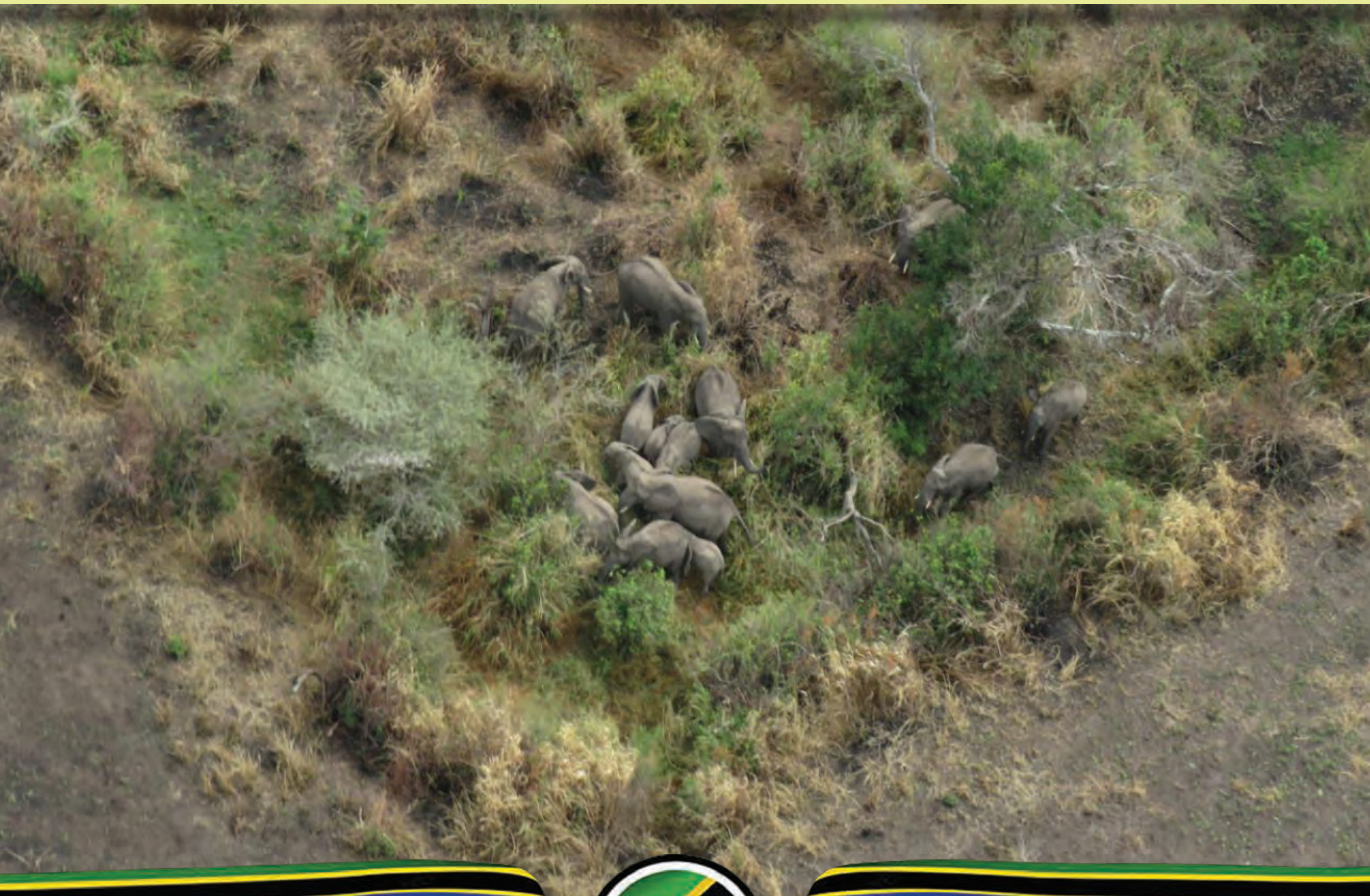
THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF NATURAL RESOURCES AND TOURISM

TANZANIA WILDLIFE RESEARCH INSTITUTE

AERIAL WILDLIFE SURVEY OF LARGE ANIMALS AND HUMAN ACTIVITIES IN THE SAADANI-WAMI-MBIKI ECOSYSTEM, DRY SEASON 2022



Editors:

Alex Lobora
Eblate Mjingo
Stephen Nindi
John Bukombe
Hamza Kija
Edward Kohi
Machoke Mwita
John Sanare

Published by:

Tanzania Wildlife Research Institute,
P. O. Box 661,
Arusha, Tanzania.
Tel: +255 734 094646

Email: barua@tawiri.or.tz

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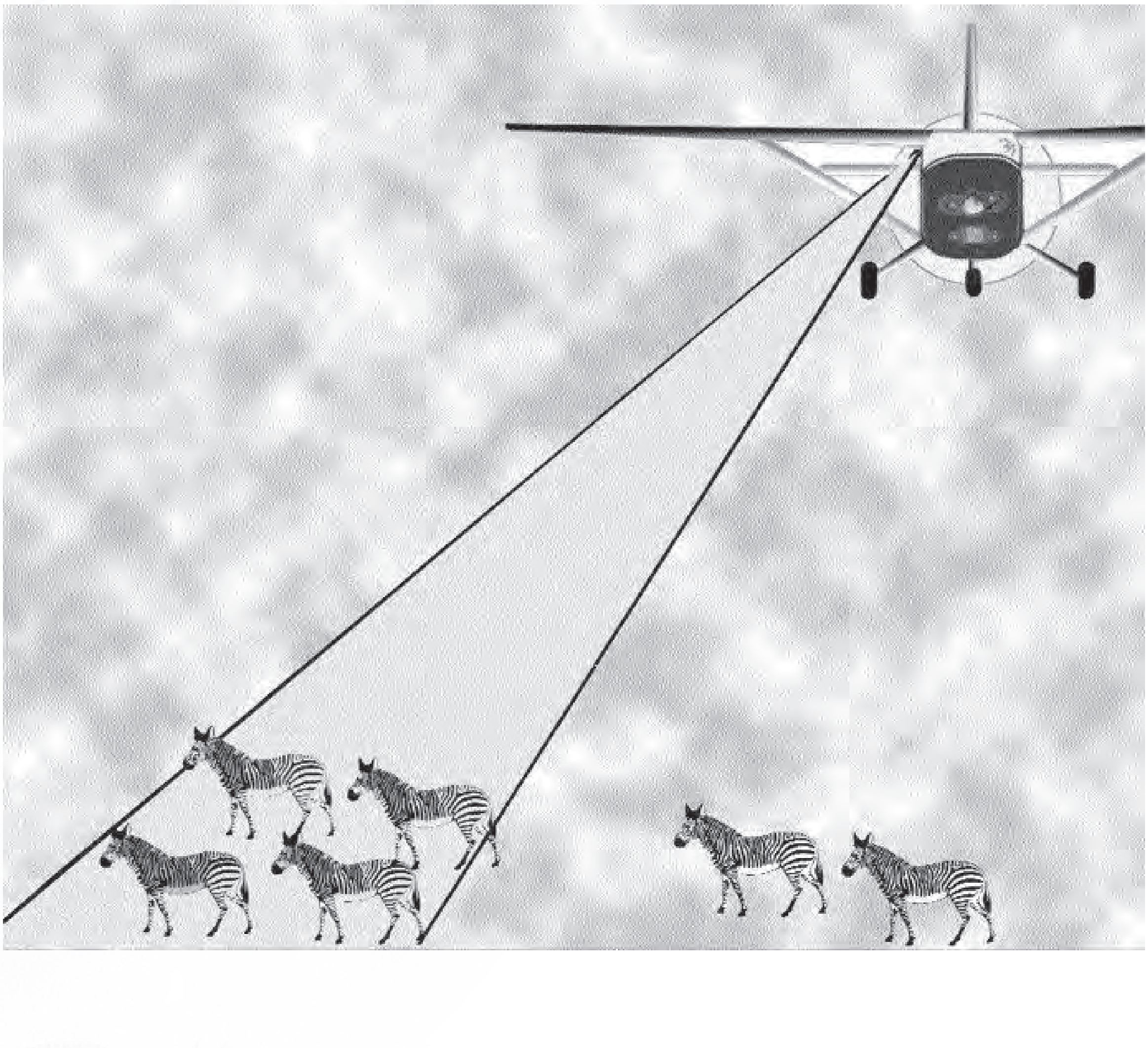
Systematic Reconnaissance Flight (SRF) Census Report

Aerial Wildlife Survey of Large animals and human activities in the Saadani-Wami-Mbiki Ecosystem, Dry Season 2022



Conducted by

TANZANIA WILDLIFE RESEARCH INSTITUTE

The successful implementation of the Saadani-Wami-Mbiki ecosystem aerial survey was a product of thorough planning, hard work, and good collaboration between government organisations led by the Tanzania Wildlife Research Institute. Other partners include;

	TANZANIA NATIONAL PARKS P. O. Box 3134, Arusha Email: info@tanzaniaparks.go.tz	Tanzania National Parks (TANAPA) was established in 1959 to manage and regulate the use of areas designated as National Parks.
	TANZANIA WILDLIFE MANAGEMENT AUTHORITY Dar-es-Salaam Road Kingolwira Area P. O. Box 2658, Morogoro Email: cc@tawa.go.tz	Tanzania Wildlife Management Authority (TAWA) was established by Ministerial order in 2014 to sustainably conserve and utilise wildlife resources in Game Reserves, Game Controlled Areas and Open Areas.

EXECUTIVE SUMMARY

This report presents the results of an aerial wildlife survey of large to small mammals and human activities in the Saadani-Wami-Mbiki Ecosystem in the dry season of 2022. The survey was conducted from 22nd to 28th September 2022, with funding from the Government of the United Republic of Tanzania. The Saadani-Wami-Mbiki Ecosystem covers a total area of 3,485 km^2 (1,154 km^2 being Saadani National Park and 2,331 km^2 of the Wami-Mbiki Game Reserve). The survey's main objective was to establish the population status of medium to large mammals and their spatial distribution as well as human activities in the ecosystem.

The survey recorded three (3) sightings of 47 individuals of African Elephants in Saadani National Park, 20 sightings of reedbuck with 43 individuals, 15 sightings of giraffes with 40 individuals, 13 sightings of impala with 37 individuals, two (2) sightings of Hippos with 36 individuals, seven (7) sightings of elands with 36 individuals, eight (8) sightings of kongoni with 35 individuals and four (4) sightings of waterbucks with 28 individuals. Furthermore, the survey recorded 11 sightings of wild pigs with 24 individuals, eight (8) sightings of kongoni with 35 individuals and one (1) sighting of Sable Antelope was also sighted with seven (7) individuals. One stage three elephant carcass was observed within a strip inside the park boundaries, representing a mortality rate of approximately 2.1%, which is significantly below the typical 8% threshold. The encroachment of humans was evident through various activities, including cattle and resource extraction practices such as tree felling, sawpits and poachers' camps. In particular, the survey recorded 25 sightings of cattle with 1186 individuals and 18 sightings of charcoal kilns in 42 different places within the park, indicating wood extraction for charcoal production. Furthermore, four (4) sightings of Sawpits were documented in four (4) places within the park suggesting the illegal cutting of trees. Additionally, thatched grass bomas were seen 16 times in three different sightings, indicating temporary human settlements within the park. Unfortunately, none of the observed species and human activities above had a sufficient minimum number of the required sightings (≥30) to generate estimates within the park and therefore, our report is based on recorded numbers, not estimates.

On the other hand, in Wami-Mbiki Game Reserve, the survey recorded 29 sightings of duiker with 53 individuals, eight (8) sightings of impala with 46 individuals, 26 sightings of bushbuck with 46 individuals and one (1) sighting of kongoni, reedbuck and warthog with one (1) individual each. Similarly, the survey recorded signs of human encroachment, including cattle, tree felling and charcoal kilns. In particular, the survey recorded 46 sightings of cattle with 3,207 individuals and eight (8) sightings of shoats with a count of 305 individuals. As observed in Saadani National Park, none of the observed species and human activities above had a sufficient minimum number of sightings (≥30) required to generate estimates within the park. However, the large number of cattle indicated in the two protected areas may explain the low sightings of species, hence the reason for insufficient sightings to generate reliable estimates. Encroachment threatens biodiversity and leads to habitat degradation and species displacement. The presence of shoats, which typically refers to domesticated sheep and goats, further underscores the human influence within the ecosystem. These animals may contribute to overgrazing and damage to vegetation, affecting the availability of food and shelter for

native wildlife. In general, these low records are concerning, as it suggests a potential disruption of the natural habitat and an imbalance in the ecosystem primarily attributed to active human activities. It is, therefore, imperative for TAWA and TANAPA to take the necessary actions to protect and sustain the wildlife populations in the two protected areas.

Key Findings and Recommendations

The survey recorded insufficient species sightings throughout the ecosystem (< 30) to generate meaningful estimates. This is primarily attributed to widespread human activities recorded in this ecosystem, especially in Wami-Mbiki Game Reserve. Regarding elephant mortality, only one stage three carcass was recorded in SNP. This number represents a mortality rate of approximately 2.1%, significantly below the normal eight (8) percent threshold. These findings highlight the success of conservation efforts in minimising elephant poaching within SNP. In general, TAWIRI recommends the following;

Law Enforcement: Strict enforcement of anti-poaching measures and regulations is essential to safeguard the wildlife populations in the two protected areas. Adequate patrolling, surveillance, and coordination with local communities can help deter illegal activities such as poaching and encroachment. Engaging local communities in conservation initiatives through education and awareness programs can foster a sense of ownership and pride in protecting the reserve's natural resources.

Habitat Restoration: Restoration efforts should focus on evacuating settlements and preventing human encroachment within the ecosystem and the two protected areas. The 2022 census revealed a high density of human settlements and activities within the reserve, suggesting the reason for the few sightings experienced during the census. The key to habitat restoration should also focus on securing connectivity between the two protected areas for gene flow, as there is currently little evidence to suggest that the movement of species exists between the two protected areas due to human activities between them. Collaboration with ecological experts and stakeholders will be beneficial in implementing effective habitat restoration strategies, including engagement of the community and relevant leaders for a smooth ride during the exercise.

Restocking: It is crucial to introduce additional individuals of the species that have experienced a notable decline, particularly in the reserve. They include Duiker, Bushbuck, Greater Kudu, Impala, Wild Pig, Eland, Kongoni/Hartebeest, Reedbuck, Warthog and Zebra, to mention a few. However, a comprehensive assessment of the reserve's ecological requirements and species distribution patterns should be undertaken to identify additional candidate species for restocking.

Multifaceted management approaches: Implementing sustainable management practices, regular monitoring, and adaptive management strategies should be integrated into the conservation plans for Wami-Mbiki Game Reserve. This will ensure the conservation of the reserve's biodiversity and enhance its resilience to future challenges.

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ABBREVIATIONS AND ACRONYMS

CIMs	Conservation Information and Monitoring Section
FSO	Front Seat Observer
GPS	Global Positioning System
GR	Game Reserve
IUCN	International Union for Conservation of Nature
MIKE	Monitoring the Illegal Killing of Elephants
NP	National Park
PA	Protected Area
RSO	Rear Seat Observer
SRF	Systematic Reconnaissance Flight
TANAPA	Tanzania National Parks
TAWIRI	Tanzania Wildlife Research Institute
TWCM	Tanzania Wildlife Conservation Monitoring
URT	United Republic of Tanzania
WD	Wildlife Division
WMGR	Wami-Mbiki Game Reserve
SWME	Saadani-Wami-Mbiki Ecosystem

GLOSSARY OF TERMS

Survey Area (Z)	The whole area in which the number of animals is to be estimated. In some censuses, the survey area is divided into sub-zones (strata) for various reasons. For example, divisions could be based on political and/or management boundaries or ecological zones.
Sample zone	That portion of the survey area searched and counted. Counting every animal in a protected area would be prohibitively expensive and time-consuming (sizes ranging from 200 to 150,000 km^2). For this reason, only parts of the survey area are searched and we assume that what is seen in those parts (samples) represents what we would be if we searched over the other parts. In SRF, the sample zone is made up of transects and each transect represents a sample unit.
Population Estimate (Y)	All animal and human activities recorded during an SRF. The assumption made is that animals are evenly distributed over the survey area so that if 10% of the area is searched, it will contain about 10% of the animals. This allows the estimation of the number of animals in the survey area. The standard error describes how exact (reliable) our population estimate is.

1.0. INTRODUCTION

Wildlife surveys provide invaluable insights into the status of wildlife populations. Different methodologies, such as aerial and ground surveys, are employed in these surveys. Aerial surveys, in particular, are advantageous for quickly covering vast expanses, mapping the distribution of wildlife, and observing human activities like livestock raising, farming, and settlement patterns within these habitats. Presently, wildlife aerial surveys in the country span major ecosystems, covering about 300,000 km² in a cycle that repeats roughly every three years (TAWIRI, 2019). Conducting periodic surveys in these habitats enables conservation managers to track wildlife population dynamics and shifts, pinpoint threats such as poaching, habitat degradation, and human interference, and elucidate remarkable phenomena like the seasonal transboundary migration of wildebeests. The maps produced from these surveys give managers a clear perspective on the spatial distribution of natural resources and their challenges, laying the groundwork for effective conservation strategies. Identifying where natural resources are located and what is affecting them provides a foundation for managers to take appropriate actions to prevent threats and protect wildlife populations.

This report presents results on the status of wildlife and human activity from the Systematic Reconnaissance Flight (SRF) survey conducted between 22 and 28 November 2022 in Saadani National Park (SNP) and Wami-Mbiki Game Reserve (WMGR). The survey was conducted during the dry season, explicitly aiming to; (i) determine the current population status of wildlife in the Saadani-Wami-Mbiki Ecosystem and compare results with the previous census and (ii) Map the distribution and density of wildlife species and human activity within the protected and adjacent community areas. According to the SRF rule, estimates for wildlife and human activities are based on the number of sightings. However, aside from human activities in WMGR which had an adequate number of sightings, estimates for other species and human activities couldn't be produced because most of the records fell short of the minimum number of sightings (≥30) necessary for estimate generation (Jolly, 1969; Norton-Griffith, 1978). Therefore, this report presents only wildlife species counted in the area and their spatial distribution and recommends ways to ensure the sustainability of the two PAs. Historically, ten (10) surveys have been conducted in SNP during the past 21 years, covering an area spanning from 1,528 km² in 1997 to 2,753 km² in 2022 (Appendix 3).

The Wami-Mbiki Game Reserve, previously known as the Wami-Mbiki Wildlife Management Area (WWMA), was reclassified as a Game Reserve in 2020. Since this new designation, the recent census marks the inaugural official wildlife survey for the area, serving as a foundational reference, detailing both the wildlife populations and human activities within the reserve. Previously, there were concerns regarding the WWMA's inadequacy in conducting effective anti-poaching patrols. This shortfall resulted in a surge in illicit activities, such as poaching, overgrazing, tree-felling, and charcoal production. In light of these challenges, the government took a strategic decision to elevate its status to a Game Reserve. This move aimed to integrate it more effectively within the Saadani-Wami-Mbiki Ecosystem (SWME), where wildlife interactions had previously proven more harmonious and successful. Recognising the importance of preserving the wildlife within this ecosystem, gaining a comprehensive understanding of the area's biodiversity and resources became essential.

2.0. SURVEY AREA AND METHODS

2.1. Survey area

2.1.1. Saadani-Wami-Mbiki Ecosystem (SWME)

The Saadani-Wami-Mbiki Ecosystem (SWME) consists of two protected areas, namely the Saadani National Park and the Wami-Mbiki Game Reserve (WMGR). These two protected areas are approximately 45 km apart and artificially connected by natural habitat fragments requiring immediate protection. The SWME is situated between Latitude 5° 56' and 6° 13' S and Longitude 38° 42' to 38° 49' E (Fig. 1), encompassing a vast area of 3,485 km^2 (of which 1,154 km^2 is SNP and 2,331 km^2 is WMGR). The Saadani-Wami-Mbiki wildlife corridor connects SNP and WMGR to form one ecosystem, namely Saadani-Wami-Mbiki Ecosystem (SWME), forming the remaining wilderness and big game populations. The ecosystem is enriched by the Indian Ocean Coastal line, the Wami River as well as the Zaraninge Forest and is the only coastal ecosystem forming a unique terrestrial-marine nexus in Tanzania. It harbours globally significant populations of wildlife species, including the African elephants, lions, Cape buffaloes, leopards, Masai giraffes, Lichtenstein's hartebeest, waterbucks, blue wildebeests, bohor reedbucks, hippopotamuses and crocodiles.

The ecosystem is home to big game populations of global significance, boasting iconic African Savannah elephants, majestic lions, powerful Cape buffaloes, graceful Masai giraffes, and elusive leopards. Additionally, the ecosystem supports a diverse array of smaller and medium-sized wildlife species, such as Guinea fowl and other fascinating creatures. What sets this reserve apart is its unique combination of natural features, including the Indian Ocean Coastline, the meandering Wami River, and the captivating Zaraninge Forest, which together form a remarkable terrestrial-marine nexus, making it the only coastal ecosystem of its kind in Tanzania.

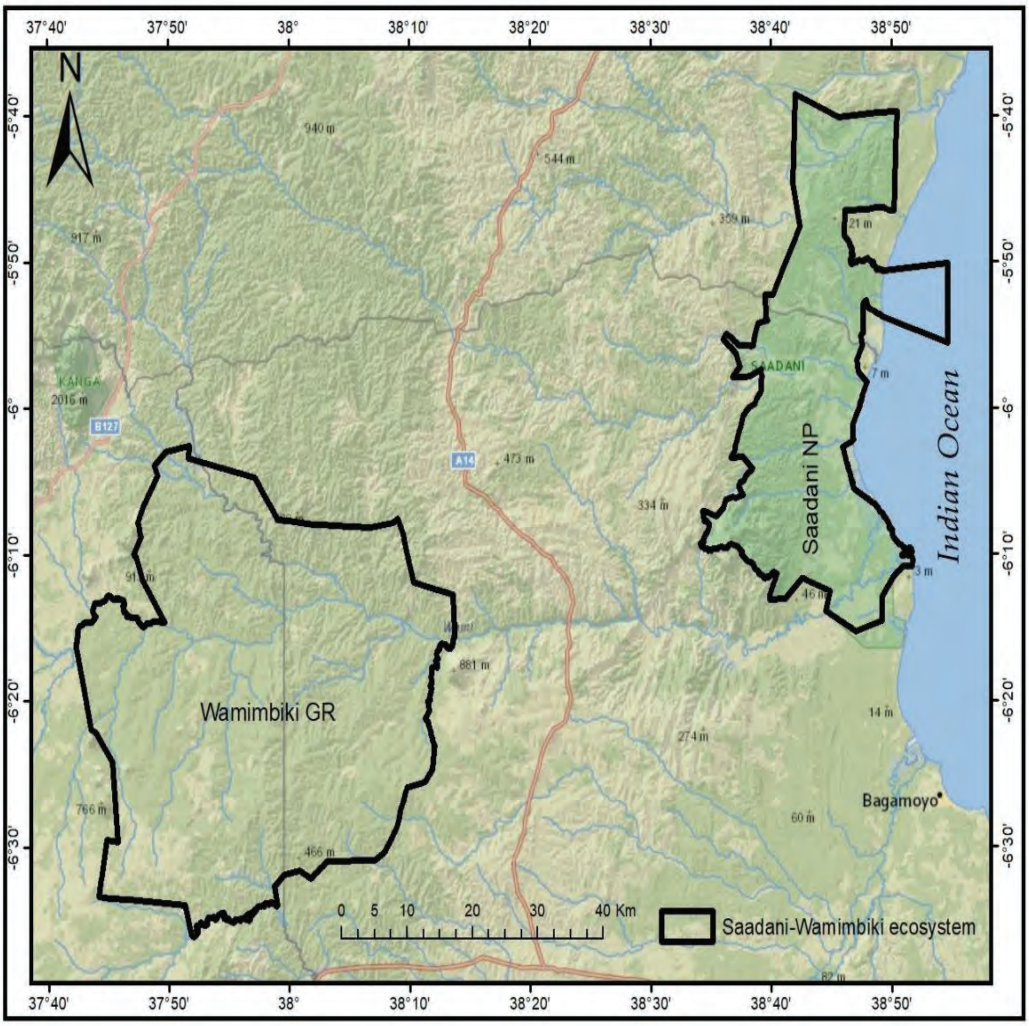

Figure 1: Location of Saadani-Wami-Mbiki Ecosystem

2.1.1 Saadani National Park

Saadani National Park (SNP) is in Eastern Tanzania, spanning three districts of Pangani, Bagamoyo and Handeni. It lies between Latitude -5° 38' 32" to -6° 16' 26" South and Longitude 38° 34' 07" to 38° 54' 35" East (Fig. 2). The park is the only protected wildlife area in Tanzania situated along the coast of the Indian Ocean, approximately 100 km north of Dar-es-Salaam, near Bagamoyo township. Originally, the area was gazetted Saadani Game Reserve, covering an initial area of approximately 200 km^2. On the 24th of January 1969, Southern and North Mkwaja, a former ranch spanning 400 km^2, was incorporated into the reserve, along with Zaraninge, a closed canopy tropical forest covering 200 km^2. In 2005, the Saadani Game Reserve was elevated to National Park status, becoming the 13th national park under the Tanzania National Parks authority (TANAPA) jurisdiction and expanding to an area of 1,100 km^2 to ensure higher levels of protection. The park headquarters is based at Mkwaja (Fig. 2).

SNP's landscape primarily consists of flat to undulating terrain, featuring a diverse vegetation mosaic of forests, savannas, and grasslands. The dominant vegetation types include acacia woodland, coastal thickets, and miombo woodland. Additionally, the park plays a crucial role in preserving a substantial area of mangrove forest around the mouth of the Wami River on its southern boundary. The Mkwanja and Zaraninge plateaus, adorned with ancient coastal forests, are particularly noteworthy for their rich variety of indigenous vegetation, which provides essential support for diverse bird and animal life (Burgees *et al*., 1992; Blosch & Klotzli, 2002). Regarding the climate, the rainfall pattern in the area is bimodal, with a short rainy season occurring from October to December, where monthly averages surpass 100 mm, and a long rainy season extending from March to the beginning of June (Tobler, 2001; Bloesch & Klötzli, 2002). Conversely, the dry season is January, February, July, August, and September (Cech, 2008). Due to the relatively modest annual rainfall of around 900 mm and the nutrient-deficient soils (Cech, 2008), the savannah in this region can be classified as humid dystrophic (Huntley, 1982 & Tobler *et al*., 2003). Despite distinct wet and dry seasons, the humidity remains relatively high throughout the year, resulting in no severe dry months (Bloesch & Klötzli, 2002). The mean annual temperature is recorded at 26˚C, with an annual range of 5˚C and a daily range of 8˚C (Bloesch & Klötzli, 2002).

The park provides a habitat for a diverse array of approximately 30 mammal species, including hartebeest, waterbuck, bohor reedbuck, giraffe, various duiker species, warthog, and wildebeest. Notably, there are also predators present, such as Lions, some of which were introduced to the area (Rodgers & Swai 1978; TAWIRI 2010) and as a result, it is crucial to conduct frequent monitoring to ensure scientifically sound management of the ecosystem. The park boasts a landscape characterised by acacia woodland, coastal thickets, and miombo woodland. Moreover, it encompasses a significant expanse of mangrove swamps located around the mouth of the Wami River on its southern boundary. The park's location close to the equator and its coastal setting along the warm Indian Ocean exposes it to tropical climatic conditions. The region experiences two distinct wet seasons: the 'long rains' from March to May and the 'short rains' from October to November. Throughout the wet season, average temperatures remain consistently high year-round, with afternoon temperatures reaching around 33°C/91°F and night-time temperatures hovering at approximately 23°C/73°F. Conversely, during the Dry season spanning June, July, August, and September, afternoon temperatures are slightly cooler, averaging around 31°C/88°F, while night-time temperatures cool down to about 21°C/70°F.

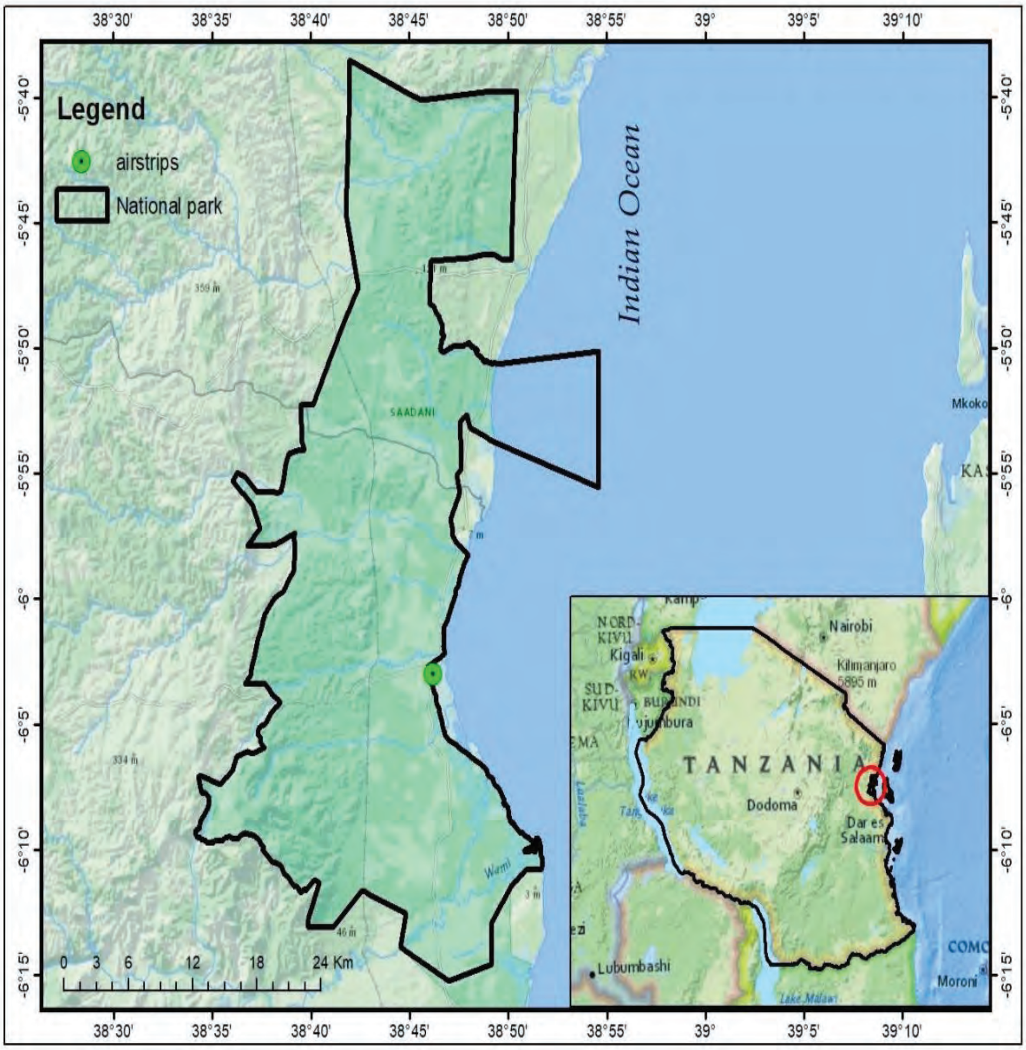

Figure 2: Location of Saadani National Park

2.1.2 Wami-Mbiki Game Reserve

Wami-Mbiki Game Reserve (WGR) is situated in the central-eastern part of Tanzania, encompassing latitudes 06˚ 10' 00" to 06˚ 30' 00" S and longitudes 37˚ 50' 00" to 38˚ 15' 04" E (Fig. 3). The core wilderness area of WGR spans an extensive 2,500 km^2, which includes land from 24 villages across two Districts, namely Bagamoyo and Chalinze. The reserve is abundant in birdlife, featuring a variety of miombo specialities such as the racket-tailed roller, pale-billed hornbill, rufous-bellied tit, and miombo wren-warbler, along with numerous other bird species. The predominant vegetation type within the reserve comprises open and closed woodlands, bushland, and inundated grasslands. Additionally, the WGR is blessed with rivers and natural ponds that serve as essential water sources for the ecosystem.

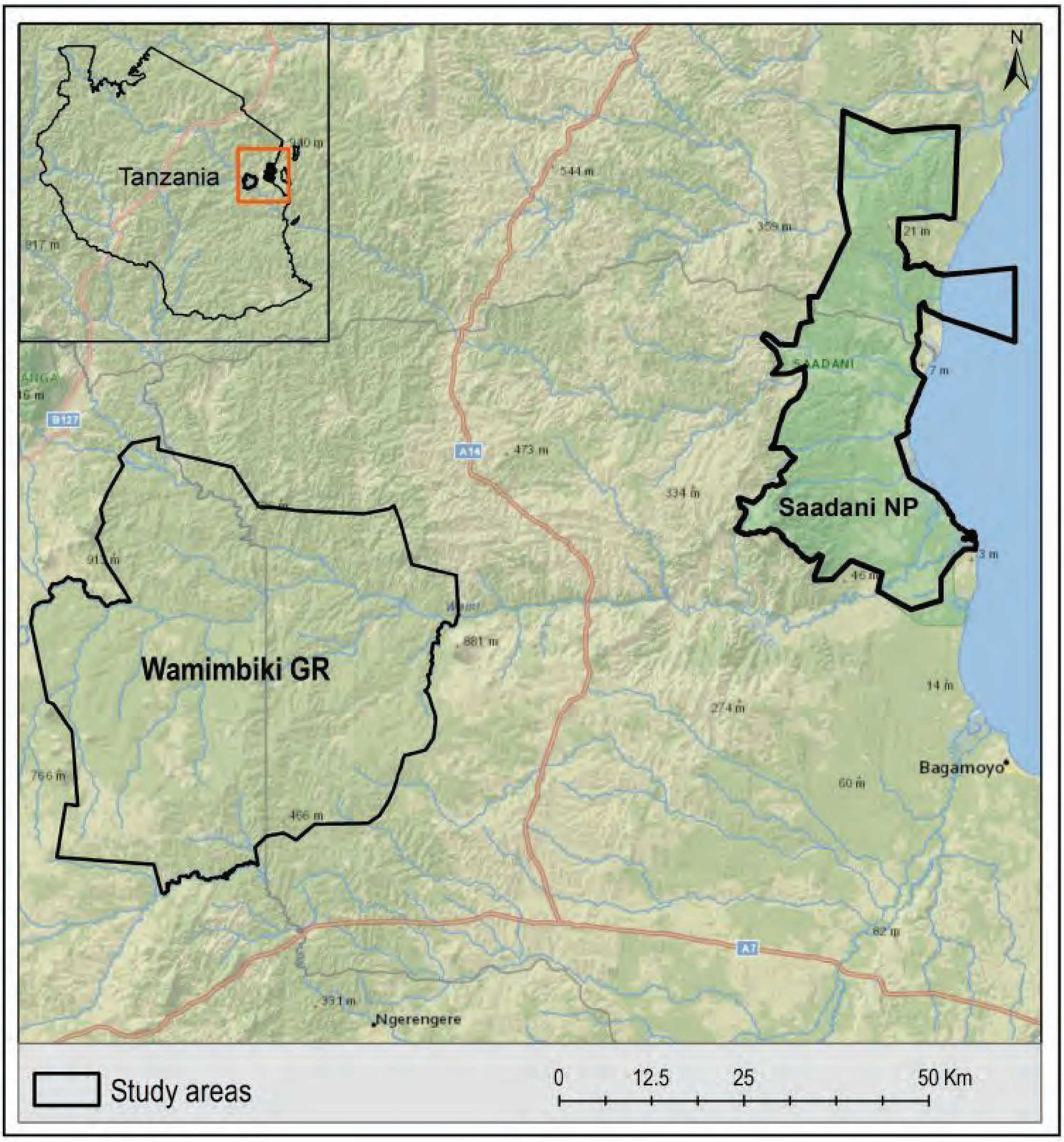

Figure 3: Location of Wami-Mbiki Game Reserve

The Wami River divides the WGR into two segments (north and south) (Fig. 4). The area's climate is warm tropical, with short rains from October to December and long rains from March to May, ranging between 600 and 1200 mm per annum. The average annual temperature ranges between 26 and 28^{0}C, with altitudes ranging between 350 and 400 m above the sea level. The area is interspersed with rocky hillsides of thin soil cover and valleys with deep clay or alluvial soils. The major human activities include agriculture, wildlife and forest conservation, and livestock grazing,. The area's vegetation is predominantly miombo woodlands, whereas the climate is generally warm with a daily mean temperature of 250C and receives over 1000 mm of rainfall annually (Mariki, 2018). The GR is drained by the Lukigura, Wami and Ngerengere rivers (Fig. 4).

The Wami River divides the WGR into two segments, north and south (Fig. 4). The climate in this reserve is warm and tropical, characterised by short rains occurring from October to December and long rains from March to May, with an annual rainfall ranging between 600 and 1200 mm. The average annual temperature in the area ranges between 26 and 28 degrees Celsius (Mariki, 2018). The altitude varies from 350 to 400 meters above sea level, and the landscape is a mix of rocky hillsides with thin soil cover and valleys containing deep clay or alluvial soils. The primary land uses include agriculture, wildlife and forest conservation, livestock grazing and human settlements. The predominant vegetation type is miombo woodlands and climate is generally warm, with a daily mean temperature of 25°C and over 1000 mm of rainfall annually (Mariki,2018).

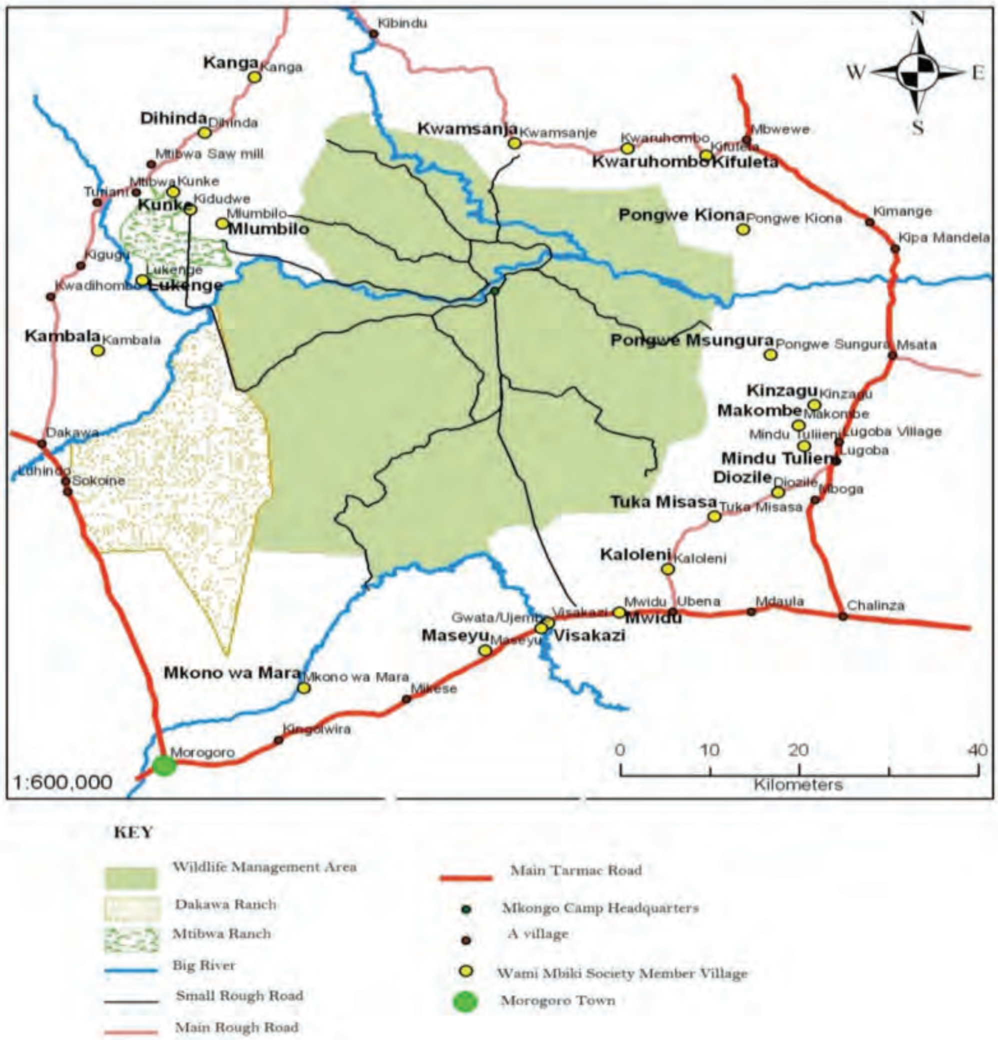

Figure 4: Villages and Land Use of the Wami-Mbiki Game Reserve
(**Source**: Mariki, 2018)

2.2 . Materials and Methods

2.2.1. Training

Prior to fieldwork, the core census team at TAWIRI (i) selected crews with experience in wildlife census from within the wildlife sector, including knowledge in flying with small aircraft and wildlife species identifications, (ii) tested the crew on visual acuity and colour blindness before the start of the exercise by using approved test kits, (iii) calibrated and familiarised flying crew with equipment use and flying endurance for at least two sessions of 4:30 hours for experienced observers and three sessions of 5 hours for new observers after training, (iv) trained crew on how to take photographs of all groups and carcasses of elephants, and all animal groups with more than ten individuals and (v) trained all crew members in counting animals in the photographs to ensure easy recall of data during the actual exercise.

2.2.2. Transect design and Flight Plan

Using QGIS, the core team generated survey transects spaced at 2.5 km, with transect orientation varying due to the nature of the terrain and ecological gradient to maximise the number of samples (Figs. 5 & 6). Transects were a priori evenly subdivided into subunits with a distance of no more than 2.5 km in length (40 seconds of flying time) and uploaded onto GPS units. The on-transect navigation was maintained using handheld GPS (Garmin 62S, 64S, 65S) and 695 models mounted to the aircraft to assist the pilot in transect navigation and radar or laser altimeter (Lightware SF30-D Laser Rangefinder). The total planned transect flight time ranged from a minimum of 5 to a maximum of 30 minutes and counting sessions (on transect time) did not exceed 4 hours from start to finish, with most being less than or equal to 3 hours and 30 minutes.

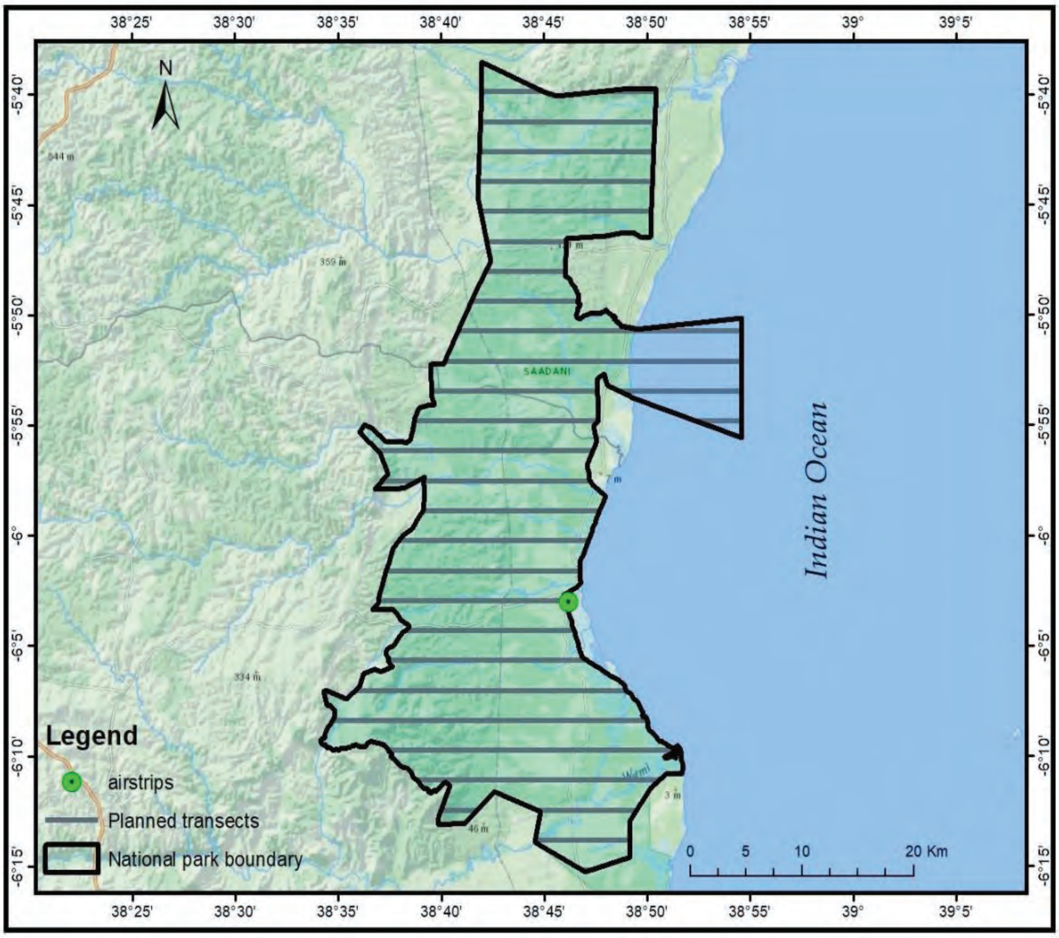

Figure 5:Planned transects for the 2022 dry season aerial survey in SNP

The subunits were then uploaded onto GPS units for easy navigation during the survey. Geo-referenced coordinates were prepared and uploaded to GPS units (Garmin 62S, 64S, 65S, and 695 models) to determine the aircraft's precise location along the transects. Additionally, radar or laser altimeters (specifically the 200m Lightware SF30-D Laser Rangefinder) were used to measure the aircraft's altitude above ground level. This information further assisted in data collection and ensured the consistency and accuracy of the survey.

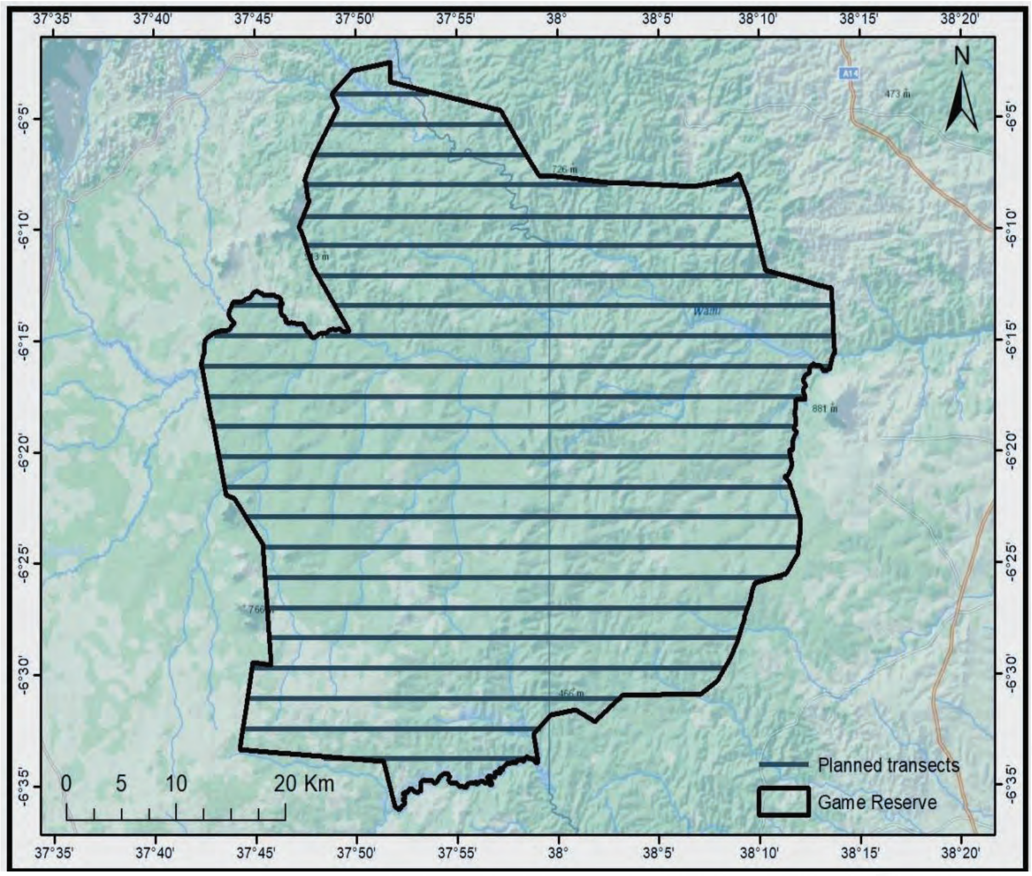

Figure 6: Planned transects for the 2022 dry season aerial survey in WGR

2.2.3. Data collection techniques

The census utilised a Systematic Reconnaissance Flight (SRF) technique described in detail by Norton-Griffiths (1978). This technique has been widely adopted for assessing wild animals' distribution and population size in various regions such as Africa, Australia, and North America. During the survey, the aircraft was manned by a crew of four. The pilot was responsible for navigating the aircraft according to a predetermined survey plan uploaded onto the GPS prior to the flight. The Front Seat Observers (FSO) were tasked with recording metadata related to each transect, such as its start and end points, flight height above ground using a radar or laser altimeter in each subunit, and the presence or absence of water and burnt areas. The FSO also communicated subunit identification numbers to the Rear Seat Observers (RSO). The RSOs were responsible for counting and recording all sightings of wild animals and human activities observed in each sub-unit along the transect. Large groups of more than ten individuals were photographed during the survey for verification purposes. After each flight session, the RSOs transcribed recorded data onto data sheets. The geographical position of each subunit, called out by the FSO, was recorded along with its observations and later transcribed onto data sheets. Streamers attached to the wing strut on each side of the aircraft defined the sample area for counting, with a target width of 150m on the ground. This target width was calibrated before the census and with supplementary data collected regularly to ensure consistency. Despite a few criticisms regarding its lower accuracy and precision compared to other methods, the SRF technique remains highly regarded as the most cost-effective approach for conducting surveys over large protected areas. It allows for relatively inexpensive coverage and systematic monitoring of wildlife populations.

Recorded elephant carcasses were categorised using guidelines recommended by the MIKE-CITES program (IUCN, 1998; Griffin *et al*., 2003; Craig, 2012). These guidelines outlined specific characteristics used to assign carcass classes (1-4) and approximate ages since the animal's death. The first class, carcass stage 1 (EC1), described a carcass less than one-month-old with flesh, a rounded appearance, and frequently with vultures present. The ground may still be moist from body fluids. The second class, carcass 2 (EC2), typically referred to carcasses less than one-year-old with rot patches and skin still intact and with the skeleton not scattered. Carcass 3 (EC3), the third class, usually indicated carcasses older than one year with white bones, absent skin, and vegetation regrowth in rot patches. The fourth and final class, carcass IV (EC4), described very old carcasses up to 10 years. It is important to note that the first three classes are recommended for ascertaining the mortality rates of elephants in a given population.

2.2.4. Census parameters and track-log

During the actual census, animal species observed within transects, flight height and speed were recorded to provide an understanding of how well the survey crews were performing and an indication of the count's accuracy. In addition, survey standards for flight parameters were evaluated during training and at regular intervals during the count. Important quantitative parameters such as aircraft speed, altitude, flying height above ground and heading obtained from GPS track log data were mapped and reviewed with survey crews to ensure that survey standards were being met (Table 1).

Table 1: Basic SRF census parameters recorded during the 2022 survey

Parameters	**SNP**	**WMGR**
Survey area (km²)	1,154	2,331
Sample Areas (km²)	83	578
Transect distance	265	903
Total number of transects	13	23
Total number of subunits	480	311
Sample Fraction %	6.7	4.03

Parameters	SNP	WMGR
Flying height (ft.):		
Mean	369	380
Standard Deviation	55	67
Minimum	240	206
Maximum	460	458
Strip width (m)		
Left	145	138
Right	141	142
Total	286	380
Ground speed (km/h)	168	176

The total area covered by the aircraft was about 1154 km² in the SNP and 2331 km² in the WMGR, with 26 and 23 transects, respectively (Figs. 5 & 6). The mean height above ground for all aircraft was 369 and 380 feet, respectively, and ground speed averaged 168 km/h for SNP and 176 for WGR. (Table 1). Transect strip widths were between 138m and 145 m, as one aircraft maintained a low flying height and thus smaller strip widths (138m & 141m) (Table 1). Apart from the quantitative parameters using Mapsource software version 6.1.6, tracklogs from the pilot and FSO GPS were downloaded and subsequently mapped using QGIS (Fig.7&8).

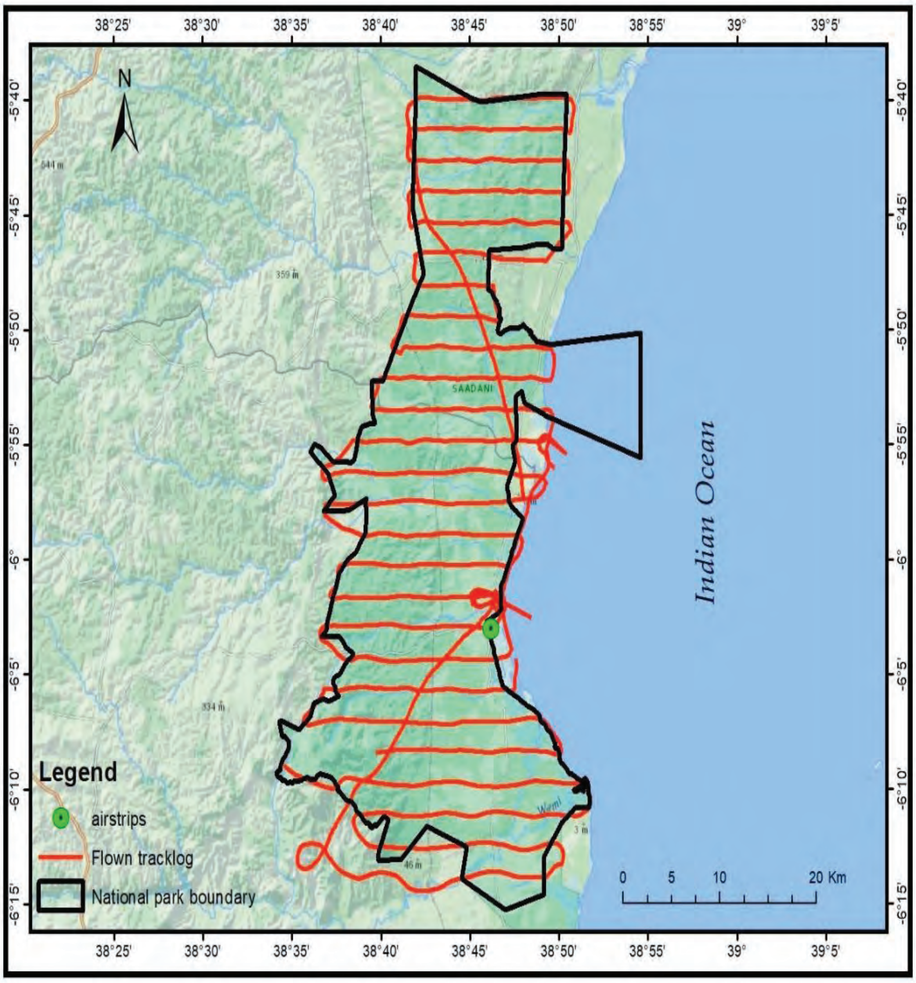

Figure 7: Track log of flown transects in the SNP, 2022

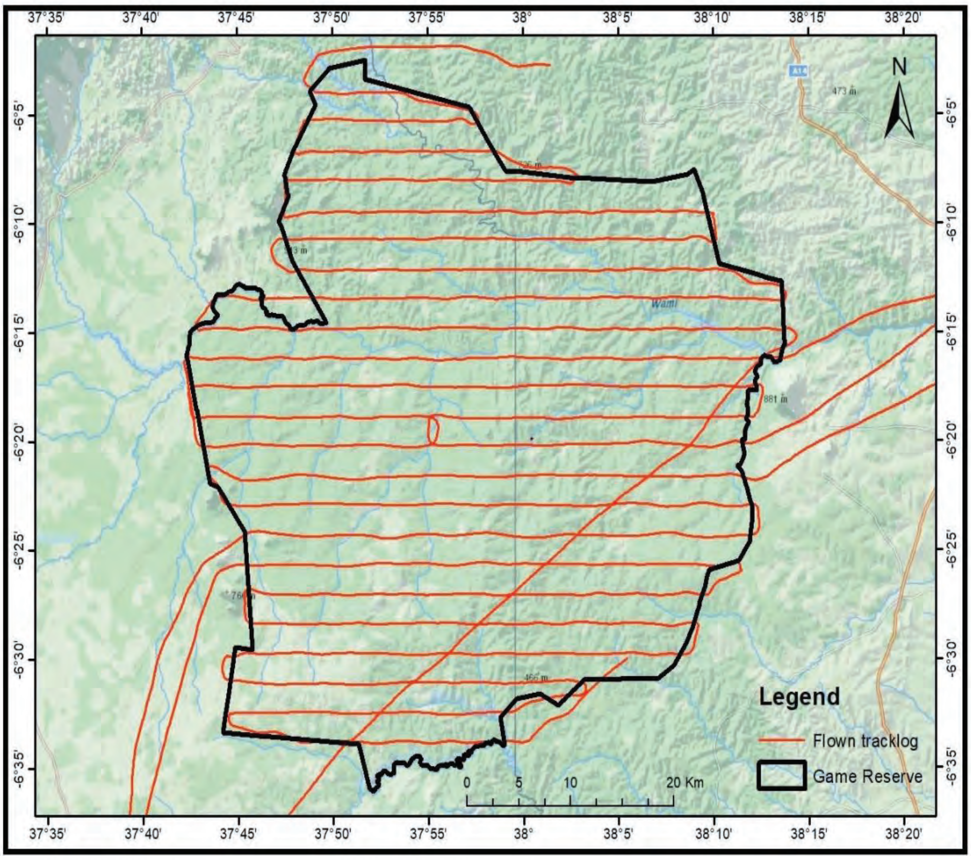

Figure 8: Track log of flown transects in the WMGR, 2022

2.2.5. Data Analysis

Data collation from all transects flown and the subsequent cleaning was done using Microsoft Excel and three lists of observed species alongside their sighting frequency and counts were generated (Tables 2, 3 & 4). None of the observed species attained the minimum required number of observations (≥ 30) required to qualify for the generation of estimates and are therefore reported as absolute counts (Tables 2,3&4). The only estimate calculated in this report is for cattle in the Wami-Mbiki Game Reserve which were observed at 46 different sightings. QGIS 3.6 was used to obtain species densities, distribution, and human activities with i) density, indicated by shades of darker colours where higher concentrations were recorded and ii) point observations (dots) indicating locations where observations were made. Finally, carcass ratio, an index used to ascertain whether mortality in the elephant population is unnaturally high (Douglas Hamilton & Burrill, 1991), was calculated from the proportion of dead to live+dead elephants using the following formula:

Carcass ratio: *100

c *is for the number of carcasses counted*; E is the *number of live elephants counted*

3.0. RESULTS

3.1. Wildlife and human activities estimates in the ecosystem

The survey documented twenty-four (24) medium to large mammal species and one avian species within the ecosystem (Tables 2 & 4). However, the frequency of sightings for all observed species was less than 30, rendering them unsuitable for population estimates based on the SRF rule. Consequently, only the raw metrics are reported (Tables 2 & 4). Additionally, due to the absence of estimates for all observed species, a direct comparison with previous results to generate species trends was impossible.

3.1.1. Wildlife estimates Saadani National Park

A total of 12 wildlife species were documented in SNP. Among these, 12 species had counts ranging from 10 to 47 individuals, and their frequency of sightings varied from 2 to 20. The recorded species included 11 mammal species, one (1) avian species and one (1) reptile species (Table 2).

Table 2: Wildlife sightings, counts and elephant carcass in the Saadani National Park

SN	Wildlife	Sighting frequency	Counted
1	African Elephant (*Loxodonta africana*)	3	47
2	Bohor reedbuck (*Redunca redunca*)	20	43
3	Giraffe (*Giraffa camelopardalis*)	15	40
4	Impala (*Aepyceros melampus*)	13	37
5	Hippopotamus (*Hippopotamus amphibius*)	2	36
6	Eland (*Taurotragus oryx*)	7	36
7	Hartebeest (*Alcelaphus buselaphus*)	8	35
8	Waterbuck (*Kobus ellipsiprymnus*)	4	28
9	Warthog (*Phacochoerus africanus*)	11	24
10	Sable Antelope (*Hippotragus niger*)	4	12
11	Crocodile (*Crocodylus porosus*)	3	10
12	Duiker (*Cephalophus monticla*)	7	10
13	Ground-Hornbill (*Bucorvus leadbeateri*)	3	5
14	Elephant Carcass stage 3	1	1

3.1.1.1. African Elephant (*Loxodonta africana*)

Unlike the previous census of 2014, this survey sighted elephants three (3) times with 47 individuals (Table 2). However, accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). While the survey could not provide an exact estimate of the elephant population for comparative analysis, previous censuses indicate that the park has a few clustered herds roaming around the park which may require a total count method to ascertain the actual population size. Their distribution extended across the park's southern, central, and northern parts (Fig. 9), indicating the availability of suitable habitats and resources in various areas. The species is known to have extensive ecological needs, including access to water sources, ample feeding grounds, and appropriate shelter (Ngene *et al*., 2017). The presence of these vital resources in the southern, central, and northern regions of SNP supports the wide distribution of elephants in the park. This distribution information holds immense importance for conservationists, as it helps identify critical elephant habitats, allowing adequate protection and management strategies (McComb *et al*., 2010, Pettorelli *et al*., 2014). The number of elephants in SNP underscores the park's significance as a conservation area for these iconic species. By closely monitoring elephant populations and their distribution patterns, conservation efforts can gain valuable insights into their ecological roles and behaviours, enabling informed measures to safeguard their well-being and preserve their natural environment.

Regarding elephant carcasses, only one stage three (EC3) elephant carcass was observed in the northern part of SNP (Fig. 9). This represents a carcass ratio of 2.1%, which is considerably below the standard threshold of 8%, consistent with the 2.1% recorded in 2014, indicating minimal to no excess mortality in both the park and the broader ecosystem.

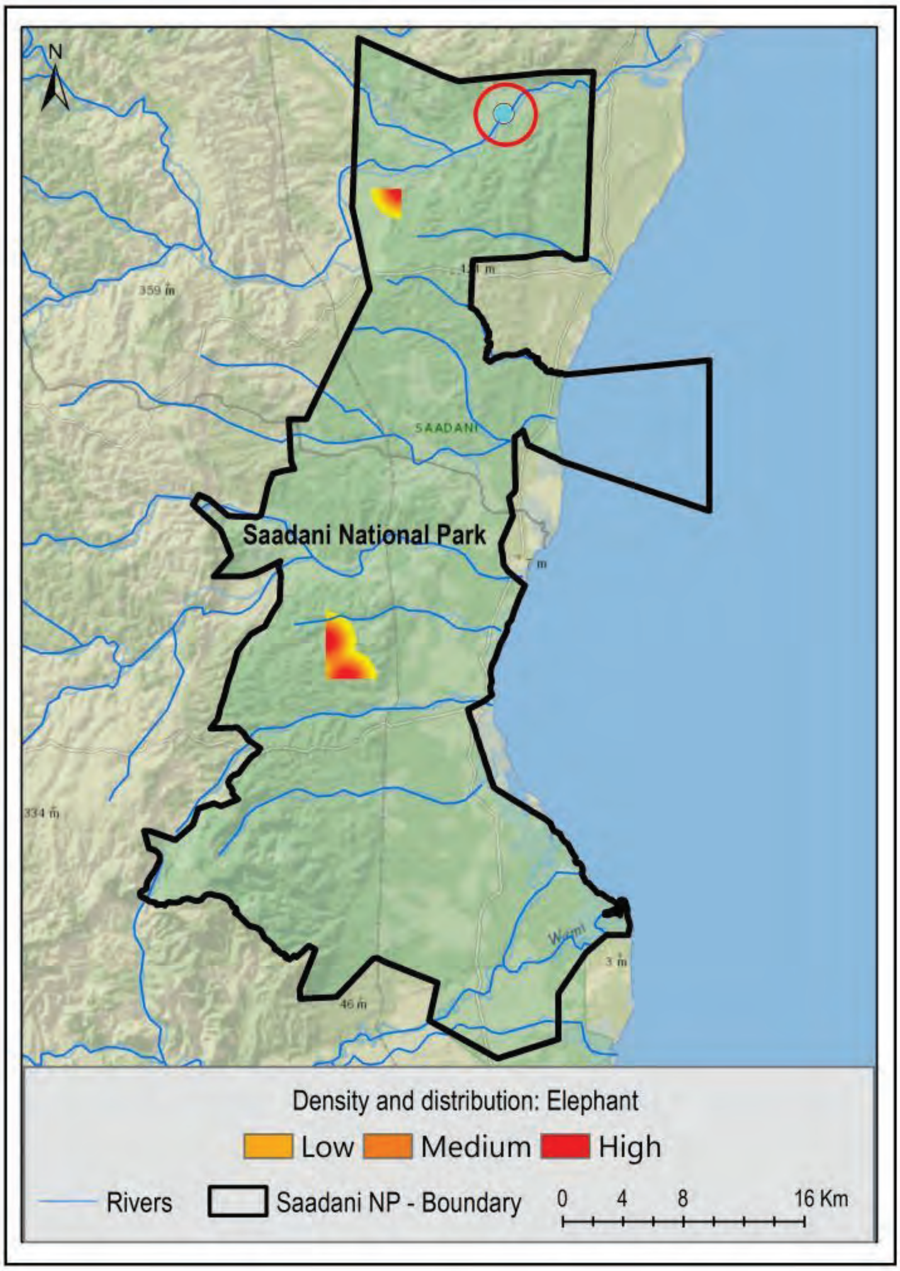

Figure 9: Distribution of elephants in the SNP, 2022.

3.1.1.2. Bohor reedbuck (*Redunca redunca*)

Bohor reedbuck was observed 20 times in SNP with a total count of 40 individuals, making it the first most sighted species (Table 2). Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). The distribution of the species within the park appears to be skewed in the south-eastern part of the park, as well as in the central Mkwaja area and the northern regions of the surveyed area (Fig. 10). These areas are likely to provide suitable habitat and resources for reedbuck, such as grassy plains or savannahs, which are their preferred habitats (Amare, 2015). The presence of reedbucks suggests that these areas offer favourable conditions for their survival, including abundant food, water sources, and suitable shelter (Halsdorf, 2011; Fynn *et al*., 2016).

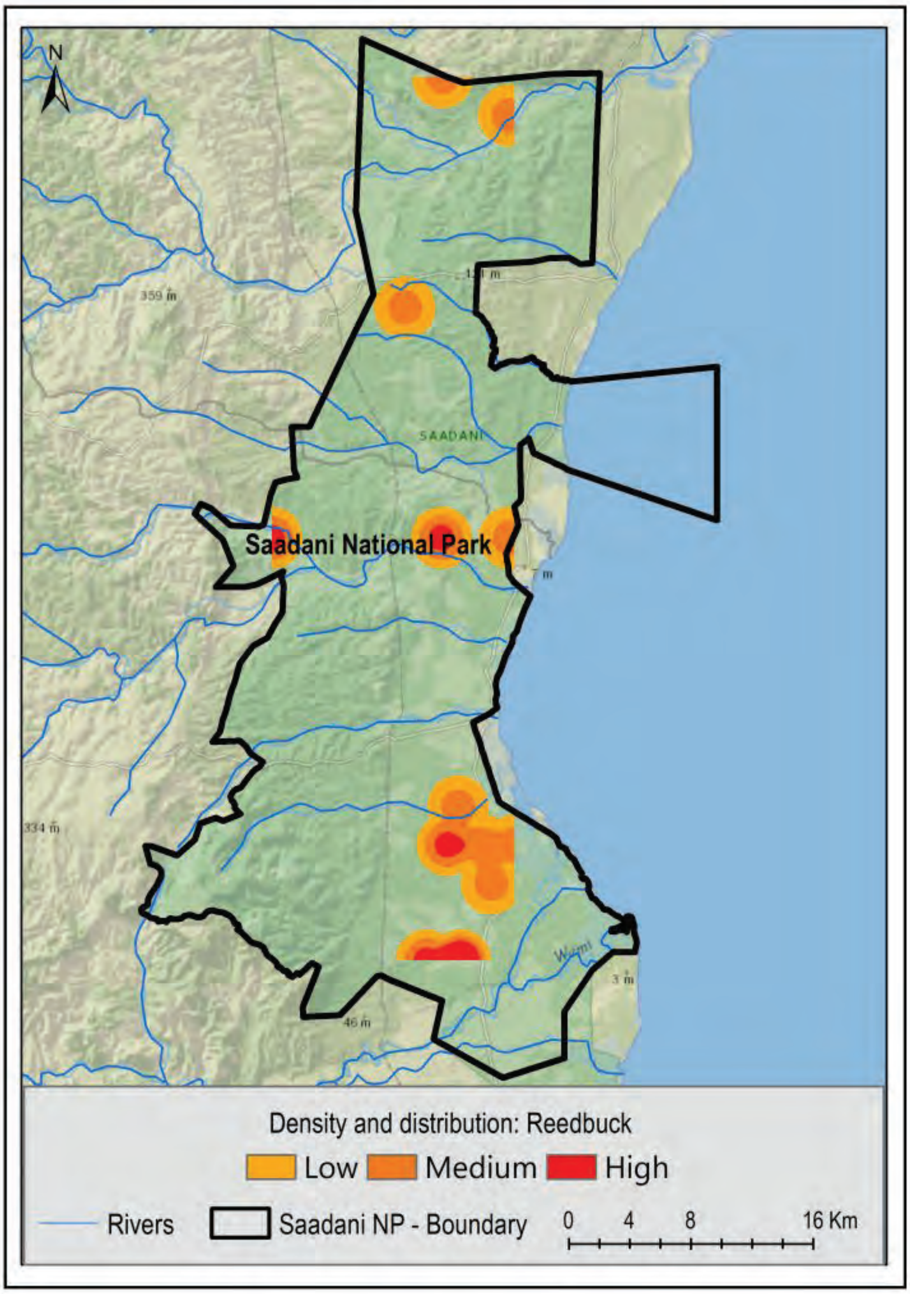

Figure 10: Distribution of Bohor Reedbuck in the SNP, 2022

3.1.1.3. Giraffe *(Giraffa Camelopardalis)*

Giraffe was observed at 15 different sightings, with a total count of 40 individuals across the entire park. Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). The distribution of giraffes within SNP was relatively widespread across the eastern part of the park, particularly in the southeast areas (Fig. 11). The presence of giraffes suggests that suitable habitats and food resources are available across various areas of SNP (Campus 2011, Njovu *et al.,* 2016). The higher sightings in the southeast indicate that this location may provide favourable conditions for giraffes, such as suitable vegetation, water sources, and browsing opportunities (Diplock *et al.,* 2018).

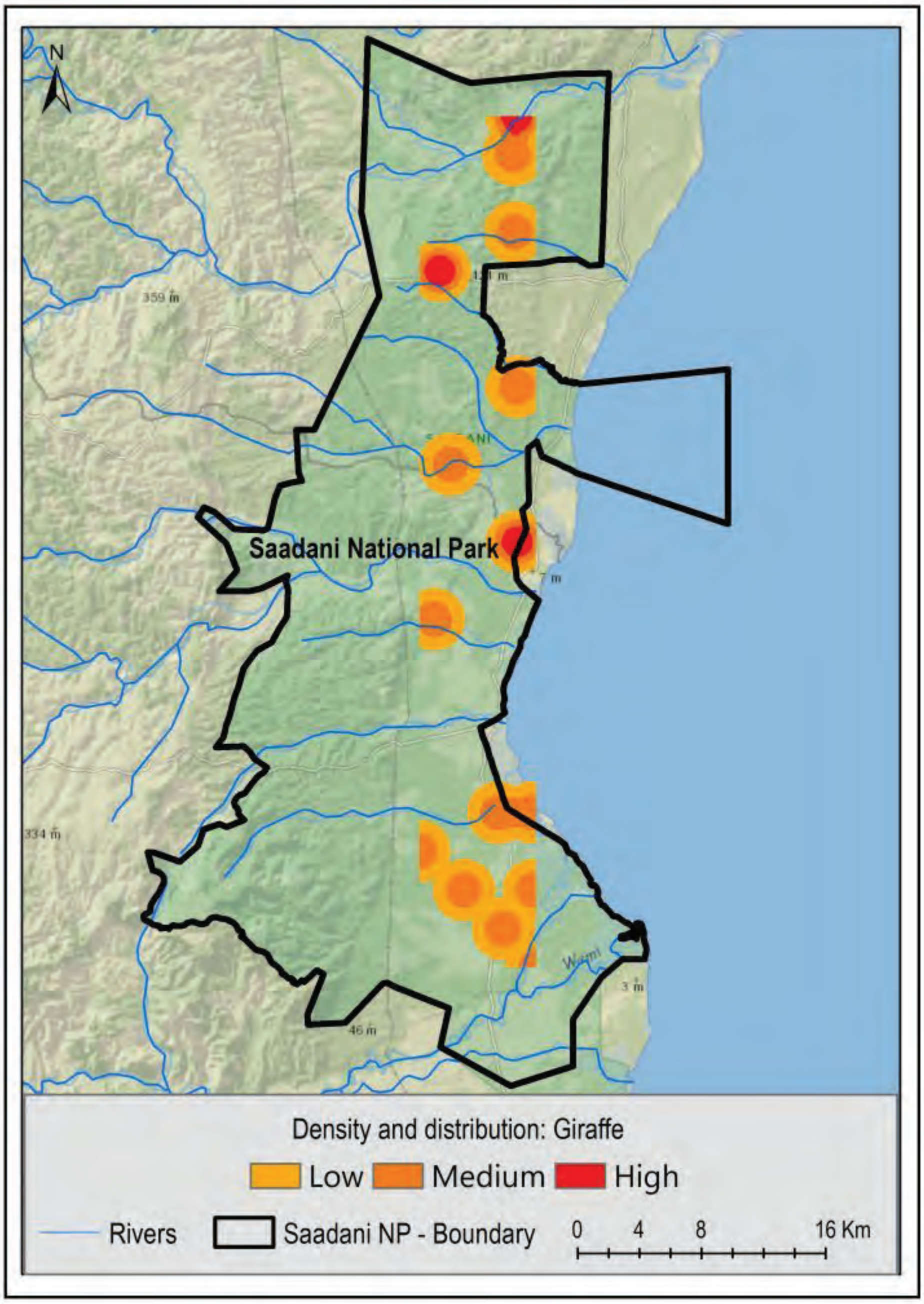

Figure 11: Distribution of Giraffe in the SNP, 2022

3.1.1.4. Impala (*Aepyceros melampus*)

Impala, a commonly observed species in SNP, was spotted 13 times with 37 individuals. Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). The distribution of impala within the park appeared to be concentrated primarily in the central-eastern part (Fig. 12). The concentration of impala sightings in the central-eastern region suggests that this area provides favourable habitat conditions for these animals. Factors such as vegetation type, availability of food resources, water sources, and suitable shelter may contribute to the observed distribution pattern (Halsdorf, 2011; Leuthold, 2012; Mongale, 2023).

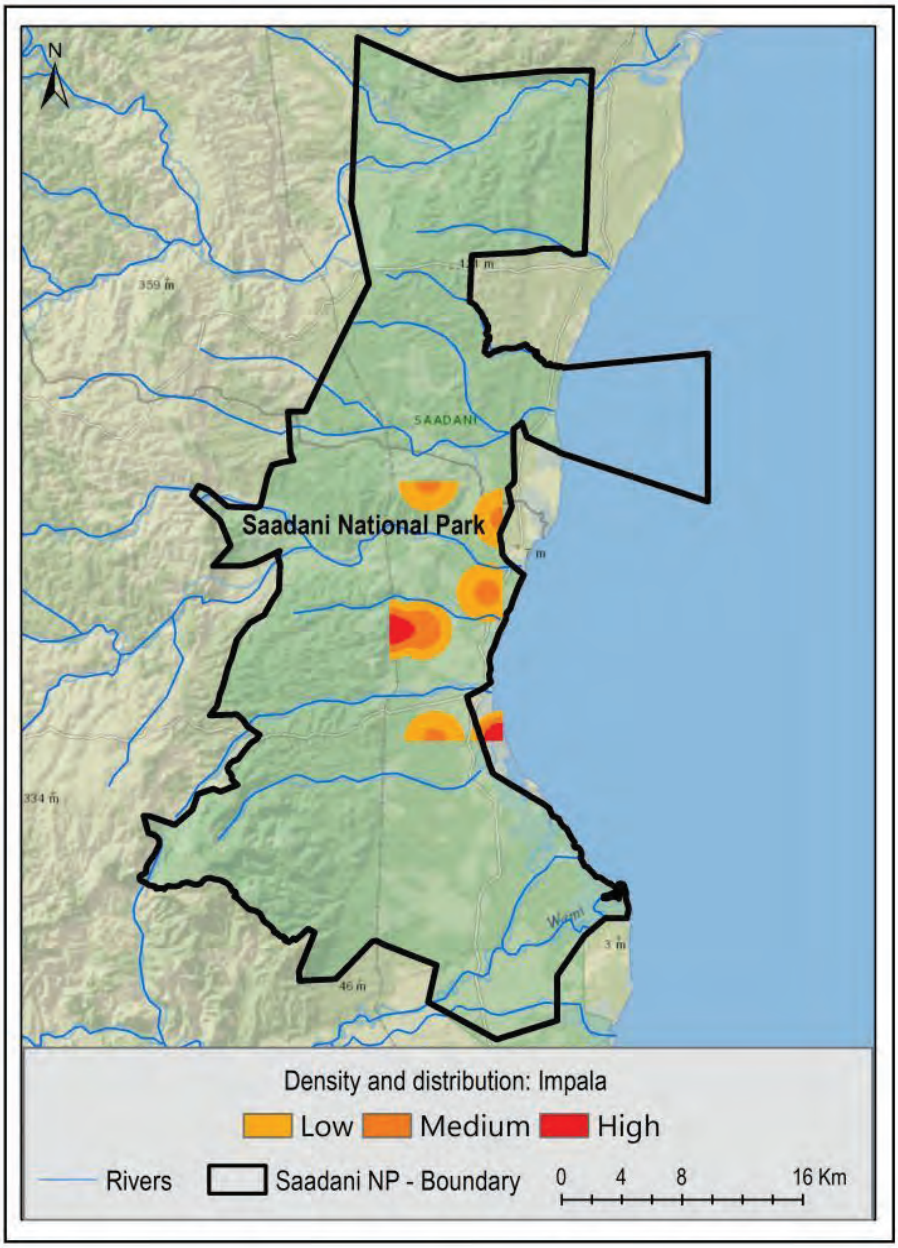

Figure 12: Distribution of Impala in the SNP, 2022

3.1.1.5. Hartebeest (*Alcelaphus buselaphus*)

Kongoni, the seventh most frequently observed species in SNP, were sighted at eight (8) different locations, with a count of 35 individuals across the park. Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). Their distribution within SNP was concentrated in the middle and southern parts (Fig. 13). The presence of kongoni in these areas suggests suitable habitats in the middle and southern regions of the park. These areas likely provide favourable conditions for the species, such as open grasslands or savannahs, which are their preferred habitats for grazing (Halsdorf, 2011; Muir *et al*., 2015). Understanding the distribution of Kongoni within SNP is essential for effective wildlife management and conservation efforts. By identifying the areas where they are more concentrated, conservationists can implement targeted measures to protect their habitats, ensure the availability of grazing resources, and maintain a healthy population. This information will contribute to the overall preservation and sustainability of the Kongoni population in the park, which is crucial for maintaining the ecological balance and biodiversity of SNP.

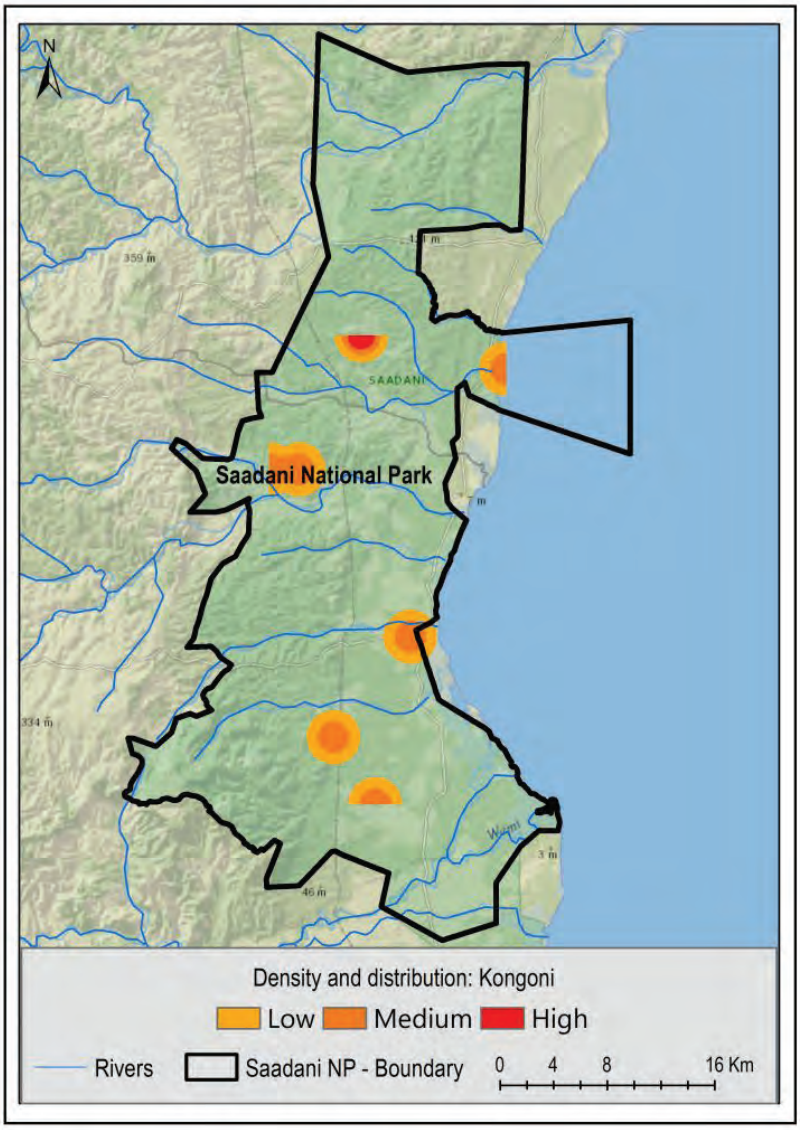

Figure 13: Distribution of Kongoni in the SNP, 2022

3.1.1.6. Waterbuck (*Kobus ellipsiprymnus*)

With a total count of 28 individuals, waterbuck was observed in four (4) sightings within the park. The distribution of waterbuck was concentrated in the central western and northern parts of the park (Fig. 14). Accurate population estimates for the species within the park could not be ascertained owing to an inadequate quantity of sightings (≥30). The presence of the species indicates the existence of good habitats that provide suitable conditions for their survival. The species prefer areas near water sources, such as rivers or wetlands, and they often inhabit grassy plains or woodland areas (Leuthold, 2012; Okello *et al*., 2015; Saha *et al*., 2023). These factors could have contributed to the presence of waterbuck and their ability to thrive in these areas (Leweri, 2011; Saha *et al*., 2023). Understanding waterbuck's distribution and habitat preferences is crucial for wildlife management and conservation in SNP. By identifying the areas where waterbuck is most concentrated, conservationists can implement measures to protect these habitats, ensure the availability of water sources, and promote the overall well-being of the waterbuck population in the park.

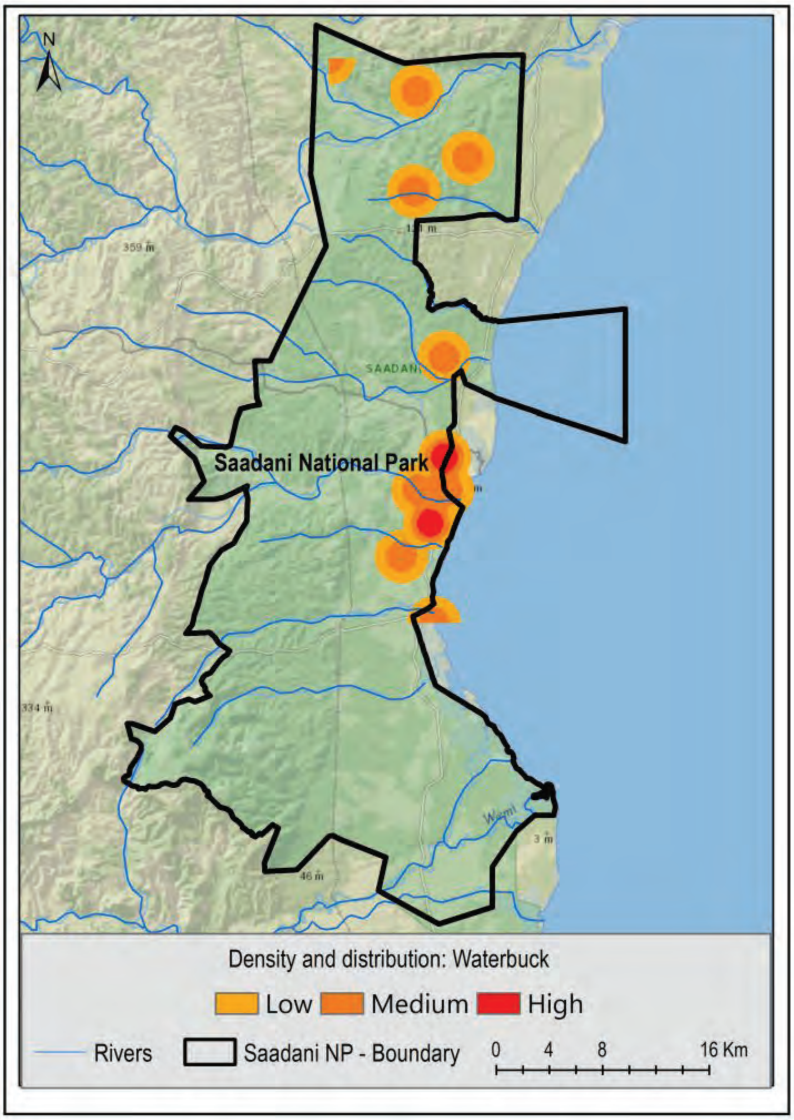

Figure 14: Distribution of Waterbuck in the SNP, 2022

3.1.1.7. Roan & Sable antelope (*Hippotragus equinus & Hippotragus niger*)

Roan and Sable antelopes, with a combined count of 37 individuals, were observed four (4) times in various locations throughout SNP. Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). The distribution of both species extended from the northern parts to the south (Fig. 15). The presence of Roan and Sable antelopes across this wide range suggests that they have established habitats in different parts of the park. These antelope species inhabit open grasslands and savannahs, where they can find suitable grazing areas and access water sources (Gandiwa *et al*., 2011; Estes, 2012; Leuthold, 2012). The distribution of Roan and Sable antelopes from the northern parts to the south of SNP indicates their ability to adapt to different ecological conditions within the park.

By utilising diverse habitats, they can meet their dietary and ecological requirements, such as grazing grass and browsing on shrubs (Leuthold, 2012; Fynn *et al*., 2016; Van Soest, 2018). Understanding Roan and Sable antelopes' distribution and habitat preferences is crucial for effective wildlife management and conservation in SNP. By recognising the areas where they are commonly found, conservationists can implement measures to protect these habitats, ensure the availability of suitable food and water resources, and promote the well-being of both antelope populations. This knowledge will contribute to the overall preservation and ecological balance of SNP.

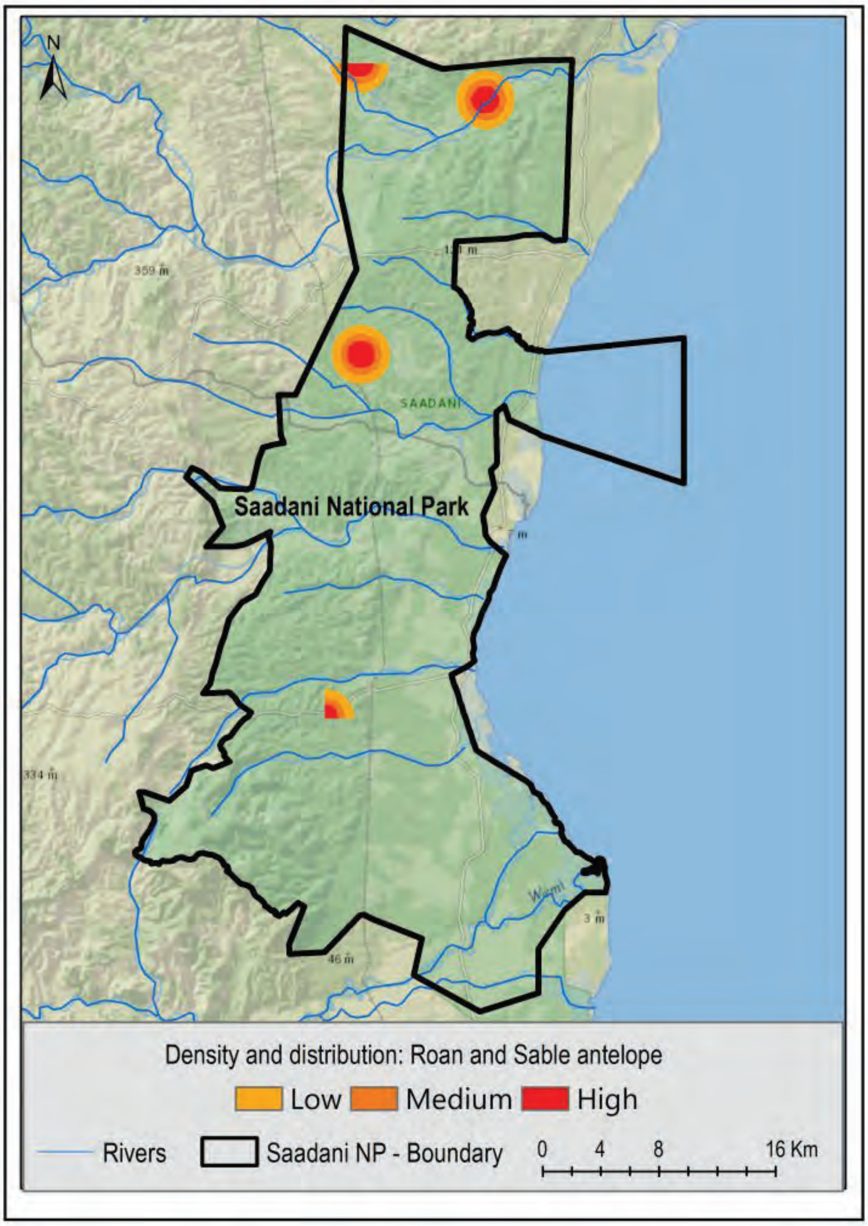

Figure 15: Distribution of Roan and Sable antelope in the SNP, 2022

3.1.1.8. Warthog (*Phacochoerus africanus*)

Warthogs, with a count of 24 individuals, were sighted at 11 across the park. Accurate population estimates for the species within the park could not be ascertained due to inadequate sightings (≥30). The distribution of the species extended from the northern parts to the south of SNP (Fig. 16). Their presence suggests that they are adaptable animals capable of thriving in a variety of habitats, including grasslands, woodlands, and savannahs (Teklehaimanot & Balakrishnan, 2017; Girma, 2018). They are often found near water sources, such as rivers or waterholes, where they can satisfy their need for both drinking water and mud wallowing (Bracke, 2011; Leuthold, 2012). The spread of warthogs from the northern parts to the south of SNP indicates their ability to utilise diverse environments within the park. This adaptability is likely a key factor in their survival and persistence in different park areas. Understanding their distribution and habitat preferences is important for effective wildlife management and conservation efforts. Conservationists can use this knowledge to implement measures that protect their habitats, ensure the availability of water sources, and promote a healthy warthog population in the park. Maintaining the well-being of warthogs contributes to the overall ecological balance and biodiversity of SNP.

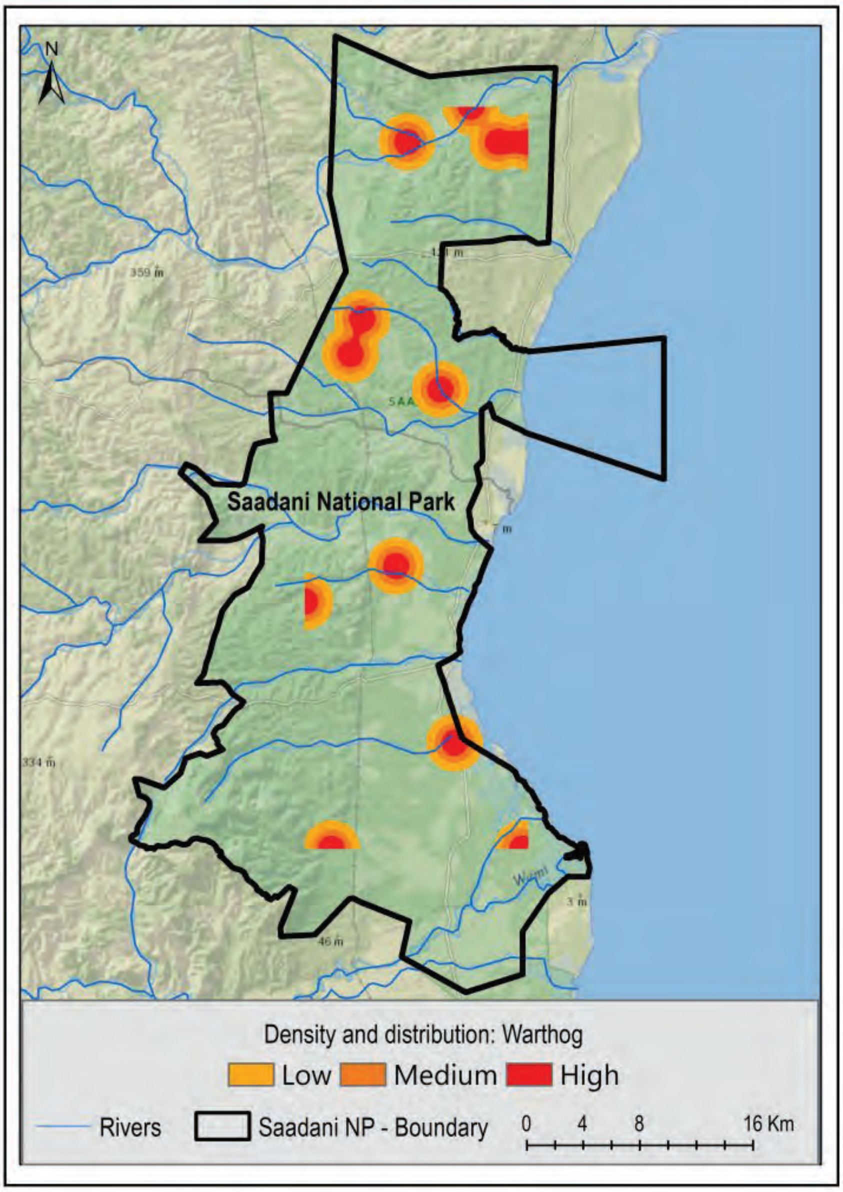

Figure 16: Distribution of Warthog in the SNP, 2022

3.1.1.9. Other Species

The rest of the sighted wildlife species in the park, including Zebra, Ground Hornbill, Dikdik and Hippo, had relatively low counts and sightings compared to the species discussed earlier. Overall, accurate population estimates for these species within the park could not be established due to inadequate sightings required by the SRF method (≥30). Reedbuck, Zebra, Ground Hornbill, Dikdik, and Hippo were distributed in various locations throughout the park (Fig. 17). While they may not have been as frequently encountered or counted as some other species, their distribution suggests that they can utilise different areas within the park. The spread of these species from the northern parts to the south of SNP reflects their ability to find suitable grazing resources for herbivores (Zebra, Dikdik, Hippo) and Avian (Ground Hornbill). Despite their lower counts, these species play important ecological roles within the park's ecosystem. Zebra, for example, are important grazers that help maintain the grasslands, while Ground Hornbills are significant in controlling insect populations. Dik-dik and Hippos also contribute to the park's biodiversity in their respective ways. While the focus may often be on the more prominent species, understanding the distribution and habits of these "other" species is still valuable for conservation efforts. It helps ensure that a holistic approach is taken towards wildlife management, allowing for the conservation of the entire ecosystem.

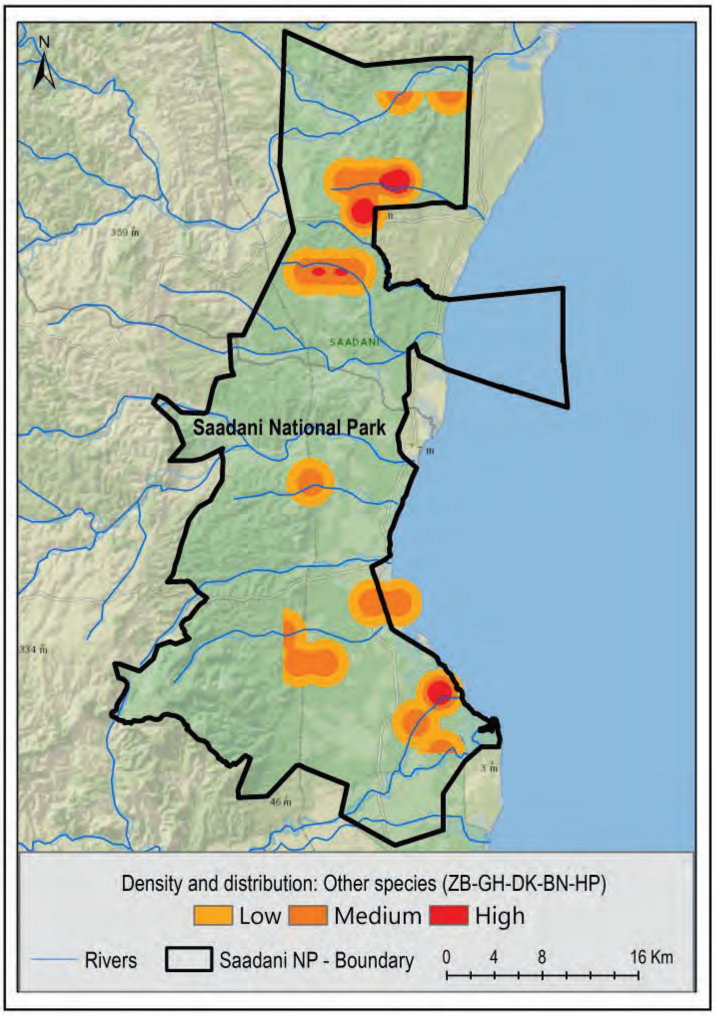

Figure 17: Distribution of Zebra, Ground Hornbill, Dik-dik and Hippo in the SNP, 2022

3.1.2. Human activities in Saadani National Park

Human encroachment in SNP primarily revealed the existence of livestock numbers, poacher camps, logging, and cultivation. The distribution of these activities varied across parts of the park. During the survey, livestock, specifically cattle, were frequently observed (Table 3), followed by charcoal kilns, sawpits, and settlements (thatched and bati houses as well as boma). A Canoe was also observed, showing the presence of fishing activities.

Table 3: Human activities in the Saadani National Park

Human Activities	Sighting	Animal Counted
Cattle	25	1186
Charcoal Kiln	18	42
Sawpit	4	4
Thatched	3	16
Bati House	1	1
Boma Unoccupied	1	1
Canoe	1	1

3.1.2.1. Livestock

Within Saadani National Park, the predominant livestock observed were cattle. However, accurate estimates for livestock within the park could not be ascertained due to an inadequate quantity of sightings as required by the SRF method (≥30). Cattle sightings surpassed all other human-related activities in the park. Their presence was notably concentrated in the southern parts of the park, extending to the northeastern sections (Fig. 18).

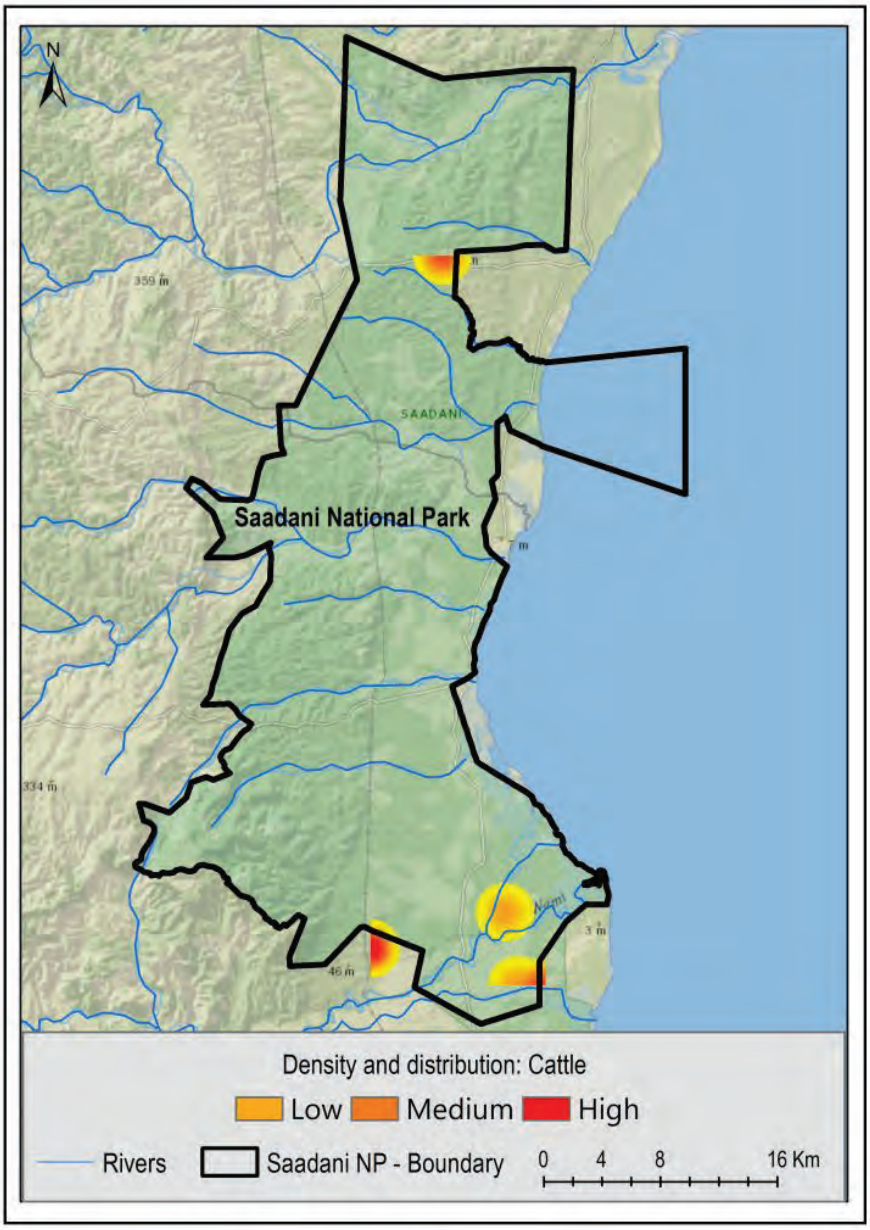

Figure 18: Distribution of Cattle in the SNP, 2022

3.1.2.2. Settlement

Human settlements were observed in the form of thatched and bati houses and boma. These were spotted in the southeastern and western parts of the park. Though only two spots were seen, it was noted that these concentrations were high (Fig. 19), thus suggesting potential for further expansion into other areas.

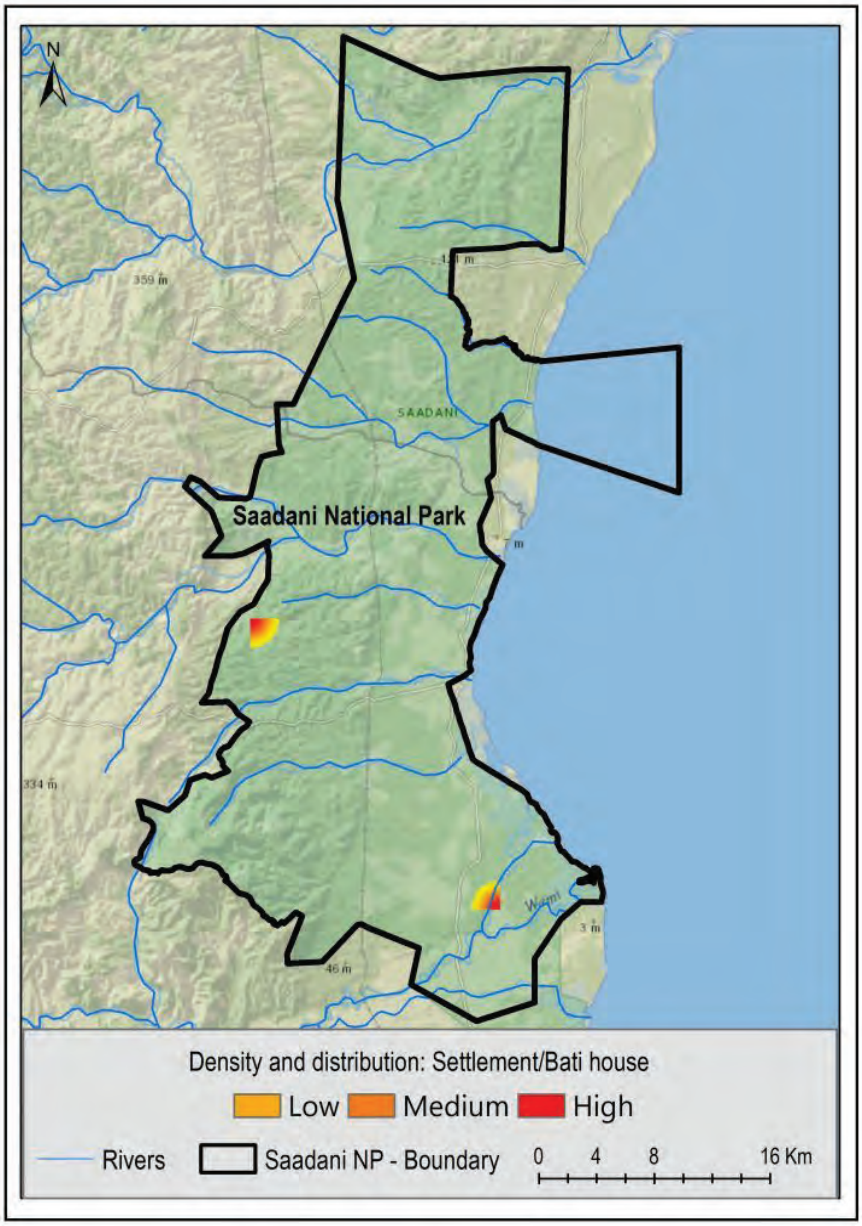

Figure 19: Distribution of Settlement in the SNP, 2022

3.1.2.3. Other Human Activities

Other observed human activities included charcoal kilns, with 42 counts spread across 18 sightings, identified 16 bomas (poachers' camps) constructed with thatched grass, observed at three different locations, pointing to poaching incidents. However, accurate estimates for human activities within the park could not be ascertained owing to an inadequate quantity of sightings (≥30). Cultivation and other activities were concentrated in the southern parts of the Park (Fig. 20). Settlements, on the other hand, were observed in the southern and central-western parts of the park (Fig. 19).

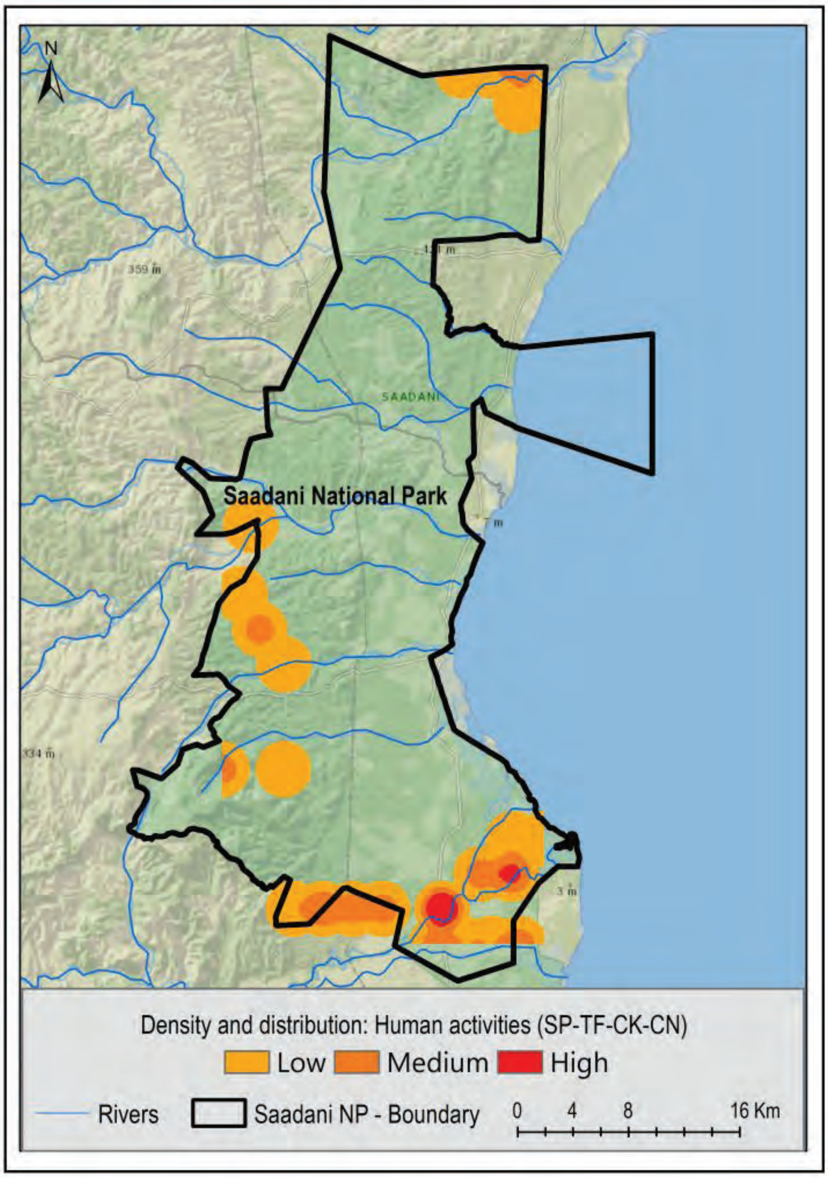

Figure 20: Distribution of other activities (Charcoal Kilns, Canoe,) in the SNP, 2022

3.1.3. Wildlife sightings and counts in Wami-Mbiki Game Reserve

A total of 12 wildlife species were recorded in WMGR, consisting of 11 mammal species and one avian species (Table 4). In contrast with SNP, the frequency of sightings for each species in WMGR was below the minimum threshold (≥ 30), which is required for generating population estimates as per the SRF rule. Therefore, only the actual counts of individuals are reported. The most frequently sighted species was the duiker, with 53 counts at 29 sightings, followed closely by bushbuck with 46 counts at 26 sightings, the Ground Hornbill with 32 counts at 12 sightings, the Greater Kudu with 24 counts at 9 sightings, and the Impala with 46 counts at 8 sightings. Baboons had 17 counts at 3 sightings, while Wild Pigs and Zebras had 4 counts at 2 and 1 sighting, respectively. The remaining four species, namely Eland (4 individuals), Kongoni/Hartebeest (1 individual), Reedbuck (1 individual), and Warthog (1 individual), were sighted only once in the entire survey area and no elephant carcasses were observed in the reserve during the survey. The records results provide valuable insights into the diversity and abundance of wildlife species in WMGR. The higher counts and sightings of certain species, such as Duiker, Bushbuck, and Ground Hornbill, suggest their relatively higher population density in the reserve. Conversely, the limited sightings of other species highlight their rarity in the area. Understanding these population dynamics is essential for effective wildlife management and conservation efforts in WMGR.

Table 4: Wildlife sightings and counts in Wami-Mbiki Game Reserve

SN.	Wildlife	Sightings	Animal Counted
1	Duiker (*Cephalophus monticla*)	29	53
2	Cape bushbuck (*Tragelaphus sylvaticus*)	26	46
3	Impala (*Aepyceros melampus*)	8	46
4	Ground-Hornbill (*Bucorvus leadbeateri*)	12	32
5	Greater Kudu (*Tragelaphus strepsiceros*)	9	24
6	Baboon (*Papio cynocephalus*)	3	17
7	Eland (*Taurotragus oryx*)	1	7
8	Wild Pig (*Sus scrofa*)	2	4
9	Zebra (*Equus quagga*)	1	4
10	Hartebeest (*Alcelaphus buselaphus*)	1	1
11	Bohor reedbuck (*Redunca redunca*)	1	1
12	Warthog (*Phacochoerus africanus*)	1	1

3.1.3.1. **Duiker** (*Cephalophus monticla*)

Among the various species observed within the reserve, the duiker was sighted 29 times, comprising 53 individuals (Table 4). Despite these observations, determining precise population estimates for this species within the reserve remained elusive due to the insufficiency in the number of recorded sightings, a criterion requiring a minimum of 30 instances. Notably, these duiker species showcased an extensive distribution across diverse areas of the reserve (Fig. 21). The findings emphasise the widespread presence of the species throughout the various areas of the reserve, contributing to its rich and diverse ecological makeup.

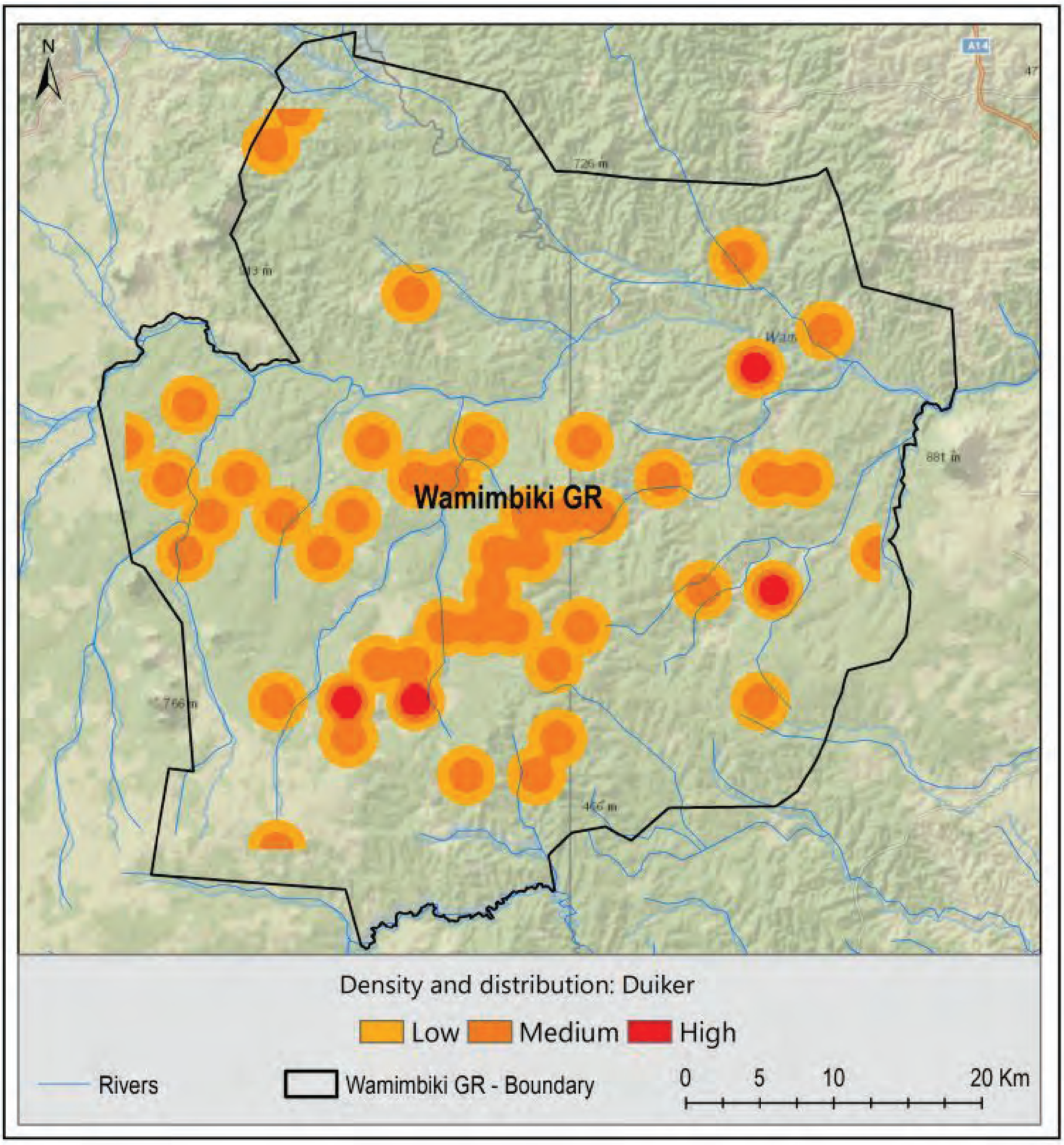

Figure 21: Distribution of Duiker in the WMGR, 2022

3.1.3.2. Cape Bushbuck (*Tragelaphus sylvaticus*)

The bushbuck was the second most frequently sighted (26) species, with 46 individuals in the WMGR (Table 4). Despite these observations, determining precise population estimates for this species within the reserve couldn't be done due to insufficiently recorded sightings, a criterion requiring a minimum of 30 instances. The species is known to be a browser, feeding on leaves and shoots; therefore, their presence implies the availability of specific habitats that support their dietary preferences (Halsdorf, 2011; Leuthold, 2012). The species distribution patterns were primarily concentrated in the northern and central-eastern parts of the reserve (Fig. 22). By identifying the areas where they are most commonly found, conservationists can implement measures to protect their habitats and ensure the availability of suitable vegetation for browsing. This knowledge is vital for maintaining a healthy bushbuck population and preserving the delicate balance of the ecosystem in the park. Conservation efforts aimed at protecting the habitats of bushbucks will not only benefit this particular species and have positive ripple effects on the entire ecosystem. As browsers, bushbucks control vegetation growth, affecting other species dependent on the same vegetation. Therefore, preserving their habitats can contribute to the overall health and diversity of the ecosystem.

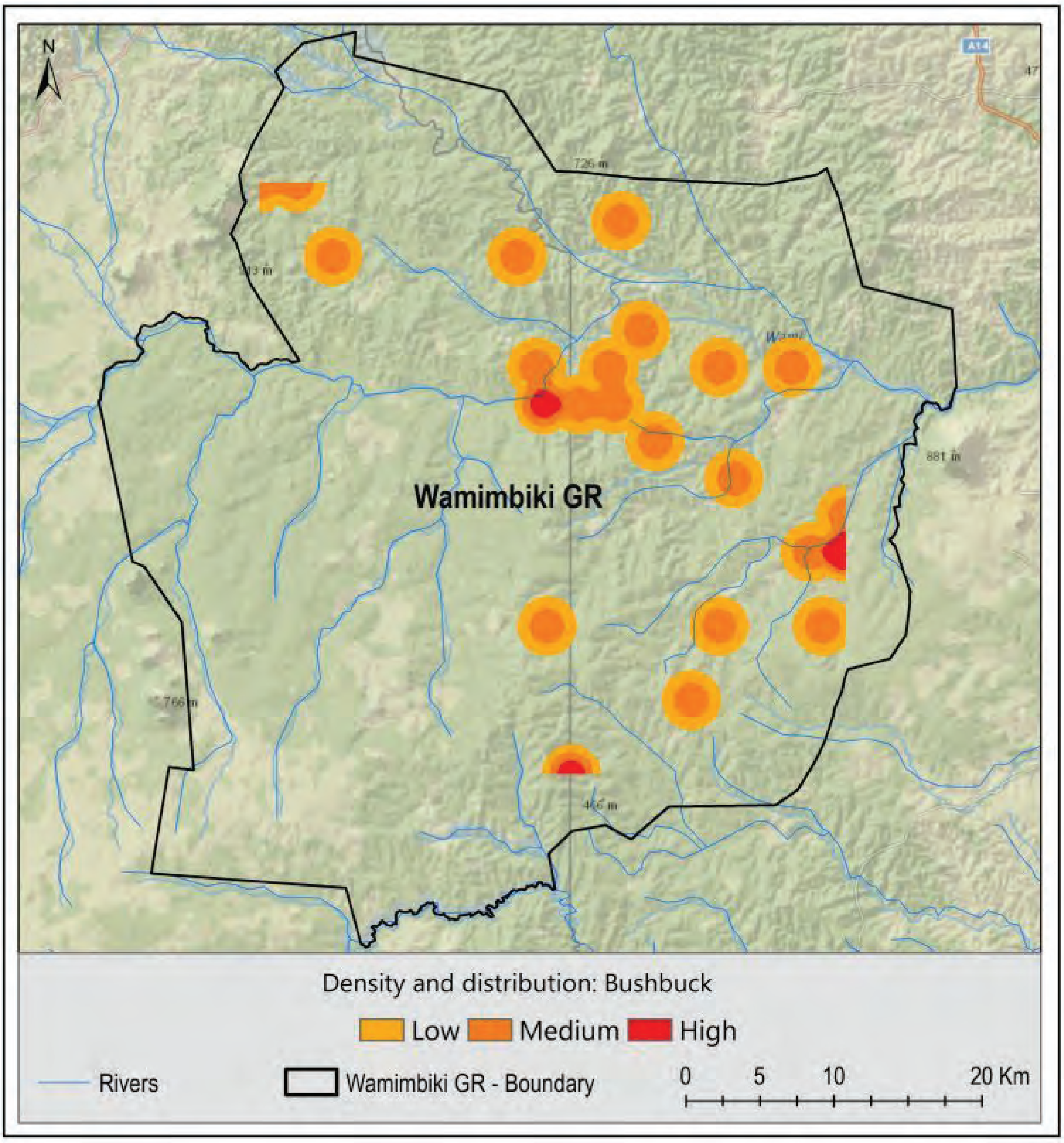

Figure 22: Distribution of Bushbuck in the WMGR, 2022

3.1.3.3. Impala (*Aepyceros melampus*)

Impala were sighted in eight (8) different locations with 46 individuals across the WMGR (Table 4). The species distribution was primarily concentrated in the central and eastern parts of the reserve (Fig. 23). Determining precise population estimates for this species within the reserve couldn't be done due to insufficient recorded sightings, a criterion requiring a minimum of 30 sightings.

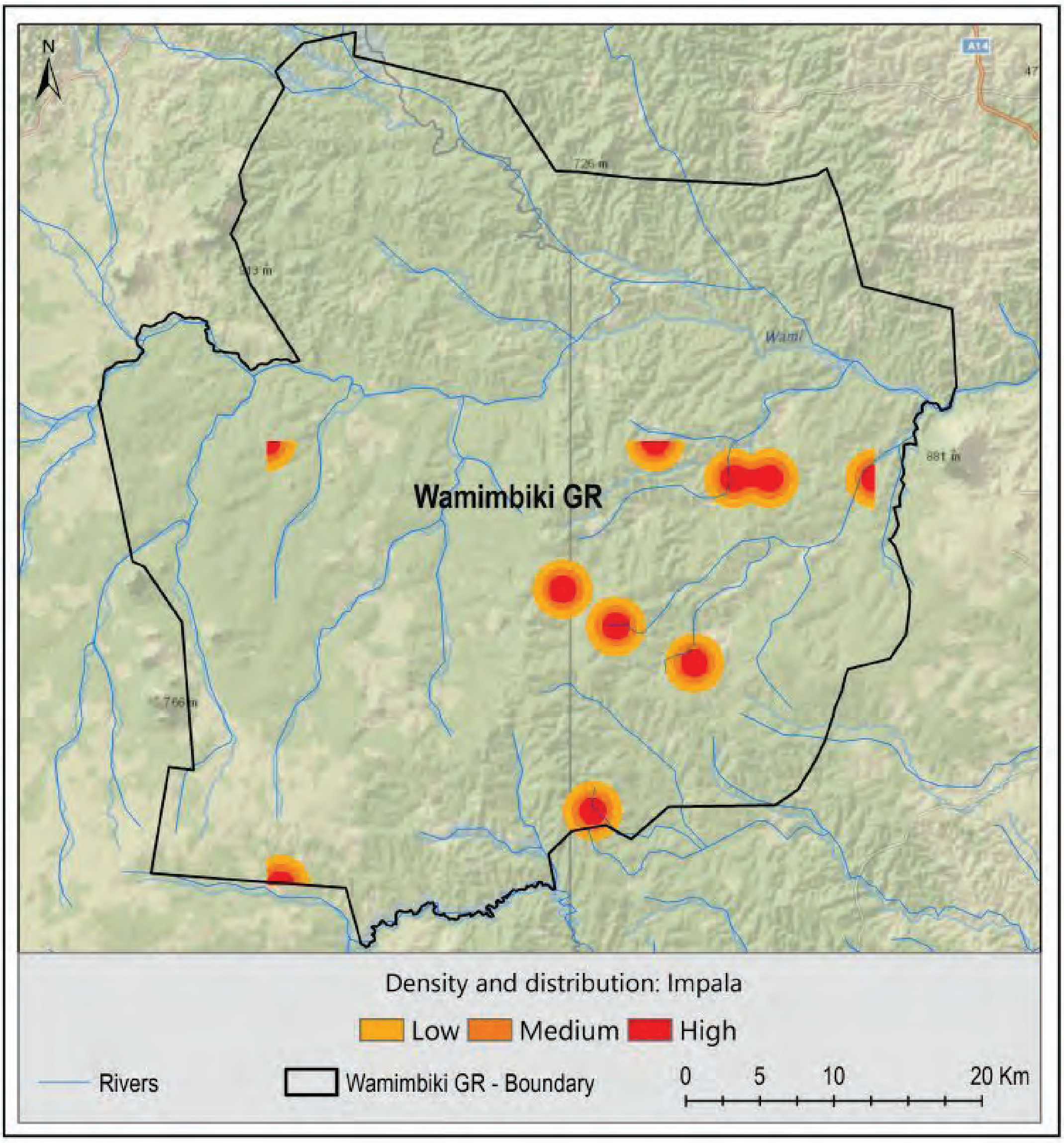

Figure 23: Distribution of Impala in the WMGR, 2022

3.1.3.4. Greater Kudu (*Tragelaphus strepsiceros*)

Greater Kudu was sighted nine (9) times with 24 individuals in the WMGR (Table 4). The species exhibited a high concentration in the central and eastern areas as well as towards the southern parts of the reserve (Fig.24). Determining precise population estimates for this species within the reserve couldn't be done due to the insufficiency in the number of recorded sightings, a criterion requiring a minimum of 30 sightings.

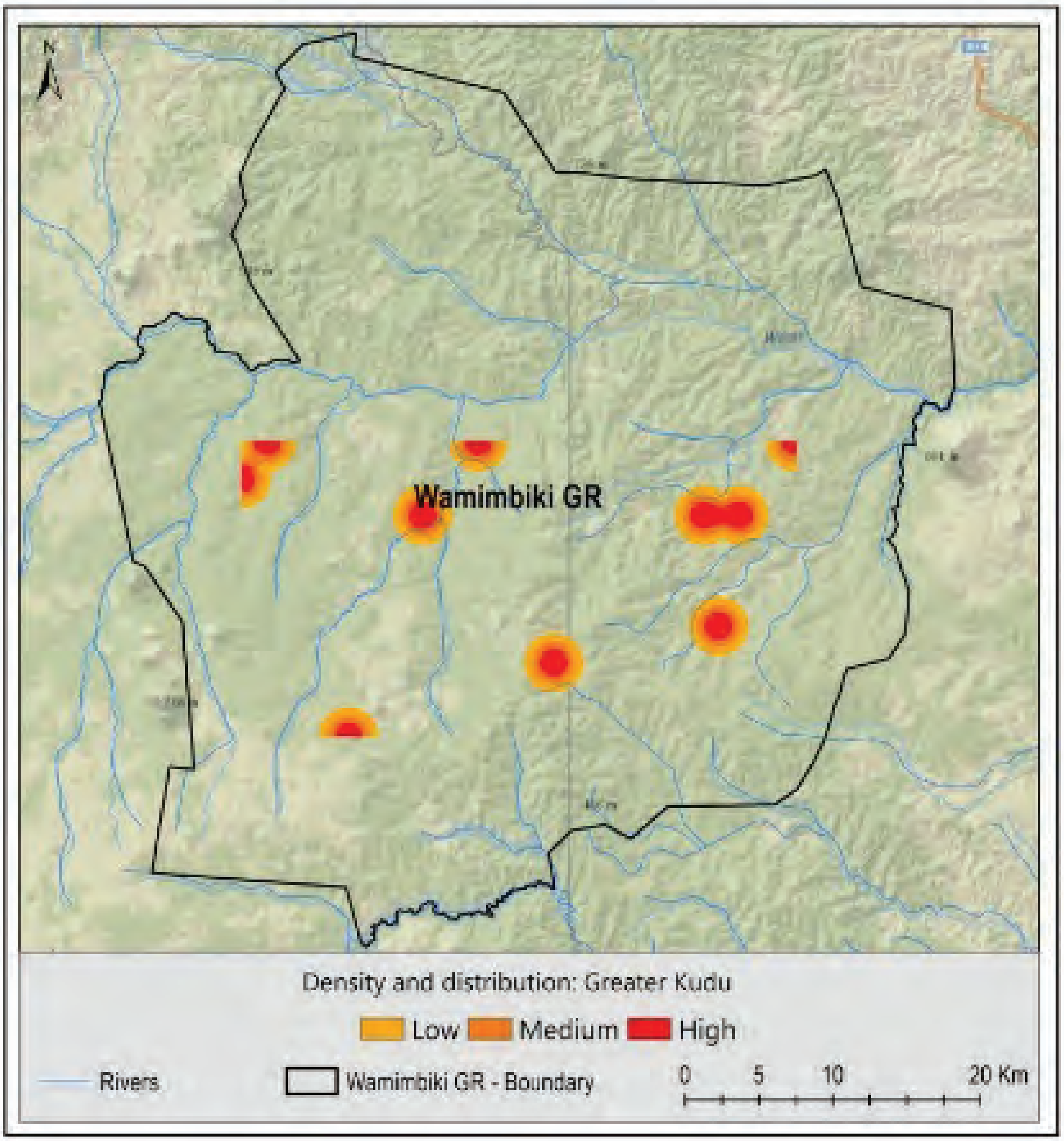

Figure 24: Distribution of Greater Kudu in the WMGR, 2022

3.1.3.5. Ground Hornbill (*Bucorvus leadbeateri*)

Ground Hornbill counts reached 32 individuals across 12 sightings in the WMGR (Table 4). The species were located in the reserve's central western and eastern parts (Fig.25).

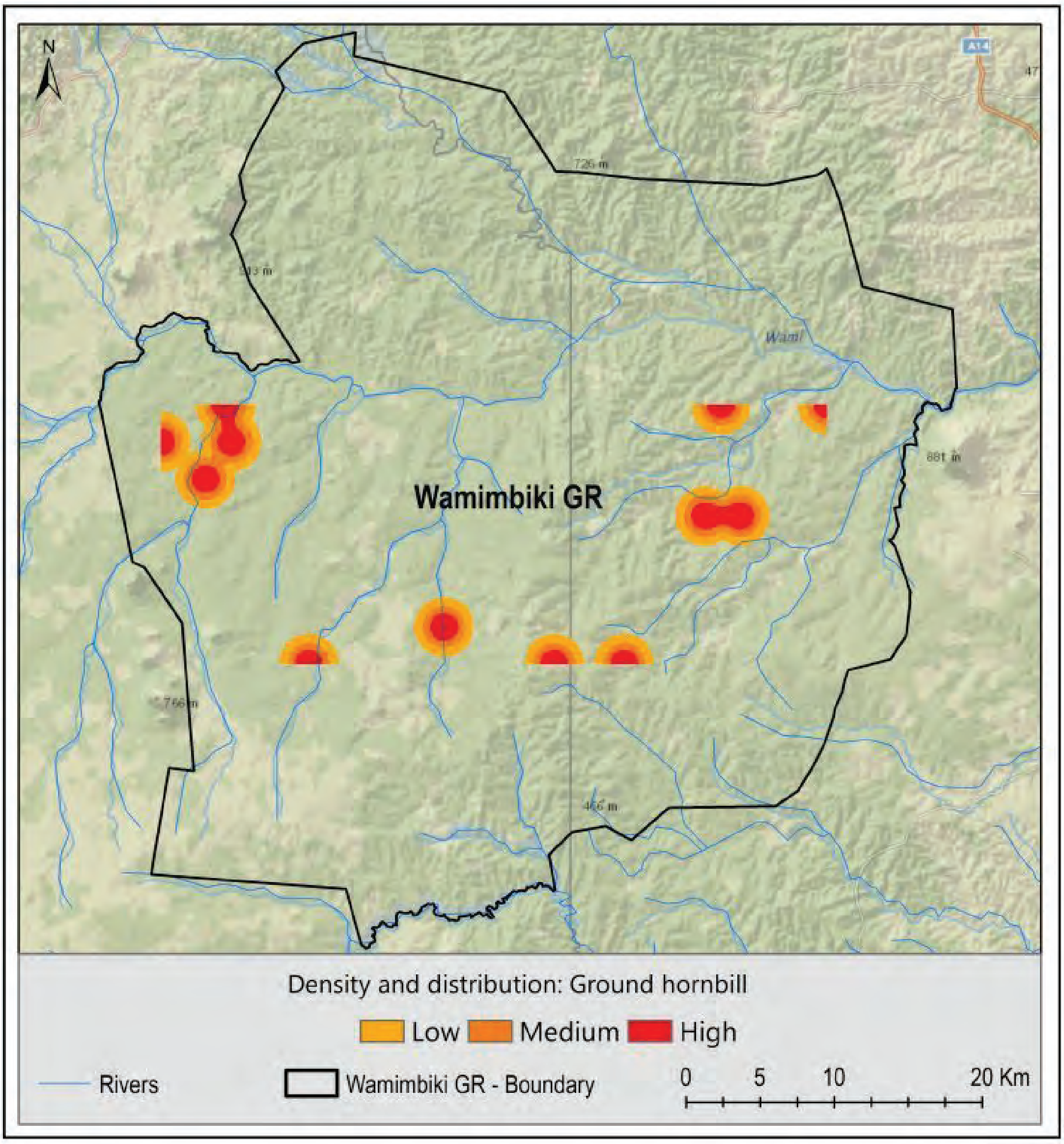

Figure 25: Distribution of Ground Hornbill in the WMGR, 2022

3.1.3.6. Baboon (*Papio cynocephalus*)

Baboon counts reached 17 individuals across three sightings in the WMGR (Table 4). A few sightings were in the eastern and southern parts of the reserve (Fig. 26). It is important to note that SRF is not an appropriate method for surveying primate species but depending on the habitat type, it can record their distribution as presented in this report.

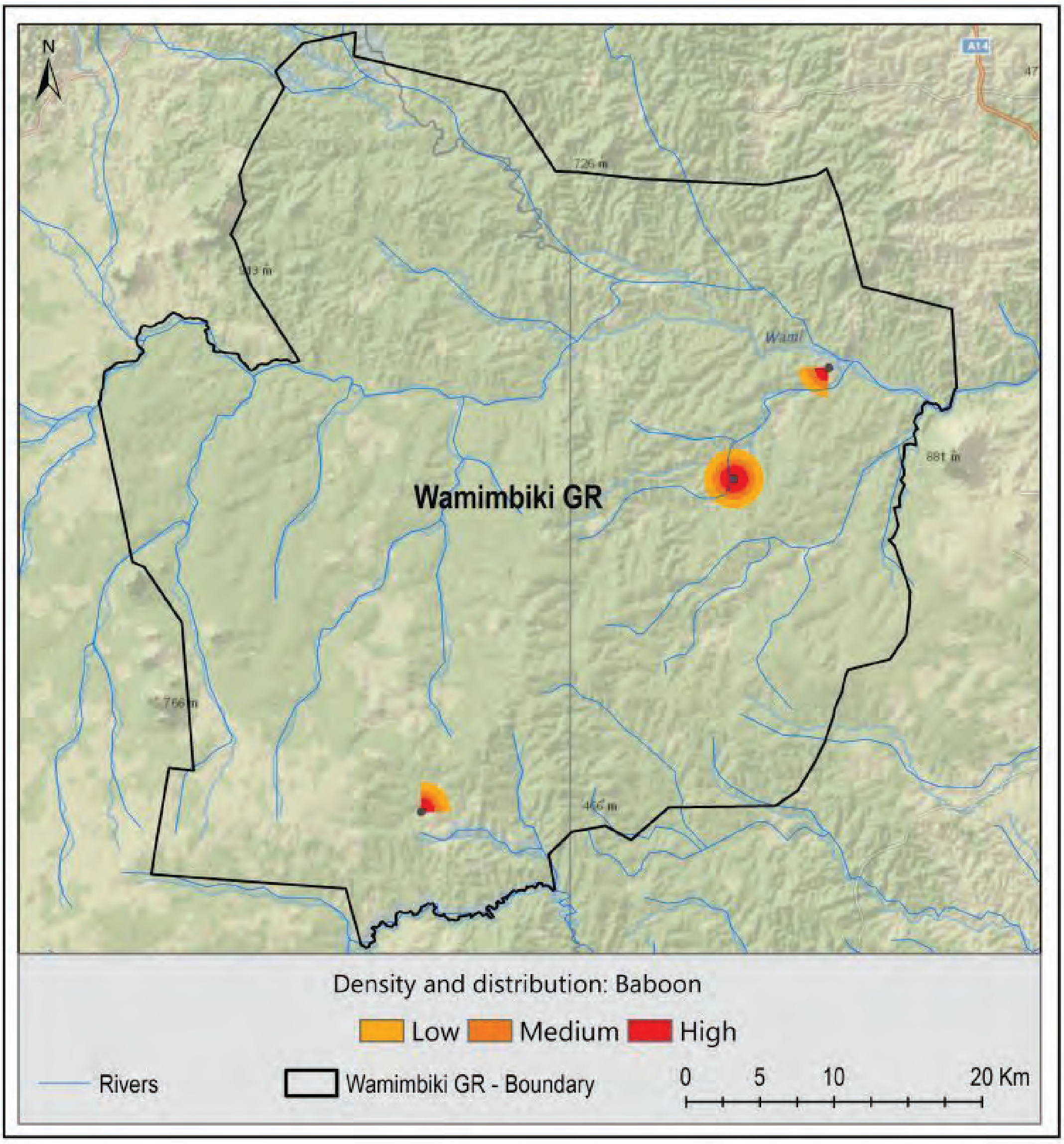

Figure 26: Distribution of Baboon in the WMGR, 2022

3.1.3.7. Other species (ED, ZB, GK, RB and WH.)

FIve (5) other recorded species included elands, zebra, reedbuck, and warthog. These species exhibited relatively low counts and were mostly distributed in the central and southern parts of the reserve, suggesting suitable habitat availability in those parts (Fig. 27).

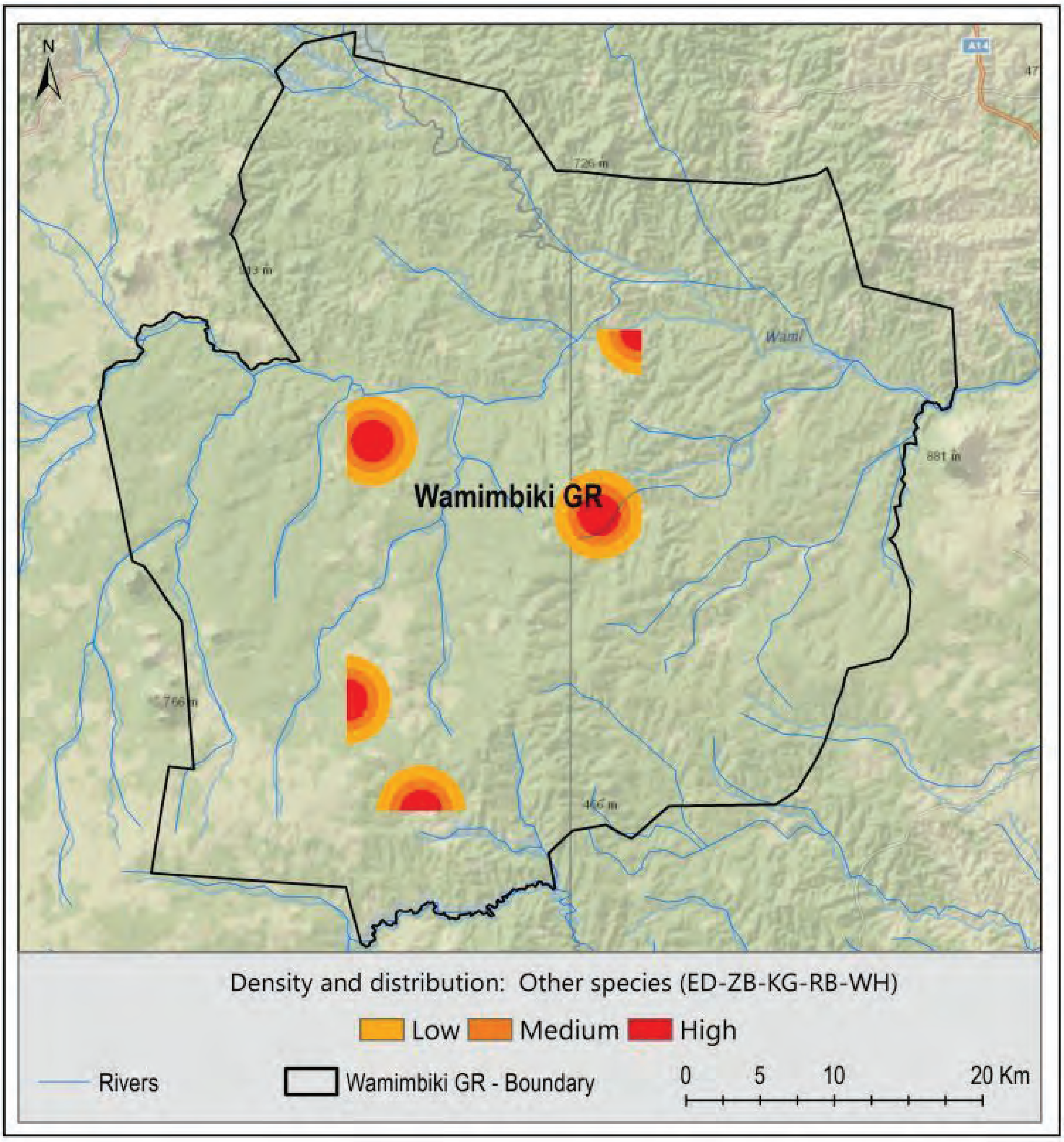

Figure 27: Distribution of Other species in the WMGR, 2022

3.1.4. Human activities in Wami-Mbiki Game Reserve

Human activities recorded in the WMGR encompassed encroachment, including livestock grazing (cattle, donkeys, and shoats), poaching, tree felling for charcoal and timber, construction of houses and bomas, as well as settlements (Table 5). It was further noted that, apart from livestock and settlement, the integrity of WMGR is threatened by many other notable activities, which include poacher camps, Fisher's camps, saw pits, and charcoal kilns. As specifically discussed, these activities were widely and evenly spread across the survey area. Generally, human activities recorded in both SNP and WGR highlight the presence of encroachment and emphasise the need for effective management and conservation efforts to mitigate the impact on wildlife and their habitats.

Table 5: Human activities in the WMGR

SN	Human Activities	Counted	Sightings	Estimate	Std Err
1	Cattle	3,207	46	14,567	3,267
2	Shoats (sheep and/or goats)	305	8	N/A	N/A
3	Charcoal Kiln	194	23	N/A	N/A
4	Boma Abandoned	189	25	N/A	N/A
5	Saw Pit	48	28	N/A	N/A
6	Donkey	24	7	N/A	N/A
7	Poacher's Camp	17	17	N/A	N/A
8	Hut/House with Mabati Roof	17	12	N/A	N/A
9	Boma Occupied	16	7	N/A	N/A
10	Footpath	2	1	N/A	N/A
11	Boma Unoccupied	1	1	N/A	N/A
12	Fish Camp	1	1	N/A	N/A
13	Tree Falling	1	1	N/A	N/A

N/A-Sightings less than 30

3.1.4.1. Livestock (Cattle and Shoats)

Cattle were sighted on 46 occasions, comprising 3,207 individuals (Table 4). The estimated cattle population within the reserve was approximately 14,567 individuals, with a margin of error of ±3,267. The frequency of cattle sightings was notably prominent, particularly evident in the northwestern sectors of the protected area (Fig. 28).

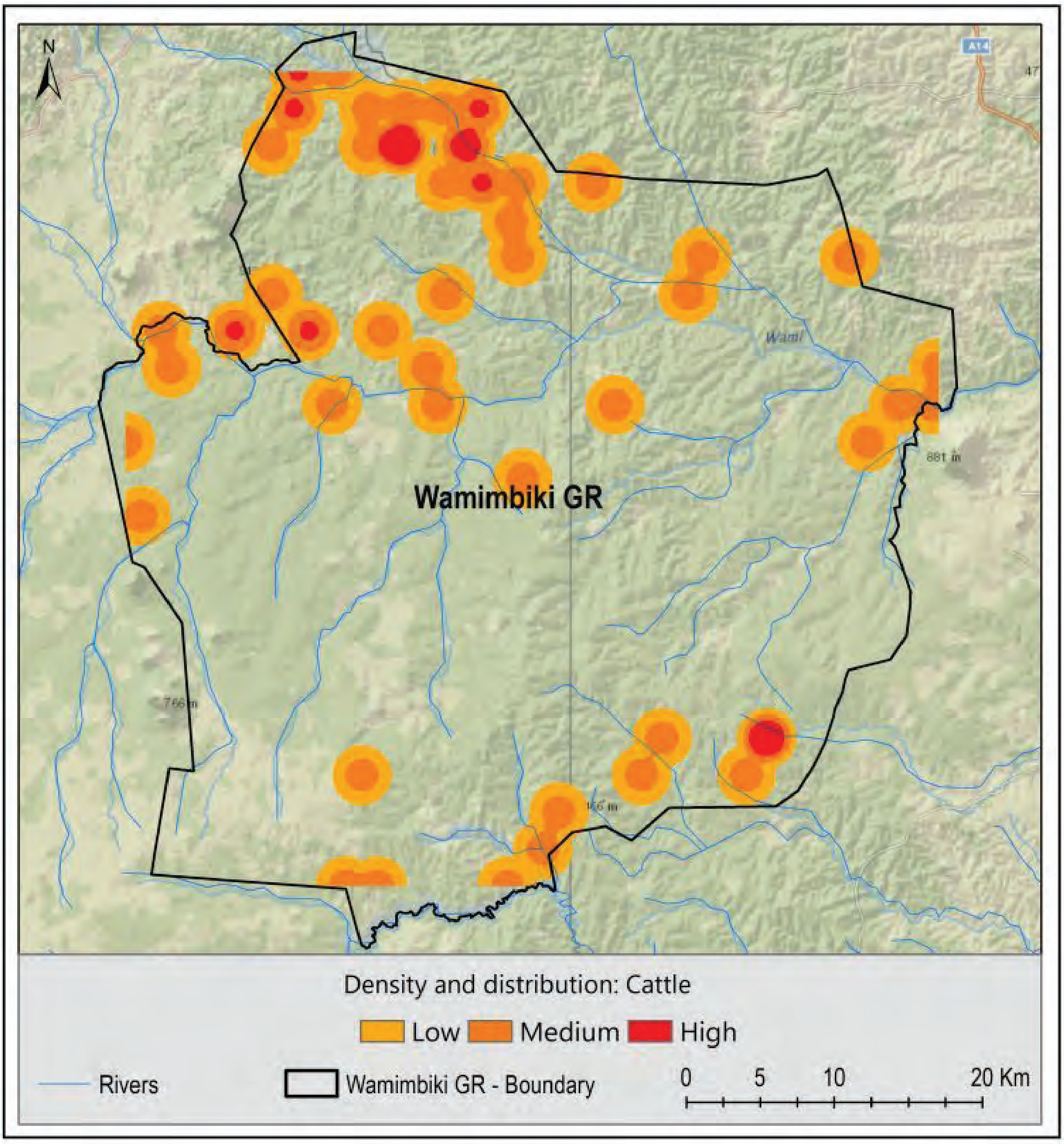

Figure 28: Distribution of Cattle in the WMGR, 2022

Conversely, while still present, Shoats were comparatively less frequently sighted and primarily concentrated within the northern parts of the reserve. Notably, there were no observations of shoats within the central expanse of the reserve, an observation succinctly (Fig. 29).

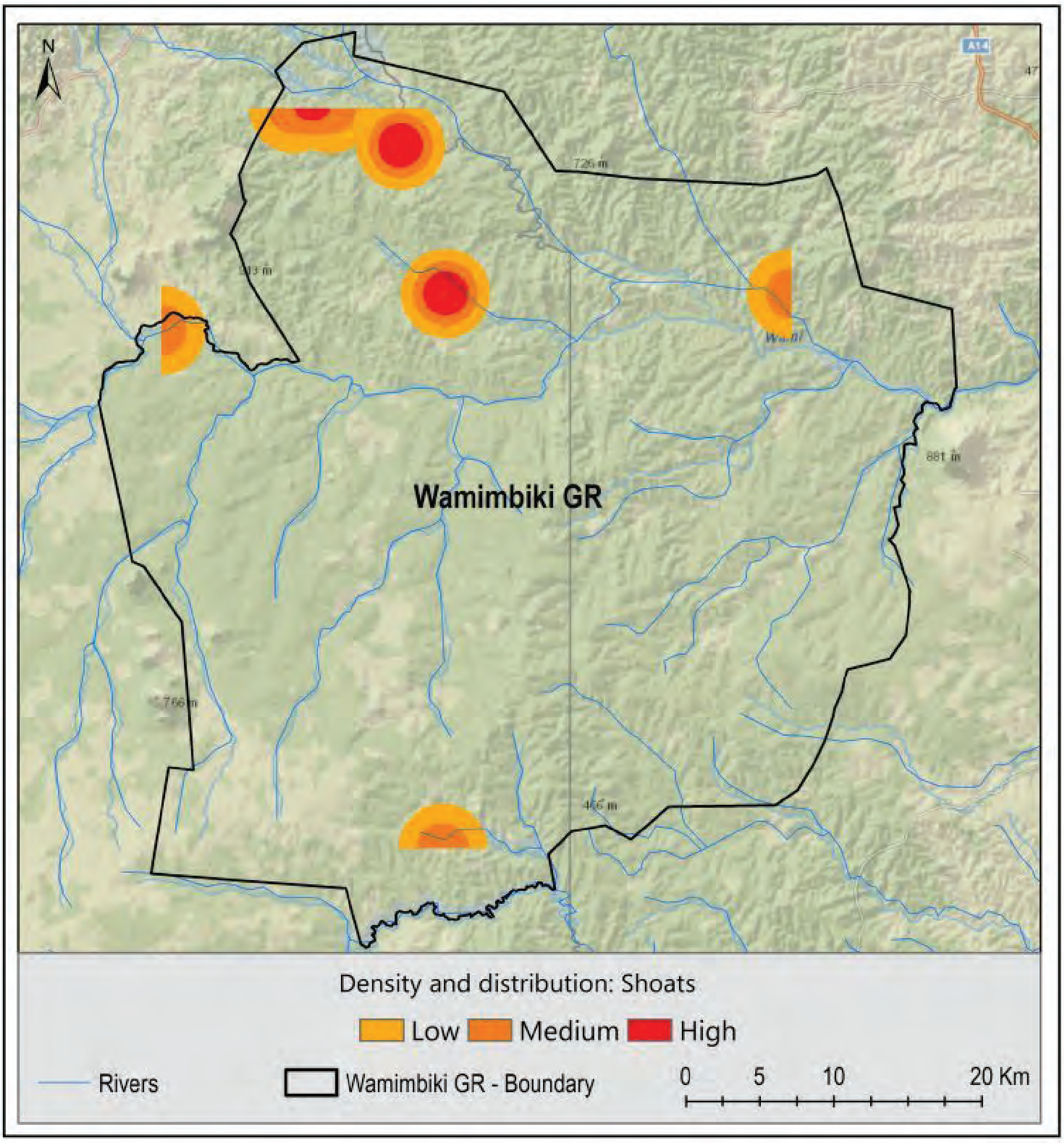

Figure 29: Distribution of Shoats in the WMGR, 2022

3.1.4.2. Cultivation

Cultivation was sighted as Hut/House with mabati roof boma occupied (Table 4). The distribution of cultivation in the reserve was primarily skewed towards the northwestern parts (Fig. 30) and a few others were observed in the east and south of Wami-Mbiki.

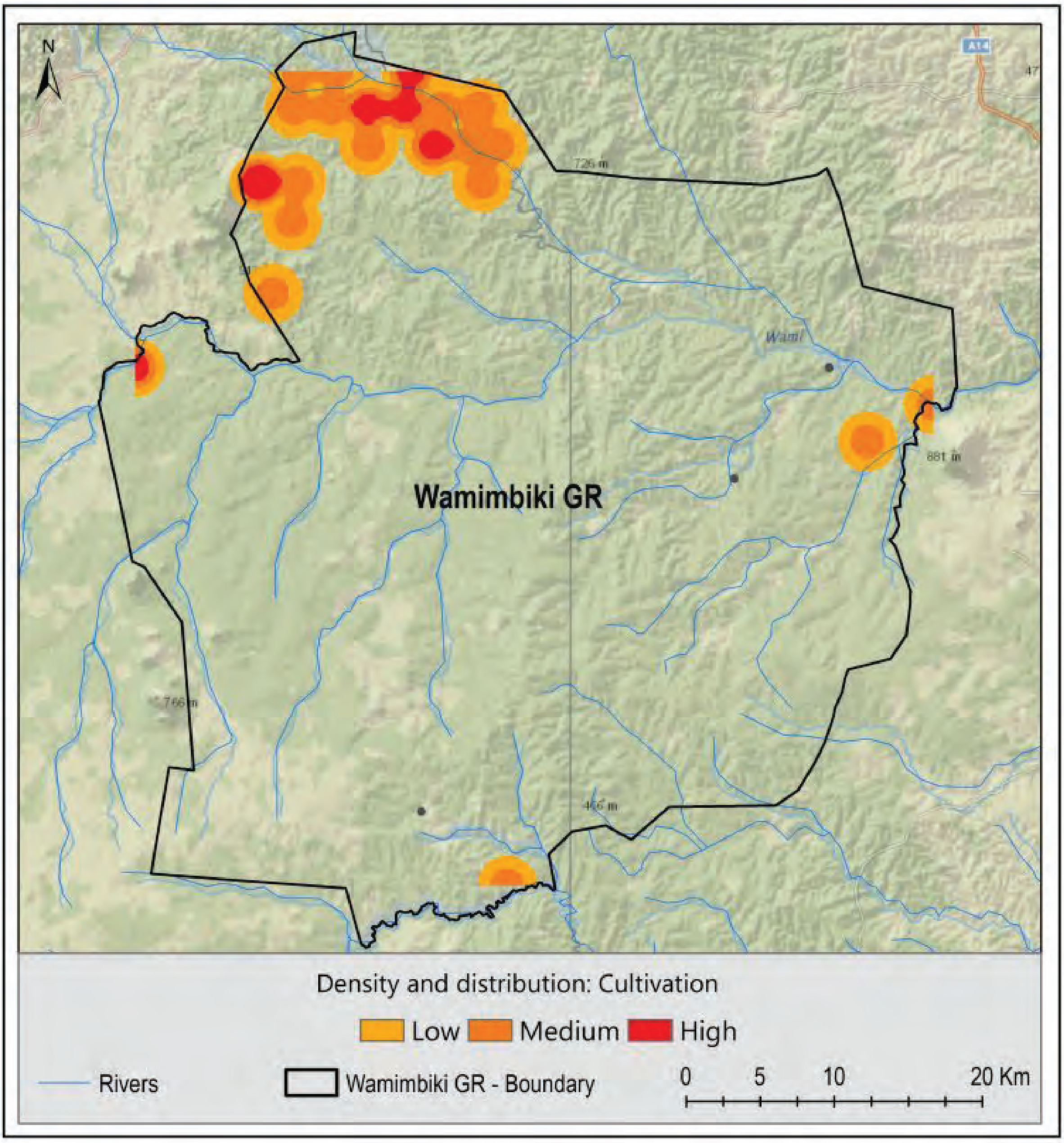

Figure 30: Distribution of Cultivation in the WMGR, 2022

3.1.4.3. Permanent Settlement

On the other hand, settlements were widespread across the reserve in the form of hut/house or boma, which were either occupied or unoccupied. These activities were densely spread across the reserve, and most were occupied by humans (Fig. 31), with only two unoccupied bomas in the north and southeast of the reserve (Fig. 32).

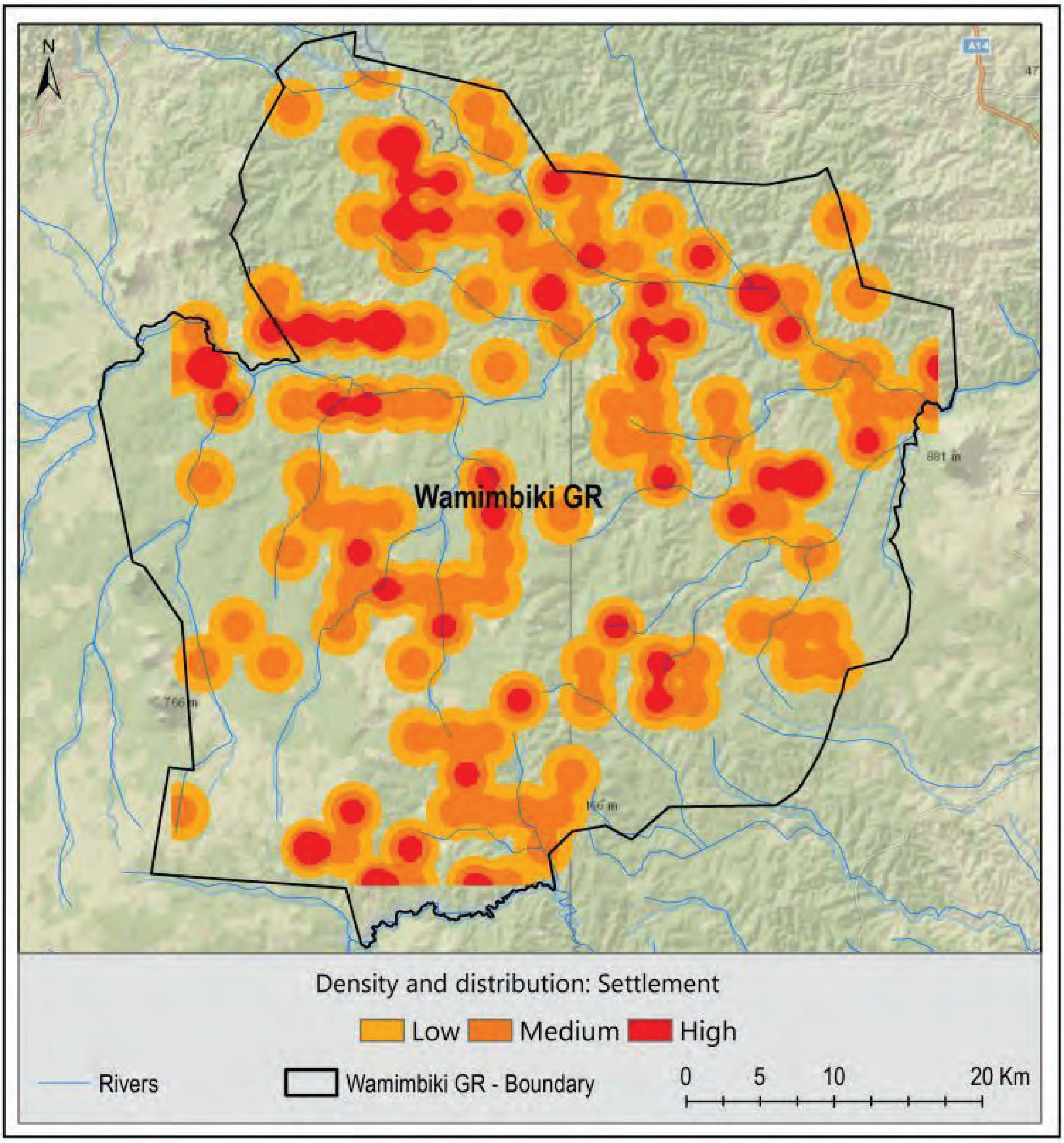

Figure 31: Distribution of Occupied Boma in the WMGR, 2022

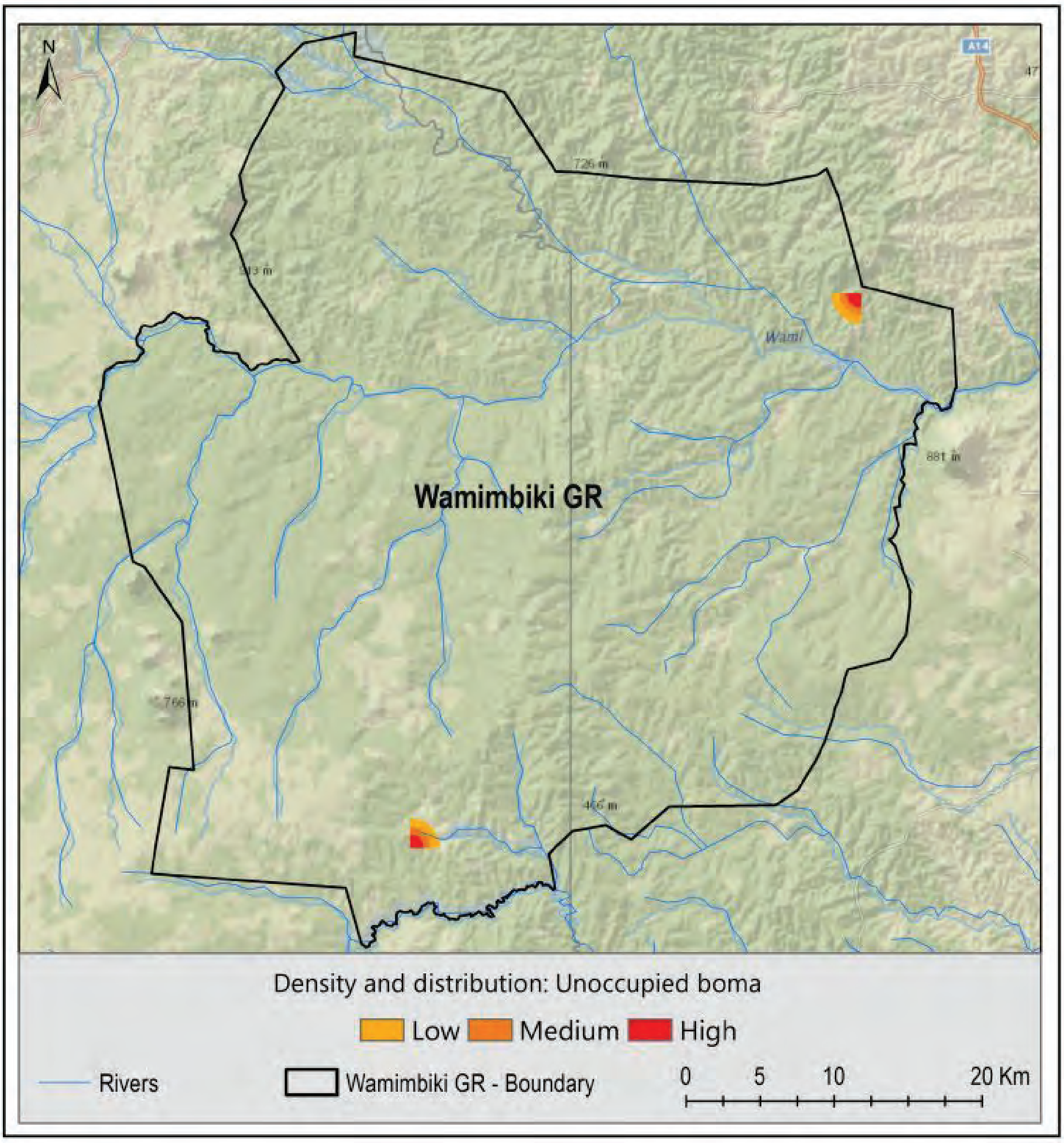

Figure 32: Distribution of unoccupied boma in the WMGR, 2022

3.2. Conclusion and Recommendations

The current survey continued to reveal the presence of various human activities within the park, providing valuable information for understanding the extent and impact of human encroachment. Human encroachment within the park poses a significant challenge to wildlife conservation and ecosystem integrity. Livestock grazing can lead to habitat degradation and competition for resources with native wildlife. Poaching poses a severe threat to endangered species and disrupts the delicate balance of the ecosystem. Generally, logging activities can result in habitat loss and negatively affect the park's biodiversity. Cultivation and settlements encroach on the natural habitats of wildlife and can lead to further fragmentation of the park's landscape. Efforts to manage and mitigate human encroachment are essential to preserve SNP's unique and diverse ecosystem long-term. Effective conservation strategies, community involvement, and law enforcement efforts are necessary to protect this iconic and ecologically vital area.

The observed old elephant carcasses in SNP indicate successful recent government efforts to combat poaching and protect the elephant population. Strengthening these anti-poaching actions is essential for long-term sustainability. However, the limited number of observations in the protected areas hinders a comprehensive understanding of wildlife populations and dynamics. In particular, the absence of wildebeest sightings in the current survey raises concerns about habitat changes. Conservation efforts are necessary to revive populations and preserve wildlife in line with historical figures, emphasising the significance of ongoing conservation measures. Continuous monitoring and proactive actions are essential for protecting and preserving diverse wildlife in SNP and the WMGR. Widespread human activities pose significant challenges to habitat conservation, making implementing effective anti-poaching measures and sustainable wildlife management practices crucial. Prompt actions are needed to protect habitats, address factors contributing to population decline, and restore populations in both areas. Coordinated efforts for wildlife population and habitat restoration are crucial. The following are recommended;

Law Enforcement: Strict enforcement of anti-poaching measures and regulations is essential to safeguard the wildlife populations in the two PAs. Adequate patrolling, surveillance, and coordination with local communities can help deter illegal activities such as poaching and encroachment. Engaging local communities in conservation initiatives through education and awareness programs can foster a sense of ownership and pride in protecting natural resources in the two PAs.

Habitat Restoration: Restoration efforts should focus on evacuating settlements and preventing human encroachment within the reserve. The 2022 census revealed a high density of human settlements and activities within the reserve, suggesting the statuesque. Collaboration with ecological experts and stakeholders will be beneficial in implementing effective habitat restoration strategies. We suggest the engagement of the community and relevant leaders for a smooth ride during the exercise; and

Restocking: It is crucial to introduce additional individuals of the species that have experienced a notable decline within the reserve. They include Duiker, Bushbuck, Greater Kudu, Impala, Wild Pig, Eland, Kongoni/Hartebeest, Reedbuck, Warthog and Zebra, to mention a few. However, a comprehensive assessment of the reserve's ecological requirements and species distribution patterns should be undertaken to identify additional candidate species for restocking.

Multifaceted management approaches: It is crucial to emphasise the importance of a long-term perspective when implementing these measures. Sustainable management practices, regular monitoring, and adaptive management strategies should be integrated into the conservation plans for the two PAs. This will ensure the conservation of the reserve's biodiversity and enhance its resilience to future challenges.

3.3. Acknowledgments

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5.0. APPENDICES

5.1. Appendix 1: Flight crew

Role of Crew	5H – SNP (TANAPA)
Pilot	Mackyu Kajwangya (TANAPA)
FSO	Hamza Kija (TAWIRI)
Left RSO	Albert Mangowi (TANAPA)
Right RSO	Azori Migezo (TAWA)

5.2. Appendix 2: List of ground crew

Scientific Supervision	Dr. Ernest Mjingo (TAWIRI)
Field Supervision	Dr. Edward Kohi (TAWIRI)
Logistics and Coordination	Dr. Edward Kohi (TAWIRI)
Survey Technical Advisor	Machoke Mwita (TAWIRI)
Data entry	Mr Maijo Simula (TAWIRI), Dr Bukombe John (TAWIRI)
Validation and Verification	Mwita Machoke (TAWIRI), and Dr. Edward Kohi (TAWIRI)
Data analysis	Mr. Mwita Machoke, Mr. John Sanare (TAWIRI), Hamza Kija (TAWIRI)
Mapping & geo-referencing	Hamza Kija (TAWIRI), Mwita Machoke (TAWIRI) and John Sanare (TAWIRI)
Reporting:	Dr. Alex Lobora, Dr. Bukombe John, Dr. Hamza Kija, Dr. Edward Kohi, Mwita Machoke, John Sanare), and Howard Frederick (TAWIRI)

5.3. Appendix 3: SRF Wildlife Surveys in Saadani National Park, 1991-2022

Year	Season	Census Technique	Area covered*	Area (km²)	Source
1991	Dry	SRF	Saadani Game Reserve	1,545	TWCM (1991)
1992	Wet	SRF	Saadani Game Reserve	1,528	TWCM (1992)
1997	Wet	SRF	Saadani Game Reserve	1,528	TWCM (1997)
1998	Dry	SRF	Saadani Game Reserve	2,753	TWCM (1998)
2001	Dry	SRF	Saadani Game Reserve	2,753	TWCM (2001)
2004	Dry	SRF	Saadani National Park	2,597	TAWIRI (2004)
2007	Dry	SRF	Saadani National Park	2,502	TAWIRI (2008)
2010	Dry	SRF	Saadani National Park	2,085	TAWIRI (2010)
2014	Dry	SRF	Saadani National Park	1,154	TAWIRI (2015)
2022	Dry	SRF	Saadani National Park		TAWIRI (2023)

Director General
Tanzania Wildlife Research Institute
P. O. Box 661
Arusha - Tanzania

Tel: +255 734 094 646
E-mail: barua@tawiri.or.tz