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Ecosystem services values for local people in participatory forestry context: The case of karura urban forest reserve

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ABSTRACT

While green urban infrastructure has been widely successful in the global North to ease the pressure from rapid urbanization, developing economies in the global South are also embracing sustainable urban planning by integrating forest management approaches that prioritize ecological benefits of urban forests. Karura Forest Reserve (KFR) in Kenya is an important urban forest ecosystem that provides multiple benefits to the residents of Nairobi city. Our research addresses a significant gap in the literature by exploring the benefits provided by KFR to the local community. The aim is to evaluate the ecosystem services provided by KFR to the local people, with the objectives (i) to estimate the direct and indirect benefits of employment for Friends of Karura Community Forest Association (FKF-CFA) members, (ii) to evaluate the effect of periodic deadwood removal by the Huruma community-based organizations (CBOs), and (iii) to provide a holistic economic perspective based on total revenue from entrance fees. We used survey methods to collect primary data by applying mixed format questionnaires to FKF-CFA and Huruma CBOs members. The secondary data on visitors' entry logs were sourced from the FKF-CFA clerk records. A descriptive statistical analysis was conducted in R-studio, and a Fisher's exact test to assess the association between perceived benefits of FKF-CFA staff to their livelihoods. The total economic value of benefits derived from KFR was estimated at US$ 526,027 per annum. Direct ES benefits to FKF-CFA members had an estimated annual value of US$ 91,656, monetary valuation of deadwood collection was estimated at US$ 21,957 per annum, and revenue from entrance fees was estimated at US$ 412,414 annually. Our study illustrates also the successes achieved through the integration of participatory forestry on livelihoods and recommends urban forest management models that incorporate the community's perspectives.

1. Introduction

The integration of green infrastructure in living spaces was a phenomenon reported in early civilizations, such as the Greek and Roman cities (Gschwantner et al., 2009). In Asia, Suzhou Garden philosophy (Zhang, 2018) can be traced to ancient China during the Tang Ming dynasties. In Mesoamerica, the Aztec, Maya, and Incan civilizations had elaborate gardens and green spaces in ancient city architecture (Berjman et al. 2019). Similarly, the architecture of Yoruba palaces (Palace et al. 1990) in West Africa incorporated elaborate garden designs. The utilities associated to the early urban green spaces centred on provision of fuel wood, timber for construction and agricultural expansion during the Middle Ages in many European centres (Stanley et al., 2012). Further, the Renaissance period gave rise to interest in aesthetic values of green spaces and urban forestry, associated with social and political hierarchies, like the Place des Vosges in France (Hoft-March 2017), and the Bloomsbury square in England (Andersson, 2012). Contemporary designs of green spaces and urban forests in built environments can be traced to North America around the early 1960s (Helms, 1998); it was centred on improving the inhabitants' well-being while considering their psychological and socio-economic impact on built spaces (Konijnendijk et al. 2004). Food and Agriculture Organization defines urban forestry as woodlands or trees outside forests within urban spaces (FAO, 2023). Green urban infrastructures, such as parks, street trees, arboretums and roof gardens are widely acknowledged as important components in modern urban planning (Dover, 2015). They improve environmental quality in urban spaces and provide essential ecosystem services (ES) (Tan et al., 2021).

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Globally, the current designs of most major cities have prioritized ecologically sustainable models of urban infrastructure, promoting greening through urban forestry (Feng et al. 2017), roof gardening, urban hydroponic agriculture (Schnitzler, 2013), and responsive water-flow designs (Cotthem, 2005). The integrated governance approach towards the management of urban forests has proven most successful in Europe, Australia, and North America (Konijnendijk, 2003). For instance, the Melbourne urban forest fund (a public-private partnership), provides financial assistance to increase vegetative cover in the city and is leads to increased tree cover, roof gardens and parks (Nature Conservancy, 2019). In Barcelona, the special protection plan for Collserola Natural Park proposed a public-private governance structure to improve service delivery of ecological values by restoring the built heritage and improving interconnectivity among conservation spaces (Urban Next Lexicon, 2022). In Leipzig, environmental-based Non-Governmental Organisations (NGOs) partnered with the city to increase tree coverage through city tree planting campaigns to successfully meet the yearly target of one thousand trees (Stadt Leipzig, 2017). Another example is New York City's Central Park, the largest urban forest park in the city, the ecological status of which is maintained by the city department of parks and recreation though various collaborations and partnerships with civil society groups, city investors, NGOs, and donors (Nowak et al., 2018).

In the global South, growing economies of West Africa and Sub-Saharan Africa have shown interest in terms of investments and commitments (OECD/UN ECA/AfDB, 2022) with a view to establishing green urban infrastructures in cities (Hosek, 2014). Major challenges cited across scholarly articles include lack of sustainable urban plans for rapidly developing cities (Rigon et al., 2018), land tenure issues regarding public parks (Noorloos et al., 2019), land grabbing and population pressure in cities (Cobbinah et al., 2017), and weak enforcement of regulatory frameworks at local municipal levels (Murtala, 2019). For instance, Cobbinah et al. (2023) highlighted the increased number of encroachments which had negative effects on the ecological integrity of Achimota Forest Reserve, an important forest ecosystem in greater region of Accra, Ghana. Similarly, Krüger, et al. (2019) established that urban pollution from heavy metals and encroachments on public green spaces were major threats to urban forestry in the Western Cape of South Africa. Moreover, other studies have demonstrated preferences of city residents towards urban forest and perceived ES benefits (Endreny, 2018). Gwedla et al. (2019) reported that over 80% of the respondents in ten urban centres in South Africa had positive perceptions of trees in public areas and recognized their positive impact on the environment. In Addis Ababa, the assessment of selected ES benefits concluded that urban forest on Mount Entoto had a high carbon storage potential despite the influence of tree species variability (Solomon et al., 2024).

Currently, the legal framework of forest policy in Kenya recognises forest resources as a pillar for economic development as established in the 2010 Constitution. The forest management practices over the last decade have been responsive to the policy shifts and international climate change initiatives such as the Reducing Emissions from Deforestation and Forest Degradation (REDD+) (Chisika et al., 2024). Chapter 5 on land, environment, and natural resources emphasises the need for development and management of the forestry sector through provisions guaranteeing concessions to natural resources, including forest concessions through laws and Acts of Parliament. Forest Conservation and Management Act 2016 (Republic of Kenya, 2016), provides legal basis for institutional arrangements and interventions for equitable sharing of forest resources with the communities through Forest Conservancy Committees and Community Forest Associations (CFAs). This is the legal context in which Karura Forest Reserve (KFR) in Nairobi is jointly managed by Kenya Forest Service (KFS) and Friends of Karura Community Forest Association (FKF-CFA) (KFS, 2010). This very well-known forest sets the pace on urban forestry in East Africa (Osewe et al., 2024), being a significant urban forest ecosystem contributing towards making the city more liveable and sustainable by providing essential ES that maintain ecological balance (Chisika et al. 2023). Further, it has a well-documented political history (Peter et al. 2006), being recognised for its role in the environmental activism and democratization reform process in Kenya during the 1990s (Njeru, 2010).

Given the heightened visibility of KFR, it has been subjected to a lot of social, political, and scientific interest. Previous studies have focused on the influence of western-driven democracy reforms during the 1990s in the context of KFR and the political patronage associated with misuse of public resources (Njeru, 2013). The perspectives drawn from Njeru (2010) on the protests and civil actions against government-agenda to privatize KFR, establishes its historical and political significance in modern-day Kenya. One of the notable activists who championed for the environmental protection protest is the Nobel Peace Laureate Wangari Maathai (Oniang' et al., 2011). Moreover, Shah et al. (2022) identified the contribution of KFR recreational values to the urban and peri-urban areas neighbouring the ecosystem. Socio-economic factors, such as visitors' level of income affected the type of ES values appreciated i.e., visitors from high income neighbourhoods showed more appreciation towards intrinsic ES values like recreational facilities, while visitors from low-income neighbourhoods showed more interest towards wood-based forest products such as dead wood. More studies have predominantly focused on the eco-tourism aspects of KFR as an urban forest, highlighting the variety of recreational services present within the ecosystem (KFS, 2010; Makonjio et al., 2015b; Manji, 2017; Keige, 2019).

KFR has been the epicentre for the complex socio-political and economic dynamics in Kenya, which is valuable as a case study area for understanding broader urban forestry challenges. Moreover, this would offer insights on issues such as governance structures, socio-economic disparities in access to ES, and the role of CFAs in forest management which are similar challenges in urban forestry within the global South. Despite the scientific and political interest, there are no studies focusing on the role of KFR in providing benefits for local community members. Based on the analysis of the perceptions of FKF-CFA members and Huruma community-based organizations (CBOs), this paper aims at evaluating the ES that KFR provides to local people. For the FKF-CFA members, it estimates their direct and indirect benefits from their employment in KFR, while for Huruma CBOs it evaluates the effects of periodic removal of deadwood from the forest. To provide a holistic perspective on the ES provided by KFR to local people, this paper also uses visitor log data (January- December 2021) to frame the KFK-CFA economic context for the findings.

2. Methods

2.1. Study area

KFR is situated at latitudes 1° 14′ 15.00″ South and longitudes 36° 49′ 14.99″ East. The current size of KFR is 1041 ha and it consists of two main blocks to the West and to the East as illustrated in Fig. 1. The larger portion is Karura & Eastern Salient (Mazingira) of 797 ha and to the west there is Sigiria section, of 244 ha.

Established in 1932, under Legal Notice no. 44/1932, the KFR size has changed significantly resulting from a total of 5 excisions from 1951 to 1997 and adjusted additions (1954 and 1993) (KFS, 2010). The excisions have been subject to criticism especially in the context of political patronage during the 1990s which fuelled irregular and illegal allocations of forest land to private individuals or politically connected persons (Kieyah et al. 2010). In this context, KFR was the epicentre of organised resistance in the country against grabbing public land for private interests (CoI, 2003).

2.2. Data collection

The primary data were collected using survey methods evaluating direct and indirect benefits of employed FKF-CFA members in KFR, and

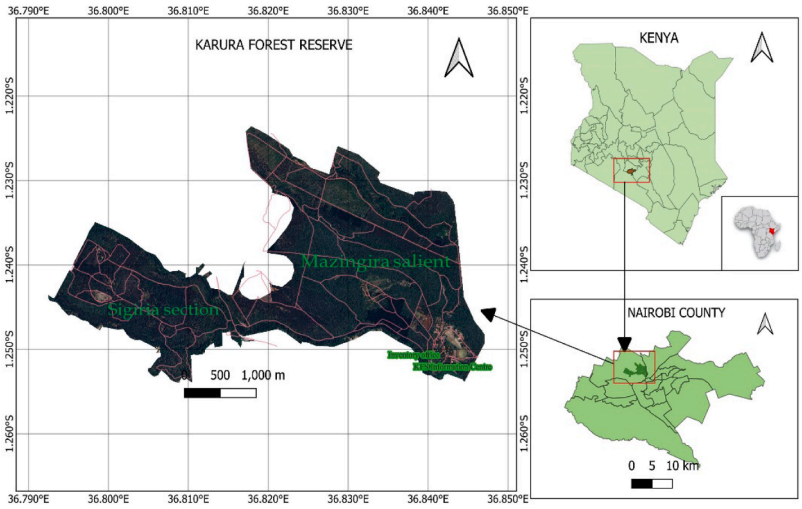

Fig. 1. Map of Karura Forest Reserve.

the benefits associated with periodic removal of deadwood from the forest by Huruma CBOs. To capture quantitative data from closed-ended questions using a Likert scale, two questionnaires were used:

I. The one addressing benefits of FKF-CFA members, issued to respondents from FKF-CFA i.e., KFS, Karura Forest Environmental Education Trust (KFEET), scouts, gate clerks, office administrators, maintenance teams, bicycle recreation staff and contracted CBOs; the questionnaires targeted all employed KFK-CFA members at the time of the study, including the temporary employees (casual labourers and contractual basis employees).
II. The one addressing the benefits associated with periodic removal of deadwood - issued to organized groups (CBOs); the questionnaire targeted all people involved in deadwood removals during one week at the time of the study to complement survey data with qualitative insights.

Questionnaires associated with removal of deadwood were administered on Tuesdays and Fridays, which were designated days for deadwood collection by local CBOs from the Huruma community under the supervision of KFS and FKF-CFA. Questionnaires on perceived benefits to FKF-CFA members were administered on working days from Monday to Friday. These specific days were chosen to align with ongoing forest management activities, ensuring responses were grounded in real time experiences and observations. Both approaches captured measurable outcomes and community perspectives on forest management practices. Participants were assessed based on topics as indicated in Table 1.

The secondary data on visitors' entry logs were sourced from FKF-CFA records (January - December 2021).

2.3. Data processing

Three datasets were used to evaluate the ES of Karura Forest Reserve, the first two datasets were derived from the questionnaires issued to FKF-CFA members and Huruma community CBOs respectively. Subsequently, the datasets were categorized to form numerically coded classes and descriptive statistical analysis, such as calculating means, frequencies, and percentages, was conducted in R-studio. The third dataset was sourced from visitors' entry log data for 2021, which represented the number of visitors and the corresponding entrance fees paid. It formed a numeric column-type dataset which was used to determine the total annual revenue from visitation entrance fee.

For the ES valuation of FKF-CFA benefits, direct economic benefits, such as the total wages, were determined by extrapolating responses from the collected data. The total earnings in Kenyan Shillings (KES) were estimated by multiplying the weighted average of earnings range with the average number of monthly employees (50):

$$\text{weightedaverage} = \sum (\text{median wage} \times \text{percentageofemployeesinwagerange})$$

Additionally, a Fisher's statistical test was conducted to determine any significant differences between categories defined by responses to Q.1.3 (employment categories) and Q.1.9a (satisfaction levels of employment). Further, descriptive statistics was carried out to determine the diverse perceptions regarding the topics in question Q.1.9b (satisfaction with amount of wage), Q.1.9c (development of new skills or improvement of existing ones), Q.1.9d (financial needs met by income) and Q.1.9e (developed sense of belonging amongst other staff).

For the assessment of deadwood collected by Huruma community CBOs, the total amount collected in a week was estimated using the midpoint of each range to find an average weight per response and then multiplied by the number of responses. The monetary valuation was determined using the price of fuelwood based on consumer price indices (KNBS, 2019) and the average weekly number of people involved in

Table 1
Topics discussed in the mixed-format questionnaires issued to KFR respondents.

Questionnaires	Topics discussed
Questionnaire i. Perceived benefits to FKF-CFA members	Q.1.1. Age Q.1.2. Gender Q.1.3. Employment category Q.1.4. Period of employment Q.1.5. Frequency of work in KFR Q.1.6. Type of work provided Q.1.7. Monthly earnings range Q.1.8. Wages satisfaction level Q.1.9. Perceptions regarding (a) employment, (b) wage, (c) skills, (d) financial needs and (e) sense of belonging
Questionnaire ii. Benefits associated with removal of deadwood	Q.2.1. Community/Association name Q.2.2. Participation in deadwood removal activities Q.2.3. Sources of information about deadwood removal activities Q.2.4. Quantities collected Q.2.5. Benefits of removing dead wood Q.2.6. Perceived effects of dead wood removals on adjacent communities Q.2.7. Level of satisfaction with dead wood extraction activities

deadwood removals. Lastly, we presented a comparative analysis of the results.

3. Results and discussions

A total number of 50 questionnaires were filled in by the employed KFK-CFA members, corresponding to the average number of monthly employees involved in KFR related activities. The distribution illustrates the staff category of the respondents in Fig. 2. The highest number of responses were received from the scouts (40%), the largest staff category in Karura Forest (KFS, 2010), while the KFEET and contracted CBO-MASSROOM were represented by one person each. The distribution underscores the role of scouts given their dynamic range of activities, which include supporting routine patrols conducted by KFS rangers, acting as guides for visitors, participating in trail clearing, and responding to emergencies (FKF, 2019).

3.1. Valuation of direct ES benefits using wages of FKF-CFA staff

The total earnings estimated the direct financial benefits received by FKF-CFA staff at KES 14.9 million (US$ 91,656) per annum detailed in Table 2. The wage ranges represent the individual staff income used as indicator of the monetary compensation for services towards conservation and management of KFR. Our results highlighted the intrinsic link between environmental stewardship and socio-economic well-being by assessing the tangible and immediate financial gains that economically empower the FKF-CFA workforce. Similarly, Olander et al. (2018) highlighted the benefits of using indicators such as income to link ESs, community well-being and ecosystem health. The study suggested that indicators like income offer more practical and measurable ways to assess the economic impact associated with working in KFR.

Although the median wages for 66% of FKF-CFA workers who earn less than KES 30,001 in KFR was lower than the national average wages of KES 29,530 for Agriculture, Forestry, and Fisheries personnel (KNBS, 2019a), 34% earned above the national average wages. However, according to the key economic indicators report (KNBS, 2019b) for household income categories, urban cities like Nairobi typically have three income groups: (a) lower income group earning less than KES 23, 670, (b) middle-income group earning more than KES 23,670 to 119, 999, and (c) upper-income groups earning above KES 120,000. Therefore, the median wages for many of the FKF-CFA workers align more closely with the middle-income group according to Kenya National Bureau of Statistics household income categories (KNBS, 2022).

In Sudan, Adam et al. (2024) used income from the sale of baobab as indicator for ES to analyse livelihood dynamics. The study revealed that the profits from sale of baobab reduced the inequality amongst households with diverse income generating models and improved the livelihood security. Similarly, Barrett et al. (2001) used income ranges to assess the household livelihood diversification in response to forest policy shocks amongst the rural communities in Kenya and Côte d'Ivoire; the findings indicated that low-income households were less likely to respond to the shocks and slow to uptake new and emerging opportunities. The extrapolated responses in Table 2 from FKF-CFA workforce provided insight into how income played a crucial role in empowering and enabling the staff, particularly the staff from Huruma community who live near KFR. Furthermore, it offered a framework for comprehending the measurable aspects of ES benefits and for contextualizing the effect on their livelihoods. This informs policy strengthening community engagement in forest conservation through structured employment programs to enhance both livelihoods and environmental stewardship.

Table 2
Estimated earnings based on extrapolated responses from FKF-CFA workforce.

Earnings range in Kenyan Shillings (KES) Per month	Median wage	Percentage share	Weighted average ∑ (Median wage × Percentage)
≤10,000	5000	8%	400
10,000 - 15,000	12,500	4%	500
15,001 −20,000	17,500	2%	350
20,001 - 25,000	22,500	34%	7650
25,001 - 30,000	27,500	18%	4950
30,001 - 35,000	32,500	34%	11,050
		100%	∑ 24,900
Total monthly earnings = Weighted Average × Number of Employees (50)			∑ 1245,000
Total annual earnings = Total monthly earnings × 12 months (1year)			KES 14,940,000

3.2. Perceived ES among FKF-CFA staff in KFR

The percentage distribution of FKF-CFA workers surveyed revealed that a significant portion of staff were casual labourers and those on a contractual basis as detailed in Fig. 3. The different categories were related to the duties assigned and terms of employment. Rotational and flexible types of employment were necessitated by the need to engage and support the local community through CBOs for tasks such as maintaining paths, tending of seedlings, and overseeing tree nurseries. The rotational approach enhanced equity between the CBOs and community involvement in conservation efforts (FKF, 2019). Similarly in Malawi, Likongwe et al. (2021) established that community involvement in the management of urban green space in Zomba city contributed towards the improvement of biodiversity and provisioning ES. Moreover, the study attributed successes of species regeneration in both Sazdi and Chiperoni hills to the local community CBOs collaboration with key stakeholders, such as the forest department and local chiefs.

The socio-economic conditions of forest adjacent communities often influence their perspectives on the value attributed to ES due to the direct impact on their livelihoods (Osewe et al., 2024b). For instance, the diversification of livelihood income resulted in positive attitudes of local communities towards restoration of mangroves on the east coast of

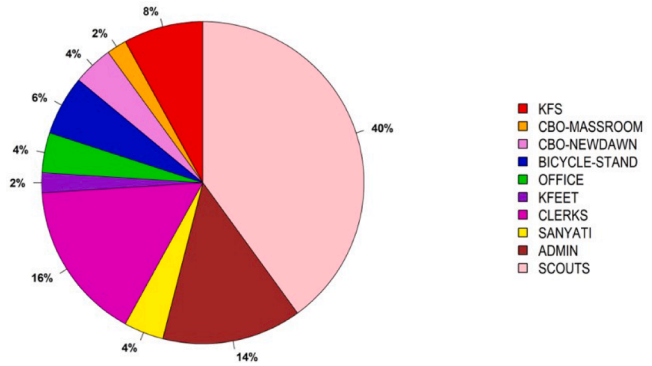

Fig. 2. Distribution of surveyed staff categories amongst FKF-CFA respondents.

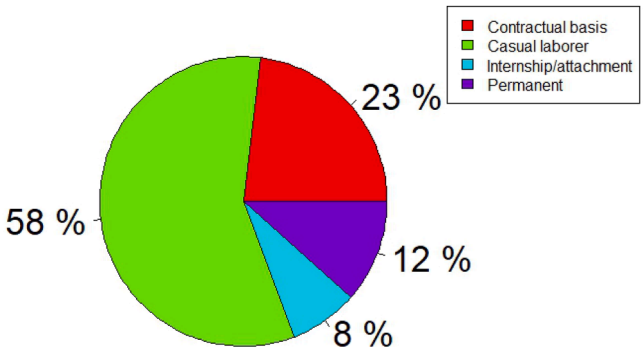

Fig. 3. Share of employment categories across FKF-CFA respondents.

India, which improved level of support towards mangrove conservation efforts (Badola et al., 2012). Moreover, similar studies established that the link between dependency on forest resources and livelihoods are more pronounced in forest ecosystems within rural settings (Yego et al., 2021; Osewe et al., 2023) compared to urban forest ecosystems because of limited access to alternatives due to low-income levels. In Mexico, Cinner et al. (2004) affirmed that the socio-economic background of respondents was the most important factor influencing perspectives on the environmental conservation in Mahahual. The study established that those respondents from higher incomes appreciated intrinsic values and were more receptive towards conservation efforts, while the respondents from lower incomes prioritized direct benefits and showed least concern about conservation efforts. Therefore, for better urban forest management in the global South, frameworks that provide economic incentives for lower income levels could consider prioritizing while reinforcing conservation values among higher income levels.

3.2.1. Perceived ES benefits to livelihoods

We further assessed whether the different employment categories influenced the perception of FKF-CFA staff on the benefits to their livelihoods, with the aim to gain a comprehensive understanding of the dynamics of work and employment that influence forest-based livelihood perceptions. The Fisher's exact test in Table 3 compared the responses for perception of improved livelihoods (Q.1.9a) based on the different employment categories (Q.1.3). Our result showed a p-value of $0.42 \geq 0.05$ and therefore the distribution of responses in Q.1.9a was not significantly different depending on the response given for Q.1.3. Based on this result, we can conclude that there is no significant relationship between the employment categories and the perception of improved livelihoods.

The diversification of income sources, either by self-employment or formal type of employment, has been cited by similar studies as a contributing factor towards improvement of livelihoods for communities living near natural resources (Adam et al., 2024; Radeny et al., 2007; Yego et al., 2021). Our findings suggest that the positive attitudes towards management and conservation of Karura Forest by FKF-CFA staff who are also from the nearby Huruma community, were influenced by perceptions of improved livelihoods. Furthermore, the positive attitudes are attributed to the sense of job security and work-related benefits (Duan et al., 2021).

A global review by Angelsen et al. (2003) exploring the nexus between forest communities and poverty alleviation established that multifaceted approaches towards integration of local communities in resource management as well as providing market-based alternatives were more likely to have a positive impact towards poverty alleviation. Moreover, the study highlighted positive perceptions towards ES benefits from the local communities that had income as safety net that cushioned them from direct dependence on forest products.

3.2.2. Perceived benefits of working for fkf-cfa

We obtained 50 responses for each question prompt on perspectives regarding the benefits of working in Karura Forest and summarised results in Fig. 4. The responses provided comprehensive insight on staff sentiments contributing towards improving job satisfaction and overall productivity. Halkos et al. (2010) also highlighted the link between job

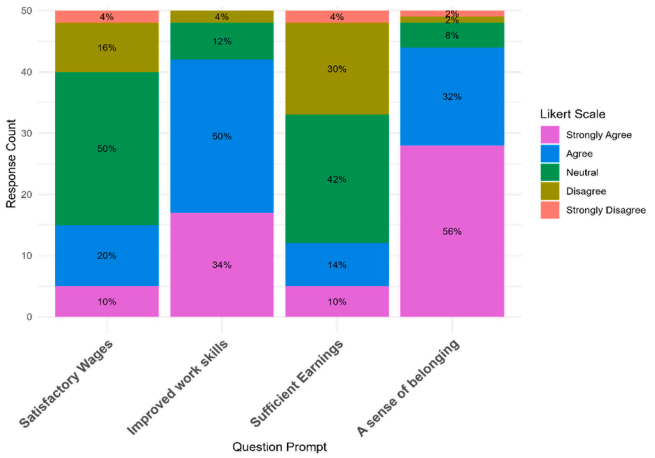

Fig. 4. Distribution of FKF-CFA staff perspectives on benefits of working in KFR.

satisfaction and high productivity. Of the total responses obtained for the question prompt on satisfactory wages, 30% felt their wages were satisfactory by either agreeing or strongly agreeing while 20% felt dissatisfied by either disagreeing or strongly disagreeing. Half of them at 50%, remained neutral. These findings on wage satisfaction suggested a balanced view on the adequacy of wages as compensation and highlighted areas for potential improvement in FKF-CFA compensation structure.

84% of the respondents either agreed or strongly agreed to the fact that their work skills had significantly improved at KFR. Our findings suggested that working at KFR had fostered growth in terms of refining existing skills and acquiring new ones. Similar studies by the International Labor Organization established that improved worker skills lead to more productivity and high-quality workmanship where there is a positive association between job satisfaction and skills proficiency (OECD/ILO, 2017). Wielers et al. (2021) also highlighted skill development opportunities contributing towards greater work commitment and improved quality of work. Moreover, the positive perceptions by FKF-CFA staff indicated the potential for continued professional development and job satisfaction amongst the staff.

24% of the respondents either agreed or strongly agreed that their earnings met their financial needs. 34% of the respondents either disagreed or strongly disagreed and felt their income were insufficient. A majority remained neutral at 42%. Our findings highlighted the influence of income adequacy and work satisfaction. Ehsan et al. (2012) established a nexus between income and work satisfaction, with employees who reported to have sufficient earnings showing high levels of job satisfaction. Similarly, Okumu et al. (2020) established that employment status and ability of households to meet their financial needs from their CFA earnings in Mau Forest ecosystem (Kenya) influenced their level of satisfaction towards the forest conservation activities. Furthermore, the study highlighted the unwillingness of households who felt dissatisfied with CFA earnings or those without income to engage in CFA activities or community forestry.

A vast majority of the respondents (88%) either agreed or strongly

Table 3
Fishers exact test on the perception of livelihoods based on employment categories.

Question Q.1.9a	Contractual employees	Casual laborers	Internships/ attachment	Permanent employees	n	p-value	test
Has working in Karura improved your livelihood?	1 (8.3%)	1 (3.3%)	1 (25%)	0 (0%)	3	0.42	**Fisher**
	2 (17%)	10 (33%)	0 (0%)	1 (25%)	13	–	–
	4 (33%)	10 (33%)	1 (25%)	3 (75%)	18	–	–
	5 (42%)	9 (30%)	2 (50%)	0 (0%)	16	–	–
	(n = 12)	**(n = 30)**	**(n = 4)**	**(n = 4)**			

agreed that they felt a sense of belonging, highlighting their profound connections to their colleagues and nearby community while working at KFR. Our findings suggest that many of the staff perceived their role in KFR as fostering meaningful connections and had positive attitudes towards the organizational work culture. The sense of belonging amongst FKF-CFA staff and connection to the communities around Karura Forest played an integral role in fostering integration of participatory forest management (PFM) as envisioned in the Forestry Act of 2016. Studies have established that decentralized forest management frameworks have proven effective in addressing complex socio-ecological challenges of fringe communities (Bixler, 2014; Charnley et al., 2007). For instance, Mbeche et al. (2021) highlight the contributions of PFM in Mt. Elgon Forest ecosystem towards developing a sense of cohesion and shared purpose in resource management in the context community engagement though CFAs. Similar findings were highlighted by the success of participatory management models in Arabuko Sokoke (Kenya) (Matiku et al., 2013) and Tanzania (Treue et al., 2014).

3.3. Valuation of collected deadwood as a provisioning es to huruma community

36 members of Huruma CBO were involved in deadwood removal in the week of the study and all of them filled in the second questionnaire. The total monetary value for collected dead wood by CBOs from Huruma, detailed in Table 4, was estimated at KES 3.56 million (US$ 21,957) per annum. About 68% of households in Kenya still rely on wood fuels as the major source of energy (Osewe et al., 2022). Similarly, Takase et al. (2021) established that the dependence of wood fuel is more prevalent in rural areas, amongst low-income urban residents, and within informal settlements in Kenya. Our findings suggested that the adjacent Huruma community collected deadwood for subsistence, and this could be attributed to prevalent income limitations for alternative energy sources. For instance, Zulu (2010) also revealed that socio economic factors such as electricity access, poverty and income inequality contributed towards the demand for wood fuel in Zomba and Lilongwe cities of Malawi.

The arrangement between FKF-CFA and Huruma CBOs for periodic removal of dead wood was mutually beneficial because it reduced the risk of forest fires, fostered growth of healthy trees stands enhancing wildlife habitat and providing source of fuel wood (KFS, 2010). In the context of other urban forests in Nairobi (Ngong Forest Reserve), Furukawa et al. (2011) revealed that inhabitants from informal settlements foraged dead wood for subsistence purposes like heating and cooking. Further, Stoppok et al. (2018) established that households in Kenya had the highest energy use per capita with fuel wood as main cooking fuel and the primary factor influencing widespread use. Similarly, Kituyi et al. (2001) revealed that rural households in Kenya used firewood as their main fuel source while charcoal was used majorly in urban households. In both instances, the use of fuel wood was dependent on resource availability and socio-economic factors.

Although accessibility was controlled and monitored by FKF-CFA staff at Huruma gate, the proximity by distance to the informal settlements was a significant influence on the probability of unmonitored foraging. In Tanzania, positive attitudes regarding forest management resulted from inconclusion of forest fringe communities which ultimately improved long-term ES provision (Corbera et al., 2020). Ali et al. (2007) also highlighted the effectiveness of community involvement in forest management in Pakistan to enhance their social assets and perceptions on forest resources. The CBOs positive perceptions regarding urban forest foraging were possibly influenced by the FKF-CFA approach towards including local communities in forest governance through PFM frameworks (Khan et al., 2022). Our findings highlighted how involvement of local communities in urban forest ecosystems can lead to sustainable management especially when conventional methods of alienation are not effective (Treue et al., 2014). In terms of policy, these findings encourage formal partnerships between local CBOs and forest management entities seeking to integrate community-led initiatives into urban forest management.

3.4. Valuation of recreational es based on revenue from entrance fees

The total monetary value for recreational ES, based on the analysis of visitation data (January - December 2021), detailed in Table 5, was estimated at KES 67.2 million (US$ 412,414) per annum. Our findings indicated an existing local and international demand for Karura Forest, which was affirmed by similar studies on its ecotourism potential (Makonjio et al., 2015a; Shah et al., 2021). The consistent daily entries throughout the year suggest a willingness to pay for recreational values. Most visitors were local (citizens and residents), surpassing the number of non-residents, indicating an acknowledgment of the ES values offered (Liu et al., 2021). Considering the direct, indirect, and induced effects of visitor expenditures for ecotourism in KFR, our results highlighted the ecological value derived from the diverse aspects like species variability, habitats, and serene tranquil scenery within KFR (Furukawa et al., 2016).

The total revenue from entrance fees offers reliable indices for assessing the demand for recreational ES in KFR which affirms the appreciation of its intrinsic values. The entrance fees also provide a

Table 4
Estimated value of deadwood as provisioning ES to the Huruma community.

Number of responses per focus group (*resp*)	Estimated range of deadwood collected once a week	Weighted average for each range (Median)	Total collected for each range = (Median x *resp*)
21	≤ 50 kg	25kg	525 kg
12	51–100kg	75kg	900 kg
3	101–150kg	125kg	375 kg
	∑ 1800 kg		
Total annual deadwood collection = {∑ 1800 kg × 52 weeks (1year)}	∑ 93,600 kg		
Total estimated annual monetary valuation = (∑ 31,200 kg × 38 KES/kg)	KES 3556,800		
*Unit cost KES/kg based on consumer price indices (KNBS, 2019)			

Table 5
Estimated revenue based on visitation data (January – December 2021).

MONTHS	Individual entrance fee KES 100 Citizens	Individual entrance fee KES 200 Residents	Individual entrance fee KES 600 Non-residents	Total number of Visitors	Total entrance fee revenue = (individual entrance fee × Number per category)
JAN	37,328	8589	1259	47,176	6206,000
FEB	30,819	6465	872	38,156	4898,100
MAR	30,363	6273	714	37,350	4719,300
APR	36,534	5869	525	42,928	5142,200
MAY	38,688	6810	595	46,093	5587,800
JUN	36,929	6589	1250	44,768	5760,700
JUL	37,625	6546	1176	45,347	5777,300
AUG	37,227	6589	1250	45,066	5790,500
SEP	36,916	6546	1176	44,638	5706,400
OCT	46,782	7821	1353	55,956	7054,200
NOV	32,934	6385	1484	40,803	5460,800
DEC	26,807	6088	2003	34,898	5100,100
Annual estimates (12 months)				∑ 523,179	∑ KES 67,203,400

sustainable source of revenue to finance and cover costs of expenditures associated with daily operations of KFR such as staff salaries. For context, KFR retains a surplus of KES 52.3 million (USD $320,758) per annum based on our estimates of salaries (Table 2) and entrance revenues (Table 5). Fee-based models where a demand for intrinsic value exists are more preferred as it removes natural resources from the fate of the "tragedy of commons" (Meisinger, 2022). For instance, in Japan respondents showed more appreciation towards fee-based national parks which had a higher demand compared to non-fee-based alternatives (Shoji et al., 2021). The positive perceptions of visitors contribute to the development of a dependable multifunctional forest management approach to valuing intrinsic ES which play a key role in overall well-being of an urban population (Endreny, 2018). At the same time, the demand for visiting green urban spaces, such as KFR contributed to increasing awareness of the importance of urban forest ecosystems (Solomou et al., 2019). These findings emphasize the need for structured policy which allows for investment in urban green spaces to enhance self-sustaining financial mechanisms that reduce reliance on external funding.

4. Conclusion

The economic value of ES derived from KFR as contribution to local people through provisional ES like deadwood and FKF-CFA salaries had a total estimate of KES 18.5 million (USD$ 113,5) per annum. Financial compensation for work done for the KFR economically empowered the members of the local community by improving their levels of household income. The average salary was above the minimum average national wages for workers in the categories of Agriculture, Forestry, and Fisheries and a majority had middle income wages characterization for an urban city like Nairobi. A majority of the FKF-CFA on contractual employment basis were from the Huruma community and therefore employment opportunities availed at KFR provided additional source of household income as well as biofuels in form of deadwood for household use. Furthermore, the valuation of indirect benefits, such as recreational ES for KFR, affirmed the appreciation of intrinsic values estimated at KES 67.2 million (US$ 412,414) per annum. The financial envelope of KFK-CFA integrates these values which sustainably cover expenditures of KFR due to consistent solid demand for touristic ES inferenced by payment of entrance fees.

This research outlined perspectives of FKF-CFA staff and influence of perceptions on resource stewardship for KFR. The wages influenced the perceptions of improved livelihoods and of staff satisfaction with conservation work at KFR. Variations on work satisfaction were drawn depending on the different employment categories. Positive perceptions of improved livelihoods were more prevalent among permanent employees compared to the casual labourers. Perspectives on staff sentiments also gave insights into job satisfaction and productiveness. The staff who felt content with their salaries, had financial needs met and felt integrated by having improved skills, developed a sense of belonging that fostered meaningful connections and positive attitudes towards the organizational work culture.

Our study illustrates practical outcomes realized though the integration of participatory urban forestry on livelihoods and demonstrate effective natural resource management models that incorporate the communities' perspectives to provide meaningful multifaceted benefits. In the context of urban forestry in the Global south, we recommend PFM approaches that guarantee equitable sharing of forest resources with the communities through the involvement of stakeholders as demonstrated by FKF-CFA, Huruma CBOs and KFS. The findings provide a good example of how multipurpose urban forests can provide benefits for the population of Nairobi city and contribute to the surrounding communities' welfare in multiple ways through ES provision. There is need to develop an urban forest policy plan for forest managers in Kenya that recognizes these interconnected benefits associated with participatory urban forestry. Therefore, developing a structured framework could expand PFM to other urban forests in Kenya which may offer equitable benefit-sharing to enhance sustainability and social inclusion. The financial sustainability demonstrated by the management structure in KFR could serve as a funding model to be implemented by other urban forestry initiatives. Based on our findings, we also recommend establishing capacity-building initiatives for local CBOs to reduce over-dependency on KFR and diversify their income.

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CRediT authorship contribution statement

Erick O. Osewe: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bogdan Popa:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Joram K. Kagombe:** Supervision, Project administration. **Ibrahim Osewe:** Writing – review & editing, Validation, Software, Investigation, Formal analysis. **Ioan Vasile Abrudan:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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