NATIONAL SECURITY

A Journal of the National Defence University-Kenya

Volume: 3
Issue: 2

Research Article Open Acces

Beyond Carbon Sequestration: Evaluating Participatory Forest Management Practices towards Climate Change Mitigation-A Case of Karura Forest Ecosystem, Nairobi City County, Kenya

John Kipkemoi Rono,[1]* Cliff Obwogi, and Gladys Chepkirui Rotich

[1] jrono4268@gmail.com
* Corresponding author

Abstract

Climate change mitigation strategies have long focused on the idea of carbon sequestration and did not consider the opportunities of a greater range of forest management. The article analysed how Participatory Forest Management (PFM) could be used to address climate change and to ensure sustainable forest management in the Karura Forest in Kenya. It explored how PFM can be used to facilitate the carbon sequestration process, improve biodiversity, livelihoods and empower communities. The study employed a mixed-methods design, incorporating surveys conducted among community forest association members, key informants, focus group discussions (FGDs) and an analysis of changes in forest cover. The sample size (n = 209) employed by the study matched that of the Conservationists in the Friends of Karura Community Forest Association (FKCFA), Resident Association Community Leaders and Government Ministries, Departments and Agencies. PFM has been attributed to the increase in carbon captured in forests. The forests also play a significant role in mitigating the effects of climate change, which is one of the most pressing issues in the world, as they absorb greenhouse gases. The Karura Forest Ecosystem is situated near Nairobi County in Kenya and it is threatened by the unsustainable use of resources and the pressure of population growth. PFM, which entails the participation of local communities in forest management, has been a solution to consider. PFM has vast potential and its potential in enhancing the capability of Karura Forest to address climate change issues is being considered. The paper discusses the effects of PFM on climate change mitigation programs, drawing on theoretical factors from the Common-Pool-Resource theory and environmental governance principles. The findings demonstrate that PFM has a positive impact on various fronts, including forest restoration, enhanced carbon capture, effective forest management, local empowerment and stewardship and biodiversity protection. Results show that PFM in Karura Forest has increased carbon stocks, restored biodiversity and enabled local communities by utilising sustainable resources and generating income. The paper emphasises that PFM is an all-inclusive approach that extends beyond carbon sequestration to support the goals of sustainable development.

Received: 25 May 2025
Revised: 20 August 2025
Accepted: 19 October 2025
Published: 15 December 2025

Citation: Rono, K. J., & Obwogi, C., & Rotich, C. G., (2025). Beyond Carbon Sequestration: Evaluating Participatory Forest Management Practices towards Climate Change Mitigation: A Case of Karura Forest Ecosystem, Nairobi City County, Kenya. *National Security: A Journal of National Defence University-Kenya*, *3*(2), 98–111.

DOI:

https://doi.org/10.64403/cmkz7865

Keywords: *climate change mitigation and effects, participatory forest management*

Introduction

Forests are important in mitigating climate change in enabling the absorption of carbon dioxide into the atmosphere through sequestration. This is made possible by the biomass and soils of the forest, thereby reducing the impact of global climate change. The concept of carbon sequestration can be explained as the forest ecosystem's capacity to absorb and store carbon, which is one of the most significant indicators of the forest's impact on the climate. Despite the prevalence of carbon sequestration in forest management mechanisms that can be used to mitigate climate change, the process has a limited scope because it does not fully reflect the ecological and social dimensions of sustainable forest management.

Participatory Forest Management (PFM) is the management of forests by the Kenya Forest Service and local communities, which implies shared decision-making, mutual benefit and the sharing of conservation efforts. It not only enhances the possibility of carbon sequestration but also integrates local governments, community livelihoods and ecological management. However, under it, climate change mitigation is operationalised as a decrease in the concentration of greenhouse gases and an increase in forest carbon sinks through PFM-based interventions, including reforestation, forest cover conservation and sustainable resource use. PFM can enable more holistic and sustainable results through involving local communities in the decision-making process and providing them with a sense of ownership of forests.

The forest ecosystem in this context is Karura Forest. Its vegetation, soils, water systems, and biodiversity are interacting to maintain ecological balance, regulate the local climate, and support community livelihoods. As a result of the implementation of Participatory Forest Management (PFM), social cohesion and local economic development have been strengthened greatly through involving the communities in the decision-making processes related to the forest. The involvement of the communities, in turn, has increased the resilience of the forest ecosystem. Thus, PFM is acting as a mediator, allowing for a reconciliation between environmental conservation and socioeconomic development, as well as aligning the interests of diverse stakeholders for mutual benefit.

The objective of this paper is to analyse the activities of PFM as associated with carbon sequestration and climate change reduction in the Karura Forest ecosystem. Specifically, it also examines how community engagement, intervention strategies for sustainable forest management and joint governance mechanisms can enhance the forest's capacity to store carbon, improve ecological resilience and contribute to broader climate mitigation goals. The study also focuses on the interplay between forest conservation and livelihoods, as well as the ecosystem performance of the people, highlighting the importance of participatory approaches in developing sustainable forest management in urban settings.

Despite being situated near the central business district of Nairobi, the Karura Forest ecosystem is a significant carbon sink, biodiversity hotspot and recreational landscape that helps to enhance the urban environment. However, population growth, land use and other competing socioeconomic factors have placed a heavy burden on the ecological well-being of the forest. PFM has been adopted through the Kenya Forest Service and the Friends of Karura Community Forest Association (FKCFA). This approach has led to a participatory style of protecting and exploiting this resource sustainably. Karura Forest is therefore significant in the study of how PFM can enhance the success of carbon sequestration so that the outcomes of mitigation of climate change are maximised and conservation and community benefits are maximised in an urban setting. The case evidence can prove significant in duplicating such participatory conservation models in other urban forests of Kenya and other nations.

Theoretical Framework

This paper employs two theoretical complements, namely Common Pool Resource (CPR) Theory by Elinor Ostrom (2008) and Environmental Governance Theory (EGT) by Arts and Tatenhove (2004). These theories were what gave the analytical foundation for the role of Participatory Forest Management (PFM) in carbon sequestration and reduction of climate change in the Karura Forest ecosystem, the Nairobi County. The CPR theory assumes that through collective action, rule-making and self-governance, communities can effectively manage shared natural resources (such as forests, fisheries and water systems) instead of using centralised or privatised systems of administration. Theoretical framework of CPR is used in this research to analyze the relationship between the PFM and forests' sustainable use and carbon storage. More precisely, it studies the community participation brought by PFM, the local rules formation, and the sharing of the benefits as factors affecting the mentioned eco-benefits.

Within the setting of Karura Forest, the CPR theory can be applied to analyse the cooperative management of forest resources by local communities in collaboration with the Kenya Forest Service (KFS) through the Friends of Karura Community Forest Association (CFA). This theory was helpful in the study because it enabled the study to comprehend the establishment, implementation and adherence to local forest use rules by communities, as well as how collective forms of governance strengthen the sustainable use of resources. The study was able to measure community involvement in establishing access and harvesting forest products regulations, as well as the benefits derived by the forest-adjacent community (e.g., ecotourism revenue, beekeeping income, forest work contracts) and how these are fairly distributed among stakeholders through the CPR theory.

The practical value of the theory to the current study lies in its ability to explain the association between collective management and quantifiable conservation responses, such as the retention of forest cover and the accumulation of biomass. CPR theory is thus incorporated in the analysis of the variables of community governance, especially in determining the role played by participatory decision-making towards better performance of forest health and climate mitigation. Nevertheless, the CPR theory has some weaknesses, such as its homogeneity assumption with reference to the user groups, which in a socially diverse and urbanized environment like Karura might not be applicable. This has been recognized in the study as the research investigates the effect of differences in the interests of various communities, power relations and the degree of dependency on participation and compliance in the PFM model.

EGT focuses on the contribution of institutions, stakeholders and policy processes in the development of environmental management outcomes. It confirms that sustainable resource management requires multi-stakeholder partnerships, transparency in decision-making and coherence in the policy-making levels that are governed. This paper uses the theory to discuss how institutional coordination between KFS, Friends of Karura CFA, Government agencies, NGOs and the contribution of the private sector in mitigating climate change by managing forests better. The framework assists in the assessment of Stakeholder participation and empowerment in decision making, Institutional arrangements that lead to roles, rights and responsibilities and Policy linkages between local PFM practices and the national climate change strategies. The application of EGT in this study is beneficial in providing the macro-level of the study to supplement the micro-level of the community that is applied by CPR. It informs the discussion on the ways policies and institutional alliances operationalize PFM and the role of these governance practices in increasing or limiting the carbon sequestration capacity of Karura.

Incorporating this theory in the body of the work enlightened the analysis of how KFS-CFA collaboration conforms to the principles of environmental governance in transparency and inclusiveness. Whether the participatory structures indeed empower local people or strengthen the hierarchies by negotiating forest access rights and benefit sharing between various actors and investigating whether the participatory structure can lead to decentralization or merely strengthen the existing hierarchical structure.

The theory's application is well-seen in the results section, where the paper measures the effect of governance quality on forest restoration success and also examines if the institutional synergy is supporting long-term

carbon management in Karura Forest. Nonetheless, the Environmental Governance theory has its opposition. It is pointed out by the academics that it generally underestimates the power imbalances which are built into the participatory frameworks. In the case of Karura, this could be the case whereby the voices of the local communities have a lesser influence compared to that of the more powerful actors, such as the government or private investors. The limitations acknowledged by the authors have a direct effect on the research as they give it a viewpoint to judge and promote more just and inclusive governance processes.

Methodology

The study used a mixed-method design to measure the effect in order to find out the effect of PFM initiatives on the Karura Forest Ecosystem. It was planned to expand on the one interest in carbon sequestration and explore the wider gains of PFM practices to climate change mitigation, sustainable forest management and community development. The first one was a quantitative forest cover change analysis, during which forest cover change in the Karura Forest was analysed. This action has been carried out through remote sensing. Landsat satellite data from various times were adopted (Rahman et al., 2022). The data on the variations in the forest cover were given with the assistance of the software that examines the shifts of the spectral properties of the land surface throughout the time span (KFS Report, 2023). This fact was a good base to be used in the investigation of the impacts of PFM practices on the health and regeneration of forests.

The community participation of the communities residing around the forest was to be used to capture the mechanisms of social and economic impacts of the PFM. This research used a household survey, as this is the right option according to Lassa et al. (2023) in the case of this study. A sample of one hundred and sixty-six members of the Community Forest Association (CFA), among other stakeholders, was sampled and a structured questionnaire was administered to record data about the perception of the role played by PFM in their livelihood, forest resources availability and income-generating opportunities. Besides that, the Focus Group Discussions (FGDs) were held with the community members and other stakeholders to hear their experiences and impressions of PFM in less stringent terms (Persha et al., 2021). This qualitative data was helpful in giving details on the social aspect of the implementation of PFM initiatives.

Semi-structured interviews were used to interrogate major informants so as to gain a more accurate understanding of the institutional form that is behind PFM in the Karura Forest Ecosystem, as opined by Arts and Tatenhove (2004). The population sample was selected among 413 informants that belonged to the government agency KFS, which was involved in the forest management, Non-Governmental Organisations (NGOs) that participated in the PFM activities and individuals who are leaders in communities and their role in governing forests cannot be ignored. Based on the formula of Krejcie and Morgan (1970), 209 respondents were sampled to be questioned. The interviews examined these stakeholders' perceptions about the achievements, obstacles and the general performance of PFM in meeting its objectives. The distribution of sample size is shown in Table 1.

Table 1
Sample Size Distribution

Category	Target Population	Sample Size
Friends of Karura CFA: Conservationists in Karura CFA, Resident Association, Community Opinion Leaders	400	196
FKFCFA Management: Government Ministries, Departments and Agencies, Partners	13	13
Total	413	209

Source: *Researcher, (2025)*

Findings

Participatory Forest Management Practices for Climate Change Mitigation and Sustainable Development

Critical carbon sinks like the Karura Forest Ecosystem facilitate in absorbing carbon dioxide in the atmosphere, which plays a significant role in climate change mitigation (Pandey & Shukla, 2015). Nevertheless, traditional methods of forest management in most cases have been focused on timber harvesting and short-term financial gains, which have led to deforestation, loss of habitat and a decrease in biodiversity, posing a threat to ecosystem stability and storage capacity in the long run. PFM has arisen in the context of the KFS as a rather radical approach to the matter of governance, which focuses on collaborative governance, community involvement and sustainable utilization of resources. PFM is applied in Karura Forest, where KFS and the Friends of Karura CFA share the co-management of the forest and where the local development requirements are in line with conservation requirements. PFM balances the protection of the environment and socioeconomic development because the communities are incorporated in the management of the forests, where they encourage sustainable livelihood and climate resilience (Agrawal, 2001).

Karura PFM methodology can assist in surmounting such issues as encroachment in the urban zone, illegal logging and deterioration of the ecosystems and promote social inclusion and economic empowerment. It gives the different groups: the youth, women and the marginalised city dwellers, the power of forest protection and the benefits that are shared by the inclusive involvement and decision-making process. The model enhances the ecological power and ability of Karura to capture carbon and share the benefits of conservation with the users equally.

Enhancement of Carbon Sequestration as a remedy to Climate Change

PFM is essential to climate action, particularly through enhancing carbon sequestration. PFM programs have promoted sustainable conservation regimes in Karura Forest, which has a high implication on the storage of carbon. According to Rahman et al. (2022), when the community is involved in safeguarding forests, the outcome of the process of forest sequestration improves directly. The Karura CFA, with KFS and stakeholders on conservation activities, is in the vanguard of planting trees, monitoring forests and recovering their degraded areas that enhance the role of the forest as a significant urban carbon sink. PFM employs forest management practices such as sustainable approaches like enrichment planting, assisted natural regeneration and selective harvesting that encourage further carbon storage. According to Sunderlin et al. (2014), these practices have no impact on the output and purity of forests. They protect the native tree species and reduce the degradation of the urban growth and resource consumption in Karura. The government agencies and partners in the marketing of such activities of the community contribute to the enhancement of resource mobilisation in the forest restoration and carbon sequestration, which contribute to the reduction of climate change.

The carbon storage of the biomass at Karura is beneficial in managing the climate through the decrease in CO2 concentration in the atmosphere. According to Griscom et al. (2017), this type of natural sink can be essential in the mitigation activities throughout the world. It is through photosynthesis that trees, roots, stems and soils absorb and store carbon and therefore, PFM under sustainable management is highly significant. An illustration of how participatory forest governance within an urban environment can facilitate national climate action, improve air quality and offer recreational, aesthetic and educational opportunities to the urban population is demonstrated through Karura. Although this is happening, PFM is limited by a number of obstacles, including limited funding, lack of technical capacity, inconsistent policies and overlapping land-use interests (Rahman et al., 2022). Karura is a city that is under continuous pressure between conservation and urban development. To enhance the advantages of PFM in the management of climate, policymakers and stakeholders ought to enhance institutional frameworks, financing and community education. The improved collaboration will transform Karura into an example of community-based forest management that will improve the global climate mitigation agenda and sustainable development agenda in Kenya.

Environmental Protection and Biodiversity

PFM also plays a role in biodiversity conservation, other than carbon sequestration (Agrawal, 2001). Co-management at Karura Forest has amplified the advantages of the local co-management and reduced the loss of forests and fragments of the habitat (Persha et al., 2021). PFM also maintains the integrity of the diversity of the species by deterring the unpleasant acts of illegal logging, encroachment and poaching by the communities through the management, surveillance and enforcement of the practices. This participatory approach builds a feeling of ownership and responsibility, which increases the sustainable relationships of human nature. According to Persha et al. (2020), community engagement not only protects biodiversity but also helps in sustaining vital ecosystem processes, such as air purification, groundwater renewal, carbon storage and cultural and recreational facilities, which can be used to improve urban resilience. Healthy and diverse forests also ensure soil stability, water quality and pollination functions that play a critical role in ensuring ecological balance and adaptability to climatic conditions (Egoh et al., 2021). It is also in accordance with the Kunming-Montreal Global Biodiversity Framework (KMGBF), which sees the world living in harmony with nature by 2050 and aims to prevent the extinction of biodiversity by 2030. This vision is mirrored in the PFM practices in Karura because they incorporate the conservation objectives with open governance, which will not only encourage the restoration of the national forests but also the global biodiversity objectives.

The holistic approach of PFM involves the ecological, social and economic aspects to ensure that there is a balance between human needs and the environment. According to Egoh et al. (2021), sustainable management improves biodiversity and assists people residing near forests to sustain their livelihood. The PFM model developed by Karura, therefore, makes the restoration of forests in Kenya operationalized in the context of the KMGBF to enhance conservation, social equity and sustainable resource use.

Sustainable Livelihoods

PFM initiatives can play a critical role in the accomplishment of Sustainable Development Goals (SDGs) by enabling communities and diversifying the source of income (Lassa et al., 2023). PFM has created sustainable enterprises and conservation-linked livelihoods in Karura Forest. Other activities like harvesting of Non-Timber Forest Products (NTFPs), honey, mushrooms, medicinal plants and ecotourism activities earn people money and do not harm forests (Persha et al., 2020). These projects support local economies and ecological and socioeconomic goals are interpreted as a co-management of the environment and these concepts demonstrate the possibility of participatory governance combining ecological and socioeconomic goals.

No longer as extensive reliance on illegal logging and charcoal burning, as the organized harvesting of NTFPs and the growth of ecotourism have decreased it. According to the principles of PFM, local organizations are occupied with beekeeping, guided tours and cultural exhibits that provide jobs and boost the economy. The

activities contribute to the stewardship and strengthen the local ownership of forest resources (Persha et al., 2020). The ecotourism infrastructures provided by Karura, nature trails, cycling paths, picnic sites and birdwatching areas, are a source of consistent income that is used to maintain the forest, to give the youth a job and for eco-education. This will decrease reliance on extractivist activities and increase urban ecological health.

The initiative supports SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 13 (Climate Action) and SDG 15 (Life on Land) by incorporating PFM in the sustainable development agenda of Kenya. The inclusive governance approach has brought communities, government and conservation partners to work together in a way that has produced some practical results for human well-being and environmental stability (Lassa et al., 2023). The revenues of PFM-backed enterprises are commonly reinvested in education, health and project work in the community, building social resilience. According to Agrawal, economic empowerment creates ownership and stewardship, thus encouraging sustainable forest management (Agrawal, 2001). PFM in Karura empowers women and youth in the gender equity and social inclusion aspect, which are the primary ideals of sustainable development.

PFM enhances the biodiversity, refreshes habitats and unites the community, in addition to economic benefits. It conserves the ecosystem services such as the storage of carbon, the regulation of microclimate and the maintenance of a watershed using a good managerial approach of the resource, supervision and conservation education. As evidenced by the Karura experience, the PFM triggers, which are designed to create sustained prosperity in the economy, social equity and environmental purity, are self-sustaining.

Community Participation and Collective Action

Active involvement of the local communities in the management of the forests is one of the pillars of the Participatory Forest Management (PFM) (Agrawal, 2020). An example of inclusive participation in Karura Forest, Kenya, which can be found in KFS and FKCFA, shows how inclusive participation can be turned into tangible environmental and social benefits. Such a kind of co-creation promotes local ownership and accountability and drives the work towards protection, restoration and sustainable utilisation of resources (Persha et al., 2021). The PFM of Karura will facilitate the communities to develop and enforce the rules that regulate the use of forests with the stakeholders in the planning, monitoring and enforcement of the rules to bring out transparency and adherence. It is a governance model that is founded on the Common-Pool Resource theory by Ostrom (1990) and provides the local knowledge, cultural values and social capital to make collective responsibility in ensuring the ecosystem is preserved. The constant meetings, joint patrolling and ordinary management contracts have not only improved ecological performance but also unity in the community.

Community participation has enhanced social resiliency and identity. The communities also offer equality in sharing the benefits and sustainable use of forests by the creation of co-created rules (Persha et al., 2020). With the joint effort, Karura has become a viable and secure city green space that facilitates recreation, education and biodiversity by turning it into a forest that was formerly degraded and insecure. The PFM framework of Karura also makes adaptive management possible. According to the theory of Ostrom (1990), community-based initiatives such as habitat restoration, fire management and ecological monitoring are meant to balance the local livelihoods with the conservation agenda. The integration of the traditional ecological knowledge and scientific processes makes the management more accommodating and malleable.

Besides this, PFM has become an environmental education and civic engagement venue. The guided walks, awareness campaigns, restoration and upbringing of intergenerational co-management involve the youth and women groups. This marginal involvement gives strength to the governance and also the feeling of closeness to nature contributed by people. Lastly, Karura explains how, through participatory governance, forest management can be transformed into a social enterprise that is founded on shared trust and accountability. PFM in Karura has found out that community-based conservation enhances ecological resilience, equity and

is a direct cause of sustainable development by promoting transparency, inclusiveness and dialogue. The model offers significant information on the city management of forests in Kenya.

Collaboration and Stakeholder Engagement

The success of a good PFM is premised on the effective collaboration of different stakeholders. The Karura Forest conservation outcomes could be successful, depending upon the partnership of forces of KFS, FK-CFA, the county government, NGOs and private sector players. The multi-stakeholder model also ensures that management decisions are taken through various expertise, perspectives and resources in a bid to encourage legitimacy and accountability (Arts & Tatenhove, 2004). Karura portrays that the management of urban forests needs integrative and sustained efforts that are inclusive. The joint management agreements will enable KFS and FK-CFA to share the tasks of protection, resource allocation and community involvement. The NGOs, such as Friends of Karura Trust, coupled with international partners, support the capacity building, biodiversity monitoring and environmental education. Concurrently, the participation of the players in the privatised sector is in corporate social responsibility (CSR) programs for reforestation, waste disposal and recreation infrastructure development.

The mobilisation of resources and knowledge sharing comes as a result of teamwork (Larson et al., 2021). Karura has cross-sector partnerships, which have brought together financial, technical and human resources to assist in conservation and livelihoods. Government agencies provide policy and technical advice; the NGOs need technical advocacy and training at the community level; the local groups provide traditional knowledge and practical experience in the utilisation of forests. This synergy improves forest management, helps ecological restoration and livelihoods by the use of sustainable activities such as beekeeping and guided ecotourism.

The social legitimacy of the forest is also enhanced with the collaboration of the stakeholders. The trust and reduced disagreement in relation to access to resources have been developed through open planning, participation in decision-making and joint patrols. Such collaboration will transform the state-managed role of forest regulation to a social role. In simple terms, the experience of Karura emphasises the concept that effective PFM is grounded on partnerships that unify the collective strengths to common interests of flexibility and community advantage. In line with Arts and Tatenhove (2004) and Larson et al. (2021), participatory environmental management can not only result in ideal conservation but also in reinforcing social fabric and economic inclusion, which is the transformative force of participatory environmental management.

Challenges and Considerations

Despite being relatively successful, Karura Forest PFM implementation is a challenge which is conditioned by socio-political and ecological complexities. The most notable ones are land and tenure of resources. Tennessee's rights should be obtained through effective participation and ownership (Larson et al., 2022). Although a co-management system between KFS and FK-CFA ensures that the roles are properly outlined, the systems of community control and benefit sharing are not specified. Conflicting land claims and pressure of urban expansion are also present and make access and control more difficult. These concerns offer a case in support of the policy development to ensure that the involvement is inclusive, fair and legally safe.

Reasonable distribution of benefits also plays a crucial role in ensuring participation. The fair distribution of financial and non-financial gains supports the integration of the community and the long-term involvement (Schanz et al., 2021). Even though PFM activities exist in Karura, such as ecotourism, beekeeping and restoration, there is occasionally an imbalance in distribution. Transparent systems of governance, accountability as decision-making structures should be encouraged to enhance fairness, especially to women, youth and marginalised groups of people. Asymmetry of power is also experienced by the stakeholders, making it harder to work together. The differences in institutional capacity, access to resources and leverage can be the obstacles to effective coordination between KFS and FK-CFA, NGOs and the partners. Capacity

building, equal representation and continuing dialogue are some of the inequalities that can be addressed in order to make the voices of the less dominant heard in the governance systems.

Other types of stress that exist in the urban environment of Karura include encroachment, pollution and competing land use. A controversy is going on between conservation and recreational and infrastructural needs. Urban planning is therefore important to be incorporated with the forest policy and community participation to make sure that ecological integrity is not compromised in the process of achieving urban sustainability. Despite the notability of these issues, they also provide institutional learning and innovation. According to Larson et al. (2022) and Schanz et al. (2021), policy remedies, namely legal reform, social dialogue and institutional strengthening, should be applied to address tenure insecurity, inequity and governance gaps. The concept of enhancing the presence of the community, aligning with institutionalisation of benefit-sharing models, is significant in Karura so that PFM is progressive with respect to conservation and fair development.

Lastly, the Karura experience establishes that the success of PFM cannot be achieved without the participation of the community and partnership, but also open and transparent governance, which can be altered to accommodate evolving challenges. On a proactive level related to these constraints, Karura can continue to be an example of participatory urban forest management in Kenya and other African nations.

The Future of Participatory Forest Management

The future of PFM is bright, as the tool has been evolving according to environmental and socioeconomic issues as a comprehensive answer. PFM is a feasible approach to the constantly expanding climate change, which can be used to mitigate the impact and attain sustainable development. It can increase the resilience of the ecosystems, capture carbon and enhance livelihoods in the localities, as noted by Schanz et al. (2023). To achieve such a potential, it must be innovative and make shifts at all times. PFM must evolve to become a must-have as the ecological and social environments will evolve in order to become efficient. Based on the article by Schanz et al. (2023), it is advisable to approach the management perspective as adaptive, meaning to integrate the information, technology and feedback by stakeholders as an ongoing decision-making cycle. This approach will enable PFM to accommodate complex realities and the uncertainty of the future.

We can use the growth of efficient models in Kenya, like the Karura, to offer avenues to empower the national forest management, climate change and urban sustainability. Continuous research, policy advocacy and empowering the people will be significant in improving its impacts. PFM may continue to bridge the conservation and development divide by making sure that the local practice is integrated with bigger points, such as the Sustainable Development Goals and Forest and Climate Change Strategies employed in Kenya. Last but not least, a long-term commitment, innovation and inclusion can promise the future of PFM. PFM, which is premised on shared governance, scientific knowledge and evolutionary learning, will remain one of the keys to developing resilient communities and ecosystems in Kenya and the rest of the world.

Findings

The assessment of the PFM model in Karura Forest Ecosystem shows that there is a high number of ecological, social and governance outcomes that coincide with the management of forests sustainably. Within the past decade, Karura has been transformed into a prototype of a community-based restoration, a neglected and overrun urban forest (Friends of Karura, 2018). This situation is an indication of the success of the inclusion governance structures that have empowered the local communities through offering them co-management contracts with KFS. There is empirical evidence that PFM has led to the enhancement of forest cover and ecosystem well-being. Between 2010 and 2018, 190 hectares of degraded land were reforested with

participatory reforestation, enrichment planting and removal of invasive species, reestablishing native tree cover reduced to roughly 25 per cent over 40 per cent (Friends of Karura, 2018). These results correspond to the findings of the National Forest Programme in Kenya (MENR, 2020), which explains the forest recovery in urban areas with the help of the participatory conservation models. The Karura case is an example of how community involvement, which is supported through the institutions, turns the tide of urban deforestation and increases resilience in the forests. Practically, restoration is most likely to succeed when conservation is socially held instead of being foisted on the populace.

PFM has also made possible the introduction of Sustainable Forest Management (SFM), which has reduced deforestation and degradation. Community patrols, controlled harvesting and controlled grazing are some of the efforts of the Friends of Karura CFA that have cut illegal logging and encroachment (Abuto, 2014). The studies by Keige (2019) and Matiku (2017) support the idea that community-based surveillance and ecotourism opportunities help to increase adherence to forest laws and offer alternative ways of making a living. Karura, therefore, shows how decentralized forest control enhances environmental management by making the local interests consistent with the long-term conservation benefits.

Among the most significant ecological results, one can distinguish the recovery of biodiversity. The rehabilitation of native plants and wetland habitats has led to the reintroduction of native wildlife, such as bird and butterfly species that had been forced out due to habitat loss (Friends of Karura, 2018). PFM is associated with increased species richness and stability in the ecological context of comparative studies in Arabuko-Sokoke and Eburu forests (Matiku, 2017; Gachanja et al., 2019). Enhanced biodiversity has enhanced the benefits provided by the ecosystems such as pollination, cycling of nutrients and soil stabilisation. These findings reinforce the fact that the recovery of biodiversity in the environment of PFM is both ecological and social. It enhances environmental morality, social cohesiveness and shared conservation accountability.

Karura has also been able to reforest, contributing to its ability to act as a carbon sink in the green infrastructure in Nairobi. The carbon stock and remote sensing show that the carbon concentration of the biomass in the restored land is high and it is adjusted to the carbon estimates regarding the national forests (Rodriguez-Veiga et al., 2020; Osewe, 2025). Sequestration of the atmospheric carbon by Karura aids Kenya in fulfilling its commitments in the Paris Agreement and the national climate plans. However, continuous measurement, reporting and verification (MRV) systems are also essential in order to measure their contribution. Karura is an excellent example of how, when urban forests are managed in a participative way, they can provide benefits to the global climate as well as to the local ecosystem, like cleaning the air and controlling temperatures.

PFM has also played a significant role in preventing unlawful activities in the forest through community guarding and joint enforcement. Education and sensitisation of the environment, as well as collaborations with the CFA and the KFS, have significantly minimized the activities of illegal logging and encroachment (Keige, 2019). The 2015-2020 data on enforcement indicate a steady fall in the reported crime, in line with the increased community patrols and better reporting systems. Such governance advantages justify the arguments of CPR and Environmental Governance models, in which the sharing of power and responsibility reduces opportunistic actions and enhances compliance (Ostrom, 1990; Arts & Tatenhove, 2004). Nevertheless, fair distribution of benefits and long-term investments is essential in ensuring motivation and perpetual confidence among community members.

Although these have been achieved, there are a number of challenges. PFM benefits are not fully achieved because of limited funding of community operations, ambiguity in benefits-sharing plans and the conflict between conservation and city development priorities (Keige, 2019; Larson et al., 2022). It is necessary to strengthen the legal status of CFAs, facilitate financial transparency and gender and youth inclusion in the governance outfits. The experience of Karura, therefore, points to the fact that ecological restoration is not enough; social justice, policy coherence and mechanisms of adaptive governance responsive to the developing urban pressures are requirements of sustainable forest management.

Conclusion

This paper used both qualitative and quantitative research designs, where satellite images were used to analyse the area, community surveys and community interviews were conducted to investigate the role of Participatory Forest Management (PFM) in climate change mitigation and sustainable development in Karura Forest. Results indicate that PFM enhances community ownership, accountability and ecological stewardship, which results in restoring forests, increasing their cover and increasing their carbon sequestration. The active participation of the locals in reforestation and sustainable development of the resources has rejuvenated the lost areas, curbed deforestation and revitalised the biodiversity through improvement of monitoring and enforcement. Aboriginal knowledge, coupled with modern conservation science, has led to the development of a broad range of habitats, an increase in the stability of the ecosystem and the conservation of species.

Besides the ecological gains, PFM has also boosted social and governance as well as environmental consciousness. Community-based patrols with the assistance of the Kenya Forest Service (KFS) have reduced forest fires and unlawful activities and this is how community empowerment using institutions can be effective. Typically, a good example of an effective model of participatory governance that connects biodiversity conservation with civic responsibility, national forest restoration objectives and the Kenya national climate change pledge is the Karura. The continued existence of these is not possible without the institutional support, community capacity building and the socioeconomic incentives in the forest governance structures.

Recommendations

The deployment of PFM that has been used by Karura should be employed to guide the deployment in other forests within Kenya, but local socioeconomic, cultural and ecological factors should be modified. The approaches to traditional land use systems and livelihood patterns can be customised to prevent irrelevance and lack of sustainability.

Developing capacity at the community level, through perpetuation of training, discussion areas and involvement in decision making, will be useful in enhancing ownership and inclusion, particularly among the women and youth. Introduction of effective monitoring and evaluation mechanisms to monitor forest cover, biodiversity and social benefits.

Conservation and poverty reduction should be combined through incorporating PFM with sustainable livelihood projects, including ecotourism, non-timber forest products and climate-smart livelihood initiatives. This incorporation facilitates sustainable environmental management and ensures that the conservation of forests upholds both community welfare and ecological integrity.

References

Agarwal, B. (2001). Participatory Exclusions, Community Forestry and Gender: An Analysis for South Asia and a Conceptual Framework. *World Development*, *29*(10), 1623-1648.https://doi.org/10.1016/S0305-750X(01)00066-3

Abuto, J. O. (2014). *Community Empowerment and Its Influence on Participatory Forest Management in Karura Forest, Kenya*. University of Nairobi. https://erepository.uonbi.ac.ke/bitstream/handle/11295/76054/Abuto%20Catherine%20A_Determinants%20of%20participatory%20Forest%20Management%20on%20Conservation%20of%20karura%20forest,%20in%20Nairobi%20County,%20Kenya.pdf?sequence=3

Agrawal, A. (2020). Common property, institutional change and sustainability. *World Development*, 136, 105080.https://doi.org/10.1016/s0305-750x(01)00063-8

Agrawal, A. (2021). Studying the commons: A field misplaced and methods mistaken? *World Development*, 140, 105322. https://www.sciencedirect.com/journal/world-development/vol/140/suppl/C

Agrawal, A., Chhatre, A., & Hardin, R. (2020). Changing landscapes: Shifting governance of forest commons in the global South. *Academic Press*. https://doi.org/10.1126/science.1155369

Arts, B., & Tatenhove, J. (2004). Political ecology and environmental governance. *Environmental Science & Policy*, 7(5), 347-357. https://doi.org/10.1007/978-94-015-9524-7_10

Arts, B., & Tatenhove, J. V. (2004). Policy and power: A conceptual framework between the "old" and "new" policy idioms. *Policy Sciences*, 37(3–4), 339–356. https://link.springer.com/article/10.1007/s11077-005-0156-9

Bohnet, I., Cox, C., Fehr, E., & Gächter, J. (2021). The psychology of cooperation: Selective incentives and social cohesion. *Annual Review of Economics*, 13(1), 607-634.https://ideas.repec.org/f/c/pbo282.html

Egoh, B. N., Fonseca, M. B., Naeem, S., Phillis, A., Sanchirico, M., Tallis, H., & Yang, H. (2021). Integrating ecosystem services into conservation decision-making: A conceptual framework. *Ecological Economics*, 186, 107090. https://doi.org/10.1016/j.ecolecon.2007.04.007

Friends of Karura. (2018). *Karura Forest Restoration and Conservation Report 2010–2018.* Nairobi: KFS. https://www.friendsofkarura.org/wp-content/uploads/2018/12/KaruraForestBiodiversity_A0_181112_opt.pdf

Gachanja, M., Matiku, P., & Mwangi, J. (2019). *Participatory Forest Management and Biodiversity Outcomes in Kenya.* Nature Kenya Technical Report. https://doi.org/10.21203/rs.3.rs-846149/v1

Griscom, B. W., Buschman, J., Neill, P., Fay, M., & Ashton, P. M. S. (2017). Wald redux: The role of natural climate solutions in the Paris Agreement and beyond. *Environmental Research Letters*, 12(4), 040406.https://cgspace.cgiar.org/items/542817c9-5fe1-47c9-8d99-36132d373d41

Keige, P. (2019). *Participatory Forest Management and Conservation Outcomes: A Case of Karura Forest, Kenya.* Kenyatta University. https://erepository.uonbi.ac.ke/bitstream/handle/11295/109410/Keige_Impact%20of%20Benefit%20Sharing%20Arrangements%20on%20Sustainable%20Management%20of%20Public%20Forests%20-%20%20a%20Case%20Study%20of%20Karura%20Forest%20in%20Kenya.pdf?sequence=1&isAllowed=y

Krejcie, R. V., & Morgan, D. W. (1970). *Determining Sample Size for Research Activities*. Educational and Psychological Measurement, 30(3), 607-610. https://doi.org/10.1177/001316447003000308

Langston, A., & Lund, J. (2021). The promise and pitfalls of participation: Rethinking environmental governance in a changing climate. *Environmental Policy and Governance*, 31(2), 147–162. https://doi.org/10.1002/eet.v31.1

Larson, A. M., Brockington, D., & Sunderlin, W. D. (2021). Local conservation efforts and institutional fit: A meta-analysis of community forest management in tropical forests. *Ecological Economics*, 189, 10713. https://doi.org/10.1016/j.ecolecon.2021.107105

Larson, A. M., Darauf, S. R., & Mwangi, E. (2022). Securing Tenure Rights for Effective Community-Based Forest Management in Kenya. *Land Use Policy*, 110, 105708.https://doi.org/10.1016/j.forpol.2022.102718

Larson, A. M., Solis, D., & Banjade, M. (2022). Tenure rights and forest governance in Africa: Challenges and opportunities. *Forest Policy and Economics*, 137, 102–113. https://www.cifor-icraf.org/publications/pdf_files/Books/BLarson1201.pdf

Lassa, J. V., Sunderlin, W. D., & Mwangi, E. (2023). The socioeconomic impacts of participatory forest management: A review of the empirical evidence. *Forest Policy and Economics*, 133, 102652. https://doi.org/10.1016/s1389-9341(21)00258-6

Matiku, P. (2017). Community Participation and Biodiversity Outcomes in Coastal Kenya's Forest Reserves. *Biodiversity and Conservation*, 26(4), 1123–1142. https://ir-library.ku.ac.ke/server/api/core/bitstreams/fc00e2e8-753f-4faf-8dfa-b2c63d73c9f4/content

MENR (Ministry of Environment and Natural Resources). (2020). *Kenya National Forest Programme 2016–2030.* Government of Kenya. https://faolex.fao.org/docs/pdf/ken190060.pdf

Mwangi, E., Weigelt, J., Muriuki, J., & Nolte, C. (2020). Participatory Forest Management and Sustainable Landscape Management: A Review of Interactions and Effects on Landscape Mosaic Change. *Land*, 9(12), 502. https://doi.org/10.3390/land13091439

Osewe, M. (2025). *National Assessment of Forest Carbon Stocks and Trends in Kenya.* Kenya Forest Service. https://www.kenyaforestservice.org/

Ostrom, E. (1990). *Governing the commons: The evolution of institutions of collective action*. Cambridge University Press. https://doi.org/10.1017/cbo9780511807763

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1848&context=nrj

Ostrom, E. (2008). The challenge of common-pool resources. *Environment: Science and Policy for Sustainable Development*, *50*(4), 8-21. https://doi.org/10.3200/envt.50.4.8-21

Pandey, S., & Shukla, N. (2015). *Carbon sequestration in forest ecosystems. Climate Change: Risks, Mitigation and Adaptation* (pp. 265–278). Springer, Cham. https://www.academia.edu/download/58440068/39._Dr_Sandeep_article_int_j_env_Egypt__Feb._2019.pdf

Persha, L., Agrawal, A., & Larson, A. (2020). Institutional friction and fire governance: Redistributing rights and responsibilities in a Tanzanian wildlife management area. World Development, 134, 104982. https://www.3ieimpact.org/sites/default/files/2019-01/ie34-tanzania-joint-forest_0.pdf

Persha, L., Agrawal, A., & Larson, A. (2021). Institutions and incentives for sustainable forest management: Evolving interactions between communities and the state. *Ecology and Society*, 26(1), 12. https://www.nature.com/articles/s41558-023-01863-6

Rahman, M. M., Paul, S. K., & Akhter, S. (2022). Participatory forest management (PFM) for climate change mitigation and adaptation: A review. *Journal of Forest and Livelihood*, 16(2), 229–242.

https://www.researchgate.net/publication/363065247_review_on_participatory_forest_management_and_climate_change_mitigation_and_adaptation_in_ethiopia

Rodríguez-Veiga, P., Wheeler, J., Louis, V., Tansey, K., & Balzter, H. (2020). Forest biomass carbon mapping in sub-Saharan Africa using ALOS PALSAR data. *Carbon Balance and Management*, 15(1), 1–13 https://doi.org/10.1007/s40725-017-0052-5

Schanz, H., Wertz-Kanounnikoff, S., Börner, J., & Wunder, S. (2021). Equity in benefit sharing from REDD+ and PFM: A comparative analysis of emerging trends. *World Development*, 147, 105585.

Schanz, H., Wunder, S., Börner, J., Gretzinger, T., & Treue, B. (2023). The future of participatory forest management (PFM): Facing new challenges. *Environmental Science & Policy*, 130, 218-226. https://figshare.mq.edu.au/ndownloader/files/38419742

Stephens, T. (2023). The Kunming–Montreal Global Biodiversity Framework. *International Legal Materials*, *62*(5), 868–887. https://doi.org/10.1017/ilm.2023.16

Stephens, T. (2023). The Kunming–Montreal Global Biodiversity Framework. *International Legal Materials*, *62*(5), 868–887. https://doi.org/10.1017/ilm.2023.16

Sunderlin, W. D., Angelsen, A., Belcher, B., Nasi, R., Santoso, L., & Wunder, S. (2014). Shared interests, conflicting claims and emerging institutions: Exploring governance synergies and trade-offs in REDD+. *World Development*, 55, 195-207. https://figshare.mq.edu.au/ndownloader/files/38419742

Sunderlin, W. D., Pratama, A. D., & Noordwijk, M. V. (2020). The Importance of Social Capital in Collaborative Forest Management in Indonesia. *Land Use Policy*, 99, 105087. https://iopscience.iop.org/article/10.1088/1755-1315/1266/1/012027/meta

Van Swaay, C. A. M., Van Strien, A. J., Termaat, T., Biesmeijer, J. C., & Van Dyck, H. (2019). Range contraction and extinction in the Dutch breeding bird community (1990–2015). https://link.springer.com/chapter/10.1007/978-3-030-59875-4_13