G. B., et al. (2018). "Impacts of community forest management on tree density and biomass in the humid tropics." Agroforestry Systems, 92(5), 1551-1566.

Noulèkoun, F., Mensah, S., Kim, H., Jo, H., Gouwakinnou, G. N., Houéhanou, T. D., Mensah, M., Naab, J., Son, Y., & Khamzina, A. (2023). Tree size diversity is the major driver of aboveground carbon storage in dryland agroforestry parklands. *Scientific Reports*, *13*(1). https://doi.org/10.1038/s41598-023-49119-9

Nunes, Meireles, Gomes, P., & Ribeiro, A. (2020). Forest Contribution to Climate Change Mitigation: Management Oriented to Carbon Capture and Storage. *Climate*, *8*(2), 21. https://doi.org/10.3390/cli8020021

Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (1996). Niche construction. *The American Naturalist*, *147*(4), 641-648

Poudyal, B. H., Maraseni, T., & Cockfield, G. (2019). Impacts of forest management on tree species richness and composition: Assessment of forest management regimes in Tarai landscape Nepal. *Applied Geography*, *111*, 102078. https://doi.org/10.1016/j.apgeog.2019.102078

Ramos, Y. A., Aguiar, B. A. C., Silva, M. V. C., Matos, R. E. S., Coelho, M. C. B., & Giongo, M. (2019). STRUCTURE AND FLORISTIC COMPOSITION IN A DENSE OMBROPHILOUS FOREST AREA UNDER FOREST MANAGEMENT. *FLORESTA*, *49*(4), 793. https://doi.org/10.5380/rf.v49i4.59264

Rico, G. W., et al. (2020). "Community-led forest management and its role in maintaining carbon stocks: Insights from Brazil." Journal of Cleaner Production, 251, 119742.

Romero, F. M. B., Jacovine, L. A. G., Ribeiro, S. C., Ferreira Neto, J. A., Ferrante, L., da Rocha, S. J. S. S., Torres, C. M. M. E., de Morais Junior, V. T. M., Gaspar, R. de O., Velasquez, S.

I. S., Vidal, E., Staudhammer, C. L., & Fearnside, P. M. (2020). Stocks of Carbon in Logs and Timber Products from Forest Management in the Southwestern Amazon. *Forests*, *11*(10), 1113. https://doi.org/10.3390/f11101113

Salmi, A., Quarshie, A., Scott-Kennel, J., & Kähkönen, A.-K. (2023). Biodiversity management: A supply chain practice view. *Journal of Purchasing and Supply Management*, 100865–100865. https://doi.org/10.1016/j.pursup.2023.100865

Sassen, M., & Sheil, D. (2013). Human impacts on forest structure and species richness on the edges of a protected mountain forest in Uganda. *Forest Ecology and Management*, *307*, 206–218. https://doi.org/10.1016/j.foreco.2013.07.010

Schaedel, M. S., Larson, A. J., Affleck, D. L. R., Belote, R. T., Goodburn, J. M., & Page-Dumroese, D. S. (2017). Early forest thinning changes aboveground carbon distribution among pools, but not total amount. *Forest Ecology and Management*, *389*, 187–198. https://doi.org/10.1016/j.foreco.2016.12.018

Schmitt, C. B., et al. (2018). "Carbon storage in collaborative managed forests: Insights from Southeast Asia." Global Change Biology, 24(4), 1324-1334.

Shono, K., Cadaweng, E. A., & Durst, P. B. (2007). Application of Assisted Natural Regeneration to Restore Degraded Tropical Forestlands. *Restoration Ecology*, *15*(4), 620–626. https://doi.org/10.1111/j.1526-100x.2007.00274.x

Silva Pedro, M., Rammer, W., & Seidl, R. (2014). Tree species diversity mitigates disturbance impacts on the forest carbon cycle. *Oecologia*, *177*(3), 619–630. https://doi.org/10.1007/s00442-014-3150-0

Solomon, N., Pabi, O., Annang, T., Asante, I. K., & Birhane, E. (2018). The effects of land cover change on carbon stock dynamics in a dry Afromontane Forest in northern Ethiopia. *Carbon Balance and Management*, *13*(1). https://doi.org/10.1186/s13021-018-0103-7

Thammanu, S., Han, H., Marod, D., Srichaichana, J., & Chung, J. (2021). Above-ground carbon stock and REDD+ opportunities of community-managed forests in northern Thailand. *PLOS ONE*, *16*(8), e0256005. https://doi.org/10.1371/journal.pone.0256005

Thammanu, S., Marod, D., Han, H., Bhusal, N., Asanok, L., Ketdee, P., Gaewsingha, N., Lee, S., & Chung, J. (2020). The influence of environmental factors on species composition and

distribution in a community forest in Northern Thailand. *Journal of Forestry Research*, *32*(2), 649–662. https://doi.org/10.1007/s11676-020-01239-y

Turyahabwe, N., Godfrey, J., Tweheyo, M., & Balaba, S. (2012). Collaborative Forest Management in Uganda: Benefits, Implementation Challenges and Future Directions. *InTech EBooks*. https://doi.org/10.5772/28906

Waring, B., Neumann, M., Prentice, I. C., Adams, M., Smith, P., & Siegert, M. (2020). Forests and Decarbonization – Roles of Natural and Planted Forests. *Frontiers in Forests and Global Change*, *3*(1). https://doi.org/10.3389/ffgc.2020.00058

Wood, A., Tolera, M., Snell, M., O'Hara, P., & Hailu, A. (2019). Community forest management (CFM) in south-west Ethiopia: Maintaining forests, biodiversity and carbon stocks to support wild coffee conservation. *Global Environmental Change*, *59*, 101980. https://doi.org/10.1016/j.gloenvcha.2019.101980