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RESEARCH ARTICLE

Seasonal Habitat Shifts and Wetland Dependence of Grey Crowned Crane in Urbanising Kenya

Carolyne M. Wachu[1] | Benson M. Mwangi[2] | James Jumbe[1] | Wanyoike Wamiti[3] | Joseph Mwangi[3]

[1]Department of Zoological Sciences, Kenyatta University, Nairobi, Kenya | [2]Department of Physical and Biological Sciences, Murang'a University of Technology, Murang'a, Kenya | [3]International Crane Foundation, c/o Community Action for Nature Conservation, Nairobi, Kenya

Correspondence: Carolyne M. Wachu (karolskeeter@gmail.com)

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ABSTRACT

The Grey Crowned Crane (*Balearica regulorum*) has experienced major global population declines, leading to its uplisting to Endangered status on the IUCN Red List of Threatened Species. In Kenya, the Nairobi metropolitan area supports one of the country's substantial remaining populations of this species, yet data on temporal and spatial variation in population and habitat associations remain limited. This study conducted systematic censuses at 130 sites across five counties between June 2023 and February 2024 to assess patterns in population and habitat use across wet and dry seasons. The observed crane population was estimated at 1116 individuals, based on the average of wet and dry season counts, with seasonal crude densities of 0.127 individuals/km^2 in the wet season and 0.14 in the dry season. Adults comprised 93.6% and young individuals 6.4%, with Kiambu County recording the highest proportion of young cranes (44.4%). Crane abundance varied substantially among counties and was positively associated with the availability of suitable wetland habitats. Habitat use shifted seasonally, with greater wetland occupancy during the wet season and increased use of grasslands during the dry season. These patterns highlight the species' strong dependence on wetlands and its flexible foraging behaviour in modified landscapes. Our findings emphasise the ecological value of even small or degraded wetlands and call for their integration into urban conservation and land use planning frameworks.

1 | Introduction

The Grey Crowned Crane (*Balearica regulorum*) is an iconic and ecologically significant bird species. It was uplisted from Least Concern to Vulnerable on the IUCN Red List of Threatened Species in 2009, and further to Endangered in 2012 due to its rapid and continuous population decline (BirdLife International 2012). It is among the fastest-declining crane species globally (Beilfuss et al. 2007), with an estimated 80% reduction in numbers over the past 45 years (BirdLife International 2016). In Africa, the population declined from over 100,000 individuals in 1985 to approximately 22,300 by 2016 (Morrison et al. 2019). The Kenyan population reflects this trend too, with numbers falling from 35,000 in 1985 (Urban 1988) to 8334 in 2023 (Wamiti et al. 2023; Kenya Wildlife Service 2025). The key drivers of this decline include habitat loss and environmental degradation, primarily caused by human encroachment into wetlands and associated land use changes (Harris and Mirande 2013; Morrison 2015; Wang et al. 2020). Many Grey Crowned Cranes in East Africa now rely on human-modified landscapes, nesting in wetlands adjacent to cultivated fields (Olupot et al. 2010).

Optimal foraging theory offers a valuable framework for understanding crane habitat selection in dynamic and human-altered landscapes. The theory posits that animals choose foraging sites that maximise energy intake while minimising

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effort and risk (Kie 1999). In the context of the Nairobi metropolitan area (NMA), Grey Crowned Cranes navigate a heterogeneous landscape of wetlands, grasslands, and agricultural fields, each of which varies seasonally in food availability, accessibility, and exposure to human disturbance. Seasonal shifts in habitat use, such as increased reliance on wetlands during the wet season and greater use of grasslands or farmlands during the dry season, can be interpreted as strategic responses to changing resource distributions. These patterns support the idea that cranes adaptively forage across habitats in ways that optimise energy gain in a rapidly urbanising environment.

Although national surveys have documented Grey Crowned Crane populations in Kenya (Bakari et al. 2019; Wamiti et al. 2023), little is known about how ecological theory explains crane dynamics within urbanising landscapes. Using the NMA as a case study, this research investigates how habitat availability and seasonal variation influence population distribution and habitat use of Grey Crowned Cranes in a human-modified environment. Specifically, the study was guided by the following research questions:

- How does Grey Crowned Crane's abundance and density vary spatially across different counties within the NMA?
- Is there a significant seasonal variation in Grey Crowned Crane population size within the study area?
- How do habitat type and suitable wetland availability influence the seasonal use and spatial distribution of Grey Crowned Cranes?

These questions aim to inform conservation strategies in the NMA and offer insights that are transferable to other urban and peri-urban regions experiencing similar ecological pressures.

2 | Materials and Methods

2.1 | Study Area

This study was conducted across approximately 8330 km^2 of the NMA, an area identified based on prior crane sightings reported by Wamiti et al. (2023). The region includes Nairobi City County and parts of Kiambu, Murang'a, Machakos and Kajiado Counties (Figure 1), extending between latitudes 0° 50.91′ S to 1° 55.36′ S and longitudes 36° 36.09′ E to 37° 29.95′ *E. Nairobi* City lies at an altitude of approximately 1795 m above sea level.

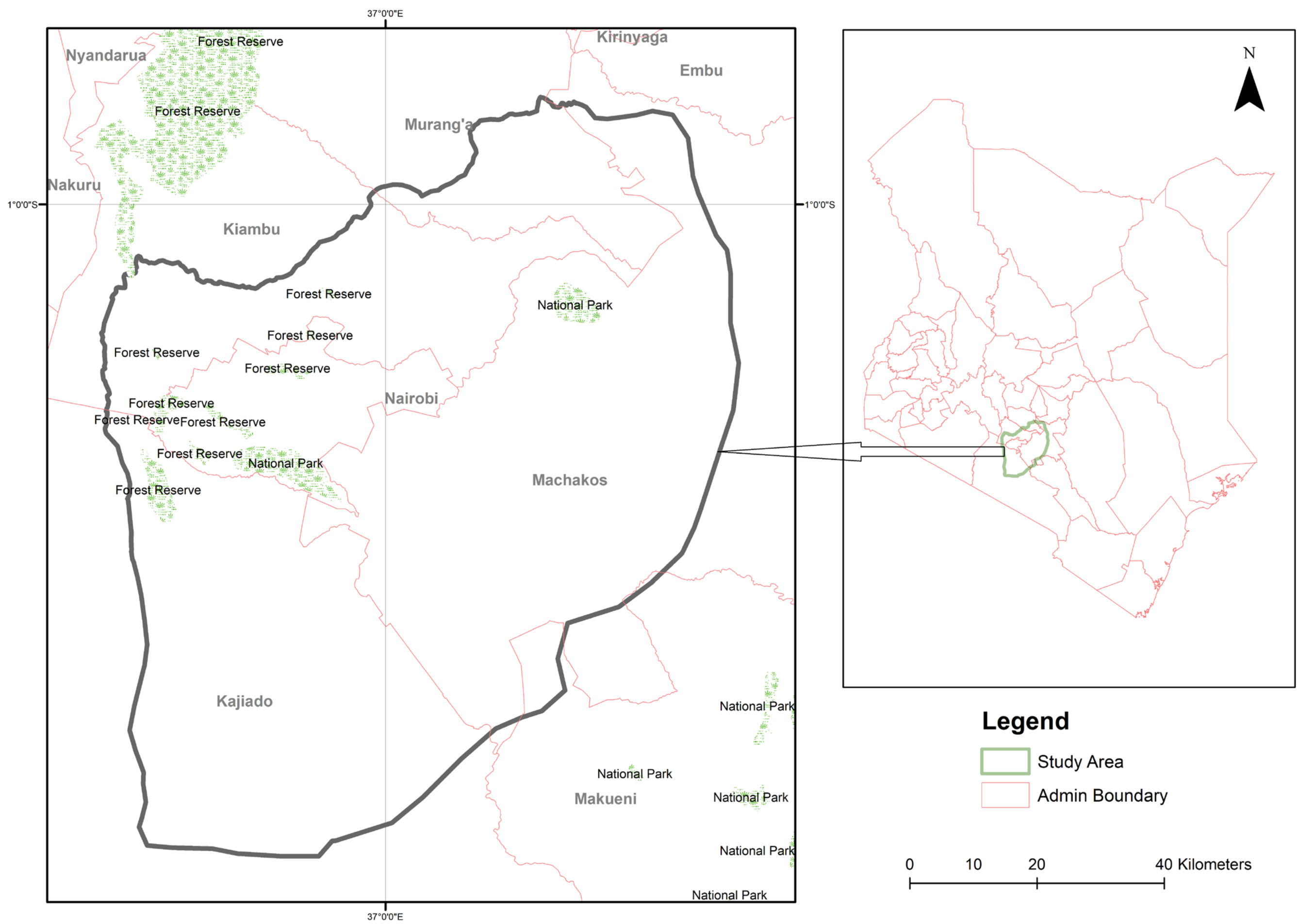

FIGURE 1 | Geographical location of Nairobi metropolitan area in Southern Kenya and its major urban centres.

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The landscape comprises hilly terrains, plains, and river valleys. The area experiences bimodal rainfall, with long rains from March to May and short rains from October to December, averaging 900 mm annually. Temperatures range from below 10°C in July to above 26°C in December (Omoto 2009; Omwenga 2010).

The NMA supports diverse crane habitats, including wetlands, grasslands, and cultivated fields. Major rivers such as the Nairobi and Athi sustain critical wetland systems (Masese 2010; Maina et al. 2021). Key wetlands such as Nairobi Dam, Ondiri Swamp, Ruiru Dam and Karura Forest Wetlands are increasingly threatened by urban development, pollution, and land encroachment (Muriithi 2014; Wangari 2022). Dominant wetland vegetation includes *Saccharum* species along rivers, *Cyperus* in marshes, and *Typha* in permanently flooded zones. Grasslands, including those in Nairobi National Park and Kapiti Plains, are characterised by species such as *Cynodon dactylon* and *Themeda triandra*. Agricultural landscapes and infrastructure, including highways and farms, contribute to land-use complexity.

2.2 | Data Collection

Data were collected through systematic censuses, direct observations, and GPS mapping from June 2023 to February 2024, covering the wet season (June–July) and dry season (January–February). A total of 130 sites were included in the census effort across Kiambu (51 sites), Murang'a (32), Nairobi (34), Machakos (7) and Kajiado (6). These sites were selected by first identifying potential wetlands using Google Earth Pro, which guided the location of areas likely to support crane presence due to wetland presence. Additional sites were located based on information from local guides and community members, who pointed out commonly used areas for foraging, drinking, and roosting.

Cranes were counted during peak activity hours (0600–1100 and 1400–1700) using direct observation with 10×42 and 8×40 binoculars to reduce disturbance (Butcher et al. 1990). A mechanical tally counter was used for larger flocks. Each observer conducted two counts; where results differed by less than five individuals, the higher count was used. Larger discrepancies required a recount (Wamiti et al. 2023). In the study, the crane population was based on direct census counts recorded during field surveys.

Cranes were classified by age as adults or young (chicks, juveniles and subadults) based on morphological features such as gular colour, following Nagwere (2014). GPS coordinates were recorded using a Garmin eTrex 10 to geo-reference crane sightings. For each site where cranes were encountered, observers visually estimated the area utilised (in km^2) based on field knowledge and visible landscape boundaries to support ecological density calculations. Wetland suitability was determined based on crane presence, vegetation characteristics, water availability, and disturbance levels. Only wetlands where crane use was confirmed during the census were considered suitable.

Habitat types were categorised into wetlands (e.g., marshes, swamps, dams, flooded fields, quarry ponds, sewage ponds) and terrestrial habitats (e.g., grasslands, cultivated fields, tree cover, and man-made structures such as rooftops, towers, disused urban sites).

2.3 | Data Analysis

Population estimates were derived using the average of wet and dry season counts to ensure a consistent and seasonally balanced measure of crane abundance. In contrast, density calculations were based on seasonal counts to facilitate seasonal comparisons and allow alignment with other ecological studies that report seasonal-specific densities.

Two types of density measures were computed. Crude density was calculated by dividing the number of cranes per county by the total surveyed area, providing an estimate of general population distribution. Ecological density was calculated by dividing the number of cranes by the estimated area where cranes were observed during field surveys, offering a more refined view of habitat-specific usage. These calculations were performed separately for wet and dry seasons.

Since crane count data did not meet the assumptions of homogeneity of variances (Levene's test; Maina et al. 2021), non-parametric statistical tests were used. The Kruskal–Wallis *H* test (Sherwani et al. 2021) assessed differences in crane counts across counties and habitat types. The Mann–Whitney *U* test (Spino et al. 2019) was used to examine differences in crane counts between seasons, age groups, and habitat types across seasons.

To assess the relationship between crane abundance and habitat availability, Spearman's rank correlation coefficient (r_s) was used to test the association between total crane counts and the number of suitable wetlands recorded per county. This analysis was based on wetlands where crane use was confirmed. All analyses were conducted in SPSS version 25, with statistical significance set at $p \leq 0.05$.

3 | Results

A total of 1116 Grey Crowned Cranes were recorded across 130 surveyed sites in the NMA, based on the average of wet and dry season counts. The cumulative area surveyed across all counties was 8328.36 km^2 (Table 1).

Ecological density was highest in Kiambu County, with 0.95 individuals/km^2 in the wet season and 1.12 individuals/km^2 in the dry season. Murang'a and Nairobi counties also recorded relatively high ecological densities, with 0.89 and 0.61 individuals/km^2 in the wet season, rising to 1.02 and 0.74 individuals/km^2 in the dry season, respectively. In contrast, Machakos and Kajiado counties recorded notably lower ecological densities, with values ranging between 0.02 and 0.03 individuals/km^2 in the wet season and 0.01 to 0.02 individuals/km^2 in the dry season.

Crude density patterns mirrored this trend. Murang'a County recorded the highest crude density, with 0.54 individuals/km^2 in the wet season and 0.62 in the dry season; followed by Kiambu with 0.36 and 0.42 individuals/km^2. In contrast, Machakos and

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Kajiado counties had substantially lower values in both seasons, ranging from 0.01 to 0.02 individuals/km^2.

Statistical comparison of total crane counts across counties using the Kruskal–Wallis H test revealed significant differences in median values ($H = 0.817$, $p < 0.05$). In contrast, the Mann–Whitney U test indicated no significant difference ($U = 5400$, $p > 0.05$) in crane counts between the dry and wet seasons despite higher counts being recorded in most of the sites during the dry season (Figure 2).

Adult cranes constituted 93.6% of all individuals recorded across all sites (Table 2), indicating their dominance in the population. In contrast, young cranes accounted for only 6.4%, reflecting low recruitment. The Mann–Whitney U test revealed significant differences between adult and young crane distributions across all counties, with $p = 0.001$ in each case. Kiambu County recorded the highest number, representing 44.4% of the young crane population. Correspondingly, Kiambu also had the highest mean ranks for adults ($M = 140.46$) and young cranes ($M = 64.54$), indicating relatively better recruitment success than other counties.

Crane habitat use varied markedly between seasons. During the wet season, 595 cranes were recorded across 67 wetland sites, compared to 313 during the dry season. In contrast, 561 cranes were recorded in 40 grassland sites during the dry season, compared to 225 during the wet season (Table 3). The difference in crane use between wetlands and grasslands across seasons was

TABLE 1 | Grey Crowned Crane counts and site-specific densities recorded across counties in the Nairobi metropolitan area during the wet and dry seasons.

County	No. of other sites	No. of suitable wetlands	Wet season count	Dry season count	Surveyed area (km^2)	Area cranes were found (km^2)	Crude density (individuals/km^2)		Ecological density (individuals/km^2)	
							Wet season	Dry season	Wet season	Dry season
Kiambu	22	29	477	558	1326.25	500	0.36	0.42	0.95	1.12
Murang'a	15	17	373	428	688.30	420	0.54	0.62	0.89	1.02
Nairobi	21	13	121	148	695.10	200	0.17	0.21	0.61	0.74
Machakos	2	5	52	27	3195.30	1500	0.02	0.01	0.03	0.02
Kajiado	3	3	35	13	2423.41	1900	0.01	0.01	0.02	0.01
Total	63	67	1058	1174	8328.36	—	—			—

Note: In this study, 'county' refers to the portion of each county within the Nairobi metropolitan area (NMA), except for Nairobi City County, which is included in its entirety.

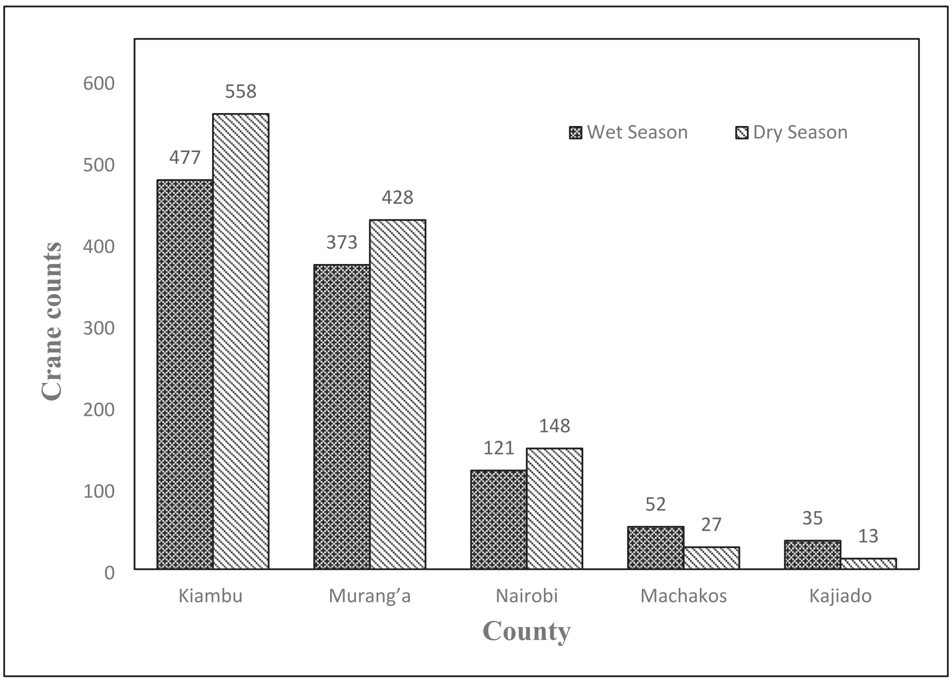

FIGURE 2 | Seasonal variations in Grey Crowned Crane populations across the Nairobi metropolitan area.

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TABLE 2 | Distribution of adult and young Grey Crowned Cranes across counties in Nairobi metropolitan area.

County	*n*	Mean rank (adults)	Mean rank (young)	*U*	*Z*	*p*
Kiambu	102	140.46	64.54	1330.0	−9.690	0.001
Murang'a	64	90.10	38.90	409.5	−8.181	0.001
Nairobi	68	97.38	39.62	348.0	−9.108	0.001
Machakos	14	21.00	8.00	7.0	−4.553	0.001
Kajiado	12	16.75	8.25	21.0	−3.245	0.001

TABLE 3 | Grey Crowned Crane counts across different habitat types during wet and dry seasons in the Nairobi metropolitan area (June 2023–February 2024).

Habitat type	No. of sites	Wet season crane numbers	Dry season crane numbers	Average crane counts
Wetlands	67	595	313	454
Grasslands	40	225	561	393
Cultivated fields	13	164	268	216
Man-made structures	6	64	24	44
Trees	4	10	8	9
Total	130	1058	1174	1116

Note: Average counts were calculated as the mean of wet and dry season observations to avoid double-counting individuals across seasons.

significant ($U=0.0$, $Z=-4.315$, $p<0.001$), indicating increased use of wetlands during the wet season and grasslands during the dry season.

Crane abundance showed a strong positive correlation with the number of suitable wetlands recorded per county ($r_s=1.00$, $p<0.001$), indicating that crane distribution was closely associated with the availability of wetlands where crane use was confirmed during the census. Kiambu County had the highest number of suitable wetland habitats (29) and supported 43.3% of the total crane population observed in wetlands. In contrast, Kajiado County had only three suitable wetland sites occupied by cranes and accounted for just 4.5% of the wetland crane population. Figure 3 provides a visual summary of these results, presenting the number of suitable wetlands and corresponding crane counts recorded in each county.

4 | Discussion

The average Grey Crowned Crane population recorded in this study within the NMA was 1116 individuals, based on counts averaged across the wet and dry seasons. In contrast, national censuses reported lower counts within the NMA, with 449 individuals in 2019 and 716 in 2023, despite similar use of direct count techniques (Bakari et al. 2019; Wamiti et al. 2023). While the core methodology remained comparable, the present study differed in its implementation by incorporating both wet and dry season surveys and achieving broader spatial coverage, including areas that were previously inaccessible or overlooked. These enhancements likely improved crane detectability, particularly in habitats where seasonal presence varies. Averaging data across seasons also reduced temporal bias, especially in counties such as Machakos and Kajiado, where cranes were more abundant during the wet season. These methodological refinements contribute to a more robust and representative estimate of the crane population in this rapidly urbanising region and provide a valuable reference point for future monitoring.

Although this study was conducted within the NMA, the findings contribute to a broader understanding of crane distribution in rapidly developing landscapes. Similar urbanising areas across sub-Saharan Africa and other global regions face comparable challenges in balancing development and biodiversity conservation (Seto et al. 2012; McDonald et al. 2019). As wet habitats continue to decline due to land-use changes, pollution, and infrastructure expansion (Davidson 2014), localised surveys can inform global crane conservation efforts, especially in areas where traditional breeding and foraging grounds are being lost.

Crane abundance varied significantly across counties, with median counts highest in Kiambu, Murang'a, and Nairobi, where suitable wetland availability was also greatest. In contrast, Kajiado and Machakos, which are drier, recorded the fewest cranes. The indication of significant differences in median values across counties statistically supported this spatial pattern. Crane abundance was strongly associated with the number of suitable wetlands recorded per county, underscoring the importance of suitable wetland availability in supporting viable populations. Counties with more suitable wetlands, such as Kiambu, supported a larger share of the total population, while drier counties, such as Kajiado, hosted very few cranes. These findings highlight the spatial link between wetland distribution and population persistence within urbanising regions.

Crane density patterns further illustrate these spatial dynamics. Ecological density, reflecting the actual area occupied by cranes, was highest in Kiambu, followed by Murang'a and Nairobi, with values ranging from 0.89 to 1.12 individuals/km^2 depending on the season. Crude densities based on the total surveyed area mirrored this trend. In contrast, Machakos and Kajiado recorded much lower values in both density types, rarely exceeding 0.02 individuals/km^2. Compared to more protected or less fragmented regions, these values are substantially lower. For

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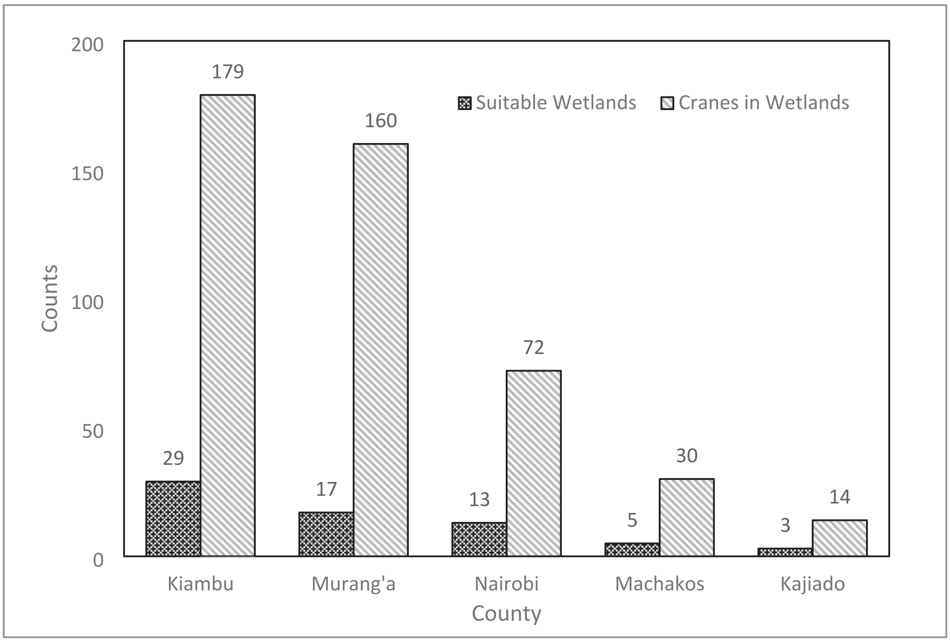

FIGURE 3 | Number of suitable wetlands where crane use was confirmed and corresponding crane counts recorded per county during the census.

instance, Wamiti et al. (2021) recorded 2.12 individuals/km^2 during the dry season and 0.99 during the wet season at Lake Ol' Bolossat, while Gichuki (1993) found densities of 1.57–2.89 individuals/km^2 in the Kitale area. Amulike et al. (2020) reported even higher seasonal variation in the Ngorongoro Conservation Area, with 2.4 and 20.2 individuals/km^2 in the wet and dry seasons, respectively. Older records also support this contrast, with Pomeroy (1980) documenting 1.0 individuals/km^2 in Uganda and Burke (1965) recording 0.4 individuals/km^2 in Kisii. The comparatively lower densities in the NMA reflect the effects of urban expansion and wetland fragmentation, which have reduced both habitat quality and availability. Nonetheless, the persistence of cranes in these landscapes highlights their adaptability and the ecological value of remaining wetland patches.

Although total crane counts were generally higher during the dry season, the difference was not statistically significant, likely reflecting improved detectability in open habitats rather than actual population changes. Similar patterns have been documented elsewhere, where dry season conditions such as reduced vegetation cover and congregation of cranes around remaining water sources enhance count accuracy (Gichuki 1993; Amulike et al. 2023; Wamiti 2022). This supports the use of averaged seasonal counts to reduce bias, particularly in counties like Machakos and Kajiado, where wet-season presence was more evident. These findings reinforce the value of multi-season monitoring to inform conservation in urbanising and fragmented landscapes (Pomeroy 1980; Meine and Archibald 1996).

The observed proportion of young cranes in the NMA was 6.4%, which falls below the reproductive levels reported in other key crane habitats in Kenya. For example, Gichuki (1993) recorded a proportion of 12.8% in the Kitale region, while Wamiti et al. (2021) reported 11.65% in Lake Ol' Bolossat. These areas are characterised by larger, less fragmented wetlands and lower human disturbance, suggesting more favourable breeding conditions compared to the urbanised and degraded habitats in the NMA. Although the presence of young cranes in this study indicates some level of recruitment, the observed proportion remains below the 10%–15% threshold typically considered necessary to maintain stable crane populations (Meine and Archibald 1996). This shortfall may be attributed to ongoing pressures such as habitat loss, disturbance from human activity, and reduced breeding success in small or degraded wetlands, emphasising the need for targeted conservation efforts to improve reproductive outcomes in urban landscapes.

Grey Crowned Cranes were most frequently observed in wetlands during the wet season, when rising water levels and increased food availability, particularly macroinvertebrates, aquatic insects, and soft vegetation, created optimal foraging and breeding conditions (Dunn et al. 2011; McKinnon et al. 2012; Santana et al. 2015). These wetlands provided secure nesting sites, access to abundant high-protein food sources, and reduced predation risks, all of which are critical for chick survival and development (McWethy and Austin 2009; Kumar and Kanaujia 2017; Wamiti et al. 2021; Lee 2024). As the dry season progressed and wetland water levels receded, many habitats became less suitable, prompting cranes to shift towards terrestrial environments such as grasslands and postharvest croplands. In these areas, cranes were frequently observed feeding on residual grain and actively foraging for invertebrates in short grass patches. These seasonal shifts are consistent with the predictions of optimal foraging theory, which suggests that animals make strategic decisions to maximise net energy gain while minimising effort and risk (Kie 1999). In increasingly fragmented and human-modified landscapes, such behavioural flexibility is critical to survival and may represent an adaptive response to habitat degradation and shifting resource landscapes on a global scale.

While terrestrial habitats in the study area did not support breeding, they served as important dry season foraging grounds, allowing cranes to persist when wetlands were dry or disturbed. Comparable habitat switching patterns have been

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documented in other crane populations and large-bodied wetland birds in both African and Asian landscapes, especially in regions facing intensive land-use change and urban encroachment (Muheebwa-Muhoozi 2004; Nagwere 2014; Olupot 2016; Fakarayi et al. 2016; Austin 2018). These findings underscore the ecological necessity of maintaining a network of seasonally complementary habitats to support cranes across their full annual cycle. As urban expansion and wetland loss continue to threaten biodiversity globally, conserving habitat heterogeneity is essential for sustaining crane populations not only in Kenya but also across other urbanising regions in sub-Saharan Africa and beyond.

Crane abundance closely aligned with the number of suitable wetlands recorded per county, confirming a strong spatial association between crane presence and suitable wet habitat availability. Counties with more suitable wetlands, such as Kiambu, supported a larger share of the wetland population, while drier counties like Kajiado recorded notably fewer cranes. Even in fragmented urban landscapes, cranes were rarely observed far from wetland patches. In some cases, they exhibited adaptive behaviour by using artificial sites. For example, over 100 individuals were observed busking at a disused polythene-lined dumping site located approximately 500 m from a frequently used wetland in Murang'a. The birds appeared to shift temporarily to this site when human activity occurred in the main wetland. Similarly, a breeding pair was observed nesting in an abandoned sewage pond in Thika. Although such artificial sites may provide short-term refuge, they are unlikely to sustain viable populations in the long-term. These findings support earlier observations by Nagwere (2014) and highlight the urgent need to protect and restore natural wetlands to safeguard the long-term survival of Grey Crowned Cranes in rapidly urbanising regions.

Our study provides important insights into the spatial and seasonal population distribution of Grey Crowned Cranes in a rapidly urbanising African landscape. The findings demonstrate that even degraded or seasonal wetlands embedded in working and urban areas continue to support essential ecological functions such as foraging and breeding. The positive association between young crane occurrence and wetland availability suggests that small or marginal wetlands can significantly contribute to reproductive success. As urban development and infrastructure expansion increasingly threaten these habitats, integrating wetland conservation into land-use planning is critical to sustaining viable crane populations in metropolitan and rapidly urbanising cities across sub-Saharan Africa. Protecting or restoring even small and fragmented wetland patches could enhance breeding outcomes for Grey Crowned Cranes and other wetland-dependent species in comparable settings.

5 | Conclusion

Grey Crowned Cranes in the NMA display pronounced spatial and seasonal population variation, strongly influenced by the availability and quality of wetland habitats. Counties with more suitable wetlands supported higher crane counts and recorded more young cranes, underscoring the vital role of wetlands in both foraging and reproductive success. The seasonal habitat shifts observed between wetlands in the wet season and terrestrial areas during the dry season are consistent with optimal foraging strategies in response to changing resource conditions. Despite urban pressures, even small or modified wetlands provide critical ecological support.

Conservation efforts must prioritise the protection, restoration, and integration of wetlands into land-use planning to ensure long-term species persistence in urbanising landscapes. We recommend further research to evaluate the ecological functionality of artificial wetlands and to explore the influence of wetland area rather than number alone on crane habitat use and population dynamics. Such insights are essential for developing targeted and evidence-based conservation strategies for wetland-dependent species in human-dominated regions.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Amulike, B. B., T. K. Fuller, P. W. Houlihan, and C. R. Griffin. 2020. "Seasonal Variation in Grey Crowned Crane (*Balearica Regulorum*) Abundance in the Ngorongoro Crater, Tanzania." *African Journal of Ecology* 58, no. 4: 685–691. https://doi.org/10.1111/aje.12738.

Amulike, B. B., C. R. Griffin, and T. K. Fuller. 2023. "Using Local Ecological Knowledge to Inform Grey Crowned Crane Distribution and Status in Tanzania." *African Journal of Wildlife Research* 53, no. 1: 29–44. https://doi.org/10.3957/056.053.0029.

Austin, J. E. 2018. "Threats to Cranes Related to Agriculture." In *Cranes and Agriculture: A Global Guide for Sharing the Landscape*, edited by J. E. Austin, K. L. Morrison, and J. T. Harris, 83–116. International Crane Foundation.

Bakari, N., D. Kimani, W. Schröder, et al. 2019. "Results of the 2019 Countrywide Census of Grey Crowned Crane *Balearica regulorum gibbericeps* in Kenya."

Beilfuss, R. D., T. Dodman, and E. K. Urban. 2007. "The Status of Cranes in Africa in 2005." *Ostrich* 78, no. 2: 175–184. https://doi.org/10.2989/ostrich.2007.78.2.11.91.

BirdLife International. 2012. "*Balearica regulorum*." The IUCN Red List of Threatened Species 2012. https://www.iucnredlist.org/species/22692028/9305115.

BirdLife International. 2016. "*Balearica regulorum*." The IUCN Red List of Threatened Species 2016. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22692046A93334893.en.

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Burke, V. E. M. 1965. "A Count of Crowned Cranes (*Balearica Regulorum*) (Bennet) in Kisii District, Kenya." *Journal of East African Natural History* 25, no. 3: 162–163.

Butcher, G. S., M. R. Fuller, L. S. McAllister, and P. H. Geissler. 1990. "An Evaluation of the Christmas Bird Count for Monitoring Population Trends of Selected Species." *Wildlife Society Bulletin (1973–2006)* 18, no. 2: 129–134. https://www.jstor.org/stable/3782126.

Davidson, N. C. 2014. "How Much Wetland Has the World Lost? Long-Term and Recent Trends in Global Wetland Area." *Marine and Freshwater Research* 65, no. 10: 934. https://doi.org/10.1071/mf14173.

Dunn, P. O., D. W. Winkler, L. A. Whittingham, S. J. Hannon, and R. J. Robertson. 2011. "A Test of the Mismatch Hypothesis: How Is Timing of Reproduction Related to Food Abundance in an Aerial Insectivore?" *Ecology* 92, no. 2: 450–461. https://doi.org/10.1890/10-0478.1.

Fakarayi, T., C. Mashapa, E. Gandiwa, and S. Kativu. 2016. "Varying Land-Use Has an Influence on Wattled and Grey Crowned Cranes' Abundance and Distribution in Driefontein Grasslands Important Bird Area, Zimbabwe." *PLoS One* 11, no. 11: e0166209. https://doi.org/10.1371/journal.pone.0166209.

Gichuki, N. N. 1993. "Factors Affecting the Reproductive Success of the Grey Crowned Crane." Doctoral Thesis, University of Cambridge.

Harris, J., and C. Mirande. 2013. "A Global Overview of Cranes: Status, Threats and Conservation Priorities." *Chinese Birds* 4, no. 3: 189–209. https://doi.org/10.5122/cbirds.2013.0025.

Kenya Wildlife Service. 2025. *National Single Species Action Plan for the Conservation of the Grey Crowned Crane (Balearica regulorum gibbericeps) in Kenya (2025–2034)*. Kenya Wildlife Service.

Kie, J. G. 1999. "Optimal Foraging and Risk of Predation: Effects on Behavior and Social Structure in Ungulates." *Journal of Mammalogy* 80, no. 4: 1114–1129. https://doi.org/10.2307/1383163.

Kumar, A., and A. Kanaujia. 2017. "Habitat Preference and Social Composition of Sarus Cranes in Unnao, District, Uttar Pradesh, India." *Biological Forum–an International Journal* 9, no. 2: 10–16.

Lee, K. 2024. *Multi-scale Patterns of Breeding Habitat Selection in Sandhill Cranes Across Canada's Eastern Boreal Forest*. University of Waterloo.

Maina, C., B. Mwangi, and J. Jumbe. 2021. "Species Composition and Distribution of Mayflies (Ephemeroptera) in Relation to Land Use Systems Along the Thika River, Kenya." *African Journal of Aquatic Science* 46, no. 2: 196–205. https://doi.org/10.2989/16085914.2020.1842169.

Masese, F. A. 2010. "Investigation of Pollutants, Determination of Physico-Chemical Characteristics of the Nairobi River and Remediation of Some Toxic Heavy Metals Using Fish Bones." Master's Thesis, University of Nairobi. University of Nairobi Research Archive.

McDonald, R. I., A. V. Mansur, F. Ascensão, et al. 2019. "Research Gaps in Knowledge of the Impact of Urban Growth on Biodiversity." *Nature Sustainability* 3, no. 1: 16–24. https://doi.org/10.1038/s41893-019-0436-6.

McKinnon, L., M. Picotin, E. Bolduc, C. Juillet, and J. Bêty. 2012. "Timing of Breeding, Peak Food Availability, and Effects of Mismatch on Chick Growth in Birds Nesting in the High Arctic." *Canadian Journal of Zoology* 90, no. 8: 961–971. https://doi.org/10.1139/z2012-064.

McWethy, D. B., and J. E. Austin. 2009. "Nesting Ecology of Greater Sandhill Cranes (*Grus canadensis tabida*)in Riparian and Palustrine Wetlands of Eastern Idaho." *Waterbirds* 32, no. 1: 106–115. https://doi.org/10.1675/063.032.0112.

Meine, C. D., and G. W. Archibald. 1996. "The Cranes - Status Survey and Conservation Action Plan." In *International Union for Conservation of Nature and Natural Resources*, edited by J. E. Austin, K. L. Morrison, and J. T. Harris. International Crane Foundation.

Morrison, K. 2015. "International Single Species Action Plan for the Conservation of the Grey Crowned Crane *Balearica regulorum*." AEWA Technical Series 73.

Morrison, K. L., T. Dodman, A. Scott, G. Shanungu, J. Smallie, and W. Versveld. 2019. "Species Review: Grey Crowned Crane (*Balearica Regulorum*)." In *Crane Conservation Strategy*, edited by T. Dodman, M. Anderson, and K. Morrison, 261–271. International Crane Foundation.

Muheebwa-Muhoozi, J. 2004. "Assessing the Status of the Grey Crowned Crane (*Balearica regulorum*) in Uganda." Master's Thesis Makerere University, Uganda.

Muriithi, M. W. 2014. "An Assessment of Human-Induced Impacts on Urban Wetlands: A Case Study of the Nairobi Dam." Master's Thesis, University of Nairobi, Kenya.

Nagwere, N. 2014. *The Diurnal Activity Pattern of the Grey Crowned Crane (Balearica regulorum gibbericeps) in Mbarara Municipality, Southwestern Uganda*. Mbarara University of Science and Technology.

Olupot, W. 2016. "Grey Crowned Crane Threat Assessment Around the Wetlands of Eastern Uganda." *Ostrich* 87, no. 3: 263–270. https://doi.org/10.2989/00306525.2016.1214931.

Olupot, W., H. Mugabe, and A. J. Plumptre. 2010. "Species Conservation on Human-Dominated Landscapes: The Case of Crowned Crane Breeding and Distribution Outside Protected Areas in Uganda." *African Journal of Ecology* 48, no. 1: 119–125. https://doi.org/10.1111/j.1365-2028.2009.01091.x.

Omoto, W. O. 2009. "Smallholder Dairy Farming Land Use in the Nairobi Metropolitan Region, Kenya." Doctoral dissertation, Bangor University, Bangor University Research Portal.

Omwenga, M. 2010. "Nairobi: Emerging Metropolitan Region, Development Planning and Management Opportunities and Challenge." Isocarp Congress, 1–12.

Pomeroy, D. E. 1980. "Aspects of the Ecology of Crowned Cranes *Balearica Regulorum* in Uganda." *Scopus* 4: 29–35.

Santana, H., L. Silva, C. L. Pereira, J. Simião-Ferreira, and R. Angelini. 2015. "The Rainy Season Increases the Abundance and Richness of the Aquatic Insect Community in a Neotropical Reservoir." *Brazilian Journal of Biology* 75, no. 1: 144–151. https://doi.org/10.1590/1519-6984.09213.

Seto, K. C., B. Güneralp, and L. R. Hutyra. 2012. "Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools." *Proceedings of the National Academy of Sciences* 109, no. 40: 16083–16088. https://doi.org/10.1073/pnas.1211658109.

Sherwani, R. A., H. Shakeel, W. B. Awan, M. Faheem, and M. Aslam. 2021. "Analysis of COVID-19 Data Using Neutrosophic Kruskal Wallis H Test." *BMC Medical Research Methodology* 21, no. 1: 215. https://doi.org/10.1186/s12874-021-01410-x.

Spino, M., S. C. Kurz, L. Chiriboga, et al. 2019. "Cell Surface Notch Ligand DLL3 Is a Therapeutic Target in Isocitrate Dehydrogenase–Mutant Glioma." *Clinical Cancer Research* 25, no. 4: 1261–1271. https://doi.org/10.1158/1078-0432.ccr-18-2312.

Urban, E. K. 1988. "Status of Cranes in Africa." In *Proceedings of the Sixth Pan-African Ornithological Congress*, edited by G. C. Backhurst, 315–329. Sixth Pan-African Ornithological Congress Organizing Committee.

Wamiti, S. W. 2022. "Factors Affecting Population, Nesting Habits, and Conservation of Grey Crowned Crane (*Balearica Regulorum*, Bennett 1834) in Lake Ol' Bolossat Basin, Kenya." Doctoral dissertation, University of Nairobi.

Wamiti, W., N. Gichuki, D. A. Sigana, P. Njoroge, G. Nowald, and D. Fox. 2021. "Population, Flocking Behaviour and Habitat Selection of the Grey Crowned Crane *Balearica Regulorum* at Lake Ol'bolossat Basin, Kenya." *Journal of East African Ornithology* 41, no. 1: 13–23.

13652028, 2025, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/aje.70084 by INASP - KENYA University of Nairobi, Wiley Online Library on [16/08/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Wamiti, W., J. Mwangi, G. Ndung'u, et al. 2023. "Kenya's Second Countrywide Census of Grey Crowned Crane *Balearica regulorum*: February-March 2023." Technical Report NABU, ICF/EWT/CANCO & NMK. Nairobi, Kenya.

Wang, C., G. Wang, Z. Guo, et al. 2020. "Effects of Land-Use Change on the Distribution of the Wintering Red-Crowned Crane (*Grus japonensis*) in the Coastal Area of Northern Jiangsu Province, China." *Land Use Policy* 90: 104269. https://doi.org/10.1016/j.landusepol.2019.104269.

Wangari, M. R. 2022. "The Status of Drinking Water at Gachagi Informal Settlement in Thika Sub-County, Kiambu County, Kenya." Master's Thesis, Kenyatta University.

13652028, 2025, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/aje.70084 by INASP - KENYA University of Nairobi, Wiley Online Library on [16/08/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License