USING GEOTAGGED PHOTOS TO DESIGN ETOSHA NATIONAL PARK MAP SET

MASTER'S THESIS

submitted in partial fulfillment of the requirements for the degree
of

Master of Science (MSc)

PARIS-LODRON UNIVERSITY SALZBURG (PLUS)

Faculty of Digital and Analytical Sciences
Department of Geoinformatics

and

PALACKÝ UNIVERSITY OLOMOUC (UPOL)

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submitted by

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Salzburg & Olomouc, May 2024

ANOTATION

The main aim of this diploma thesis is to design cartographic-style maps for younger people, the public, and experts that visualize wildlife species distribution information using geotagged photos and landscape features of Etosha National Park. The design maps are then published on the web, combined with an interactive map that allows users to dynamically interact with wildlife data and landscape features of the park in a user-friendly way. The multiple basemaps, zooming, and popups with image functionalities were also implemented in the web map to attract users.

The Etosha National Park, which covers an area of 22,937 km², is the most popular tourist destination in Namibia and is considered one of the largest wildlife sanctuaries in the world. A brief analysis was done on the acquired geotagged photos from public sources to identify wildlife species that exist at different waterholes in the park. The analysis result was used to design cartographic maps for different groups, and each map was designed using different color schemes, basemaps, infographics, intuitive graphical icons for wildlife species, and attractive symbols for landscape features of the Etosha National Park.

The user evaluation was also performed to evaluate the design of different user group maps and the users' ability to understand the information in the maps. The designed maps can act as a guide for tourists who are planning to visit Etosha National Park and gain information about the occurrence of wildlife species at different waterholes in the park.

KEYWORDS

Keywords – Visualization, Wildlife, Trophic, Waterholes, Flickr API, Buffer, Web-map

Number of pages: 53
Number of appendixes: 6

This thesis has been composed by Muhammad Bilal for the Erasmus Mundus Joint Master's Degree Program in Copernicus Master in Digital Earth for the academic years 2022/2023 and 2023/2024 at the Department of Geoinformatics, Faculty of Natural Sciences, Paris Lodron University Salzburg, and Department of Geoinformatics, Faculty of Science, Palacký University Olomouc.

Hereby, I declare that this piece of work is entirely my own, the references cited have been acknowledged and the thesis has not been previously submitted to the fulfilment of the higher degree.

M. Bilal.

20/05/2024, Olomouc, Czechia **Muhammad Bilal**

Acknowledgements

Palacký University Olomouc
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Academic year: 2023/2024

ASSIGNMENT OF DIPLOMA THESIS
(project, art work, art performance)

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Work topic:	Using Geotagged Photos to Design Etosha National Park Map set
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Theses guidelines

The thesis aim is to design a set of high-quality design maps of Etosha National Park for multiple target user groups. First, the student will do research collecting data from websites, social networks, etc. about which animals are mostly present at which waterholes. Subsequently, according to a described methodology, such data will be presented in the maps along with other thematic and topographic content aiming to provide all necessary information for visitors. Maps will be designed in at least three variants/styles – for the general public, youth, and scientists – with adequate composition elements and graphic style. COPERNICUS data will be used either in the map itself or during the data processing.

The student will attach all created datasets and thesis outputs in digital form. The student will also create a website about the thesis following the rules available on the department's website and a poster about the diploma thesis in A2 format. The student will submit the entire text (text, attachments, poster, outputs, input and output data) in digital form.

Extent of work report:	max. 50 pages
Extent of graphics content:	as needed
Form processing of diploma thesis:	electronic
Language of elaboration:	English

Recommended resources:

Recommended resources:
[1] Lim, Teckwyn & Loke, Vivienne & Solana Mena, Alicia & Pura, Param & Angah, Rizuan & Tan, Ange & Campos-Arceiz, Ahimsa. (2017). Mapping the Distribution of People, Elephants, and Human-Elephant Conflict in Temengor Forest Complex, Peninsular Malaysia. Malayan Nature Journal.
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Date of assignment of diploma thesis: **December 4, 2023**
Submission deadline of diploma thesis: **May 20, 2024**

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CONTENT

LIST OF ABBREVIATIONS

Abbreviation	Meaning
GIS	Geographic Information System
GPS	Global Positioning System
PA	Protected Area
API	Application Programming Interface
WDPA	World Database on Protected Regions
SHP	Shapefile
CSV	Comma Separated Values
KML	Keyhole Markup Language
SVG	Scalable Vector Graphics
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
UTM	Universal Transverse Mercator
URL	Uniform Resource Locator
GeoJSON	Geographic JavaScript Object Notation
GBIF	Global Biodiversity Information Facility

INTRODUCTION

National parks are frequently the top destinations for nature-based tourism because they showcase the most representative ecosystems within a country and provide a variety of benefits to individuals and communities, including physical and mental well-being, raising awareness about natural areas, and connecting with nature (Barros et al., 2019). In exchange, an increased number of visitors draws attention to the park, which can benefit local economies by creating jobs and helping to conserve the environment and wildlife species in the park (Mangachena et al., 2023).

Social media is becoming acknowledged as a significant source of information regarding a wide range of issues, including nature-based tourism, because of its high temporal and spatial resolution (Teles da Mota & Pickering, 2020). Social media platforms are frequently used to share real-time geolocated data associated with images, text, and routes, reflecting the growing use of social media apps and smartphones (Bergman et al., 2022). The user-generated content from social media provides new alternatives for assessing tourism and recreation in national parks by analyzing visitor inflow and their sentiments, assigning economic values, and helping park management monitor tourist mobility (Teles da Mota & Pickering, 2020). Such data is also useful in developing strategies to reduce wildlife stress by analyzing visitor hotspot areas (Mangachena et al., 2023).

Spatial information is a core component of geotagged data; for example, understanding where wildlife species are located and in which environments. This type of data must be condensed and presented in an understandable and visually appealing manner so it can highlight unseen facts and allow the user to interact with what they are viewing. Researchers primarily used social media platforms such as Flickr, Panoramio (now integrated into Google), and Instagram to obtain geotagged data to access nature-based tourism (Teles da Mota & Pickering, 2020).

With a great diversity of wildlife species, including attractive mammals like elephants, lions, giraffes, and zebras, Etosha National Park considered one of the largest wildlife sanctuaries in the world (de Beer et al., 2006; Kimaro et al., 2015). This research aims to create cartographically designed maps for three different target groups, including younger people, the public, and expert people, that visualize different wildlife species that could potentially be seen at different waterholes, topographical features, and amenities of the Etosha National Park. The geotagged information for wildlife species will be collected from Flickr, Google Earth, and tourist company websites like Expert Africa. These maps will also be user-tested to gain feedback and evaluate the effectiveness of cartographic design in communicating wildlife information. Additionally, these cartographic maps will also be hosted on the web so that everyone can access them through the internet and interact dynamically with the wildlife information and different thematic features of Etosha National Park.

The result of this research can act as a guide for tourists who are planning to visit Etosha National Park and gain information about the existence of wildlife species at different waterholes in the park.

1 OBJECTIVES

This thesis aims to design cartographic maps for three different user groups that visualize wildlife species locations at different waterholes using geotagged photos, along with other thematic features of Etosha National Park. The purpose of maps is to provide detailed information to younger people, the public, and experts about the existence of different wildlife species in the park. The maps will be designed based on the principles of cartographic design, including infographics, and integrated with Copernicus data. Additionally, these maps will be user-tested in terms of their design and published on the web, combined with an interactive map, so people can easily access them and dynamically interact with different features of the park.

The overall aim is further divided into three major objectives:

   I. **Develop a workflow for collecting wildlife geotagged photos from multiple public sources**.

   Research questions:

   a) Which public sources are available online that provide geotagged photos of wildlife species?

   b) What are the different methods for the extraction and preprocessing of geotagged information?

   II. **Design maps of Etosha National Park for multiple user groups, including the public, experts, and young people**.

   Research questions:

   a) What are three different optimal styles in terms of color scheme and layout can be used for designing maps?

   b) Which intuitive symbols convey more information to different groups?

   III. **User evaluation and publish map sets on a web platform.**

   Research questions:

   a) Which evaluation method will be suitable for these maps?

   b) Which web platform will be suitable for publishing maps?

   c) Which methods and technologies will be suitable for developing an interactive web map?

The result of this thesis can act as a guide for tourists who are planning to visit Etosha National Park and gain information about the occurrence of wildlife species at different waterholes in the park. Further, maps could also help park authorities assign more financial resources where wildlife is mostly seen and declare game viewing spots without disturbing the wildlife. The result will also be useful for researchers because it allows them to see the distribution of endangered species and will help them develop strategies for their protection.

2 STATE OF ART

The purpose of this chapter is to review the literature on the use of geotagged photos to design the Etosha National Park map set. The chapter begins by explaining the importance of wildlife mapping, followed by a discussion of existing studies of national park mapping around the world. The historical development and characteristics of Etosha National Park are also included in this chapter. The review will also encompass discussions on platforms that share geotagged information about wildlife and other statistical information related to national parks. Additionally, the chapter discusses existing web mapping platforms and possibilities to visualize a map set of Etosha National Park on the web. Finally, the goal of this chapter is to provide an understanding of how designing a map set helps tourists or researchers in terms of wildlife mapping and highlight research questions, methods, and findings.

2.1 Importance of Wildlife Mapping

According to ecologist and conservationist the definition of wildlife is all living organism that are beyond man's direct control, including farmed plants, wild animals, and their habitat (Yarrow, 2009). Wildlife management involves dealing with wild animal populations, habitat relationships toward wild animal populations, and manipulating habitats or populations to achieve some human goals (Yarrow, 2009). According Saltz and White (2013) Wildlife management techniques aim to investigate, reduce, increase, or maintain the animal population's at the existing level while preventing the loss of genetic variety and improving their long term survival.

The goal of wildlife management is to maintain yield while preserving the integrity of harvested populations, enhancing the survival probability for endangered species, maintaining ecosystems, and reducing overabundant and pest populations (Saltz & White, 2013). Human actions have resulted in habitat destruction, climate change, and pollution, have led to the decline of numerous species and disrupted ecological systems (Diaz et al., 2019; Dirzo et al., 2014). So, Conservation measures are necessary to prevent further losses and encourage the recovery of endangered species and habitats (Chapin III et al., 2000; Pimm et al., 2014). The integration of GIS technology and conservation biology is a rapidly emerging interdisciplinary field that has transformed conservation efforts globally.

Geographic Information System (GIS) is a powerful technology that has transformed conservation efforts by providing spatially explicit data to help decision-making (Suzzi-Simmons & Devarajan, 2023). Moreover, the researcher uses GIS technology to examine the habitat suitability and connectivity, which helps to identify biodiversity hotspots and areas that need conservation efforts (Vogiatzakis, 2003). One example is using GIS to identify crucial habitats and migratory routes for endangered species. For example, it was used to identify and map the habitats of Siberian tigers, leading to effective conservation efforts (Kerley et al., 2002).

In addition, GIS has been used to identify and map biodiversity conservation areas, including key biodiversity areas (KBA), by integrating different datasets like protected areas, land cover, vegetation, and others that helped in prioritizing conservation efforts in different parts of the globe (Langhammer, 2007). In Central Africa, research was

conducted in which GIS was used to monitor the distribution of mammal communities due to human disturbance and has helped identify key regions for conservation and management (Vanthomme et al., 2013). Another study was conducted in the Temengor Forest Complex, Malaysia, in which researchers utilized GIS technology to map the distribution of people and elephants in that forest to analyze human-elephant conflicts that led to conservation strategies (Lim et al., 2017).

Moreover, research conducted in some region of China to monitor the rapid climate change effect threatens its unique ecosystem and distinctive wildlife, including the endangered snow leopard. The GIS-based habitat Modeling was used to predict habitat suitability for endangered snow leopards (Li et al., 2016). The research of Montero et al. (2021) used GIS technology to monitor the effects of land-use change on biodiversity, including the effect of agriculture on bird population in Costa Rica. In the Central Rockies ecosystem of Canada, research was conducted to analyze the spatial relationship between grizzly bear mortalities and variables reflecting human development, terrain, and vegetation using GIS technology (S. Nielsen et al., 2009; S. E. Nielsen et al., 2004). The study's findings were used to develop management measures that sought to limit human-bear interactions and protect important grizzly bear habitats.

An interested studies carried out in which reseacher utilized GIS integrate with GPS and Remote Sensing technology to track the movements and habitat preferences of wildebeests and zebras in Serengeti National Park (Hopcraft et al., 2014; Musiega & Sanga-Ngoie, 2004). The researchers discovered that the movements of these two species were influenced by both local vegetation and regional climate patterns, with wildebeest and zebras depending on different vegetation types at different times of year. This knowledge helps wildlife management strategies to maintain ecosystem balance and protect important species. Similarly, researchers use GIS and GPS technology to analyze the predatory behavior of wolves in some parts of Scandinavia (Sand et al., 2005). They conclude that the feeding behavior of wolves largely depends on the moose, and the high kill rate of moose by wolves observed in this study as compared to previous studies.

Wildlife corridor can be describe as is a longitudinal, two-dimensional landscape element that connects multiple areas of wildlife habitat that have been connected historically over time (McEuen, 1993). For wildlife conservationists, it is difficult to ensure habitat connectivity, which allows species to move between fragmented areas. There have been a lot of studies that use GIS technology for protecting wildlife corridors, which includes mapping and analyzing routes and barriers between habitats. It helps conservation experts identify suitable places for habitat restoration, establishment, and corridor protection (Mehta & Shukla, 2022). Similarly, the study was conducted in the Pench-Satpuda wildlife corridor of central India, which is known for tiger reserves. The researchers utilize GIS and remote sensing technology to analyze the land use and land cover of this corridor over the past two decades. The researcher analyzes the severe decrease in forest and water bodies due to enthrapogenic activities, which led to a severe threat to wildlife corridors and urgent conservation strategies (Banerjee et al., 2020).

An interesting study was carried out in Wuhan, China, in which researchers analyzed how highway construction could negatively impact wildlife survival through habitat divisions and reduce connectivity, which can lead to decreases in wildlife populations and the loss of biodiversity. The researcher uses GIS and a suitability model to propose new

sites for wildlife habitat around the highway and also identify the potential migration path for wildlife (Jianchao et al., 2016). Similarly, the researcher uses the least-cost corridor function of GIS to locate potential wildlife corridors for cougars in New Mexico, United States. The researchers modeled 26 corridors, of which four were identified as critically risky because of highway crossings (Menke, 2008). This information helps conservationists reduce the impacts of future development plans.

Moreover, the research was conducted to analyze human and wildlife conflict in the Kangchenjunga Landscape, which lies between three countries: Bhutan, Nepal, and India. The researchers use GIS and remote sensing technology to model and map human-wildlife conflict hotspots in that landscape (Sharma et al., 2020). The study concluded by identifying hotspots, which make up 19 percent of the total landscape area due to anthropogenic and climatic factors. Similarly, another study was carried out in the Western Yunnan region of China that used GIS technology integrated with camera trapping or models to analyze the variation in ecosystems and human disturbances over the past 20 years that led to a loss of wildlife connectivity. The researcher found that the Asiatic Black Bear species is most affected in this region due to human disturbance and urgent conservation policies (Ji et al., 2023).

With the passage of time, the tool for supporting decision-making in wildlife management has also improved. In light of that, the study was conducted in Yunnan, China, mapping the habitat suitability of the black-and-white snub-nosed monkey by integrating multiple source datasets, sighting data from local people, and field datasets (Zhang et al., 2020). The result of the predicted suitability map was more accurate than the individual data approach. Similarly, advanced research was conducted in Sacramento National Wildlife Refuge, US, by developing a web-based GIS platform that visualizes real-time GPS tracking of wildlife data and remotely senses environmental data to analyze how animals interact and utilize habitats and ecosystems in near real time (Casazza et al., 2023). This platform aids conservation stakeholders in their planning and improves their understanding of landscape impacts like climate change on wildlife populations.

Finally, these studies illustrate how GIS technology helps in conservation efforts. Combining GIS mapping and spatial analysis techniques with conservation strategies can provide useful insights into species distribution and the factors influencing their survival. This review emphasizes the value of GIS in identifying essential habitats, prioritizing conservation efforts, and developing adaptation methods for future environmental changes. GIS can play a crucial role in biodiversity conservation and protecting the world's ecosystem.

2.2 Current Research on National Park Mapping

National parks are protected regions that preserve magnificent landscapes and wildlife for ecosystem sustainability. National parks help to prevent biodiversity loss and preserve the naturalness and beauty of our surface (Schägner et al., 2016). Several studies have been done on protecting and managing national parks around the world that contribute to nature conservation and biodiversity protection. Most studies used GIS technology integrated with remote sensing and AI technology to monitor national park wildlife, which led to effective conservation strategies.

In a study by Xu et al. (2022), the researcher analyzes the effect of climate change on the existing system of nature reserves for protecting biodiversity and ecosystem services in the Tibet region of China. The researcher uses the GIS technique to map the distribution of endangered species and spatially overlap with the distribution of water, soil, and flood storage areas. They conclude by highlighting areas for endangered species protection in the southern part of the region and suggesting expanding the existing system of nature reserves to protect biodiversity.

In another empirical study by Radan et al. (2017), the authors analyzed the wildlife distribution in Kola Ghazi National Park, Iran, by using GIS software. They used the overlapping method, in which the wildlife distribution map that is generated through the IDW technique is spatially overlapping with existing natural resource layers like water, soil, and topography. They conclude by identifying sensitive conservation areas that have a higher density of wildlife than other areas and also giving suggestions in terms of conservation strategies and ecotourism management.

An empirical evaluation by Ruda et al. (2018), analyzed the geospatial conection of animal attacks on humans in Chitwan National Park, Nepal. The researcher used GPS points of incident and overlayed them with other landscapes, including human settlement areas, to find conflict reasons. They concluded that areas where incidents more frequently occur are close to the park due to human enthropogenic activities and settlement. They created a risk zone map where potential wildlife conflict could occur and gave suggestions to prevent this situation as well.

In a study conducted by Imam et al. (2009), they evaluated the suitability of tiger habitat in Chandoli National Park, India. The researcher uses GIS tools, along with remote sensing and field data like GPS, to identify potential areas in the park that can be declared tiger reserves for the protection of tiger species. The result shows that 50 percent of the park area is suitable for tiger reserves, and they also identified and mapped a wildlife corridor that is suggested to be integrated with tiger reserve areas for sustainable species growth.

An interesting study was carried out in Wuyishan National Park, China, in which maps of the wilderness were created based on local people and expert knowledge about wildlife that exists in the park (Weng et al., 2024). The researcher concluded that the expert-based map did not reflect local people's representations accurately, and the integration of both maps represented accurate wilderness areas.

In a study by Roy et al. (2010), the researcher predicted the potential wildlife corridor path for 14 protected areas in the Orissa region of India. They used a geospatial modeling approach by integrating vegetation type and land cover datasets, including settlements and roads, into the model. This model identified suitable wildlife corridors for 12 protected areas in the Orissa region based on the variables provided and suggested that these corridors help in biodiversity conservation in that region.

An important study was carried out in Wayanad Wildlife Sanctuary, India, in which researchers analyzed the forest fire risk to wildlife and human settlement in that sanctuary (Vinod et al., 2016). The researcher mapped the fire risk zone using remote sensing and GIS techniques by integrating environmental and human-related variables. The output of that research is a fire risk zone map that shows high- and low-risk areas and suggests that this assessment can be helpful in mitigating forest fire effects and wildlife protection.

In Malaysia, the researcher conducted a study on Krau Wildlife Reserve to analyze protected areas in terms of landuse and landcover change (Shaharum et al., 2018). They created an updated land use and land cover map using remote sensing and GIS technology. They concluded by indicating that socioeconomic activities are responsible for changing the environment of Krau Wildlife Reserve, and these land use and land cover maps will be helpful in understanding the effect of human activities within and around protected areas.

In a study by Kushwah (2012), carried out in Kuno Wildlife Sanctuary, India, the researcher predicted suitable habitat areas for some herbivorous species. The researcher used GIS and remote sensing techniques along with the geostatistical method to develop a suitability model that is fed by environmental, wildlife GPS location, and land use information. They concluded by identifying nine types of forest areas that contain habitat for different species and suggesting that this information will help authorities in the better management and conservation processes of the species.

An important study was done by Kimanzi et al. (2015) in Ruma National Park, Kenya, where poaching with snare incidents was reported and caused a decline in endemic roan antelope species. The researcher mapped the spatial distribution of Sanres in the park using survey information and overlaid it with a habitat suitability map that visualizes species-abundant areas to develop effective management strategies to protect this species. They concluded by recommending routine security checks on identified snare hotspots to protect the roan antelope and other species in the park.

In a similar study carried out by Shaffer & Bishop (2016) in Tsavo National Parks, Kenya, they analyzed the poaching of African elephants for the ivory market and found a decline in their population. The researcher spatially mapped the elephant poaching incident to correlate with water, roads, and other landscape features to create a risk map. They concluded by identifying high-risk poaching areas in the park and urging authorities to take effective action for conservation of that species that will help to prevent future incidents.

In research by Bukombe et al. (2022), they assess the feasibility of a wildlife corridor between Wami-Mbiki Game Reserve and Nyerere National Park. The researcher uses GIS and remote sensing techniques, along with ground-surveyed information, to analyze landuse changes in the corridor over the past 40 years. They concluded by identifying a severe decline in forest and woodland areas due to an increase in agriculture and settlement activities that has a negative effect on wildlife species distribution. They urge authorities to enforce land use regulations to protect other corridors and raise awareness related to wildlife in communities.

In another study by Sanare et al. (2015), the researcher identified the best suitable habitat area for elephants in Serengeti National Park, Tanzania. The researcher uses the decision support system technique of GIS by incorporating river, road, forest, woodland, and grassland information. The conclusion was reached by creating an elephant habitat suitability map based on the factors provided and suggesting that those suitable areas will be useful for the grassing, socializing, and reproduction of elephants. They also urge decision-makers and wildlife management's agencies to adapt effective strategies for wildlife conservation.

The management of national parks not only contributes to stopping the loss of biodiversity and preserving the beauty of our landscape, but it also contributes to the economy. National parks offer the opportunity to visit, experience nature, and learn about biodiversity, allowing authorities to generate income and employment through tourist expenditures. In an interesting study by Schägner et al. (2016), the researcher analyzed the visitor ratio at 205 national parks in Europe. They mapped the visits of tourists to national parks and used GIS and statistical regression model to predict annual visits to all national parks in Europe. They conclude by predicting that annually, more than 2 billion people visit all national parks in Europe and contribute €14.5 billion to the economy.

In similar research conducted by Balmford et al. (2015), the researcher analyzed the visitor ratio to protected areas at the global level. They built region-specific models predicting visit rates based on protected area size, population size, remoteness, natural attractiveness, and national income. They concluded that, altogether, protected areas receive roughly 8 billion visitors annually, of which 80% are in Europe, and approximately $600 billion annually contributes to direct in-country expenditure.

In a study by Olaniyi et al. (2016), the researcher mapped the ecotourism resources that exist in T.A. Afolayan Wildlife Park, Nigeria. They use GIS and GPS technology to create an ecotourism resource map that visualizes the spatial distribution of different wildlife species and man-made features like nature trails, water wells, and museums in the park. They concluded that the resource map will help authorities make conservation efforts for wildlife and also help in the development of animal sighting spots that increase the inflow of visitors into the park.

In an interesting study by Brown et al. (2018), the researcher evaluates the quality of crowd-sourced spatial data that is collected in a project of public participatory Koala species mapping in New South Wales, Australia. The people were asked to map the location of Koala species sightings using an internet application, and that data was

assessed by the researcher in terms of positional accuracy and contributor characteristics. They concluded that positional accuracy is more spatially associated with the Koala likelihood model and suggested that to enhance the quality of crowd-source data, significant resources and community partnership are necessary.

In another study by Grünewald et al. (2016), the researcher analyzes the factors that drive tourists to visit Kruger National Park, South Africa. They mapped large mammals, vegetation cover,and infrastructure, along with conducting visitor interviews, and concluded that seeing wildlife was the main reason for visiting the park rather than the infrastructure. They urge authorities to focus on the conservation of large predators and prey because visitors are more attracted to them. Similar research was done in four protected areas in South Africa and suggested increasing viewing opportunities while reducing disturbance to wildlife to increase the visitor ratio (Arbieu et al., 2018).

Furthermore, in an interesting study by Heikinheimo et al. (2017), they analyze visitor behavior and preferences by comparing geotagged social media data and traditional survey data to map people's activities in Pallas-Yllästunturi National Park, Finland. They conclude that social media information provides more specific information about visitor use of the park and complements the traditional approach by providing spatio-temporal activity patterns of visitors.

Finally, these studies about different national parks around the world illustrate how the mapping technique of GIS technology integrated with remote sensing and AI helps to protect biodiversity and the landscape of the parks. Various studies show that the management of national parks indirectly contributes to the economy through ecotourism and alleviates poverty in those regions by creating jobs as well. There is limited research done on using social media information for national park management. In my opinion, it not only improves conservation strategies but also increases visitor ratios by integrating near-real-time information. The information from social media platforms is useful to identify hotspots where visitors encounter wildlife, and those areas can be declared as wildlife sighting points without disturbing the wildlife.

2.3 Etosha National Park Characteristics

The Etosha pan and the area around it, later known as Etosha National Park, which is situated in the north-west part of Namibia, were identified by European travelers in the mid-18th century when they visited the wild region with the Ovambo people (Galton, 1889) . The area of Etosha National Park was inhabited by Hai//om people, a group of hunter-gatherers generally referred to as the San group or Bushman, for many centuries. The term Bushman was devised by Europeans to address many ethnic groups as collective terms, for example, Kxoe, Hai//om, and Ju/'hoan groups, that exist in Etosha and surroundings region (Dieckmann, 2001). Each group occupied a different area in northern Namibia and spoke a different language, but Hai//om people are those who used to live within or around Etosha National Park, long before colonization (Suzman, 2004). The park is famous for its abundant wildlife; for example, lions, elephants, rhinos, and other large species exist in the park. According to research, two-thirds of the tourists in Namibia must visit Etosha, and see different African wildlife species in the park that motivate tourists to visit (Mendelsohn et al., 2000).

In 1884, the German Empire took control over the south-west African region, and in 1898, the Bushman or San group, including the Hei//Om people of Etosh pan, signed a treaty with the German colonizer to create peace between Bushman groups and colonizers. Further, in 1907, the German Empire declared the Etosha region a Game Reserve No. 2 with an area of 93,240 km² due to the increasing threat to animal populations from overly enthusiastic European big game hunters. Moreover, after World War I in 1915, South Africa took control over Namibia and changed laws about game reserves to allow hunting for specific animals under license. After the political shift over the years, the administration of South Africa declared Game Reserve No. 2 as the Etosha Game Park, which later became Etosha National Park in 1967. Despite Namibia's independence in 1990,   .

Tourism is a key source of revenue for local populations that are living in and around Etosha National Park. The community-based tourism initiative by the Namibian government provides economic benefit to the local community and ensures that the local people should control or maintain tourism and hunting activities in their region. Furthermore, tourism supports local communities by generating financial income, providing employment, and alleviating poverty. In Etosha National Park, tourism not only gives growth opportunities but also helps in the conservation of wildlife and ecology (Kavita & Saarinen, 2016). The hunting business in Etosha National Park supports local people by providing non-financial products such as meat and occasionally holding spiritual values. The community-based conservation initiatives that gave authority to the local community to manage and monitor biodiversity in Etosha National Park raise concern about wildlife conflict with local people by destroying crops and attacking people (Störmer et al., 2019).

In a study by Kimaro et al. (2015), the researcher conducted a survey in high and low peak tourist seasons at Etosha National Park to analyze tourist satisfaction in terms of the park environment. They use the questionaire method to ask tourists about parks and conclude that the attractiveness of the park, its facilities, and its cleanliness were the major factors in satisfaction, but they raise some concern about the cost of accommodation and services, road infrastructure, and environmental-related issues during their visit to the Etosha National Park. The researcher urges authorities that information on tourists' satisfaction will always help in understanding areas for potential improvement and increasing the tourist ratio.

The Etosha National Park, which covers an area of 22,937 km², is the most popular tourist destination in Namibia and is considered one of the largest wildlife sanctuaries in the world (Dieckmann, 2023). The Etosha Pan is an enormous flat saline seasonal depression, comprising around 4760 km², about 23% of beautiful Etosha National Park (Nakanyala, 2012). The pan is 130 km in length and up to 50 km wide, making it comfortably the largest salt pan in Africa. It is also the park's most distinctive and remarkable geomorphological landform feature, which is visible even from space. Etosha means 'big white place' in the Ovambo tribe language. It is thought that this natural mineral pan was formed 16,000 years ago when the Kunene River in Angola would have flowed all the way to Etosha and formed a massive and deep lake for some period of time. However, due to tectonic plate movement, the river would eventually shift course and head for the Atlantic, gradually drying out the lake and leaving the salt pan behind ("Etosha Pan," 2024). The Etosha Pan is classified as a wetland of international

importance and managed as a wilderness area under the IUCN conservation of protected area category. In the park, mammals use pan for water, food, migration routes, and relaxation. while birds use this pan for breeding, feeding, and migration stopovers of flamingos (Cunningham & Jankowitz, 2010).

Etosha National Park contains 114 mammal species, 340 bird species, 110 reptiles, 16 amphibians, and at least one fish species, which serve as the basis for almost all of the park tourism activity (Baker, 1996). Wildlife animals that are commonly observed in the park are elephants, black and white rhinos, black-faced impalas, lions, giraffs, leopards, steenbok, Burchell's zebra, springbok, blue wildebeest, kudu, and Damara dik-dik (de Beer et al., 2006). Different vegetation communities and the availability of water from natural springs and man-made waterholes are significant factors determining wildlife abundance in the area, and it is the waterholes, in particular, that give amazing wildlife sighting and photographing opportunities in the park (Kimaro et al., 2015).

An empirical study was conducted by the Namibian Ministry of Tourism and Environment to estimate the different species populations and their densities by doing an aerial survey of Etosha National Park as shown in the Figure 1. They concluded that, as compared to the previous ariel surveys, the population trend shows a decline for red hartebeest, springbok, and gemsbok species, an increase for ostrich species, and steady estimates for all other species (Kilian, 2015).

	Species	No seen	Lower	Estimate	Upper	Variance	95% Confidence Interval	CI as % of Population Estimate	Density (no/km²)
Ab	Red Hartebeest	247	424	889	1354	35329	465	0.523	0.048
Am	Springbok	2930	7998	10317	12636	1549199.6	2319	0.2248	0.556
Ct	Blue Wildebeest	1247	2822	4207	5592	417120.1	1385	0.3293	0.227
Db	Black Rhino	317	1098	1280	1462	7166.7	182	0.1419	0.069
Eb	Burchell's Zebra	4083	11338	14232	17126	1820077.6	2894	0.2033	0.767
Gc	Giraffe	878	2638	3172	3706	62010.7	534	0.1684	0.171
La	Elephant	890	2214	2911	3608	105660.2	697	0.2395	0.157
Og	Oryx	886	3373	4108	4843	91792.8	735	0.1789	0.221
Sc	Ostrich	783	2561	3695	4829	279615	1134	0.307	0.199
To	Eland	450	937	1321	1705	32017.0	384	29.05%	0.07

Figure 1 Species Esstimates and Densities (Kilian, 2015).

There are several studies done on Etosha National Park wildlife for their conservation and management. In a study by Turner et al. (2022), the researcher used questionnaires to ask the experts about their opinion of the biggest threats or challenges to wildlife conservation in the Greater Etosha Landscape. The dominant concerns among expert responses were climate change, land use, and human capacity that affect future wildlife conservation. They peer-reviewed 448 research articles to investigate research trends over time in the Greater Etosha Landscape and concluded that little research has been done on challenges identified by experts.

In an interesting study carried out by Tsalyuk et al. (2019), the researcher analyzes the movement of the African elephant effect by existing and past landscape variables in Etosha National Park. The researcher used GPS data for elephant movement and created satellite-based spatiotemporal maps of vegetation biomass, surface water, roads, and fences. They concluded that elephants prefer areas for movement that have higher grass biomass and prefer to walk close to water, roads, and fences. This information can be useful for park management to protect elephant movement paths and to avoid human-wildlife conflict.

In a study by Jokisch (2009), the researcher evaluates the attitudes of communities that are living around the buffer zone of Etosha National Park. They conducted qualitative interviews with landowners and land users to evaluate the socioeconomic potential of the buffer zone. The result of this study is a mix of positive and negative reviews that mainly depend on land use; some are getting financial gain due to game farming or tourism activity, and others are getting financial loss due to predators attacking their livestock. The researcher urges authorities to make the necessary measurements in terms of land use policy to avoid wildlife conflict with the communities around them.

Finally, the above studies talk about the historical development of Etosha national parks and how the government and the World Organization are applying different conservation strategies to protect the biodiversity that exists in the park. Furthermore, studies show that tourism is the key source of income for local populations that are living in and around that park through game hunting and wildlife sighting, and it contributes to the economy as well. There is a research gap on using social media platforms for wildlife conservation and management in Etosha National Park that can be beneficial for increasing tourism activity. Utilizing social media information can improve conservation strategies by integrating near-real-time information and identifying areas where visitors encounter wildlife that can be declared wildlife sighting spots without disturbing the wildlife.

2.4 Geotagged Information Platforms

In today's era, the development of information technology for communication allows people to share their ideas, thoughts, emotions, feelings, and events in the form of text, images, and videos through different social media platforms like Twitter, Facebook, Instagram, Flickr, and Foursquare with everyone and everywhere in the world (Sitthi, 2018). Due to technological advancement, social media data contains a vast amount of information, ranging from non-spatial information, such as hashtags, timestamps, and descriptions, to spatial information, such as locations and times (Sitthi, 2019). The information shared by user on social media platform integrated with location information are commonly referred to as geotagged information (Lemieux, 2015). Since the emergence of Web 2.0, an increasing number of users have posted their perspective on different social media platforms and resulting information consider as crowdsource (Sitthi, 2018).

The data from social media is useful to promote planning, Tourism business, transportation management, warning applications and integrated with GIS allow to understand the people perception spatially (Sitthi, 2018). Generally, researchers use geotagged images to analyze spatial and temporal human movements as well as the characterization of places (Lemieux, 2015). These data from social media, mainly

geotagged ones, have lots of information on people's experiences and activities in diverse environments, and they are a valuable source for studying people's spatial experiences in different environments (University of Siena et al., 2016). The emergence of geotagged data sources, such as user-generated information on social media, provides new possibilities for evaluating tourism and recreation in national parks (Wood et al., 2013). Data from photo-sharing websites appears more appropriate for tourism research, given that photography and tourism are closely connected (Prideaux & Coghlan, 2010). Such geotagged data have been used to forecast visiting rates in national parks, measure park attractiveness, map visitor flows, and assess visitor use and spatial patterns (Levin et al., 2017; Orsi & Geneletti, 2013; Sessions et al., 2016).

The potential of geotagged data from social networks has led to an increased interest in using it to study tourists' use of PAs. This interest is reflected in the rapid growth of research that employs social media, particularly geotagged data, to analyze visitor behavior and provide new insights into visitors' spatial and temporal patterns (Barros et al., 2020). Barros et al. (2022) examine 38 articles related to the use of geotagged data from social media within the context of visitor monitoring in protected areas, including national parks. They discuss different geotagged data sources and various methodological approaches used in articles to monitor visitor ratios, activities, purposes, and seasonal tours in different protected areas around the world. They concluded that geotagged data from social media for estimating visitor monitoring indicators is more reliable, cheaper, and has greater coverage. The temporal and spatial data from social media posts allows researchers to investigate where and when people go within protected areas (Wood et al., 2013).

In a study of Teide National Park, Spain, by Barros et al. (2020), they analyzed visitors' behavior using geotagged photos from the photo-sharing site Flickr and GPS traces from the web platform Wikiloc. They explore visitor characteristics like their origin and spatial and temporal movement in the park, and they also evaluate social network data with actual park statistics for coherence. They concluded by recommending some optimal locations for tourist information stands and suggesting authorities use this research for sustainable management of the national park.

In a similar study by Tenkanen et al. (2017), they analyse social media geotagged data from three platforms named Instagram, Twitter, and Flickr to estimate tourist visitation patterns in 56 natural parks located in South Africa and Finland. They used data to assess the park's popularity, the monthly visitation rate, and the correlation between social media data and official visitor statistics. They concluded that social media data could be a potential indicator to be used to monitor visitor count, which would result in gaining information about park popularity and also be correlated with the official statistics of the park using the Spearman correlation method.

Additionally, in an interesting study by Mangachena et al. (2023), they used geotagged Flickr data to analyze spatial and temporal patterns in wildlife tourism encounters with popular wildlife species in protected areas of South Africa and people's feelings towards them. They identify the hotspot areas and time of visitor encounter with wildlife using the location and time-stamp information in Flickr data across different protected areas. They concluded that Kruger National Park has more popularity than other protected areas

because of the majority of encounters in the dry season and positive expressions identified in the text of the Flickr data. This data is useful for the authorities to enhance tourists' experiences and spread community benefits from wildlife tourism. There are different social media platforms, like Flicker, Panoramio, Instagram, Twitter, Open Street Map, GPSies, and Wikiloc, that are mostly used by researchers to address issues related to nature-based tourism (Teles da Mota & Pickering, 2020). I will discuss some of them here.

2.4.1 Flickr Social Media Platform

Flickr is a popular social media website that was founded in 2004 to share high-quality images and was initially used by professional photographers as shown in the Figure 2. In 2006, Flickr added the ability to geolocate photos uploaded on their site, which can be done using GPS on mobile devices or manually adding a location on a map (Barros et al., 2020). This platform provides diversified information regarding who posts about what and from where, with large number of photographs uploaded by tourists, making it a useful data source for tourism research (Hausmann et al., 2018). In 2023, over 60 million users from different countries shared more than 10 billion photographs (Smith, 2015). Flickr provides freely accessible Application Programming Interfaces (APIs) through which users can extract information about images in terms of their location, time-stamp, tags, and description (Teles da Mota & Pickering, 2020).
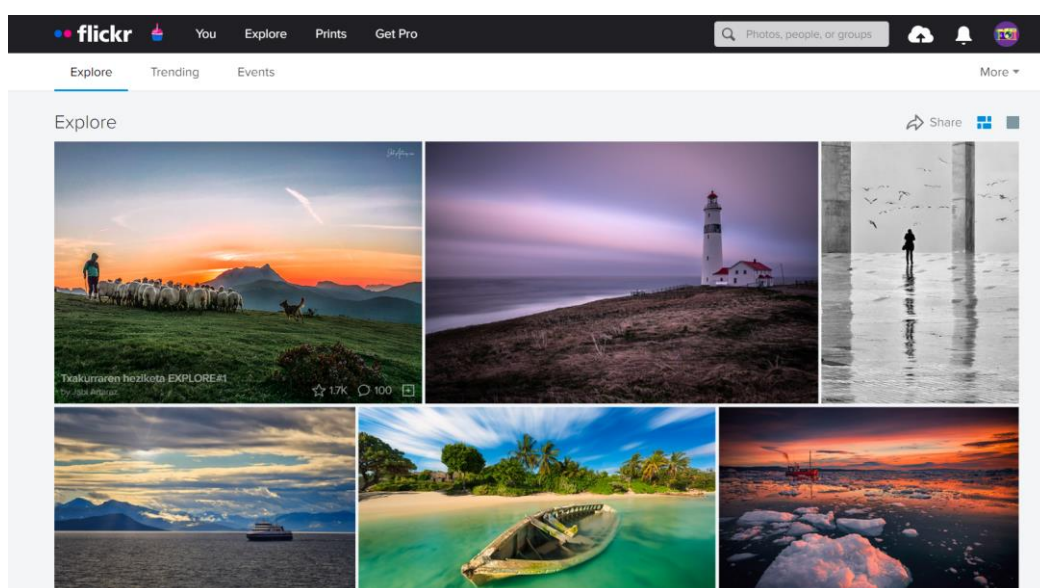
Figure 2 Main Page of Flickr Web Platform (*Flickr*, 2024).

2.4.2 Panoramio and Google Map Platform

Panoramio was a social media platform where users could share geotagged images. This website allowed users to examine photographs of places or landscapes shot and geotagged by other users (García-Palomares et al., 2015). There are multiple studies that have been done using Panoramio for tourism research (Teles da Mota & Pickering, 2020). Panoramio was acquired by Google in 2007 and shut down on November 4, 2016, moving all pictures to Google Maps and Google Earth (Tenkanen et al., 2017).

2.4.3 Instagram Social Media Platform

Instagram is a social media platform that was established in 2010 and gained popularity among people owning smartphones with high-quality cameras (Tenkanen et al., 2017). This platform allows users to capture, post, and share real-time memories with location through a mobile application (Hausmann et al., 2018). There have been multiple studies that have used geotagged data from Instagram to analyze visitor activity and behavior in different national parks (Teles da Mota & Pickering, 2020). Instagram used to provide broad access to their API for public posts, but now the access is largely confined to commercial uses, making it a more complicated platform to use in research (*Instagram Platform - Documentation*, n.d.; Tenkanen et al., 2017).

2.4.4 Protected Planet Platform

Since 1981, the United Nations Environmental Program for Biodiversity Monitoring, through its Protected Areas Programme, has been collecting and spreading global information on protected areas, which range from carefully preserved national parks to community reserves with human presence (Willemen et al., 2015). The Protected Planet platform provides a global collection of the World Database on Protected Regions (WDPA) of land and sea regions that hold high natural or cultural values as shown in the Figure 3. The data comprises polygon boundaries of protected areas, which are contributed by various governments and other agencies (UNEP-WCMC, 2019). Researchers use this platform to analyze the positive and negative impacts of visitors to national parks around the world (Tenkanen et al., 2017; Willemen et al., 2015).
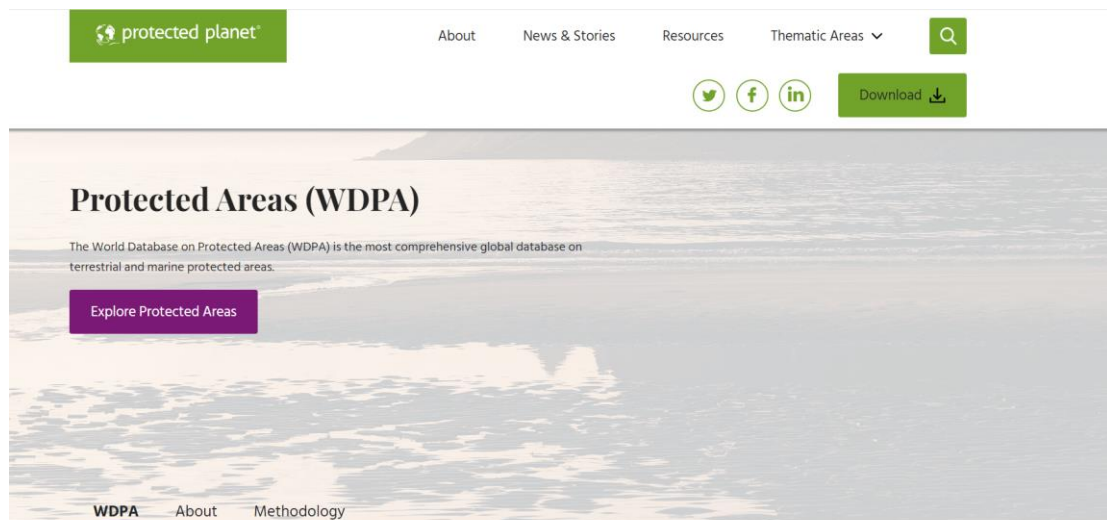
Figure 3 Protected Planet Platform to Access Protected Areas Database (*Protected Areas (WDPA)*, 2024).

Lastly, in the above literature, numerous benefits were reported using geotagged information from social media platforms for nature-based tourism. Social media provide access to a vast amount of information with high temporal and spatial resolution at a relatively low cost that can be useful for wildlife tourism. Despite the limited access to data and the source's bias, the reviewed studies indicate the reliability of geotagged data for tourism research. Most of the studies that used geolocated information were limited to creating some cartographic visualization products, such as maps of attractive spots.

2.5 Web Mapping Possibilities

The development of the internet has revolutionized human interaction in a way that people share their feelings and emotions online on different social media platforms (Tavakoli & Wijesinghe, 2019). Web-based GIS platforms now make it easier to explore, visualize, and share huge volume geographic data due to the internet's widespread use (Kalabokidis et al., 2013). These internet advancements have also altered the way tourism-related information is distributed and transformed the way individuals plan and decide their journey (No & Kim, 2015). The information about tourist destinations ranges from virtual sightseeing to detailed information about facilities, which can be accessed online, leading to tourist satisfaction. Web-based GIS systems provide flexible data exchange facilities while also allowing dynamic and interactive presentation of tourism information in terms of maps, images, and textual documentation (Tyagi, 2014). There are various studies that have been done that use Web technology integrated with GIS to promote tourism and wildlife planning.

In a study by Mango et al. (2021), they designed a web-based GIS system for managing and promoting tourism resources in Tanzania. They developed a geodatabase repository that contains information on tourism spots, then created dynamic and interactive maps that are enriched with pop-up information and spatial query capabilities for tourists to explore more information. They also tested the usability of the system by performing spatial queries and concluded that their designed WebGIS model can successfully manage, promote, and sustain the tourism industry. Similarli, In research by Zerihun, (2017), they developed a web-based GIS system that contains an interactive map that presents information related to tourism attractions, services, and wildlife in Gondor Town, Ethiopia. The system was developed using free and open-source software called Wamp Server, which is an acronym for Windows, Apache, MySQL, and PHP .

In an interesting study by Kabatha, (2018), they developed an interactive webGIS application using open source tools to map and visualize elephant telemetry data along with weather, environmental, and anthropogenic factors to analyze elephant movement patterns. The user can access, query, and visualize the time series datasets in an intuitive graphical user interface. They concluded that the main biophysical factor that influenced the immediate movement and distribution of elephants was NDVI in comparison to temperature and rainfall. The webGIS system will help authorities identify areas where conflicts with humans occur and also protect this species from poaching.

In a study by Tyagi, (2014), they developed a webGIS-based customized information system using an open-source platform called MapGuide that displays dynamic and interactive tourism information for Eastern Uttar Pradesh, India. They visualize wildlife sanctuaries and historical places in the form of maps, photographs, text, and video with commentary for virtual sightseeing to promote tourism in the region. It enables tourists to get a digital map that contains information about the major tourist spots, hotels, health centers, and transport network of the town in an easy way using the internet.

The Map of Life is an important platform for researchers that is built on a scalable web platform incorporated with a WebGIS system designed for visualizing massive amounts of biodiversity and environmental data and aims to deliver species range information, species lists, species habitat, and protection for each geographical location in the world as shown in the Figure 4. The Map of Life seeks to promote effective and global biodiversity

education, monitoring, research, and decision-making by collecting and integrating a wide range of data on species distributions and dynamics over time. The architecture of this system was built using the Google Cloud Platform, Google Earth Engine, RestAPIs, and Carto mapping services (Jetz et al., 2012).
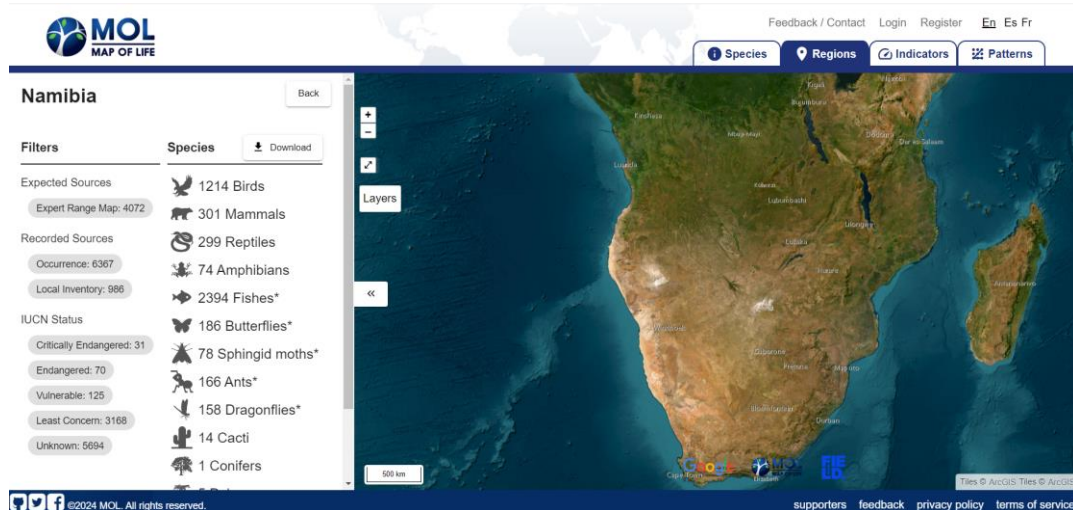

Figure 4 Web Map Interface of MOL platform visualizing Nambia Species Statisitcs(*Map of Life - Regions*, 2024).

Another interesting web platform is the Half Earth Project, which is supported by the E.O. Wilson Biodiversity Foundation to protect half of the land and sea in order to manage sufficient habitat and reverse the species extinction crisis. The web map visualizes biodiversity distribution information along with landuse pressure in terms of builtup, agriculture, and carbon footprints to analyze the effect on different species as shown in the Figure 5 (*What Is the Half-Earth Project?*, E.O. Wilson Biodiversity Foundation, 2023).
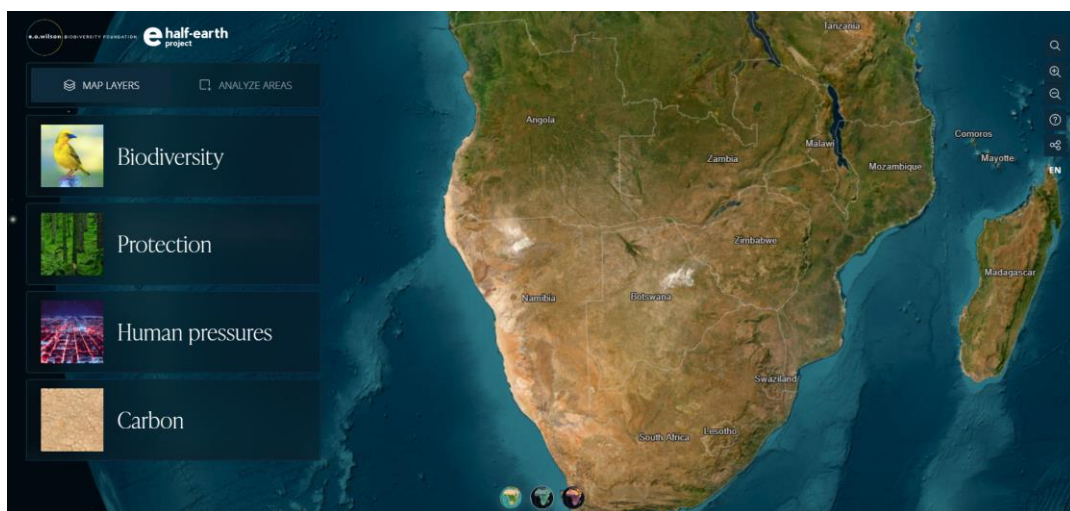
Figure 5 Web Map Interface of Half Earth Project (E.O. Wilson Biodiversity Foundation, 2023).

Finally, the above studies show how the webGIS platform is useful for tourism as well as wildlife conservation because of spatial information accessibility through the internet. In various studies, researchers have used various open-source cloud computing platforms

and mapping libraries like Open Layers, Leaflet, MapBox, CartoDB, ArcGIS Online, MangoMap, and GIScloud to develop web-based GIS systems.

2.6 Summary of Key Findings

The literature review shows that GIS can play a crucial role in biodiversity conservation and protecting the world's ecosystem. Various studies use GIS for mapping national park resources, which is useful in terms of tourism promotion that indirectly contributes to the economy as well as wildlife management. A lot of research has been done on using geotagged information from social media for analyzing visitor ratios and activities in national parks or protected areas, but it has been limited in terms of cartographic mapping of wildlife species. There is also a research gap identified in the Etosha region for using social media geotagged information for wildlife mapping and management, which can be beneficial for increasing tourism activity. Most studies also discuss how web technology- integrated with traditional GIS mapping can be useful for tourism as well as wildlife conservation.

3 METHODOLOGY

The aim of this thesis is to design cartographic maps for three user groups that visualize different wildlife species occurrences and landscape data for Etosha National Park. Additionally, these different styles of maps will be user-tested and hosted on the web, combined with interactive web map. The key focus of this research is to use geotagged photos of wildlife to create three different cartographic-style intuitive maps so user groups can easily interpret and understand information about wildlife species occurrences at different waterholes in the park.

3.1 Data Used

3.1.1 Sentinel 2 Land Cover

This global land cover is derived from Sentinel 2 imagery generated with a deep learning model that uses billions of human-labeled image pixels from the National Geographic Society. This open-source product is made by the Impact Observatory in partnership with Esri and Microsoft. The Impact Observatory provides a global land cover dataset from 2017 up to 2023.

Table 1 Specification of Sentinel 2 Land Cover

Data Source	Impact Observatory
Format	GeoTIFF
Time Period	2022
Satellite Data	Sentinel 2
Spatial Resolution	10m
Classsification Classes	water, trees, rangeland, floodedvegetation, crops, built area, bare ground, snow,and clouds

3.1.2 Protected Planet - Etosha National Park Boundary

The Protected Planet platform, under the United Nations Environmental Program for Biodiversity Monitoring, provides a global collection of the World Database on protected regions of land and sea that hold high natural or cultural values. The Park Boundary was acquired from this platform and used in the three different styles of maps.

Table 2 Specification of Etosha National Park Boundary

Data Source	Protected Planet
Publish by	Ministry of Environment and Tourism Namibia
Format	Shapefile (shp)
Status Year	1975
Reference System	Universal Transverse Mercator Zone 33S

3.1.3 Flickr – Wildlife Geotagged Images

Flickr is a social media website that was founded in 2004 and provides diversified information regarding photographs, like who posts about what and from where, and many images uploaded by tourists. Flickr provides freely accessible non-commercial Application Programming Interfaces (APIs) through which users can extract information about images in terms of their location, time-stamp, tags, and description. The geotagged images of wildlife species in Etosha are acquired from this platform and used in the map to visualize their distribution.

Table 3 Specification of Flickr Geotagged Images

Data Source	Flickr Non Commercial API
Format	CSV
Time Period	2019 - 2024
Location	Etosha National Park
Data Count	4,549

3.1.4 Google Earth Pro – Wildife Geotagged Images

Google Earth Pro is a desktop-based product of Google that allows users to view high-resolution satellite imagery, explore 3D terrain, and download it as well. This platform allows you to download available geotagged images in the photo layer category. The geotagged image of wildlife in Etosha is acquired manually from this platform.

Table 4 Specification of Google Earth Pro Images

Data Source	Google Earth Pro
Format	KML
Data Count	110
Reference System	Universal Transverse Mercator Zone 33S

3.1.5 Open Street Map Dataset

Opens Street Map is used to acquire the landscape features of Etosha National Park, like waterholes, roads, and lodges, and is used to visualized in maps.

Table 5 Specification of Open Street Map Data

Data Source	Open Street Map
Format	Shapefile (shp)
Data Category	Water, Roads, Places
Reference System	Universal Transverse Mercator Zone 33S

3.1.6 Species Estimation Statistics

An aerial survey of Etosha National Park was conducted by the Namibian Ministry to estimate the different wildlife species populations and their densities. The species estimation information is acquired from this survey report and visualized in maps.

Table 6 Species Count (Kilian, 2015)

Zebra	14232
Springbok	10317
wildebeest	4207
Oryx	4108
Ostrich	3695
Giraffe	3172
Elephant	2911
Black Rhino	1280
Red Hartebeest	889

3.2 Software Used and Platforms

In this research, a wide variety of software was used for various stages. In the preprocessing and analysis stage, QGIS and ArcGIS Pro were used the most. In the map design stage, several other programs were used to design symbols, infographics, and charts. Listed below are all the software and platforms that were used in this research, along with a short description of their role in this research study.

3.2.1 QGIS

This open-source desktop-based GIS software was used in the initial stage of this research. The wildlife geotagged images were preprocessed in this software in terms of duplication, labeling of species, and their trophic level of categorization. Tools like removing duplicate geometries, selecting by attribute or location, and spatial indexing were mostly used in this software.

3.2.2 ArcGIS Pro

This desktop base GIS software was used to do a variety of tasks, namely buffer analysis, and the initial stages of cartographic designed maps. Tools like buffer and spatial join were used to identify wildlife species cluster that located at different waterhole in the park. ArcGIS pro was also used to do Wurman Dot Density analysis that visualized wildlife distribution in the park.

3.2.3 Inkscape

It is an open-source software program for creating and designing vector graphics. Inkscape version 1.3 was used in the stage of designing cartographic maps for Etosha National Park in terms of the arrangement or alignment of map elements, infographic incorporation, and vector graphic creation for wildlife species or landscape features.

3.2.4 Canva

Canva is a graphic design platform used to create visual content such as posters, professional documents, and presentations. The scalable vector graphics (SVG) for each wildlife species was created on this platform, which in total was fifty-five and was used in the design process of the younger group map.

3.2.5 Freepik

The Freepik platform is the largest hub of free graphic resources that allow users to find free photos, vector images, and illustrations for their projects. This platform is used to get monochrome vector icons for wildlife species, which are then used in the design process of the public group map.

3.2.6 MapTiler

MapTiler is a cloud platform that allows users to create and publish an interactive map. It also allows users to host their datasets in the form of vector or raster tiles. This platform is used in this research to host a dataset of wildlife species and landscape features under a free license plan, so these datasets render faster on the web map.

3.2.7 Visual Code Studio

Visual Code Studio is a source-code editor that allows users to create and edit code in several programming formats with debugging support functionality. HTML/CSS, JavaScript, and Leaflet programming languages were used to create an interactive web map with the basic functionality of zooming in and out of a map or clickable features and pop-ups.

3.2.8 GitHub

GitHub is a platform that allows users to create, store, and manage their code repositories. This is used for hosting interactive map code and deploying it as a web page for visualization.

3.2.9 Survey 123

ArcGIS Survey 123 is a product of ESRI for creating smart interactive survey forms and providing functionality for analyzing survey responses in terms of pie charts and others. This platform is used in the stage of user evaluation of cartographically designed maps for feedback about the design and the user's ability to understand information in maps.

3.3 Methods Used and Processing Procedure

Before designing maps, a proper geotagged image acquisition method and processing procedure were selected based on an extensive literature review to understand what is publicly available online in terms of wildlife geotagged image resources. The extraction of wildlife geotagged images is done in two ways: first, using a non-commercial API from Flickr, and second, manually from Google Earth Pro. The wildlife data was then preprocessed in terms of duplication, labeling of species, and their trophic level of categorization. Another key aspect of the research is to visualize the species distribution around different waterholes in the park, so buffer analysis is also done. Additionally, wurman dots analysis was done to analyze the distribution of wildlife species in Etosha National Park.

Cartographically designed maps for different user groups are another key aspect of this research. Each map was designed based on the technological and cartographic knowledge of user groups, which include the public, experts, and young people. The design part of this research had two sub-stages. In the first stage, the main content of the map was prepared in ArcGIS Pro in terms of assigning symbols to layers, base map selection, color scheme, and labeling. In the second stage, the arrangement of map elements and infographic incorporation were done in Inkscape software. User evaluation was then carried out on the public, experts, and younger groups using Survey123 for feedback and to evaluate the map design.

The user-tested map is then published on the web platform combined with an interactive map that allows users to dynamically interact with different features of the park. The interactive was made using HTML, CSS, JavaScript, and a leaflet that visualizes basic functionality, e.g., zooming in and out of a map or clickable features and pop-ups. The general workflow is pictured below in a Figure 6.
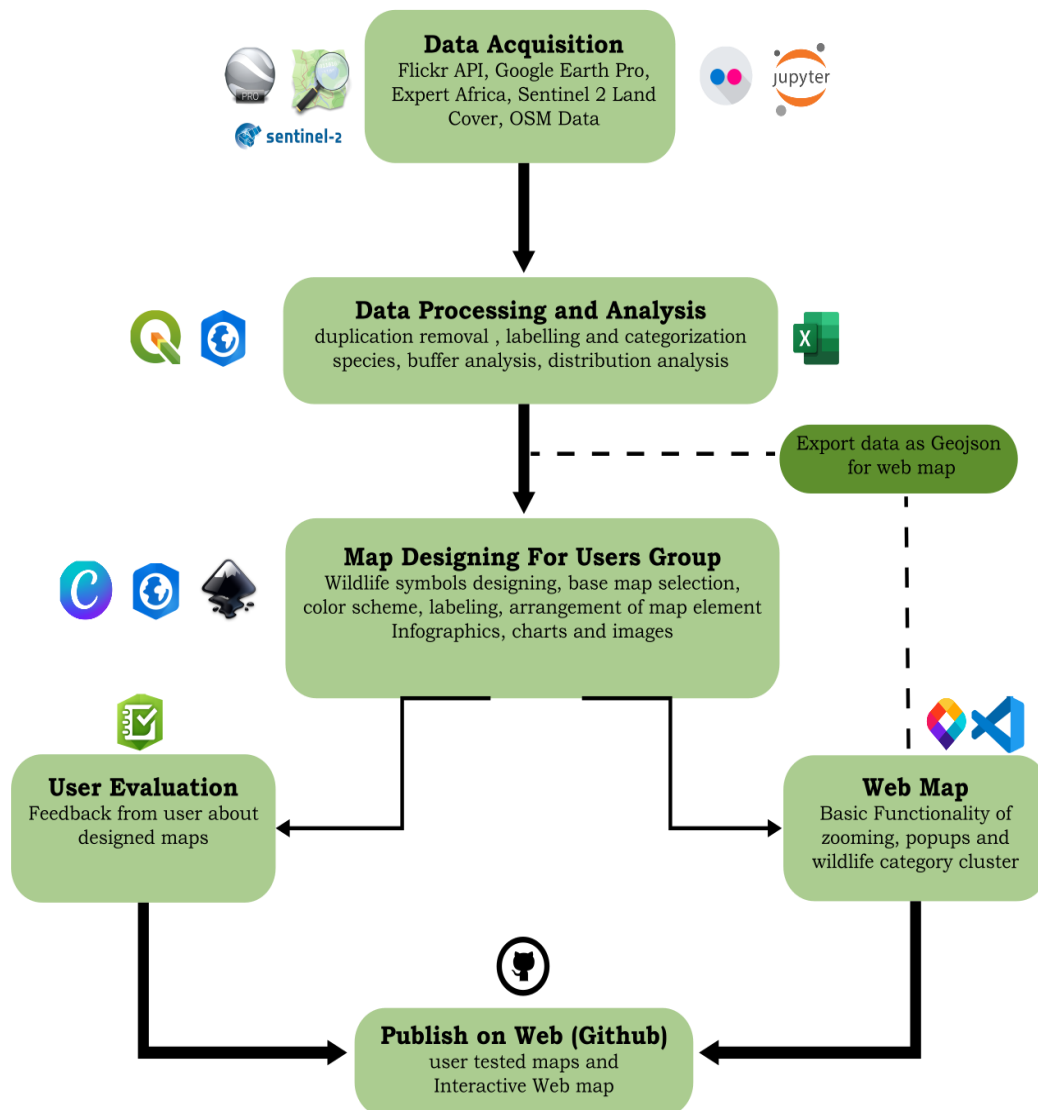
Figure 6: Methadology flow chart.

4 GEOTAGGED IMAGE ANALYSIS

The following chapter will detail all procedures relating to the acquisition, pre-processing, and analysis of the geotagged images of wildlife and related data. An insight into the selected study area is also provided. The steps conducted in this analysis stage are depicted in sequential and chronological order, from obtaining the required geotagged images to the final output of the analyzed data.

4.1 Study Area

The study area selected for this research is Etosha National Park, which is in the northwest part of Namibia (Figure 7). This park covers an area of 22,937 km², is the most popular tourist destination in Namibia, and is considered one of the largest wildlife sanctuaries in the world (Dieckmann, 2023). The word Etosha means 'big white place' in the Ovambo tribe language, and that tribe used to live inside the park and the area around it in the 18th century. Earlier, this park was considered a game reserve, but over the years, after wars and political shifts on the African continent, it was declared a national park by the administration of South Africa in 1967.

The Etosha Pan is the most distinctive and remarkable geomorphological landform feature of the park, which comprises around 23% of the Etosha National Park (Nakanyala, 2012). The Pan area turns into a lake in the rainy season and becomes dry when there is less rainfall. Usually, that seasonal change forces wildlife to gather around man-made waterholes and allows tourists to see different species in the park.
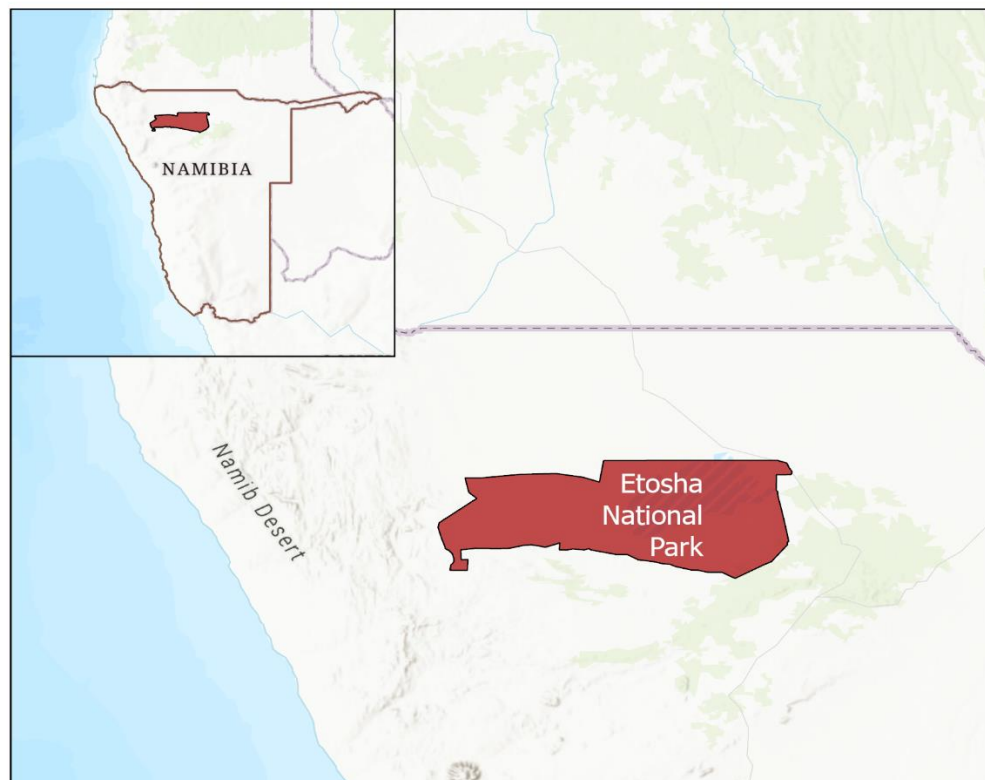
Figure 7: Etosha National Park Boundary.

4.2 Data Collection

The list of datasets that are used in this research was generally discussed above in the sub-chapter of methodology, but the acquisition method of each dataset will be explained in this chapter.

4.2.1 Flickr Geotagged Wildlife Image Extraction

Flickr provides a freely accessible range of APIs (Application Programming Interfaces) through which users can extract information about images in terms of their location, time-stamp, tags, and description. Firstly, the API key was generated using the Flickr app garden service, as shown in Figure 8.
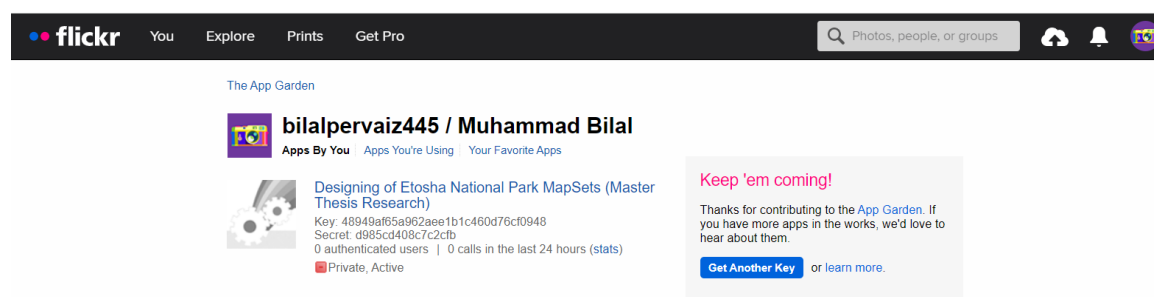
Figure 8 Flick Service Platform for API Key Generation.

In the second step, a Python script was used to extract wildlife geotagged images using the Flickr photo search API. The API returns a list of photos that match the user-defined criteria like tag name, minimum and maximum uploading dates, public license, accuracy level of location, and geolocation (Flickr Services, 2024). The Flickr photo search API only returns publicly available photos, not private ones, because that requires authentication from the service provider. The Python script that was used in the geotagged image extraction process was acquired from the GIS learning platform, and the script was enhanced according to the study area, period of geotagged images, and some additional parameters for API request (Flickr using python, 2020). The Python script can be found in Attachment 1.

The provided snippet of code below in Figure 9 and 10 shows the key part of the Python script. After defining the variables for API Key, a nested loop was used to iterate over the defined years from 2019 to 2024 and each month to search specific photos on Flickr based on certain criteria defined in the while loop:

page limit: look for photos per page,

has geo: photos with geolocation,

date taken: date of image acquisition,

bounding box: Bounding Dimensions of Etosha National Park,

privacy filter: Return only publicly available photos,

extras: attributes along with each photo.

With these criteria, it iterates through the result page and stores photos in a list called photos, then, after conversion, it gives output in CSV format.

```python
## Add your API Key and secret of Flickr
key = "48949af65a962aee1b1c460d76cf0948"
secret = "type your secretd985cd408c7c2cfb"
# Span to access the flickr server
wait_time = 1
## output file name
output_json = 'Etosha_flickr_photos'
keyword = sys.argv[1]
photos = []
l = 0
##Loop start
n= [1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3,1,2,3]
for y in [2019,2020,2021,2022,2023,2024]: ## 5 years. You can change the years to collect photos

    for k in [1,1,1,2,2,2,3,3,3,4,4,4,5,5,5,6,6,6,7,7,7,8,8,8,9,9,9,10,10,10,11,11,11,12,12,12]:
        m = k
        l = l+1
        print(l)

        days = calendar.monthrange(y,m)[1]

        if n[l-1] == 3:
            min_taken_date = str(y) + '-' + str(m) + '-21'
            max_taken_date = str(y) + '-' + str(m) + '-' + str(days)
            #reset I for the next year
            if m == 12:
                l = 0
        elif n[l-1] ==2:
            min_taken_date = str(y) + '-' + str(m) + '-11'
            max_taken_date = str(y) + '-' + str(m) + '-20'
        elif n[l-1] ==1:
            min_taken_date = str(y) + '-' + str(m) + '-01'
            max_taken_date = str(y) + '-' + str(m) + '-10'

        print(n[l-1])
        print(min_taken_date)
        print(max_taken_date)
```

Figure 9 Jupyter Notebool Environment for Python Script (Nested Loop).

```python
# connecting to Flickr
flickr = FlickrAPI(key, secret, format='parsed-json')

i = 1
while True:
    result = flickr.photos.search(
        # title = 'Etosha National Park',  #keyword change
        per_page = 700,              #number of data per page
        has_geo = 1,                 #Photo that has geo location
        min_taken_date = min_taken_date,
        max_taken_date = max_taken_date,
        bbox = '14.38637,-19.48699,17.20872,-18.38120',
#Bounding Box of study area in the order. LonLL, LatLL, LonUR, LatUR
        media = 'photos',            # collecting photos without video
        sort =  'date-taken-desc',        # collecting photos from latest
        privacy_filter =1,
        safe_search = 1,             #  photos without violence
        extras = 'geo,url_n,date_taken,views, license, description',
        page = i
    )
```

Figure 10 Jupyter Notebool Environment for Python Script (Image Criteria).

4.2.2 Google Earth Pro Wildlife Data Extraction

Google Earth Pro is a desktop-based product of Google that allows users to download available geotagged images in the photo layer category. Each geotagged image that lies in the Etosha National Park area was selected manually and saved into a specified folder along with its attributes in the software as shown in Figure 11. After collecting 110 geotagged wildlife information, that folder was downloaded as KML, which was then converted into a shapefile format in QGIS.
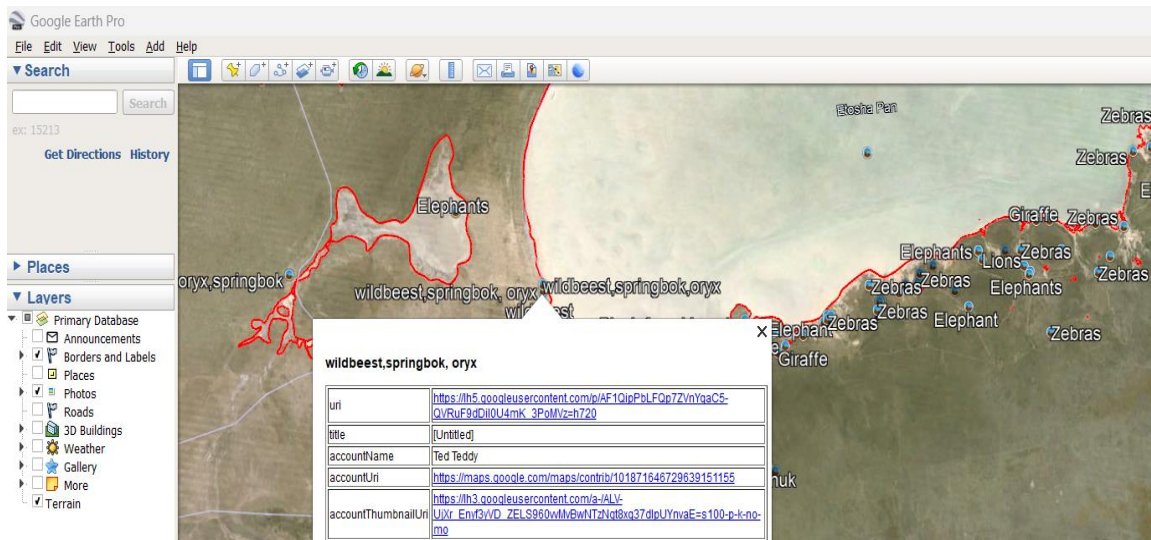
Figure 11 Google Earth Pro Interface for Data Collection.

4.2.3 Landscape Data Collection

The Open Street Map is used to acquire the landscape features of Etosha National Park. The dataset is downloaded for the country level, which includes places, roads, water, and others, which are then clipped to the area of Etosha National Park in QGIS using clip by extent tool as shown in Figure 12.
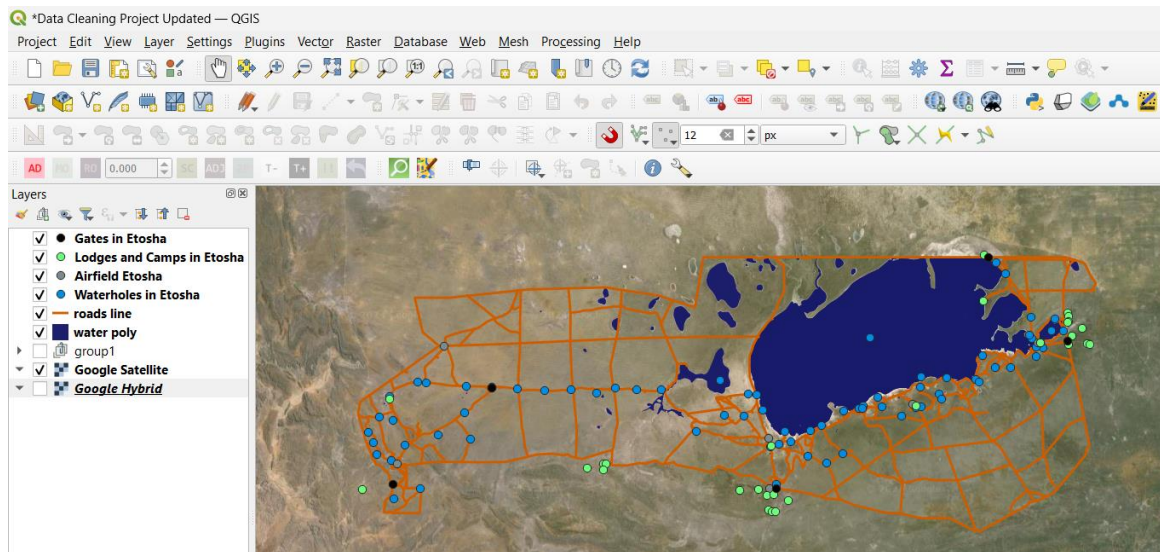
Figure 12 QGIS Interface for Landscape Data after clipped.

4.2.4 Land Cover Data Etosha National Park

The land cover data that was generated by the Impact Observatory in partnership with Esri and Microsoft was downloaded for the region of Africa of the 2022 time period from an interactive web platform of Esri Sentinel 2 land cover explorer. The land cover tile was then clipped to the area of Etosha National Park in ArcGIS Pro using clip tool as shown in the Figure 13.
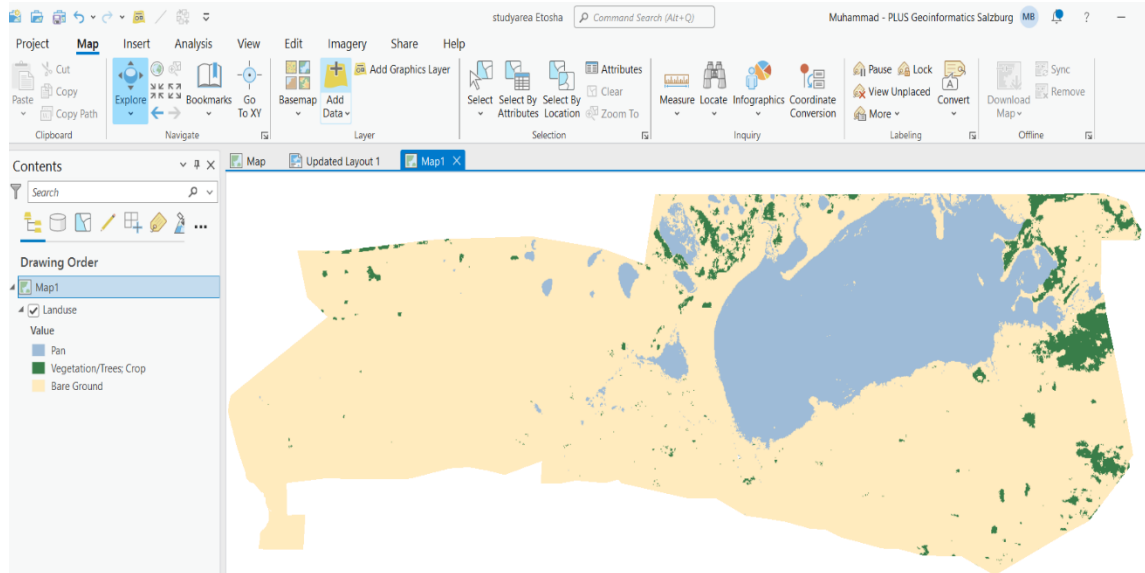
Figure 13 ArcGIS Pro Interface for Land Cover clipped to park area.

4.3 Data Pre-Processing and Management

In the second stage, after geotagged image acquisition from different sources, as mentioned in the previous chapter of data collection, it was then preprocessed in terms of duplication removal, labeling, and categorization of species. The duplication of Flickr geotagged images was removed by utilizing a semi-auto approach in which geotagged data was taken into Excel and an identify duplicate tool was applied to a secret ID column that represents a unique alphanumeric code for each record. The tool in Excel highlights the values that are repeated in the secret column, which are then removed afterward as shown in Figure 14.

Figure 14 Excel Interface of Duplication Removal.

Each geotagged image was then labeled with the exact wildlife species name that they were representing because, when images were extracted, the title of each image represented user emotions and excitement as shown in Figure 15. The labeling part was done manually by looking at each geotagged image in QGIS software.

Figure 15 Attribute table of Geotagged Images in QGIS.

After labeling geotagged images, each species is categorized according to its trophic level. The trophic level is basically the position of wildlife species in the food chain that tells us who eats what for their survival in the ecosystem. The wildlife images were then categorized in terms of herbivores, predators, and birds (*Animalia*, 2024). The Select By Attribute tool is used to update category information in the geotagged data in ArcGIS Pro and is also visualized in an intuitive manner in different user group maps as shown in Figure 16 .

Figure 16 Attribute table of Wildlife Data representing category in ArcGIS Pro.

4.4 Data Analysis

This sub-chapter will discuss the key part of this research, which is to identify wildlife species that exist at different waterholes in the park, so the buffer analysis method was used to achieve that purpose. To understand the general distribution of wildlife species in Etosha National Park, dot density analysis was also done and will be discussed in this sub-chapter. In the initial stage of the analysis part, all the acquired datasets were converted to a common format, which was feature datasets stored in Geodatabase, and their projection was transformed into Universal Transverse Mercator Zone 33S using the define projection tool in ArcGIS Pro software.

4.4.1 Buffer Analysis

To determine the species occurrence at different waterholes, a buffer distance of 500 meters was created around each waterhole using the buffer tool in ArcGIS Pro, as shown in the Figure 17. The distance for the buffer was decided after looking at geotagged wildlife images because each image was taken by visitors a little bit far away from the waterholes. From the geotagged location of each wildlife image, it was observed that most images were taken by visitors along the road while they were in some kind of vehicle, which endorsed the buffer distance approach around waterholes.
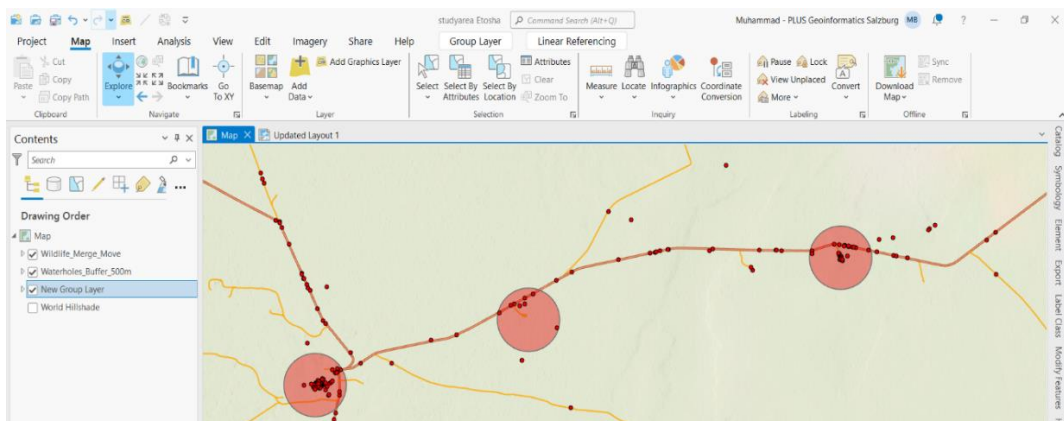
Figure 17 ArcGIS Pro Interface visualizing buffer around waterholes.

After buffer creation, wildlife species that are located within the buffer distance of each waterhole were joined spatially with the waterhole using the spatial join tool in ArcGIS Pro. So that each wildlife species record will incorporate the name of the waterhole to which they belong as shown in Figure 18.

Figure 18: Wildlife Species attribute spatial join with waterhole information.

The pie chart as shown in Figure 19 visualizes five waterhole that has most wildlife occurrence in the park that chart was generated based on buffer analysis.
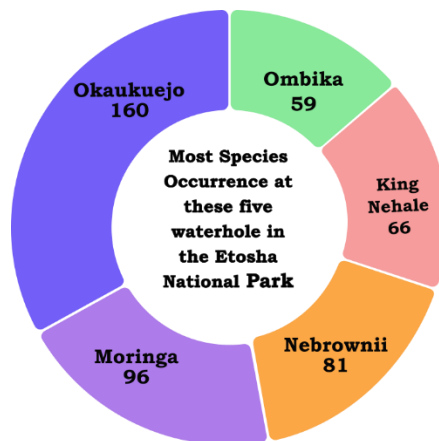
Figure 19 Waterholes that has most wildlife occurrence.

4.4.2 Wurman Dots Method

The dot density analysis was done to analyze which areas of Etosha National Park have a greater density of wildlife species. In the first stage, the park area is divided into 1 km² hexagonal grids using the generate tessellation tool in ArcGIS Pro. In the second step, the geotagged wildlife data is overlaid on the hexagonal grids and then summarized within the tool applied, which counts each geotagged data that lies inside the specific grids and stores information about the count in the grid attribute table. Finally, these summarized grids were converted to point features, and the graduated symbol method of symbology was applied to that point feature based on the count attribute, which visualized dots of different sizes to represent wildlife density in the park as shown in Figure 20. This analysis is visualized in the cartographically designed expert group map.
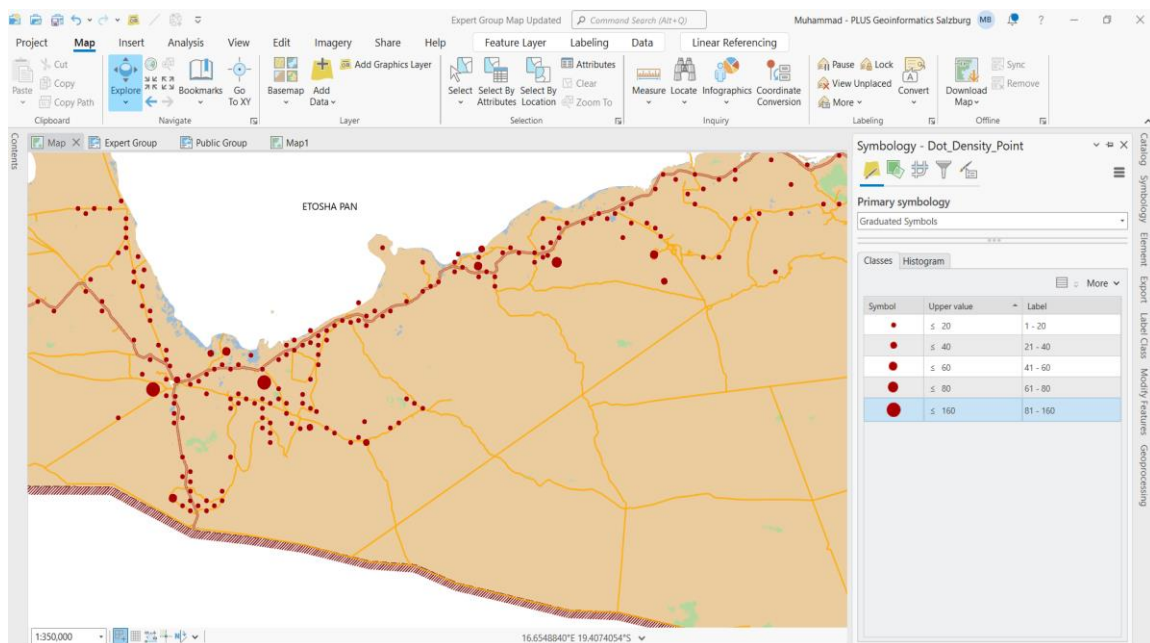
Figure 20 ArcGIS Pro Interface of Wildlife Density Distribution.

5 DESIGNING OF USER GROUP MAPS

In this chapter, the results from geotagged image analysis are used in designing different styles of maps for three user groups that include younger people, the public, and experts, which will be discussed in detail. This chapter has been divided into three sub-chapters for each target group maps, which have been further sub-divided into specific design processes. A step-by-step procedure for the design of each target group map is provided, supplemented with some discussion of technical specifications and the decision-making process.

5.1 Younger Group Map

The main aim of this map was to design it for younger people that visualize wildlife species occurrence at different waterholes and other park features in an aesthetic way that would attract their attention. To make this map aesthetic, an intuitive graphical icon for different wildlife species representation, a good colour scheme, infographics, and intuitive symbols for landscape features were used to design this map. The second consideration was to maintain a visual hierarchy while designing this map, so it would not be confusing for users to understand the information. In this chapter, cutouts of the younger map are presented to discuss design processes because of its large dimension, but the full map can be found in Attachment 2. The main component of the map was designed in ArcGIS Pro and the arrangement of map elements was done in Inkscape software.

5.1.1 Layout Selection and Structure

The layout size selection was the most important step in the design process of this map, as the area of the park is so large. To properly visualize wildlife species and landscape data in the park, different sizes of layout tests were performed to analyze the visual clarity of park features. The custom layout size, which is 594mm wide and 360mm long, was then selected for this map to visualize information. The map reference scale was set to 1:350,000 in ArcGIS Pro so that different features could be easily distinguished by users. In the stage of design structure, it was decided that map content should be placed in the center of the layout as the park is horizontally wide, textual information should be above, and legends should be placed below the map content, as shown in the Figure 21.
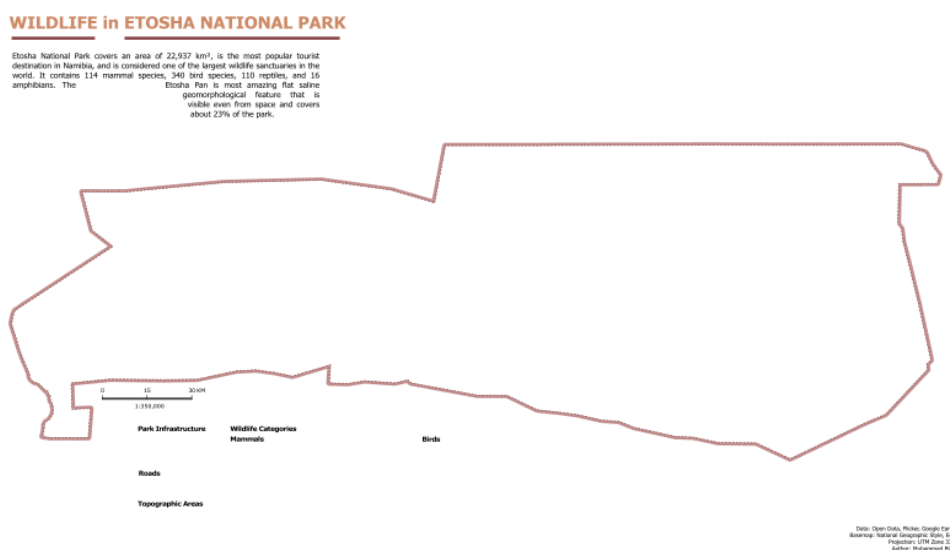

Figure 21 Younger group map layout structure.

5.1.2 Symbols Designing and Basemap Selection

Another key aspect in the design process of the younger group map was the selection of symbols for different wildlife species and landscape features of the park. The custom intuitive graphic icons were created for each wildlife species in the Canva platform that allow users to easily distinguish different species through their cognitive abilities, as shown in the Figure 22. All the icons were exported as Scalable Vector Graphics(SVG) so that the quality of the icons does not degrade. The wildlife species icons are placed properly on the map around the waterhole, so the user can easily identify to which waterhole a specific species belongs.
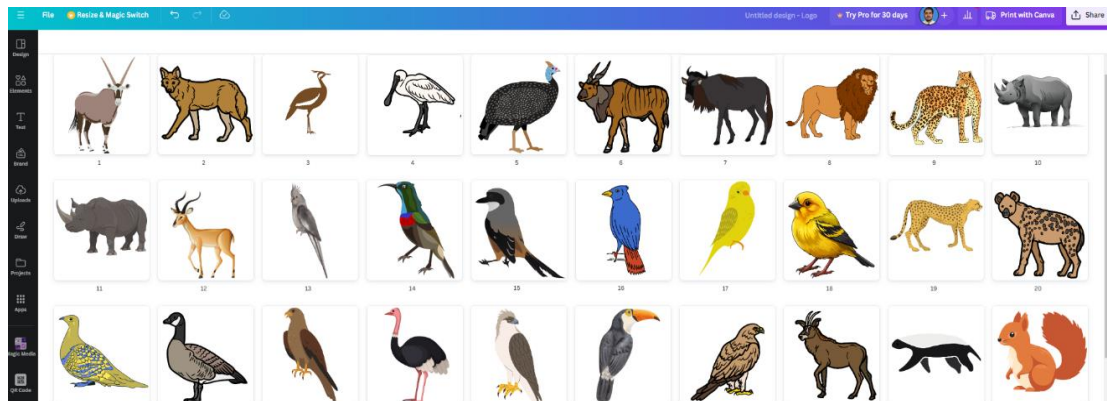
Figure 22 Canva platform interface for graphic icons creation (*Canva*, 2024).

The symbols for landscape features that include water, gates, lodges, and roads were selected from the style gallery inside ArcGIS Pro. Each landscape feature was labeled by their name using a San-Serif font because they are known for their clean and easy readability. The Tahoma font was used for headings, general text, and legends as well because it gives a modern look and is visually appealing. The symbology for land cover classes is also made in light colors so that it acts as background information on the map. The park boundary symbology was designed by creating a buffer with hatched fill, so it appears as a brown fence around the park, as shown in the Figure 23.
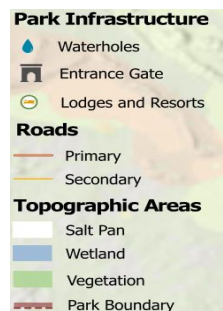
Figure 23 Younger group map cutout represent park landscape features symbology.

The color scheme is also important in the design process because it maintains the visual coherence of the map and is effective for conveying information and enhancing the user experience. In this map, light colors are mostly used, especially the light brown color for the title and park boundary, which are often associated with earthiness and nature. The basemap selected for this map was National Geographic Style blended with world hillshade basemap from ArcGIS Pro, as shown in the Figure 24.

Figure 24 National Geographic Style Basemap blended with hillshade from ArcGIS Pro.

5.1.3 Infographics and Alignment of Map Element

Graphical images with information related to Etosha National Park are also incorporated into the map, like the area of the park in comparison with New York City, to enhance the aesthetics of the map. The Kahoot game was presented as intuitive graphics asking younger ones about species they have seen in the park, which attracts younger ones towards the map. Additionally, an overview map was attached as a globe to give the user a realistic view of the park's location in Africa as shown in Figure 25.
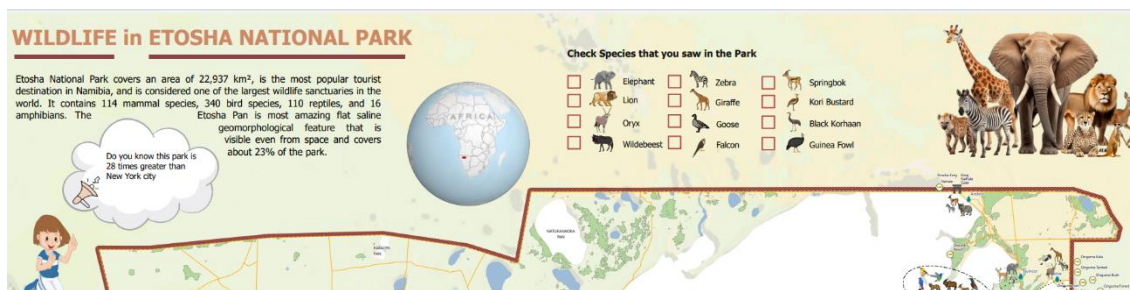
Figure 25 Younger group map cutout represent graphics, kahoot game and overview map.

The alignment of text, map elements, and graphics is crucial for creating a visually pleasing and well-organized layout. The legend and text of the map were aligned intuitively, making it easier for the user to scan and read the content, as shown in the Figure 26.

Figure 26 Younger group map cutout represent legend.

5.2 Public Group Map

The aim of this map was to be designed for the public to visualize the existence of wildlife species at different waterholes, along with additional information related to park timing and regulation, in an intuitive way so that this map can act as a guide for tourists. In the design process of this map, a custom-created intuitive icon for wildlife species, visually appealing infographics, and an attractive symbol for landscape features were used. The proper arrangement and alignment of text and graphics were implemented to maintain the visual coherence of the map. In this chapter, cutouts of the public map are presented to discuss design processes because of its large dimension, but the full map can be found in Attachment 3.

5.2.1 Layout Selection and Structure

The custom layout size selection for the public group is the same as the younger one's map, which was 594mm wide and 360mm long to visualize information related to the park. The map reference scale was set to 1:350,000 in ArcGIS Pro so that visual overlapping between different features of the park could be avoided and users could easily interpret the map. The structure arrangement for the public map is the same as discussed in the sub-chapter of the younger group map.

5.2.2 Symbols Designing and Basemap Selection

The main part of the design process for this map was to create intuitive icons for wildlife species so that they would appear visually distinct and different from younger maps. The custom intuitive monochrome icon for each wildlife species was extracted from the FREEPIK web platform and then designed based on their trophic levels, which are herbivores, predators, and birds, in the Inkscape software, as shown in the Figure 27. The symbol for the park landscape feature was selected the same as the younger group map. All the wildlife icons were placed in proper arrangement around each waterhole, and a dotted ellipse was created around some wildlife icon clusters to represent which waterholes they belonged to.
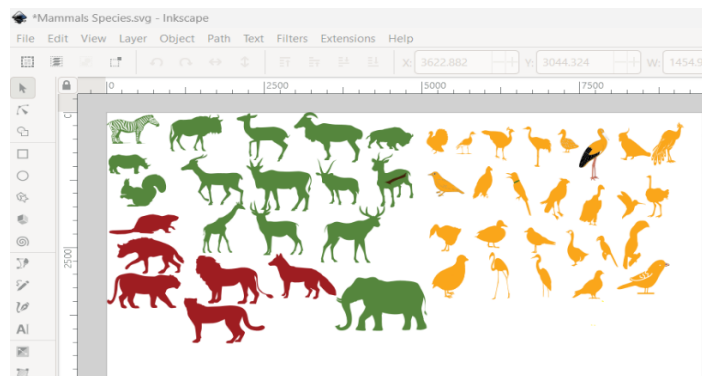
Figure 27 Inkscape interface for wildlife icon designing based on trophic level.

The font family for all the text was selected the same as discussed in the sub-chapter of the younger group map, but a light brown color scheme for the title of the legends, graphics, and chart were used to enhance the visual appeal. The basemap selected for this map was World Terrain Hillshade from the Living Atlas collection of Esri, blended with a light brown background to make it appear as a natural park area, as shown in the Figure 28.

Figure 28 World Terrain Hillshade basemap from ArcGIS Living Atlas.

5.2.3 Infographics and Alignment of Map Element

The intuitive graphical icons were used to represent Etosha National Park information related to timings, entrance gates, and regulations so that the public could plan their visit accordingly. Additionally, graphical images were used to represent which species has the highest and lowest estimation in the park. Furthermore, an overview map was attached in an aesthetic way to give the user an idea of the park's location in Namibia as shown the Figure 29.
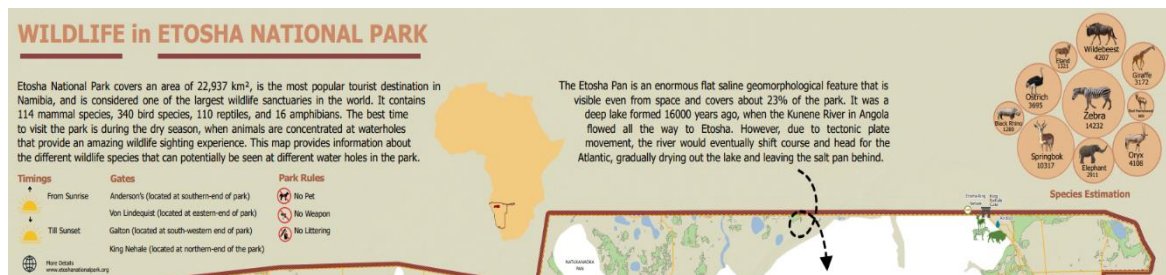
Figure 29 Public group map cutout represent overview map, graphical icons.

The legend and text of the map were aligned in such a manner as to create a visually pleasing and well-organized layout. Lastly, a pie chart was also incorporated into the map to represent the trophic distribution in the park, as shown in the Figure 30.

Figure 30 Public group map cutout represent legend and pie chart.

5.3 Expert Group Map

The main aim of this map was to be designed for expert users who understand cartographic elements and read maps. This map visualizes the most seen wildlife species at different waterholes in the park as intuitive geometrical symbols and the distribution of wildlife species as graduated symbols using dots, such as a larger distribution represented by a larger size dot. In the design process, geometrical icons for species distinction, graphic images for wildlife statistics, and aesthetic symbols for landscape features were used. The alignment of cartographic elements and graphics was implemented to maintain the visual coherence of the map. In this chapter, cutouts of the expert map are presented to discuss design processes due to its larger dimension, but the full map can be found in Attachment 4.

5.3.1 Layout Selection and Structure

The custom layout size selection for the expert group was different from the other group maps because this map visualizes different information for its reader, so the size was 500mm wide and 360mm long selected for the expert group map. The map reference scale was set to 1:350,000 in ArcGIS Pro so that visual overlapping between geometrical icons for wildlife and landscape feature symbols could be avoided, and users could easily interpret the map. The arrangement of map elements and text was the same as discussed in the sub-chapter of the younger and public group maps.

5.3.2 Symbols Designing and Basemap Selection

In the design process of this map, the two alphabets of species names put inside geometrical icons were created in ArcGIS Pro to represent different wildlife species, and the shape of each icon represents the trophic level of wildlife, like a square for herbivores, a circle for predators, and a triangle for birds. The symbols for the park landscape features were selected the same as other group maps, and red dots of different sizes were used to represent wildlife distribution. Furthermore, these geometrical wildlife icons were put in a dotted square shape in an aligned way and then connected to the waterhole to which they belonged, as shown in the Figure 31.
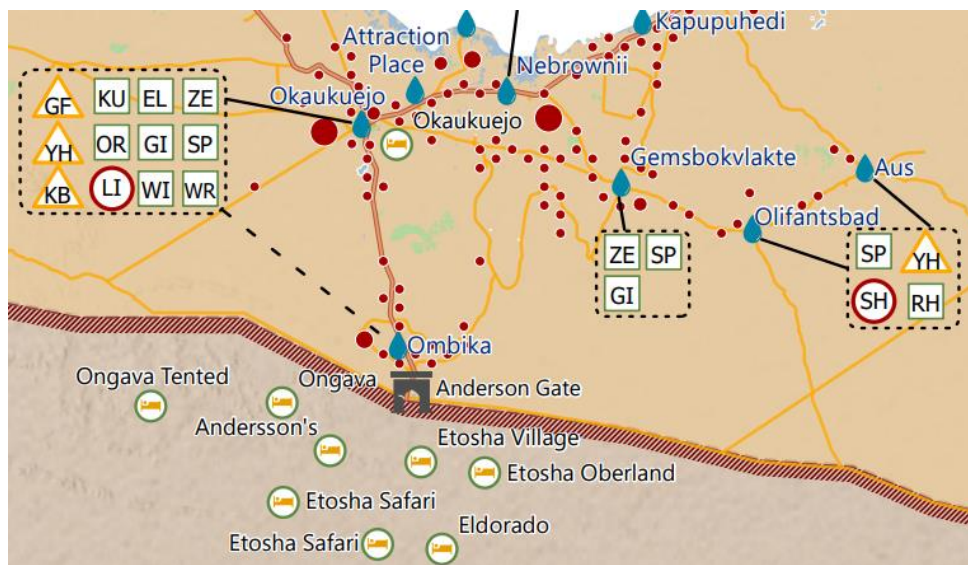
**Figure 31 Expert map cutout represent geometrical
wildlife icons and dots represent distribution.**

The font family for all the text was selected the same as discussed in the sub-chapter of the younger group map, but the white color with a shaded background color scheme for the title of the legend was used to emphasize the legend more than other elements of the map. The basemap selected for this map was Terrain Multi-Directional Hillshade from the Living Atlas collection of Esri, blended with a sand grain texture background to make it appear as a natural desert area, as shown in the Figure 32.
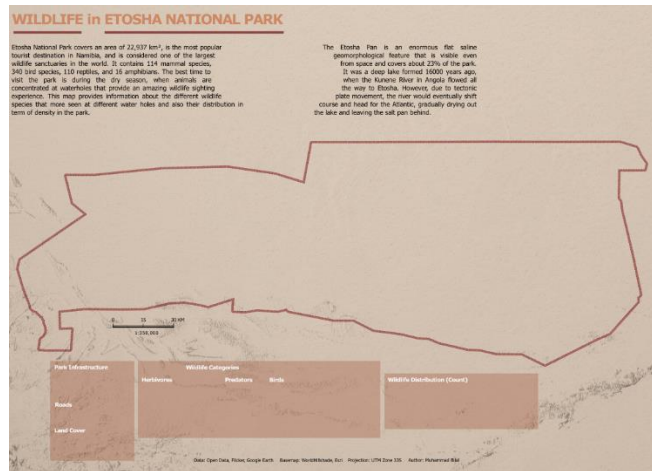

Figure 32 Basemap of expert group map.

5.3.3 Infographics and Alignment of Map Element

The graphical images were used to represent which species has the highest and lowest estimation in Etosha National Park. Furthermore, an overview map was attached in an attractive way to give the user an idea of the park's location in Namibia and enhance visual clarity, as shown in the Figure 33.
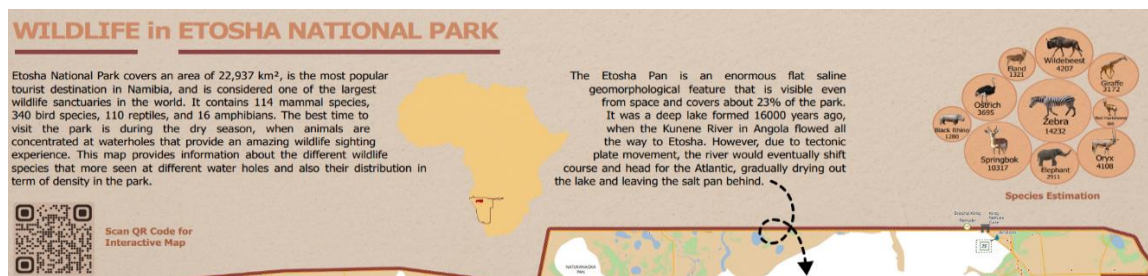
Figure 33 Expert map cutout represent text alignment, overview map, graphics.

The legends were aligned and emphasized using shading to create more visual importance than others, and a pie chart was also incorporated into the map to represent the trophic distribution as shown in the Figure 34.

Figure 34 Expert map cutout represent legends.

6 WEB MAP OF ETOSHA NATIONAL PARK

This chapter will discuss the third objective of this research, which was to publish different user group maps combined with interactive maps on the web. The purpose of an interactive web map was to allow users to dynamically interact with wildlife species data and landscape features of the park in a user-friendly way and to view, as well as download, cartographically designed different user group maps from the web map. A step-by-step procedure for the creation of a web map is provided in this chapter, supplemented with some discussion of programming libraries and the decision-making process. The programming languages that are used in the creation of web maps are HTML/CSS, JavaScript, Leaflet, and Visual Studio software used for coding. The full code for the interactive web map can be found in Attachment 5.

6.1 Data Preparation and Hosting

In the data preparation stage, all the preprocessed geotagged wildlife data and landscape features data of the Etosha National Park were converted into geojson format using the feature to JSON tool in ArcGIS Pro. Geojson is a lightweight and human-readable format based on JSON for encoding a variety of geographic structures like points, lines, and polygons in such a way that they are easily transferred or exchanged over the web, and this format is popular for web mapping applications that display and analyze spatial data. To check that the datasets are properly converted, each geojson file was uploaded on a web platform called geojson.io, developed by Mapbox, which visualizes geojson data on the map in real time, as shown in the Figure 35.
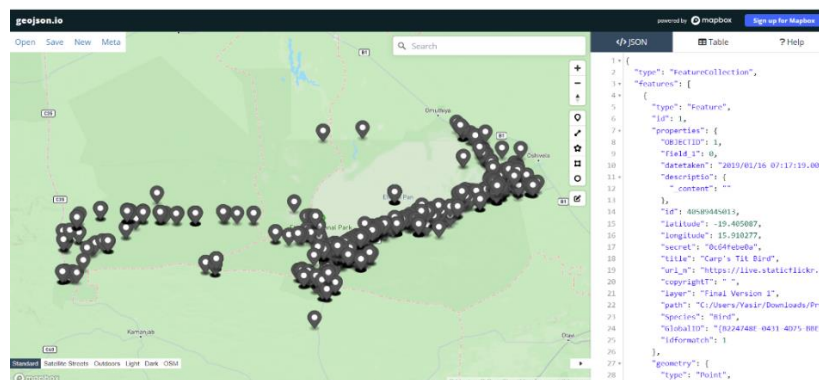
Figure 35 Geojson Dataset Visualization on geojson.io web platform.

These geojson datasets were then hosted on the Maptiler cloud platform, which helped our interactive web maps render wildlife and other landscape feature data faster on the web as shown in Figure 36.
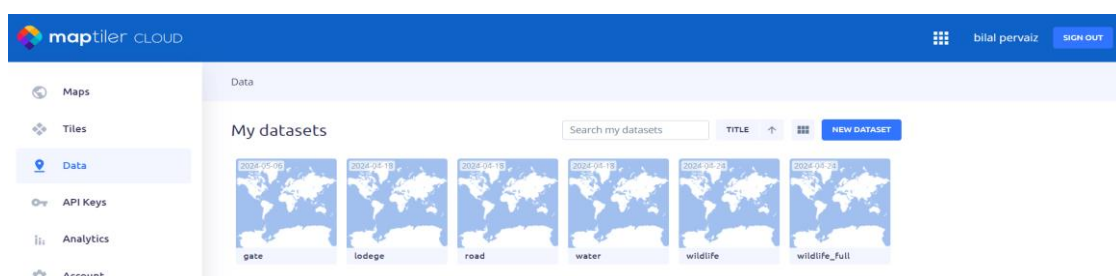
Figure 36 Maptiler Cloud Platform represent data hosting layers.

6.2 Web Map Development

The idea was to create a web map that would be easy to navigate, simple, and clear so that users with limited technological backgrounds would also use it to get information and view designed maps of Etosha National Park. The front end of the web map was designed using modern styles of mapping applications, so the maximum area of the map screen was designated for interactive maps, and a slider bar was implemented on one side of the interactive map that visualized information related to the park and provided intuitive buttons to view the cartographically designed maps. The decision about the theme and colors of the web map was to use light brown for different widgets and text headings to make the web map appear as a natural desert look and a pt-serif font was used for all the text in the web map. To engage and excite the user's interest, different basemaps that include Esri world imagery, Esri world street map, and Carto were incorporated into the web map using switch basemap plugin of leafltet library, along with zooming in and out functionality through scrolling and intuitive buttons as well. The default zoom level was also added as a widget in the application and the overall design of the web map is shown in the Figure 37.
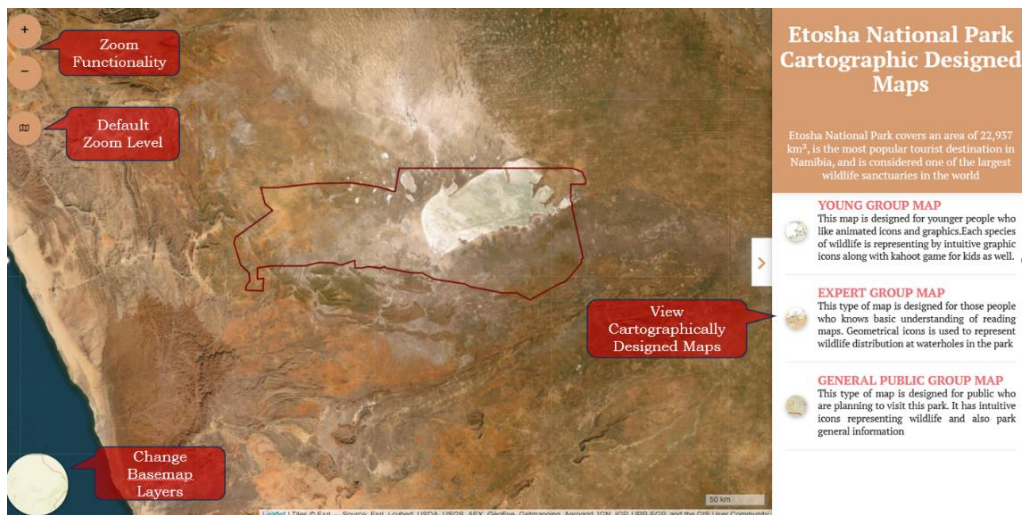
Figure 37 Web Map Design

When a user clicks on one of the desired maps, another slider will open and visualize two buttons to view and download the map. Each map was attached with a short introduction about the park and map design, as shown in the Figure 38.
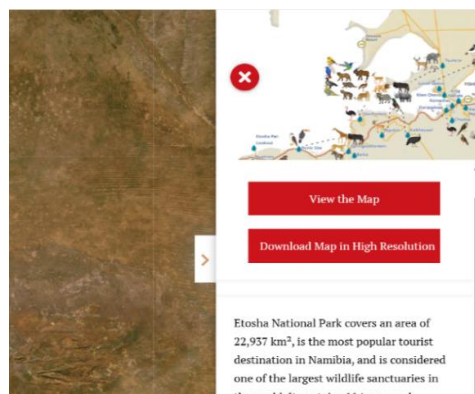
Figure 38 Web Map Slider Options

50

This web map also includes the functionality of popups using leaflet, in which users can click on wildlife data and other landscape feature datasets to visualize information. To create a sense of consistency on the web map, the same symbology for each dataset was used as in the designed maps as shown in the Figure 39.
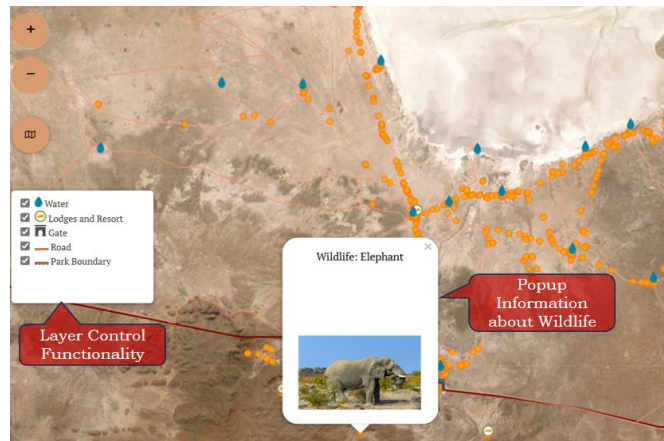
Figure 39 Popup Visualization in Web Map Interface.

In the last stage of the development phase, the cluster functionality was incorporated for wildlife data into the web map using the Leaflet Donut Cluster plugin. This functionality groups the nearby wildlife data points and makes a big donut-like circle for representation rather than individual points. The donut clusters in the web map represent the distribution of wildlife species in terms of trophic level, which are herbivores, predators, and birds, and their counts as well as shown in Figure 40.
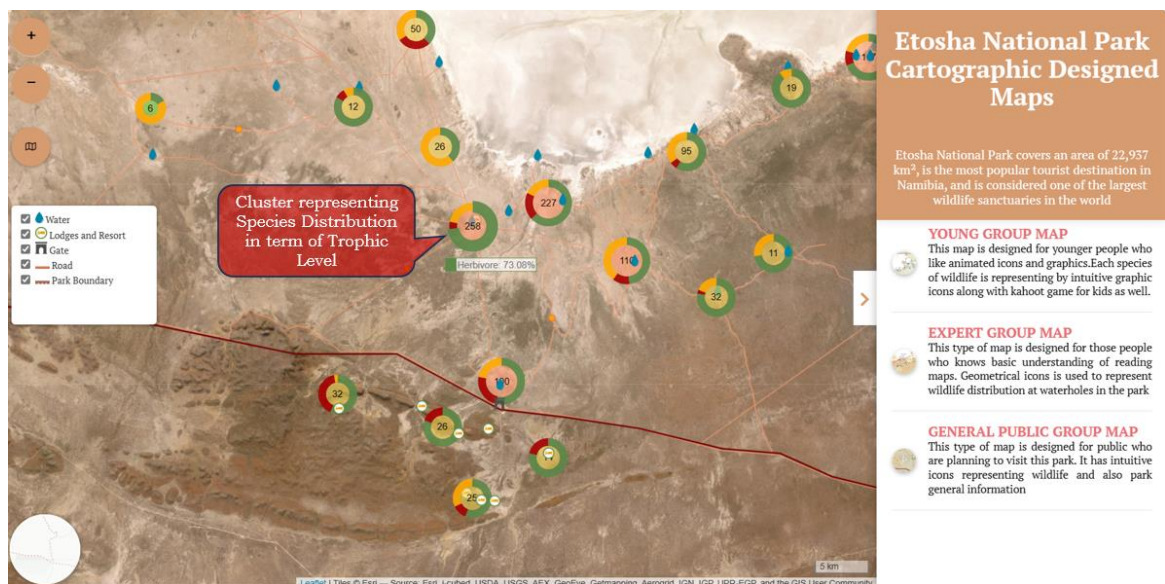
Figure 40 Web map interface visualizing cluster of wildlife species.

The overall code schema for this web map was HTML/CSS used for designing, JavaScript was used for buttons and visualization or download of map functionality, and lastly, a leaflet was used to visualize geojson datasets, layer controls, basemap switching, and donut-like cluster functionality. The overall code can be found in Attachment 5

6.3 Publishing on the Web

In this stage, the decision was made to host this web app on two platforms: one on GitHub and the other on the university's server. GitHub is the platform that allows users to create, manage, and share their codes seamlessly. This platform also provides a site hosting service that takes the HTML, CSS, and JavaScript files from the user code repository, runs them through build processes, and then publishes them as a website. For this stage, interactive map code was uploaded to a GitHub repository and then published as a web map application, as shown in the Figure 41 .
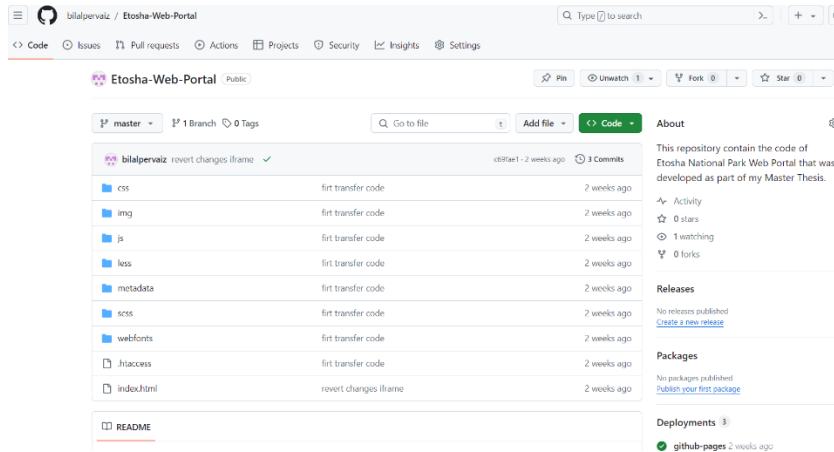
Figure 41 GitHub interface of web map code repository.

In the final step of this stage, the QR code was created to allow the users to easily access the web map, as shown in the Figure 42. The QR code is also attached to each cartographically designed map which can be found in Attachments 2, 3, and 4.
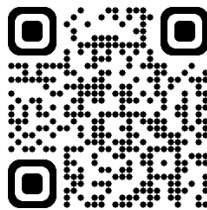
Figure 42 QR code to access web map.

7 RESULTS

This chapter consists of three parts. In the first part, the user evaluation of cartographically designed maps will be discussed in detail in terms of survey preparation and its responses, which was the third objective of this research. In the second part, the result of the designed user group maps that visualize information related to the wildlife species of the park will be discussed. In the end, the result of the web map will also be briefly discussed, which allows users to interact with wildlife species data and landscape features of Etosha National Park.

7.1 User Evaluation

This sub-chapter discusses the detailed process involved in the user evaluation stage of this research. User evaluation was done physically with three groups of people, including younger people, the public, and experts, using a digital survey form designed in ArcGIS Survey123. The purpose of the survey was to evaluate the design of different user group maps and the users' ability to understand the information in the maps. This sub-chapter is further divided into survey question preparation, design, and responses from the users.

7.1.1 Survey Questions and Designing

In the initial stage of survey question preparation, it was decided that the user evaluation of a cartographically designed map would be conducted among three different groups of people, which include younger people, the public, and experts because these maps are designed specifically for those target groups. Secondly, it was thought that the question should be designed according to the user's group mind and cover all the necessary questions about design aspects and map interpretation in terms of the readability of symbols or labels. So, three survey forms were created, and each form has two sections to gather feedback and insights from users about the designed maps.

The first section of the survey form related to the map interpretation focuses on gathering feedback regarding the map content that visualizes park information and infographics that represent statistics related to wildlife. Users were asked to identify lodges that were near specific waterholes, wildlife species around waterholes, and information related to statistical data. The reason to ask those types of questions is to evaluate the wildlife and landscape feature symbols and their labels in terms of visual identification and readability. These questions were designed to be answered with multiple choices.

The second section of the survey form related to the design aspect focuses on gathering information regarding the design of the map in terms of color scheme, wildlife icons, and other park feature symbols. In the expert group survey, this section has additional questions related to the arrangement of legends, scales, text, layout structure, and infographics because that user group has a cartographic design understanding. This section also has feedback questions that allow users to express their thoughts freely and provide suggestions to improve the map design. These questions were designed to be answered with good or bad and agree or disagree scales.

By structuring the survey into these two sections, it was intended to gather comprehensive feedback from the users, covering map interpretation, and visual experience.

The ArcGIS Survey123 platform was selected to create and design the user evaluation survey as it offers drag-and-drop form elements and design options, and it can also be shared with anyone who does not have an ArcGIS account. This platform allows us to set visibility options for specific survey questions that are visible to a specific target group. The Etosha National Park image was used as the background, and headings were inserted from the appearance section to create a similarity with the map theme. A brief introduction to the survey was provided to give users an idea of the purpose of the evaluation. The questions in both sections of the survey were marked as required questions, except for the additional feedback, and the questions for each group survey were not lengthy, so the user would not get bored with the survey. The types of question formats utilized in the survey are single-select, multiple-select, Likert scale, and single-choice grid as shown in Figure 43.

Figure 43 Survey evaluation form design.

7.1.2 Survey Responses

The user evaluation was conducted physically by presenting a printed version of the designed cartographic maps along with an online survey form to three different target groups, which include younger people, the public, and experts. This sub-chapter will discuss the results of two sections of three different survey forms that focus on map interpretation and design aspects. The total number of participants in the evaluation was 29, with 7 belonging to the younger group, 14 to the public, and 8 to experts who have an understanding of maps, as shown in the Figure 44. Before starting the evaluation, each group was briefed on the purpose and process of answering different questions by looking at the designed maps. The user's answers to all the questions in the survey honestly, according to their experiences, and some of the feedback that was useful for enhancing the map content and their design as well will be discussed in this chapter.
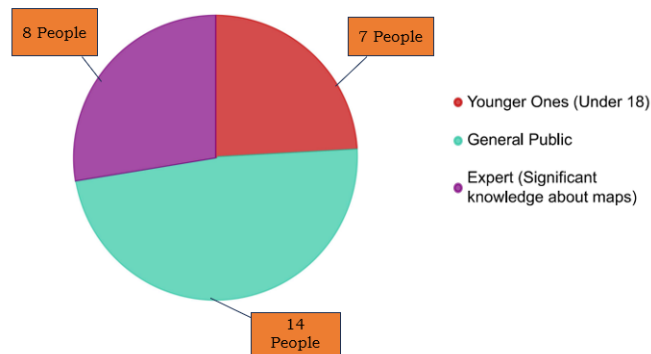
Figure 44 Demographic of the participants

Younger Group Responses

The list of questions that were asked to the younger group of people in the evaluation phase is shown in Figure 45.

Figure 45 Survey questions for younger group of people

The younger group gave an overwhelmingly positive response to the designed cartographic map in terms of layout structure, design, and map content, with only good and extremely good responses provided. In a question asked to the participant about different waterholes that have more wildlife species, 6 out of 7 people gave the correct answer for that response, as shown in the Figure 46. It was determined that the graphic icon of the wildlife species is well placed around the waterhole and easily identifiable. Similarly, in another question, the user had to identify the nearest lodge facility to Anderson Gate for that response all the participants gave the correct answers. It was analyzed that the icons of the landscape feature were easily readable and distinguishable which helped the user to calculate visual distances. At the start of the evaluation, most of the users struggled to find an answer due to the larger map size, but the strategy of placing some reference text on each question about where to look on the map for a particular question was useful for participants.
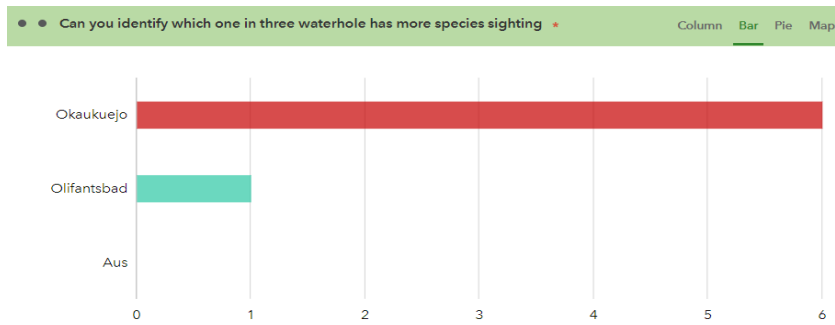
Figure 46 Bar chart representing participants response to particlular question.

Participants were also requested in the survey to rank the overall design of the cartographic map on a scale of extremely good to bad in terms of color scheme or appearance. In response, six participants predominantly rated the map in between extremely good and good, with the remaining user rating neutral, as shown in the Figure 47. Similarly, questions were asked related to wildlife icons, and all the participants rated them from extremely satisfied to satisfied.
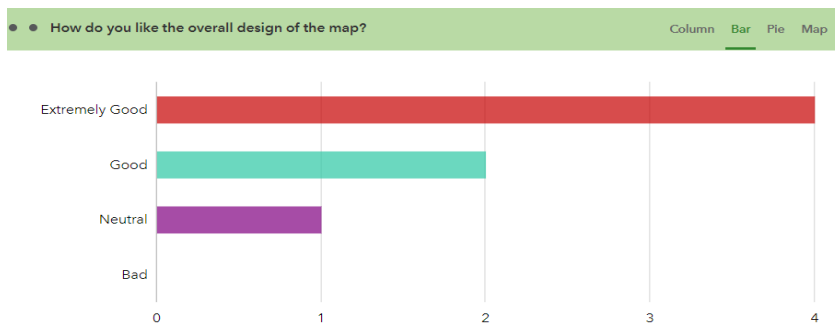
Figure 47 Bar chart representing user response to map design.

Public Group Responses

The list of questions that were asked to the public group of people in the evaluation phase is shown in Figure 48.

Figure 48 Survey questions for public group of people

The public group also gave a positive response to the designed cartographic map in terms of the arrangement of information, design, and wildlife species icons. In a question asked to the participants about their familiarity with reading the map, 9 out of 14 people said they were slightly familiar, and others said they were very familiar, which made them ideal participants for this survey. In a question asked to participants related to map content about identifying lodge facilities at a specific waterhole, 13 out of 14 participants gave the correct answer, as shown in the Figure 49. It was analyzed from that response that the symbols of the landscape features of the park are readable in terms of size and their label. To test the user's ability to locate and identify information, they were asked to identify the species that has the lowest estimation in the park, and for that response, all the participants gave the correct answers.
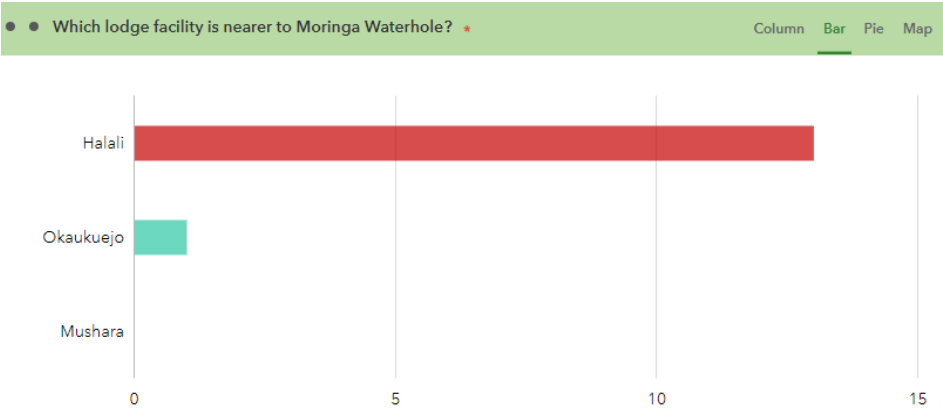
Figure 49 Bar chart representing people response about nearest lodge.

The users particularly enjoyed the use of intuitive wildlife icons and colors for their trophic distribution, and they expressed this emotion in response to the overall design question. The 12 participants predominantly rated the map in between extremely good and good, with the remaining user rating neutral, as shown in the Figure 50. The user also provides additional feedback to improve the design of the map. It was suggested to increase the font size of the feature labels a little bit so that they can be read more easily, and that suggestion was implemented as well.
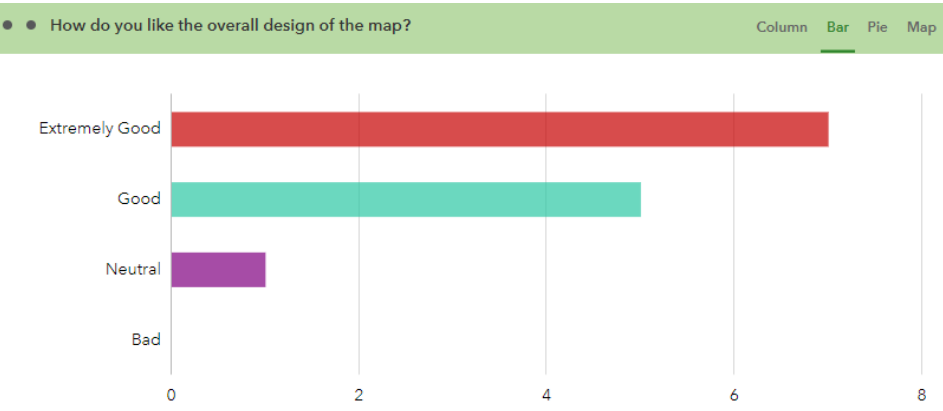

Figure 50 Bar chart representing participants responses about design.

Expert Group Responses

The expert group gave an overall positive response and feedback to improve the map design. The expert map was differently designed than the other two group maps, so some of the survey questions were more technical due to the cartographic background knowledge of the group participants. In a question asked to the participants about the greater wildlife trophic distribution at which waterholes exist, all the respondents gave the correct answer. It was found that wildlife trophic distribution representations in different geometrical shapes were properly designed in terms of their size and shape, which were easily interpreted by users. In another question, users were asked about waterholes that have a greater wildlife species distribution; 5 out of 8 people responded correctly, as shown in the Figure 51. The distribution question also highlights some issues in the ranges of wildlife distribution that were visualized using the dot density method and were corrected afterward. The survey questions for the expert group can be found in Attachment 6.
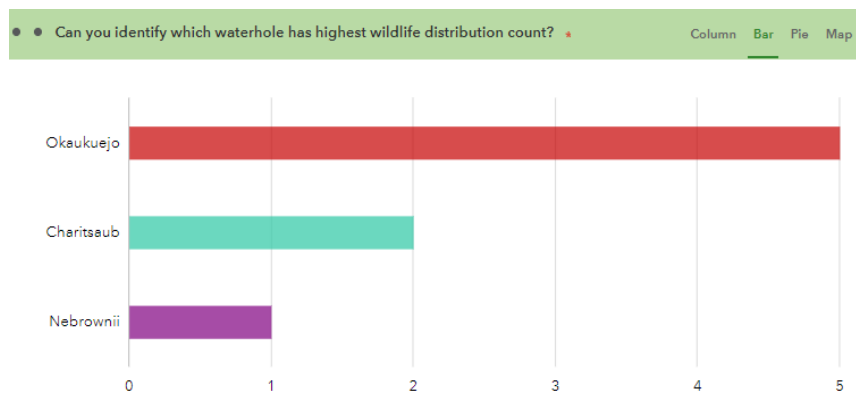
Figure 51 Bar chart representing response of participant about greater wildlife distribution.

The participant was also requested to rank the overall design of the cartographic map on a scale of extremely good to bad in terms of color scheme or appearance. In response, all the participants predominantly rated the map between extremely good and good, as shown in the Figure 52. Another technical question was asked to users related to the cartographical aspect of a designed map to rate on a scale of agree to disagree that the legend, scale, text, graphics, and layout size are well placed. In response, the majority agreed with the statement, and one stayed neutral.
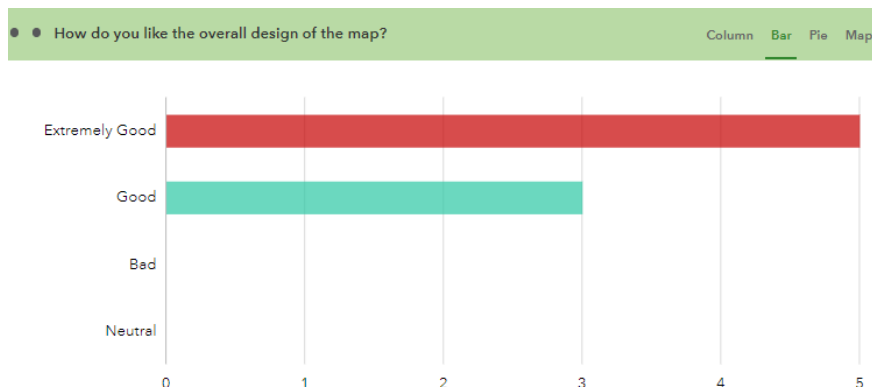

Figure 52 Bar chart of participant response about design.

Overall, the user evaluation and feedback were highly positive, and participants responded favorably to the cartographic design maps. The constructive feedback was also welcomed as an opportunity to make further improvements to the design. The complete set of user feedback and responses can be found in Attachment 6.

7.2 Results of Analysis and Map Designing

The analysis component of this research aimed to design three different cartographic style maps for younger people, the public, and experts using geotagged photos of wildlife and landscape features. The designed maps provide detailed information related to the wildlife species around each waterhole and the landscape features of Etosha National Park. The analysis component is divided into three parts, which include the data acquisition process, the designing of maps for different groups, and the user-testing of the designed maps. The first part of the analysis was the acquisition of geotagged photos of wildlife from the Flickr platform using their non-commercial API and Google Earth Pro, as discussed in Chapter 4.2. The sentinel land cover and landscape feature datasets were also collected from different sources, as discussed in the chapter on data collection. The datasets were then preprocessed and managed in terms of duplication, labeling of species, and their trophic level of categorization using Excel and QGIS, as discussed in Chapter 4.3. The preprocessed data were then used to do buffer and dot density analysis, and the results were visualized in different group maps to show information related to wildlife distribution. The second part of the analysis component was the design of three different cartographic style maps for younger people, the public, and experts. Each map was designed using different color schemes, basemaps, intuitive icons for wildlife species, and landscape feature symbology of the park, as discussed in Chapter 5. The textual information related to the park was a little bit different for each map, considering the background knowledge of each target group. The third part of the analysis component was to do the user evaluation of each cartographically designed map in terms of their design and the users' ability to understand the information in the maps, as discussed in Chapter 7.1. The total number of participants that took part in the evaluation was 29, with 7 belonging to the younger group, 14 to the public, and 8 to experts. Overall, user evaluations and feedback were highly positive towards the map design and content. The feedback from users helped make improvements to maps, especially those related to map content. The user-tested cartographically designed maps can be found in Attachments 2, 3, and 4.

7.3 Web Map

The web map result consists of an interactive map combined with cartographic maps designed for different target groups. The purpose of an interactive web map was to allow users to dynamically interact with wildlife species data and landscape features of the park in a user-friendly way and to view, as well as download, designed maps. The web map-building process consists of three stages, which include data preparation and hosting, the development of an interactive map, and publishing on the web, as discussed in Chapter 6. In the first stage, all the datasets were converted to GeoJSON format and then uploaded to the MapTiler cloud, which helped render wildlife and other landscape feature data faster on the web. In the second stage, the design of the interactive map was similar to modern styles of mapping applications, so the maximum coverage was given to the interactive map, and a vertical slider with intuitive buttons was implemented to visualize

and download cartographically designed maps. The multiple basemap, zooming, and popup with image functionality were implemented to attract users. To create a sense of visual consistency, similar symbols to designed maps were used for landscape features of the park, and light brown for different widgets was used to make the natural desert look as shown in the Figure 53. The donut cluster functionality was also implemented so that users could see the trophic distribution of wildlife in the park, as discussed in Chapter 6.2. In the third stage, web map code was uploaded to the GitHub repository and used the site hosting service of GitHub to publish web maps online that could be accessed through a specific URL. The web map as a QR code was attached to each designed map, so users could also access it through maps. The full code for the web map can be found in Attachment 5.
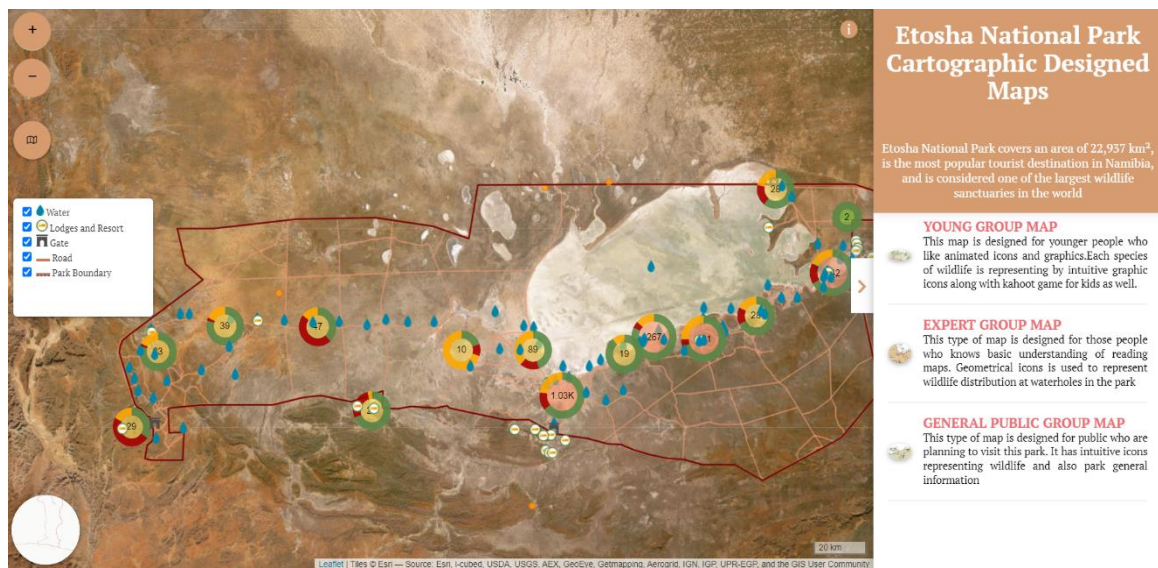
Figure 53 Web Map Interface.

8 DISCUSSION

The purpose of this research was to design three different cartographic style maps that provide detailed information related to the wildlife species occurrence around each waterhole and the landscape features of Etosha National Park. The designed maps were published on the web along with an interactive map that allows people to dynamically interact with wildlife species data and landscape features of the park in a user-friendly way. After this work, the data acquisition procedure, analysis methods, and outputs were reviewed critically to identify limitations or room for improvement in the methods used or the outputs created. This chapter will review and discuss these points, and following this, it will provide suggestions for the future potential of this research.

8.1 Critical Review of Datasets, Analysis and Results

8.1.1 Data Acquisition Limitation

In Chapter 4.2, it was discussed that all the datasets that were utilized in this research were obtained from public sources, which was one of the research objectives. The platform that was selected to acquire wildlife geotagged images was Flickr because it provides a freely accessible API through which users can extract information about images in terms of their location, timestamp, tags, and description. In the literature review, it was observed that Flickr was mostly used for analyzing wildlife tourist encounters, tourist visitation rate estimation for national parks, and similar research, which is why it was selected for this research. Nevertheless, some issues arose after extracting data from that platform, including duplication of images and titles representing people's emotions, as discussed in Chapter 4.3. The solution could be the enhancement of the Python script in such a way that it deals with duplication at the acquisition stage, and for labeling images, a deep learning model approach would be useful for species detection in images. The Global Biodiversity Information Facility (GBIF) could be another better source to acquire geotagged wildlife information. It is a multi-governmental collaborative approach to creating open-source species observation data globally. The observations logged on the platform are from accredited organizations and resources. This platform was not used in this research due to time limiation but could be a useful resource for enriching wildlife geotagged information.

8.1.2 Analysis

The analysis component of this research aimed to identify wildlife species occurrences around different waterholes in Etosha National Park using geotagged images, as discussed in Chapter 4.4. The information identified from this stage was then used to design different style maps to provide the user with accurate and detailed information about the wildlife species distribution. The buffer analysis done in this stage was relatively basic but sufficient to produce the desired results. The wurman dots method was identified as a suitable approach to represent the distribution of wildlife in the park. For future suggestions, the dot density analysis could also be combined with the multivariate method, so a change in the color of the dots could represent endangered species or their categories. The geotagged wildlife data could also be overlayed with thematic data like temperature or precipitation to identify their effect on species, which would generate another map for researchers as well.

8.1.3 Map Designing

In the map-designing stage, three different cartographic styles of maps were made for different target groups using the output of the analysis stage. The layout was decided for each map after different sizes of layout tests were performed to analyze the visual clarity of park features, another reason behind the custom layout was that people would easily carry the printed version of the map while visiting the park. The decision to use graphic symbols of wildlife in the maps was to take advantage of people's cognitive abilities for recognition, which means young people would easily interpret graphical icons. The geometrical symbols for the expert group map were used because of their cartographic background knowledge. After the design, user evaluation was also performed to evaluate the design and user interpretation of the information on the map. Overall, feedback was highly positive, and participants responded favorably to the cartographic design maps and gave additional feedback. In the context of future suggestions, the design of all maps could be improved by using different typographic styles for each map and modern-style infographics for representing statistical information. From user evaluation, people suggested making a zoom map for clustered areas in an expert map that could be useful to improve map design.

8.1.4 Web Map

The web map was also developed in this research, which was one of the research objectives discussed in Chapter 6. The web map-building process consists of three parts, which include data hosting, the development of interactive maps, and publishing on the web. The decision to choose MapTiler Cloud was to make datasets load faster on the user side. Although MapTiler Cloud is a paid platform, in their free plan, the user can upload datasets up to 100 MB, and as our datasets lie in that range, that is why it was selected. In the event of future expansion, there could be two solutions for data hosting. The first is open source, creating vector tiles of the research datasets and then publishing those progenerated tiles along with web map code on the web. Secondly, the paid version of data hosting on the MapTiler cloud could be implemented to get rid of the manual work of generating tiles. The leaflet JavaScript library was used for the development of interactive map functionalities like basemaps, zooming, and clustering. The reason to use that library was because of its open-source quality, web and mobile-friendly design, extensive documentation, and ease of use. The freely available GitHub site hosting service was then used to publish an interactive map on the web.

8.2 Suggestion for Expansion of this Research

In a broad sense, the output of this research visualized wildlife species distribution information using geotagged photos and other landscape features of Etosha National Park through cartographically designed maps and user-friendly web maps. This research concept can be easily repeated for other national parks in Namibia or in other parts of the world that could attract more tourists to the national parks by providing information related to wildlife species occurrences. The web map functionality could also expand, allowing users to enter wildlife species information with images that they have seen in the park. The enhancement of the web map could help park authorities monitor endangered species and make decisions for their protection. This research approach could also be useful for designing maps for researchers by integrating thematic layers like temperature or precipitation with geotagged wildlife information to visualize the climate effect on specie's habitats.

9 CONCLUSION

The thesis aimed to design cartographic-style maps for younger people, the public, and experts that visualized wildlife species distribution information using geotagged photos and landscape features of the Etosha National Park. The designed maps are then published on the web, combined with an interactive map that allows users to dynamically interact with wildlife data and landscape features of the park in a user-friendly way. This document has described and detailed the processes and procedures involved in achieving the aims and has successfully demonstrated the outputs of this research. The focus of this research was on the process of acquiring geotagged data and designing different-style maps for potential park visitors. The Flickr non-commercial API and Google Earth Pro were used to acquire geotagged photos of wildlife and landscape feature datasets also acquired from public sources, as discussed in Chapter 4.2.

The output of the buffer analysis identified wildlife species that exist at different waterholes, and the dot density method was used to analyze the distribution of wildlife species in the park as discussed in Chapter 4.4. The results of the analysis part were used to design maps for different target groups. Each map was designed using different color schemes, basemaps, infographics, intuitive graphical icons for wildlife species, and attractive symbology for landscape features of the Etosha National Park, as discussed in Chapter 5. The textual information related to the park was a little bit different for each map, considering the background knowledge of each target group. These maps provide information related to wildlife occurrences at waterholes, some historical facts about the park, and statistical figures of wildlife species to inform or educate the user about the characteristics of Etosha National Park.

The user evaluation of each designed map was also performed with three different groups of people in terms of their design and user ability to perceive information from the map, as discussed in Chapter 7.1. Overall, the evaluations and feedback were highly positive towards the map design and content. The feedback from users helped make improvements to maps, especially those related to map content. The user-tested map was then published on the web so everyone could access it and combine it with an interactive map that allows users to dynamically interact with wildlife species data and landscape features of the park in a user-friendly way as discussed in Chapter 6. The GitHub site hosting service was used to publish a web map as a website so anyone could access it with a specific URL.

In conclusion, the designed maps have proven to be a valuable resource that can act as a guide for tourists who are planning to visit Etosha National Park and gain information about the occurrence of wildlife species in the park. Further, the designed cartographical maps can also help park authorities assign more financial resources where wildlife is mostly seen and declare game viewing spots without disturbing the wildlife. The suggestion related to the future expansion of this research was discussed in Chapter 8.2.

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LIST OF ATTACHMENTS

Bound attachments:

Attachment 1   Python Script (https://github.com/bilalpervaiz/Geotagged-Script)

Attachment 2   Younger Group Map

Attachment 3   Public Group Map

Attachment 4   Expert Group Map

Attachment 5   Web Map Code (https://github.com/bilalpervaiz/Etosha-Web-Portal)

Attachment 6   User Evaluation Form and Responses

Free attachments

Attachment 7   Thesis Poster (Printed A2 Format)

Attachment 8   Printed Designed Maps (Younger, Public and Expert Maps)

Attachment 9   Digital Files-Zip Folder

Structure of Attachments 9

Folder	Sub-Folder	Files
Digital Files	Design Maps for Groups	Younger, Public, Expert Maps - PDF
	Thesis Data	1. Three ArcGIS Pro Projects (APRX) 2. Three Designing files (SVG) 3. Geodatabase (Wildlife and Landscape data)
	Code	Python Script, Web Map Code

Printed version of this map also provided as free attachment.

View Map in High Resolution

WILDLIFE in ETOSHA NATIONAL PARK

Etosha National Park covers an area of 22,937 km², is the most popular tourist destination in Namibia, and is considered one of the largest wildlife sanctuaries in the world. It contains 114 mammal species, 340 bird species, 110 reptiles, and 16 amphibians. The best time to visit the park is during the dry season, when animals are concentrated at waterholes that provide an amazing wildlife sighting experience. This map provides information about the different wildlife species that can potentially be seen at different water holes in the park.

The Etosha Pan is an enormous flat saline geomorphological feature that is visible even from space and covers about 23% of the park. It was a deep lake formed 16000 years ago, when the Kunene River in Angola flowed all the way to Etosha. However, due to tectonic plate movement, the river would eventually shift course and head for the Atlantic, gradually drying out the lake and leaving the salt pan behind.

Species Estimation

Wildebeest 4207
Eland 1321
Giraffe 3172
Ostrich 3695
Zebra 14232
Red Hartebeest
Black Rhino 1280
Springbok 10317
Elephant 2911
Oryx 4108

Timings

From Sunrise
Till Sunset

More Details
www.etoshanationalpark.org

Scan QR Code for Interactive Map

Gates

Anderson's (located at southern-end of park)
Von Lindequist (located at eastern-end of park)
Galton (located at south-western end of park)
King Nehale (located at northern-end of the park)

Park Rules

No Pet
No Weapon
No Littering

0   15   30 KM
1:350,000
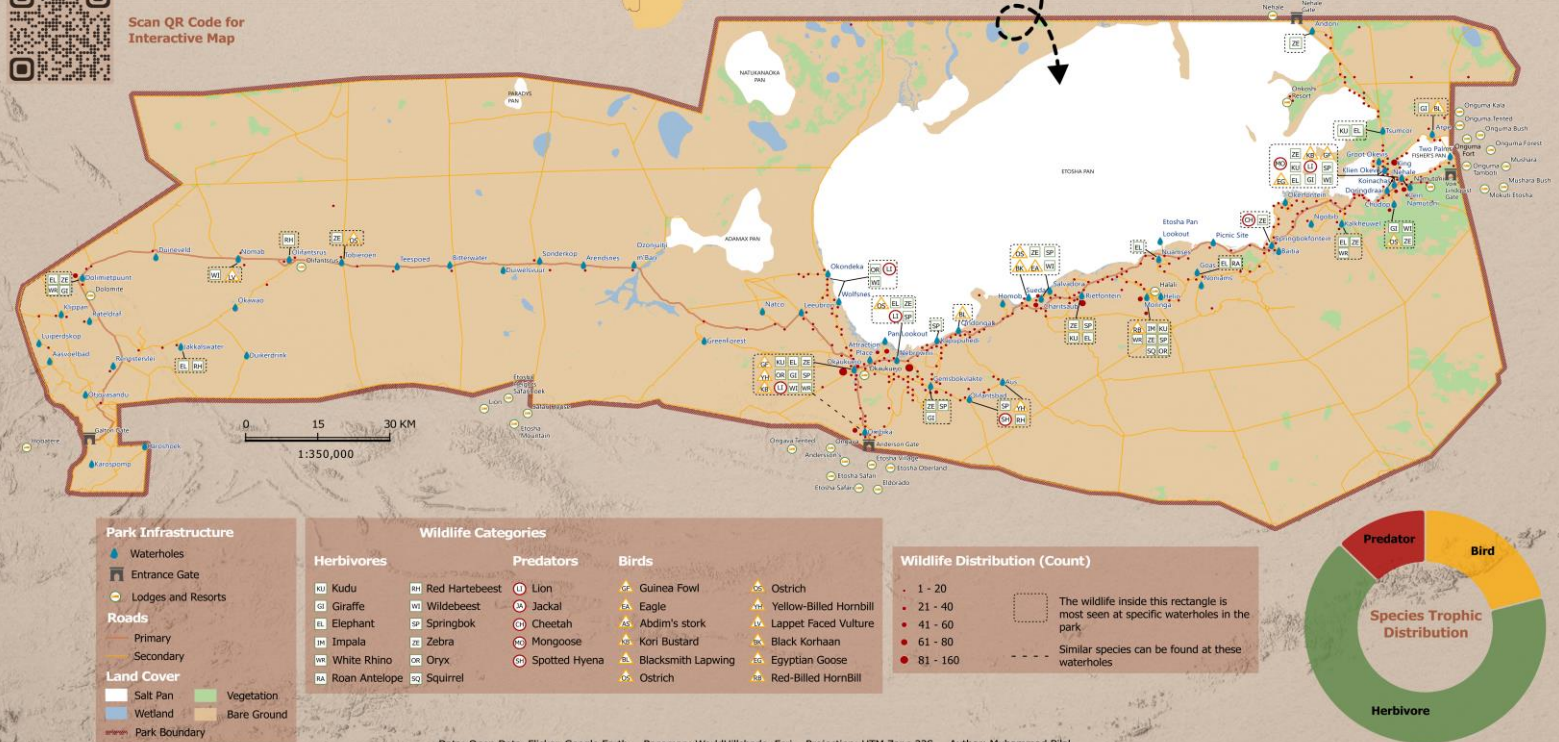
Park Infrastructure

Waterholes
Entrance Gate
Lodges and Resorts

Roads
Primary
Secondary

Topographic Areas
Salt Pan
Wetland
Vegetation
Park Boundary

Wildlife Categories

Herbivores

Kudu	Eland
Giraffe	Wildebeest
Elephant	Roan Antelope
Impala	Squirrel
White Rhino	Steenbok
Springbok	Red Hartebeest
Zebra	Warthog
Oryx	

Predators

Lion
Jackal
Leopard
Mongoose
Spotted Hyena
Cheetah

Birds

Laughing Dove	SpoonBills	Grey Go-Away	Red-Billed Quelea
Guinea Fowl	Cape Starling	Kori Bustard	Lappet Faced Vulture
Eagle	Egyptian Goose	Black Korhaan	Namaqua Sandgrouse
Lilac Breasted	Abdim's stork	Ostrich	Red-Billed HornBill
Falcon	Marico Sunbird	Yellow Canary	
Red-Billed Spurfowl	Grey Heron	Pale Chanting Goshawk	
Blacksmith Lapwing	White Backed Vulture	Yellow-Billed Hornbill	

Similar species can be found at these waterholes
Species at specific waterholes

Species Trophic Distribution
Predator
Bird
Herbivore
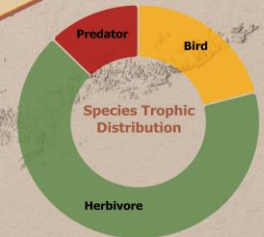
Data: Open Data, Flicker, Google Earth   Basemap: World Hillshade, Esri, Graphics by Freepik   Projection: UTM Zone 33S   Author: Muhammad Bilal

Printed version of this map also provided as free attachment.

View Map in High Resolution

Printed version of this map also provided as free attachment.

View Map in High Resolution

Attachment 6 - User Evaluation Form and Responses

Younger Group Survey

Etosha National Park Maps User Evaluation

Younger Ones (Under 18)

Map Interpretation ⊙
Please answer the following question about the content of the map

Can you tell how much times Etosha park is greater than New York city? *

check the graphic picture for reference

| ○ 20 | ○ 28 | ○ 30 |

Can you identify which waterhole is near to Anderson Gate? *
check the southern end of the map

| ○ Ombika | ○ Gemsbokvlakte | ○ Olifantsbad |

Can you identify which one in three waterhole has more species sighting *
check the southern part of the map

| ○ Aus | ○ Olifantsbad | ○ Okaukuejo |

Check those species that are found at Bitterwater waterhole? *
check the western part of the map

| ☐ Lion | ☐ Giraffe | ☐ Oryx |

| ☐ Cheetah |

Which lodge facility is nearer to king Nehale Waterhole? *
check the eastern part of the park

| ○ Namutoni | ○ Onkoshi Resort | ○ Onguma Tamboti |

General ⊙
Please examine the design and composition of the map.

How do you like the colors scheme of the map?

○———○———○———○
Not Good   Neutral   Good   Extremely Good

Are you satisfied with the selection of wildlife icon?

○———○———○———○
Not satisfied   Neutral   Satisfied   Extremely Satisfied

How do you like the overall design of the map?

○———○———○———○
Bad   Neutral   Good   Extremely Good

Public Group Survey

Map Interpretation ⏷

Please answer the following question about the content of the map

Which lodge facility is nearer to Moringa Waterhole?*
check the eastern center of the map

○ Okaukuejo	○ Halali	○ Mushara

How many species can be found at Okaukuejo waterhole?*
check the southern part of the map

○ 5	○ 10	○ 16

How many herbivores can be find at Gemsbokvlakte waterhole?*
check the southern part of the map

○ 2	○ 5	○ 6

Which specie has lowest estimation in the park?*
Check the species estimation(circle image graphic).

○ Zebra	○ Red Hartebeest	○ Springbok

Which species of trophic are greater in the park?*
Check the species tropic distribution chart.

○ Predator	○ Bird	○ Herbivore

General ⏷

Please examine the design and composition of the map.

How familiar are you with reading maps?

○————————○————————○
Not familiar   Slight familiar   Very familiar

How do you like the colors for wildlife category and their icons?

○————————○————————○————————○
Not Good   Neutral   Good   Extremely Good

How do you like the overall design of the map?

○————————○————————○————————○
Bad   Neutral   Good   Extremely Good

Do you have any additional feedback?

Response	Count
Sand Openings	1
I really like the design. It is precise and easy to read and understand it.	1
Hope you have a wonderful day ^^	1
font size and colour could be adjusted to be more readable	1

Answered: 4 Skipped: 25

Expert Group Survey

Expert Ones

Map Interpretation ▾

Please answer the following question about the content of the map

Can you identify waterhole that has maximum wildlife sightings?*

Check the southern part of the map.

○ Gemsbokvlakte	○ Okaukuejo	○ Nebrownii

Can you identify which one in three waterholes have greater herbivores species?*

Check the eastern part of the map

○ Moringa	○ Rietfontein	○ Goas

Which lodge facility is nearer to Klein Namutoni waterhole?*

check the eastern-end of the map

○ Namutoni	○ Onguma Tamboti	○ Mokuti Etosha

Which specie has highest estimation in the park?*

Check the species estimation graphic.

○ Zebra	○ wildebeest	○ Springbok

Can you identify which waterhole has highest wildlife distribution count?*

check the wildlife distribution symbol in the legend.

○ Charitsaub	○ Okaukuejo	○ Nebrownii

General ▾

Please examine the design and composition of the map.

How do you like the overall design of the map?

○———————○———————○———————○
Bad   Neutral   Good   Extremely Good

How do you like the wildlife symbols and their color?

○———————○———————○———————○
Not Good   Neutral   Good   Extremely Good

How much do you agree or disagree with the following statements about the map design?

	Disagree	Neutral	Agree
The legends and scale are well placed in the map?★	○	○	○
The text and graphics are well placed?★	○	○	○
The water label and lodges label are well readable?★	○	○	○
The size of layout is good for understanding the information shown?★	○	○	○
The overview map is well placed and designed?★	○	○	○

Do you have any additional feedback?

Response	Count
Zoom in of complex areas Labels color or water and lodge Infographic down in legend Copy right should be full	1
The scale bar should be less dominant. Would be nice if it uses gray color or or not be bold. Additionally, the pie chart color should use lighter color palette or similar tone of the map	1
Normalization of the graduated symbols need more change in simble size differeciation.	1
Good overall.	1
do some close-up or zoom to places where is a lot of symbols	1
color bar; gaps	1

Answered: 6 Skipped: 23