ASSESING IMPACTS OF HUMAN ACTIVITIES ON AFRICAN WILD DOGS HABITAT

A CASE OF NYERERE NATIONAL PARK

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A Dissertation submitted in the Department of Geospatial Sciences and Technology in partial fulfilment of the requirements for the award of Bachelor of Science degree in Geographic Information System and Remote Sensing (GIS & RS) of Ardhi University.

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The undersigned certify that they have proof read and hereby recommend for acceptance of a dissertation entitled **"ASSESING IMPACTS OF HUMAN ACTIVITIES ON AFRICAN WILD DOGS HABITAT"** for University Examination.

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MUZEZA SINYANGWE

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ACKNOWLEDGEMENTS

It is with immense joy and humility that I extend my sincerest thanks to the Creator for granting me knowledge and good health, which paved the way for the successful completion of my research.

This dissertation would not have been possible without the unwavering support and mentorship of my supervisor Dr. Atupelye Komba. Her sincerity, inspiration, guidance, and vast knowledge has been instrumental in shaping my understanding and enriching my research journey.

I am equally indebted to Dr. Dorothy Deus, Dr. Beatrice Tarimo, and the esteemed members of the panel for their valuable contributions, constructive comments, encouragement, and unwavering support throughout the process. The Geospatial Sciences and Technology Department (DGST) and its dedicated staff have played an integral role in providing an enriching academic environment that nurtured my growth and learning.

I am also deeply appreciative of all those individuals who have participated in and contributed to this research in various ways, even if they may not be mentioned on this page. Your assistance, whether big or small, has been sincerely valued and gratefully acknowledged.

Lastly, I extend my heartfelt appreciation to my family and friends for their unending love, encouragement, and understanding during the arduous research process.

DEDICATION

I dedicate this research with heartfelt appreciation and love to all those who have supported and inspired me throughout my academic journey.

To my parents Ndimbumi Mwakalobo and Damas Sinyangwe whose unwavering love and encouragement have been my constant source of strength, I am eternally grateful. Your sacrifices, guidance, and belief in me have shaped me into the person I am today. This research stands as a testament to your unwavering support, and I dedicate its success to you.

To my mentors and teachers, thank you for your wisdom, guidance, and invaluable insights. Your passion for knowledge and dedication to education have instilled in me a lifelong love for learning and exploration. I am grateful for the opportunities you have provided and the invaluable lessons you have imparted.

ABSTRACT

The African wild dog (Lycaon pictus) is an endangered species facing significant threats to its habitat due to human activities. This research aims to analyze the extent of habitat loss for African wild dogs resulting from land cover change influenced by human factors. Through the use of remote sensing data and land cover classification techniques, changes in land cover classes such as vegetation, water bodies, built-up areas, and bare land were assessed over a specific time period. The analysis revealed substantial alterations in the wild dog's habitat, primarily driven by human encroachment and the construction of infrastructure. The expansion of built-up areas led to the fragmentation and isolation of wild dog populations, impeding their movement and dispersal patterns. The results highlight the critical impact of human activities on African wild dog habitats, emphasizing the urgent need for conservation interventions. Recommendations include the establishment of protected areas, habitat restoration initiatives, effective land use planning, community involvement in conservation efforts, and stringent anti-poaching measures. These measures are essential for mitigating habitat loss, safeguarding vital habitats, and ensuring the long-term survival of African wild dogs. Conservation actions must be implemented promptly to mitigate the adverse effects of habitat loss and promote the coexistence of humans and wild dog populations. The findings of this research provide valuable insights into the consequences of land cover change on African wild dog habitats, informing conservation strategies and management practices for their protection and preservation

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LIST OF ABBREVIATIONS

GEE	Google Earth Engine
GPS	Global Positioning System
IUCN	International Union Conservation of Nature
SRTM	Shuttle Radar Topography Mission
TAWIRI	Tanzania Wildlife Research Institute
VHF	Very High Frequency
ASAL	Arid and semi-arid land
AWF	African Wildlife Foundation
FGD	Focus group discussion.
GCP	Ground control points
GIS	Geographic Information System
HWC	Human wildlife conflict
IUCN	International Union for the Conservation of Nature
LARMAT	Land Resource Management and Agricultural Technology
LULCC	Land Use and Land Cover Change
PA	Protected area(s)
SCP	Semi-Automatic Classification Plugin
WWF	World Wildlife Fund

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

To address the threat of habitat loss, biodiversity conservation often focuses on protecting species' habitat through a variety of legal and policy mechanisms (UN Environment World Conservation Monitoring Centre & International Union for Conservation of Nature 2017). Convention on Biological Diversity; UN Sustainable Development Goals). As written, these laws, policies, and treaties should be stopping or significantly slowing habitat loss and degradation, but this depends on the assumption that these laws are implemented as written. That assumption is often not independently tested, and the continued loss of species and their habitats indicate there is a substantial implementation gap (López-Bao et al. 2015; Chapron 2017). If regulatory authorities lack the means to monitor and enforce habitat protections, conservation laws may be nothing more than paper tigers (Salomon et al. 2014), and there is little reason to think legal protections will change outcomes (Keane et al. 2008; Trouwborst et al. 2017).

In that context, the African wild dog (Lycaon pictus) is among endangered species facing a significant threat to its habitat due to human activities, particularly infrastructure development. The Nyerere National park, one of Africa's largest protected areas and a critical habitat for wild dogs, has been experiencing extensive habitat loss and fragmentation due to the construction of the Nyerere Dam within the Nyerere National park which has now posed a new and severe threat to their already declining habitat.

As the Nyerere Dam project progresses, large areas of the reserve have been cleared, disrupting the natural landscape and displacing wildlife populations, including wild dogs. Moreover, the influx of human activities associated with the dam construction, such as increased encroachment, and illegal logging, further exacerbates the challenges faced by the wild dogs. These human-induced threats not only directly affect the wild dog population but also disrupt the delicate balance of the ecosystem, impacting other flora and fauna within the reserve.

Understanding the extent and consequences of habitat loss for wild dogs due to infrastructure development is crucial for implementing effective conservation measures in Nyerere National park. The findings of this study will provide valuable insights into the impact of infrastructure development on African wild dog habitats, informing conservation strategies and management practices to safeguard the species' survival in Nyerere National park and beyond.

1.2 Statement of research problem

Nyerere National Park, a crucial habitat for the critically endangered African wild dog, is confronted with formidable challenges arising from human activities. Among these activities, the construction of the Stiegler’s Gorge Hydropower Dam Project stands as a significant concern, as it creates physical barriers in the form of reservoirs or canals that disrupt the natural landscape and hinder wildlife movement. The dam construction results in extensive deforestation, land conversion, and human settlement, all contributing to the fragmentation and isolation of wild dog habitats. Moreover, the influx of human activities associated with the construction, such as encroachment and unsustainable practices, poses additional threats to the survival of this critically endangered species.

This research aims to analyze the impact of the Stiegler’s Gorge Hydropower Dam Project and unsustainable practices on the habitat of African wild dogs in Nyerere National Park. By understanding the extent and consequences of these human-induced factors, this study seeks to provide valuable insights into developing sustainable conservation measures that can safeguard the future of the African wild dog population in the park.

Figure 1.1 The Construction Site at Stiegler's Gorge, in 2020 photo by achieve baldus.

1.3 Objectives of the study

1.3.1 Main objective

- To assess the impacts of infrastructure development on the habitat of African wild dogs in the Northern part of the park.

1.3.2 Specific objectives

- To map land cover and land use changes within Nyerere National Park using satellite imagery
- Apply change detection techniques to identify and quantify the spatial extent of human activities over time in the Norther park of the park.

1.4 Research questions

- How has land cover and land use changed within the Nyerere National Park over a specific time period, and what are the major drivers of these changes?
- To what extent has the construction of the Nyerere dam affected the wild dog habitat in Nyerere National Park?

1.5 Rationale of the study

The significance of this study lies in the urgent need to understand and address the habitat loss of African wild dogs as a result of infrastructure development in Nyerere National Park. The construction of the Stiegler's Gorge Hydropower Dam Project and unsustainable practices within the park have been identified as major factors leading to habitat degradation, loss, and reduced connectivity for these majestic creatures.

Furthermore, the integration of GIS and remote sensing techniques in this study allows for a comprehensive and spatially explicit assessment of the loss of wild dog habitats. By utilizing satellite imagery, classification algorithms, change detection methods, a deeper understanding of the interactions between human activities and the wild dog habitat can be achieved.

The findings of this study will not only enhance the scientific understanding of the threats faced by African wild dogs but will also provide valuable information for stakeholders, conservation organizations, and policymakers involved in the management of Nyerere National Park. Ultimately, the research aims to contribute to the formulation of effective conservation strategies and management plans that ensure the long-term survival of the critically endangered African wild dog population in Nyerere National Park.

1.6 Beneficiaries of the research.

i. Conservation Organizations

The research findings will provide valuable insights and information to conservation organizations involved in the preservation and protection of wildlife and natural habitats. The study's data and analysis can support evidence-based decision-making, enabling more effective conservation strategies and actions.

ii. Wildlife Managers and Park Authorities

The research outcomes will benefit wildlife managers and park authorities responsible for the management and protection of Nyerere National Park. The findings can inform the development of management plans, policies, and interventions to mitigate the negative impacts of human activities on African wild dog habitats.

iii. Researchers and Academia

The study contributes to the existing body of knowledge on wildlife conservation, GIS, and remote sensing. Researchers and academia can benefit from the research outcomes as a reference for future studies, expanding the understanding of human-wildlife interactions and conservation approaches.

iv. Policy Makers and Government Agencies

The findings of the study can inform policy makers and government agencies involved in environmental and wildlife protection. The research outcomes can contribute to the formulation of policies and regulations aimed at ensuring the long-term conservation and sustainable management of natural resources.

1.7 Scope and Limitations of the Research

The scope of this research encompasses the impact of human activities, specifically the construction of the Stiegler’s Gorge Hydropower Dam Project and unsustainable practices, on the habitat of the critically endangered African wild dog in Nyerere National Park. The study will focus on assessing the extent of habitat degradation, loss, and connectivity disruption caused by these factors. Remote sensing data and land cover classification techniques will be used to analyze changes in land cover classes, including vegetation, water bodies, built-up areas, and bare land, over a specific time period.

Despite the significance of this research, there are certain limitations that need to be acknowledged. Firstly, the availability and accuracy of remote sensing data might be subject to constraints, which could impact the precision of the land cover change analysis. Additionally, the study's time and resource constraints may limit the depth of analysis for certain aspects of the impact of human activities on the wild dog population. Also, given the complexity of ecosystem dynamics, other potential factors influencing the habitat loss and degradation of African wild dogs, such as disease outbreaks or climate change, might not be fully explored within this research.

Moreover, the scope of the research will focus primarily on the African wild dog population and may not comprehensively address the broader implications of habitat degradation on other wildlife species within Nyerere National Park.

1.8 Dissertation Structure

Chapter 1: Introduction - Presents background on Nyerere National Park and African wild dogs, stating the problem of habitat loss due to the construction of the Stiegler's Gorge Hydropower Dam, outlines objectives, and discusses the research's significance and scope.

Chapter 2: Literature Review - Reviews relevant studies on African wild dogs, habitat impacts, and land cover change methodologies to establish the research framework and identify gaps in the existing knowledge.

Chapter 3: Methodology - Describes data collection, Sentinel-2A image processing, and land cover classification and change detection methods used for analysis, ensuring robust and reliable results.

Chapter 4: Results and Analysis - Presents findings on land cover changes and the impact of dam construction on wild dog habitat, providing insights into the current state of the ecosystem.

Chapter 5: Conclusion and Recommendations - Summarizes key findings, draws conclusions, and provides conservation recommendations for preserving wild dog habitats, guiding future conservation efforts in the area.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

2.1 Taxonomy and Description of Wild Dogs

Fossil evidence has not definitively determined the origin of African wild dogs (Lycaon pictus). Identifying the oldest Lycaon fossils is challenging due to difficulties in distinguishing them from early Pleistocene wolf fossils, specifically Canis africanus (Creel and Creel, 2002). Previously, wild dogs were classified alongside dholes (Cuon alpinus) and bush dogs (Speothos venaticus) due to morphological similarities. However, these similarities are no longer considered indicative of a common ancestry, and African wild dogs are now believed to be closely related to the base of the wolf-like canids (Girman et al., 1993). Proposed subspecies of African wild dogs did not have distinct geographical boundaries, and analysis of samples from intermediate areas showed a mixture of southern and eastern haplotypes, suggesting a gradual transition rather than distinct subspecies (Girman and Wayne, 1997).

The African wild dog is the largest wild canid, typically weighing around 22 to 25 kg on average (Creel and Creel, 2002). It has long legs, large rounded ears, and displays a highly variable coat pattern. Their bodies are characterized by blotches of black, white, yellow, and grey, and they are distinguished by their distinctive color distribution. African wild dogs also have a bushy tail, which is often white-tipped (Stuart and Stuart, 1996).

2.2 Ecology and behavior of wild dogs

The African wild dog (Lycaon pictus) is an endangered large carnivore that presents unique conservation challenges. They have low population densities and require extensive ranges to remain viable. Despite the presence of suitable habitat and prey, wild dogs have disappeared from many areas they previously inhabited. Populations typically have densities of around 2.0 adults and yearlings per 100 km^2, with home ranges averaging 600-800 km^2 per pack in eastern Africa. The Nyerere National park, one of the largest nature reserves housing wild dogs, has an estimated 880 adult wild dogs within its 43,600 km^2 area.

African wild dogs are highly social animals that form packs of up to 40 members, although packs of up to 100 animals have been recorded in the past. The average pack size ranges from 7 to 15 members and consists of related females and males, with only the alpha female and alpha/beta males reproducing. Dispersal groups, usually comprising young animals in their second year, leave their natal packs to seek new territories and potential mates. These dispersal groups can travel long distances, complicating the interpretation of distribution data.

Cooperation is a key aspect of African wild dog behavior. They cooperate in hunting, primarily targeting medium-sized ungulates such as impala but also preying on smaller and larger animals. Packs also cooperate in breeding, with all members assisting in caring for the young. The social bonds within a pack contribute to the defense of kills from other carnivores. African wild dogs have lower population densities compared to sympatric large carnivores. They den in scattered locations during the wet season and typically spend about three months near the natal den after the birth of pups. While they face competition from other predators, such as hyenas, lions, and kleptoparasites, they have adapted to persist in certain habitats, such as deciduous woodlands, where competitive exclusion is reduced.

2.3 Wildlife conservation policies

The Ministry of Natural Resources and Tourism is charged with formulating a wildlife policy, overseeing its administration and coordinating the development of the wildlife sector in Tanzania. The main objective of the policy is to aim at involving a broader section of the society in wildlife conservation particularly the rural communities and the private sector and in order to achieve the objective, various strategies have been set including strategies for protecting biological diversity, protecting wildlife against illegal use, conserving and managing wildlife resources, integration wildlife conservation and rural development, generating foreign exchange from wildlife utilization, strategies for developing and regulating wildlife industry, and many others.

i. Wildlife Conservation Act

The Wildlife Conservation Act was passed in 2009 to improve the measures, for safeguarding, overseeing, preserving and responsibly utilizing wildlife and its products. It serves as Tanzania’s law for conserving wildlife. The goals of the Act include protecting and managing areas abundant in wildlife conserving wildlife resources and their habitats promoting the role of the wildlife sector in Tanzania's development expanding the system of protected areas for wildlife and encouraging community involvement, in wildlife conservation.

ii. National Parks Act.

The main objective of the National Parks Act is to ensure the management and preservation of wildlife, within parks. Its purpose is to establish a framework, for the creation, regulation and oversight of parks. Additionally, it establishes the Tanzania National Parks Authority (TANAPA) as an entity entrusted with the responsibility of administering and managing parks in Tanzania. The act has various regulations including laws that prescribe conditions under which members of the public may enter, travel through or reside in any national park, conditions under which animals or any species may be photographed in the national park, regulations that regulate or prohibit lighting of fires and cutting any vegetation whether alive or dead in the national park. There also regulations that guide any construction in the national park and regulations that prohibit the destruction of any object in the national parks, whether animate or inanimate.

2.4 Stiegler's gauge project

The Tanzanian government inaugurated the construction of the so-called Stiegler's Gorge dam, officially known as the Rufiji Hydropower Project. It is built on the Rufiji River in the Nyerere Natonal park, which has been a UNESCO World Heritage Site since 1982 and is one of the most iconic wildlife areas in Africa relatively undisturbed by human activity. According to the authorities, the hydroelectric structure will be 130 meters high and 700 meters wide, covering an area of 1,350 square kilometers and with the capacity to hold back 34 billion cubic meters of water. The project, estimated to boost the country's erratic electricity generation capacity by 2,115 megawatts. In May of 2018, an Environmental Impact Assessment (EIA) report was submitted. However, this document has limitations, as it focuses on only a few environmental effects while omitting significant ones. Experts have pointed out numerous errors, factual inaccuracies, and gaps within the document. Moreover, it inadequately addresses the extensive scale and intricacies of the project being considered. While the report acknowledges certain adverse environmental effects of the dam, the authors assert that these can be mitigated. They contend that the dam will not jeopardize the Reserve's Outstanding Universal Value. Additionally, they highlight potential positive effects on the ecosystem, such as increased biodiversity. However, external specialists criticize these assertions as lacking substantiation and raising serious doubts. This skepticism also extends to the suggested mitigation strategies, which are deemed poorly reasoned and insufficient.

Nyerere National Park being a home of approximately 1300 wild dogs, is now more exposed to poaching and this is due to the fact that the project has led to the improvement of transportation systems that increases access for poachers, but also because poaching could increase with a new population living inside the current reserve.

Figure 2.1 The ongoing Stiegler's Gorge project, in 2020(photo by achieve baldus).

2.5 GIS and Remote sensing in wildlife conservation

Geographic Information System (GIS) is a technology that integrates geographic data, with different kinds of information including attributes and characteristics. GIS has offered versatility and a wide range of applications in enhancing wildlife management and conservation such as wildlife tracking for movement and behavioral analysis, wildlife research, ecological monitoring, land cover change analysis and mapping conflict hotspots (Acharrya, 2017). Numerous studies have been conducted on land use and cover changes and the resulting impacts on human activities on wildlife. For example, in Bangladesh, satellite imagery has been used to monitor land cover changes as well as in Chunati and Fashiakali Wildlife Sanctuaries (Islamet al., 2016; Billah et al., 2021).

In Africa, GIS applications have been robust in conservation including one in Ethiopia where Landsat imagery was used for classification and monitoring of spatial-temporal patterns of land cover changes between 1977 and 2017 and the implications of these changes for elephant population, distribution and seasonal migration in Babile Elephant Sanctuary (Sintayehu & Kassaw, 2019). Remote sensing involves gathering information about objects, areas, or phenomena from a distance, typically using instruments like satellites, aircraft, drones, or ground-based sensors.

It is rare that scientists have extensive knowledge in ecology, management, and remote sensing, making collaboration between scientists and conservation groups crucial (Wiens et al., 2009). Effective remotely sensed monitoring programs contain elements of information, policy, and participation in order to improve communication between managers and scientists (Skidmore et al., 1998).

Remote sensing for wildlife conservation can be classified based on either direct approach or indirect approach (Chambers et al., 2009). The direct approach suggests direct observation of spatial features, objects or communities using satellites or air born sensors using high resolution spatial sensors and hyperspectral sensors (Turner et al., 2003). The indirect parameters are dependent on the environmental parameters such as land use, land cover, species composition etc., obtained from remotely sensed data as surrogate for precise measurement of the potential species verities and patterns (Collingwood et al., 2009). Satellite Remote Sensing offers information on vegetation type, forest cover, and their changes at global, regional, national, or micro level studies (Roy et al. 1987, Unni at al. 1985, Porwal and Pant, 1986). Remote Sensing plays an important role in forest management with reference to wildlife management, fire control, grazing land management, soil and water conservation, mapping of sites suitable for social forestry and afforestation programmes.

2.5.1 Image Classification

Image classification in remote sensing refers to the process of categorizing or grouping pixels within a remotely sensed image into distinct classes or categories based on their spectral characteristics. It involves analyzing the different wavelengths of electromagnetic radiation captured by sensors on satellites, aircraft, drones, or other platforms. The goal of image classification is to identify and map specific features, land cover types, or objects on the Earth's surface, allowing for a better understanding of the landscape and its changes over time. Image classification methods can range from manual interpretation to advanced automated techniques, including supervised and unsupervised classification, machine learning algorithms, and deep learning approaches.

2.5.2 Supervised Image Classification

Supervised image classification is an approach within remote sensing and geographic information systems where pixels within an image are grouped into predetermined classes or categories using reference training samples. This technique is extensively employed to analyze and interpret remotely obtained data, like satellite or airborne pictures, aiming to generate thematic maps illustrating diverse land cover kinds or characteristics found on the Earth's terrain.

Supervised image classification plays a crucial role in wildlife habitat analysis and conservation. By leveraging spectral information from remotely sensed data and using training samples, this approach offers valuable insights into habitat distribution, quality, and changes over time. Landcover, in particular, plays a prominent role in most regional-scale habitat studies. McClain and Porter (2000), for example, used TM-derived landcover maps to evaluate white-tailed deer habitat in the Adirondacks of New York. A second study by Nielsen et al. (2003) used resource selection functions to link grizzly bear location data to a landcover map covering over 10 000 km^2 in the foothills of Alberta, Canada.

2.5.3 Classification Algorithms

Classification algorithms are computational techniques employed to group pixels in an image into diverse land cover categories by considering their spectral attributes. These algorithms have a crucial role in analyzing remotely captured data and producing maps that offer understanding about the Earth's terrain.

i. Random Forest

The Random Forest classification algorithm is a powerful and versatile machine learning technique used in remote sensing and image analysis, for categorizing data into different classes or categories. It is an ensemble learning method that combines multiple decision trees to make accurate predictions and classifications. Random Forest is particularly effective for tasks involving complex and high-dimensional data, making it a popular choice for remote sensing applications.

Random Forest is based on the concept of ensemble learning, where multiple decision trees are combined to produce a more robust and accurate final result. Each individual decision tree in the ensemble is built using a subset of the training data and a subset of the available features.

Decision trees are hierarchical structures that recursively split data based on different attribute values. They consist of nodes, branches, and leaves, where nodes represent decisions or tests on features, branches represent the outcomes of decisions, and leaves represent class labels. This classification algorithm employs a technique called bootstrapping to create multiple training datasets by sampling with replacement from the original training data. For each decision tree, a random subset of the available features is selected, reducing the likelihood of overfitting where the model learns noise from the training data.

Classification in Random Forest is based on the majority vote from the individual decision trees. For a given input or pixel in remote sensing, the algorithm passes it through each tree, and each tree votes for a specific class. The class with the most votes becomes the final prediction for the input. Random Forest is resistant to overfitting, and this is due to the random selection of features and the aggregation of multiple decision trees. It handles noisy and missing data well and is robust to outliers. Random forest can handle high-dimensional data and capture complex relationships within the data.

Other classification algorithms

ii. Support Vector Machine (SVM)
iii. logistic regression
iv. K-Nearest Neighbors

2.6 Change detection

Change detection in the context of remote sensing refers to the process of identifying and quantifying changes that occur in the Earth's surface over time using satellite or aerial imagery. It is a valuable tool for monitoring and analyzing land cover dynamics, urban expansion, deforestation, and other environmental changes. Change detection techniques involve comparing multiple images acquired at different time points and identifying areas where alterations in land cover have occurred.

2.6.1 change detection techniques

A variety of algorithms have been developed to detect changes between satellite images (Willis 2015), the change detection techniques have been used in remote sensing to identify the changes in geographical location, recognizing, classifying and quantifying the type of changes and finally assessing the accuracy through change detection statistics. Change information obtained here is simple binary differencing i.e. changes vs. no change. Different approaches have been adopted for change detection depending on its application.

i. Algebra based change detection approach
ii. Transform based change detection
iii. Classification based change detection
iv. Advanced model technique

2.6.2 Image Differencing

Image differencing is an Algebra based change detection approach which involves subtracting the DN (Digital Number) value of one data with the other one of the same pixel for the same band which results in new image. Mathematically, image differencing can be represented as follows

$$I_d(x, y) = I1(x, y) - I2(x, y) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \, equation \ (i)$$

Where I1 and I2 represents images taken from two different time periods and (x, y) are coordinates and I_d represents difference image. Both data are taken from same month in order to have a better change detection results under same climatic condition.

2.7 Modelling and prediction

The prediction of land cover is based on the analysis of historical land cover data and its relationship with driving factors such as climate variables, terrain characteristics, and human activities (Anbazhagan et al., 2011). Statistical models Markov chain models, may be used to identify the relationships and patterns between these variables (Jensen, 2005). Once the predictive model is trained and validated using historical data, it can be applied to future scenarios by incorporating projections of climate change, land use policies, or socioeconomic factors. These projections allow for the estimation of future land cover patterns and changes, providing valuable information for wildlife conservation planning, and decision-making processes. Generally, the prediction of land cover involves the use of remote sensing data, ancillary data, and predictive modeling techniques to forecast future land cover patterns and changes.

CHAPTER THREE

METHODOLOGY

3.1 Overview

The methodology chapter provides a concise overview of the research workflow, covering image data collection, land cover classification, change detection, and prediction. Satellite imagery is acquired as the primary data source, and land cover classification techniques are applied to categorize the study area into various land cover classes. Change detection analysis is conducted to identify and quantify land cover changes over time, enabling a thorough examination of habitat loss and fragmentation for the African wild dog population.

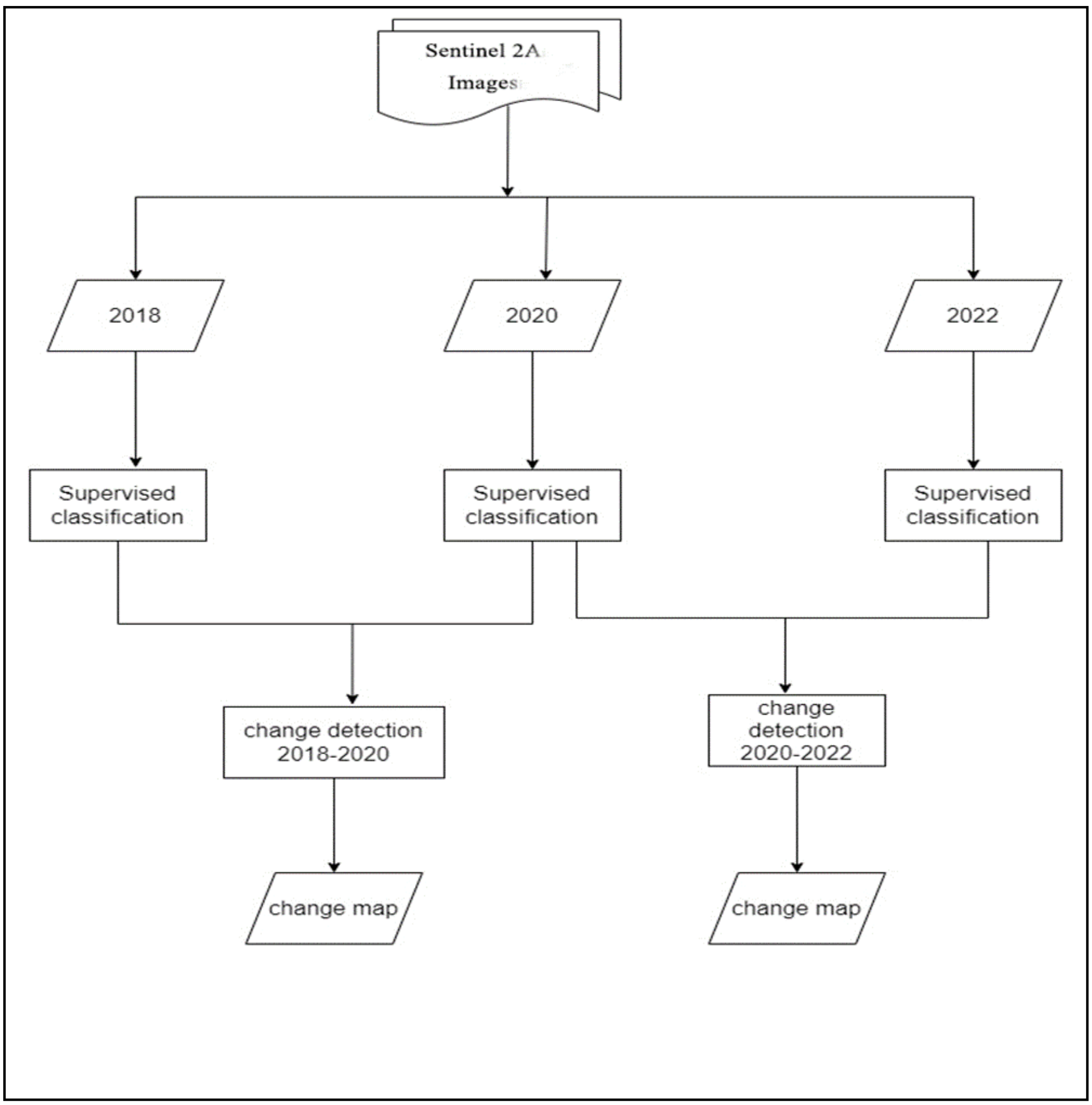

Figure 3.1 Workflow

3.2 Description of the study area

The Nyerere National Park (formerly Selous Game Reserve) lies in central south-eastern Tanzania between 130 and 500 km southwest of Dar-es-Salaam at 7° 20' to 10° 30'S, and 36° 00' to 38° 40'E, it has unique ecological significance and relatively undisturbed environment up until the construction of the Stiegler’s Gorge Hydropower Dam built on the Rufiji River within the park's boundaries from 2018 which now serves as a critical contributing factor to the study area's changing landscape and loss of habitat for the African wild dogs in Nyerere National Park. Covering nearly 50,000 square kilometers, the park is a vital sanctuary, containing a third of Tanzania's wildlife estate and supporting abundant populations of diverse wildlife, including elephants, buffaloes, giraffes, and crocodiles.

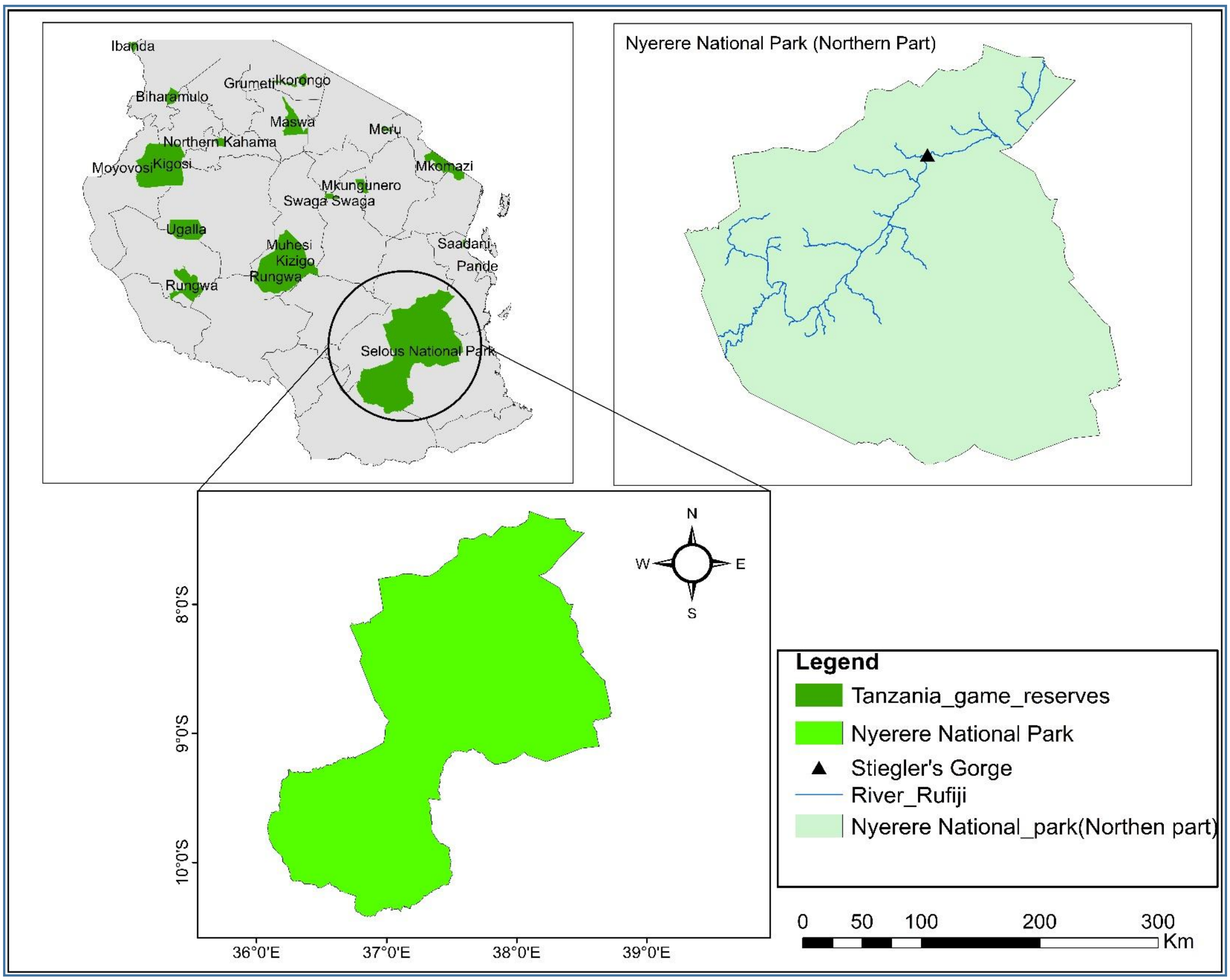

Figure 3.2 Location of the study area

Located in the northern part of the park, one of the most remarkable features of Nyerere National Park (formerly Selous Game Reserve) is the presence of critically endangered African wild dogs. This unique and concentrated population of wild dogs makes the park an ideal location to investigate the impact of the Stiegler's Gorge Hydropower Dam project on their habitat. The northern region of the park is characterized by favorable factors for the wild dogs' survival, including the meandering Rufiji River that provides a reliable water source and supports various riparian habitats. The elevation in this area varies from 30m in the northeast to 830m in the southwest, encompassing a diverse range of terrains that offer ample opportunities for the wild dogs' hunting and territorial activities.

Moreover, the vegetation zones, consisting of lush forests, dense thickets, and open grasslands, provide an abundant variety of habitats for the wild dogs' prey species, making it an ecologically rich and vital region for their survival. Studying this specific area is crucial to understanding the intricate interactions between the wild dogs, their prey, and the changing landscape due to the dam's construction, guiding effective conservation measures to preserve the delicate balance of this unique ecosystem in Nyerere National Park.

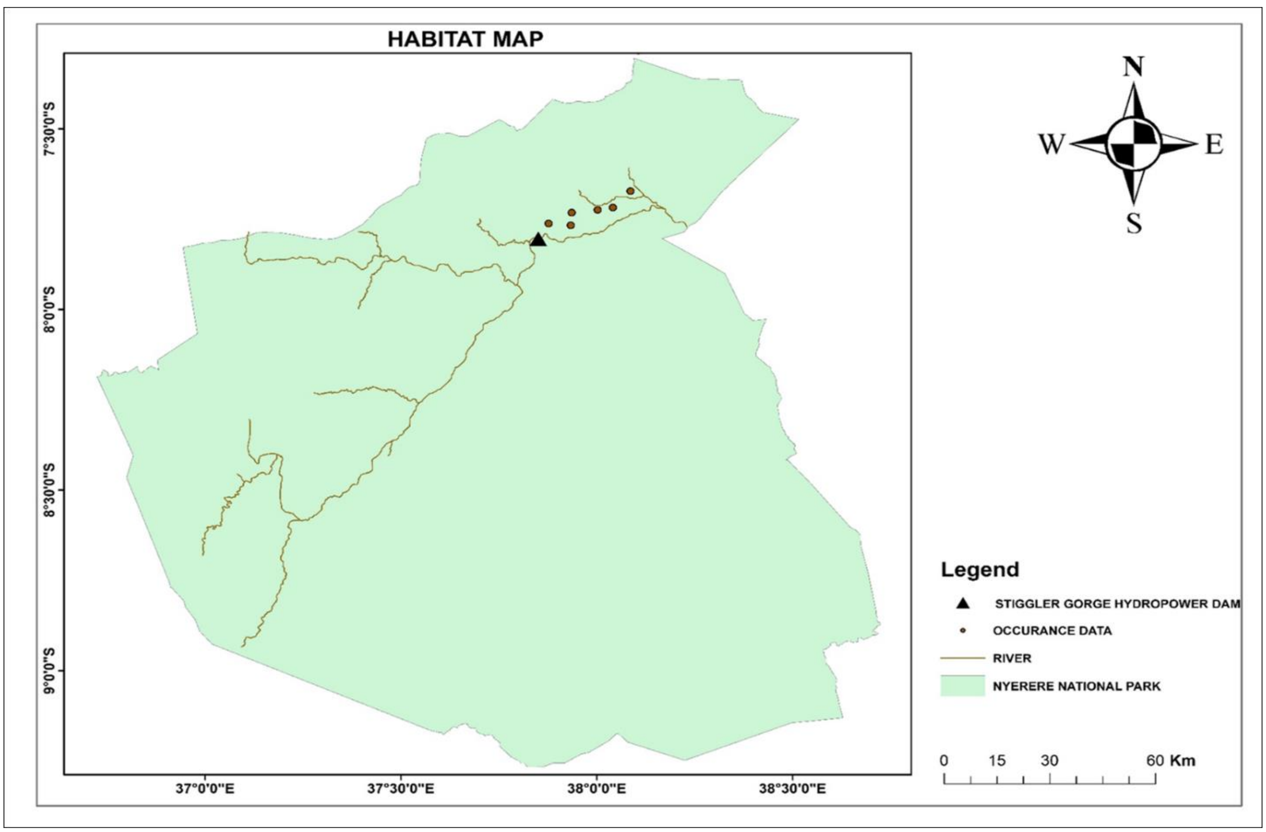

Figure 3.3 Habitat map of African wild dogs in Nyerere National park

3.3 Data collection and description

The data used for this research consisted of Sentinel-2A satellite images captured in the years 2010, 2016, and 2022. These Sentinel-2A images provided valuable information for analyzing land cover changes and monitoring the habitat of the critically endangered African wild dogs in Nyerere National Park. Additionally, data from the World Database on Protected Areas (WDPA) were utilized to gather information on protected areas within the park.

Table 3.1 Summary of data collection and their sources

NAME	SOURCE	USES
Sentinel 2A	Google Earth Engine www. earthengine.com	For analyzing land cover changes and monitoring the habitat of African Wild dogs
Protected Area(Game reserve)	WDPA	Defining the limits and Spatial extents of the national park
Occurrence data	Global biodiversity information facility (GBIF) https://www.gbif.org	Show location of African wild dogs in the park

3.5 image pre processing

3.5.1 Radiometric calibration

Perform radiometric calibration to ensure consistency and accuracy in the spectral values of the imagery. This step involves converting the raw digital numbers (DN) to at-sensor radiance values or reflectance values using the provided calibration parameters. This calibration accounts for atmospheric effects and allows for meaningful analysis.

3.5.2 Atmospheric correction

Atmospheric correction was done to remove atmospheric effects such as haze, scattering, and absorption, improving the accuracy of subsequent analysis. atmospheric correction for Sentinel 2A imagery was conducted using the Sen2Cor plugin in QGIS. This involved installing the plugin, importing the satellite imagery, configuring the parameters, running the atmospheric correction process, reviewing the corrected images within QGIS, and exporting them if needed. By applying the Sen2Cor plugin, the atmospheric effects were effectively mitigated, resulting in improved accuracy and reliability of the imagery. This allowed for more precise analysis and interpretation of land cover and vegetation, contributing to a comprehensive understanding of the study area.

3.6 Image Processing

i. **classification system selection**

Anderson's level I classification system was employed, which organized the classes into 4 major groups: Bare land, Built-up areas, Vegetation and water. This classification system was chosen due to the diverse characteristics observed in the region of interest.

ii. **Training samples**

I perform training sample by Identify multiple training samples within each land cover class by creating additional polygons. This helped the classification algorithm to understand the spectral patterns and characteristics of each class.

iii. **Supervised classification**

Supervised image classification was conducted by considering the distinct separability of the land cover classes. Features that exhibited high separability were selected as inputs for the classification algorithm, specifically the maximum likelihood classification method. This approach aimed to enhance the classification accuracy by avoiding data redundancy and focusing on the most informative features. The resulting classification process generated land cover maps for the years 2018, 2020, and 2022.

iv. **Land Cover Change**

In order to examine the dynamics of land cover over time, the classified land cover maps were analyzed using the MOLUSCE plugin within QuantumGIS. This analysis aimed to assess the relationships between different land cover classes and detect changes occurring between consecutive years. The focus was on identifying areas where land cover experienced alterations, whether in terms of decrease or increase, and documenting the transitions that took place between different land cover classes. This comprehensive approach provided valuable insights into the patterns and trends of land cover change within the study area.

CHAPTER 4

RESULTS, ANALYISIS AND DISCUSSION

4. 1 Overview

All results obtained from data processing are presented and described in this chapter in form of maps, graphs and tables representing the variables and their relationship to the output.

4.2 Land cover map

The land cover classification analysis generated land cover maps for the Nyerere National Park for the years 2018, 2020, and 2022. These maps provide valuable insights into the distribution and extent of different four land cover classes which are Vegetation, Bare land, built up and Water within the reserve.

4.2.1The land cover map for 2018

Reveals a diverse landscape within the Nyerere National Park. The dominant land cover class is vegetation, which includes forests, shrub lands, and grasslands. These areas are crucial habitats for a variety of wildlife species, including the African wild dogs. The map also indicates the presence of water bodies, such as rivers and wetlands, which play a vital role in supporting the ecological balance of the reserve. Additionally, built-up areas are observed, representing human settlements and infrastructure within the reserve, while bare land areas signify areas with limited vegetation cover.

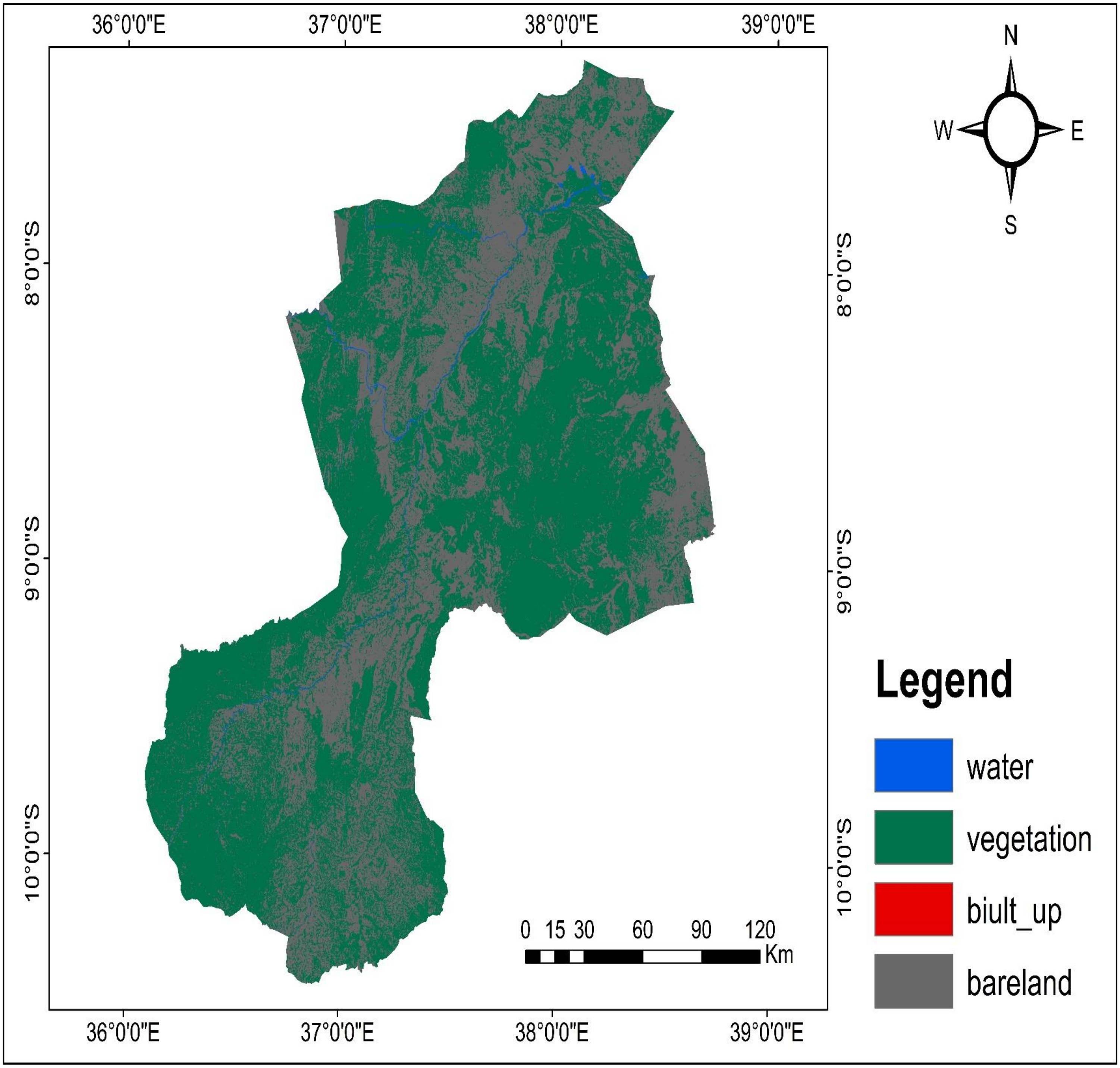

Figure4.1 Land cover map of 2018

4.2.2 The land cover map 2020

Figure 4.2 shows notable changes in land cover patterns. The expansion of built-up areas is evident, indicating human encroachment and urbanization within the reserve. This encroachment poses a significant threat to the natural habitats of African wild dogs and other wildlife species, leading to habitat loss and fragmentation. The increase in built-up areas also highlights the potential for increased human-wildlife conflicts and the need for effective conservation strategies to mitigate these conflicts.

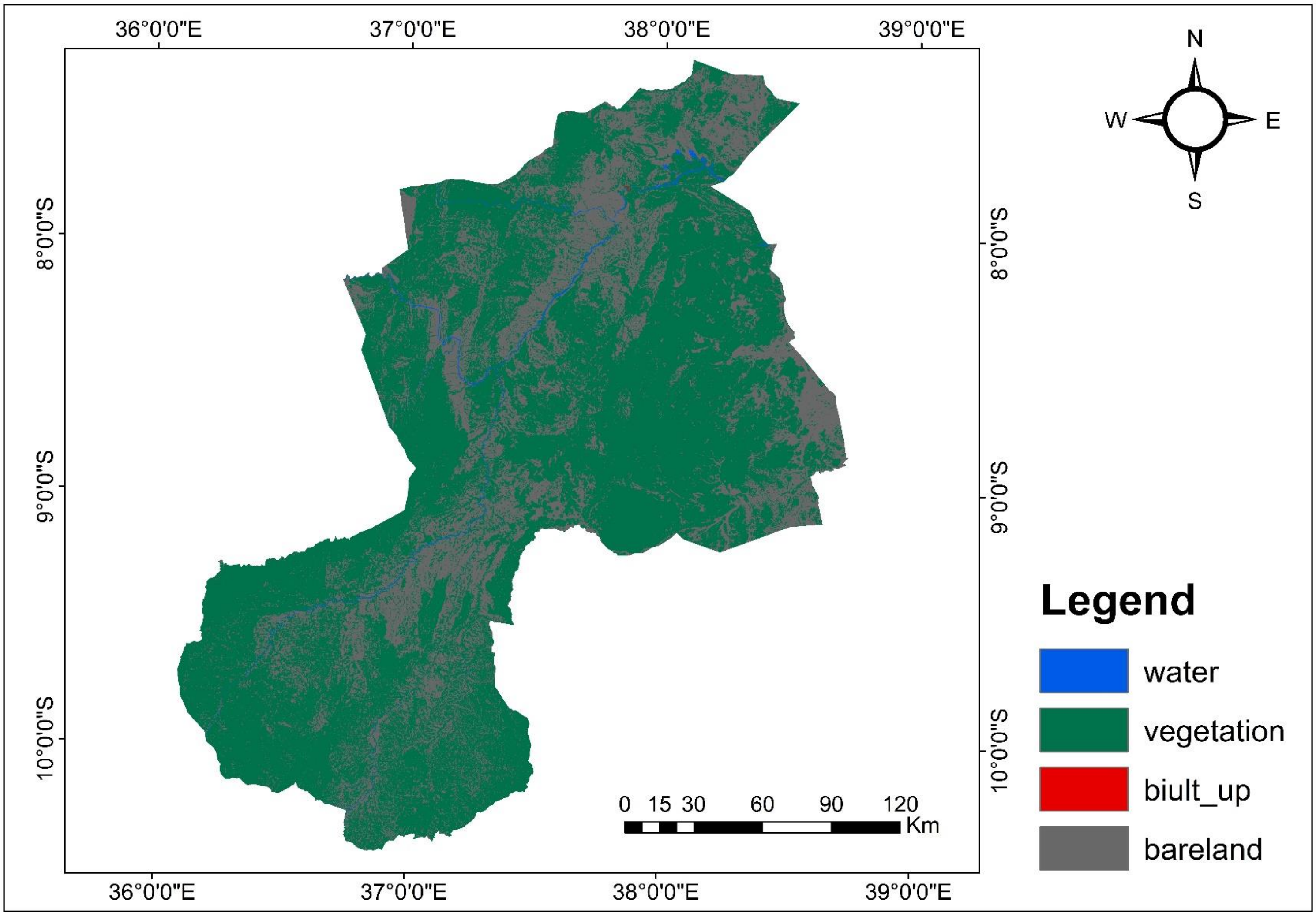

Figure 4.2 Land cover map of 2020

4.2.3The land cover map for 2022

Figure 4.3 provides a more recent snapshot of the land cover dynamics within the Nyerere National Park. Continued urbanization and infrastructure development are observed, further reducing the available habitat for African wild dogs. The loss of vegetation cover, particularly in forested areas, is concerning as it directly impacts the prey base for the wild dogs. The expansion of bare land areas suggests the degradation of previously vegetated areas, which can have detrimental effects on the overall ecosystem health.

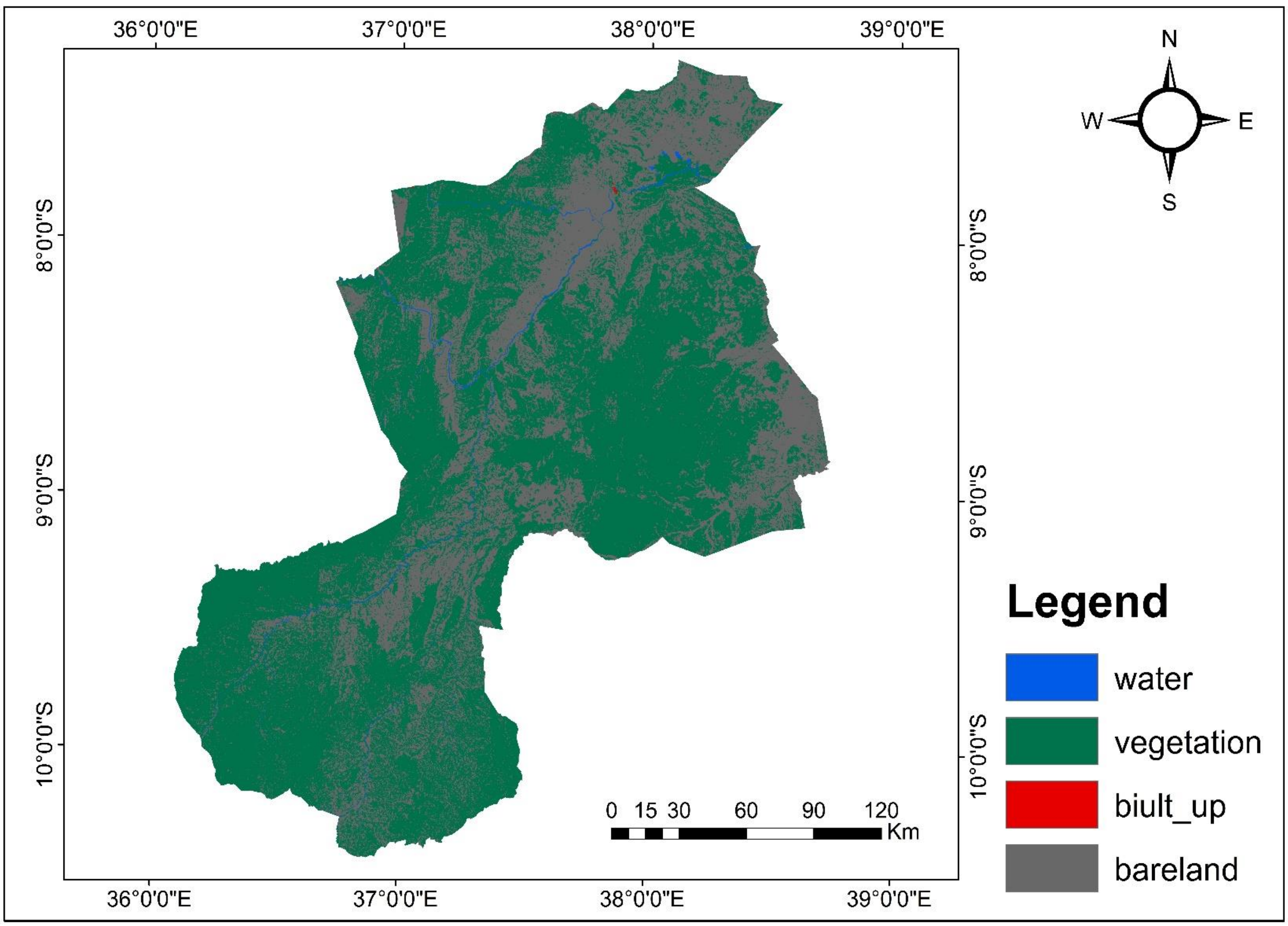

Figure 4.3 Land cover map of 2022

4.3 Change detection

The changes found between land cover map of different years are shown, where, the places containing the classes indicated in land cover map changed with time from one another meaning that, some areas with vegetation cover changed to bare land and built up and some places covered with bare land were changed and became covered water and built up same applies to areas covered with water. The change in area for classes between years are tabulated in the table 1 and table 2 for changes from year 2018 to 2022

Table 4.1Land Cover Area Changes from 2018 to 2020

Class	2018 Area (sq. m)	2020 Area (sq. m)	Area Change (sq. m)	2018 %	2020 %	Δ %
Water	7,583,200	10,041,600	2,458,400	0.39	0.52	0.13
Vegetation	1,713,283,500	1,704,952,800	-8,330,700	89.15	88.72	-0.43
Bare Land	200,946,100	206,818,400	5,872,300	10.46	10.76	0.31
Built-Up	N/A	85,000	N/A	N/A	0.00	N/A

Table 4.2 Land Cover Area Changes from 2020 to 2022

Class	2020 Area (sq. m)	2022 Area (sq. m)	Area Change (sq. m)	2020 %	2022 %	Δ %
Water	10,041,600	12,566,000	2,524,400	0.52	0.66	0.14
Vegetation	1,704,952,800	1,685,400,900	- 19,551,900	88.72	87.98	-0.74
Bare Land	206,818,400	210,974,700	4,156,300	10.76	11.03	0.27
Built-Up	85,000	128,500	43,500	0.00	0.02	0.02

The land cover change analysis revealed significant changes in the Nyerere National Park between the years 2018, 2020, and 2022. In Table 1, we can observe the changes that occurred from 2018 to 2020. The area covered by water increased by 2,458,400 square meters, indicating the expansion of water bodies within the reserve. On the other hand, the vegetation cover experienced a slight decrease of 8,330,700 square meters, which could be attributed to factors such as deforestation or natural disturbances. The bare land area showed an increase of 5,872,300 square meters, potentially due to land clearing activities. Additionally, a new class called "Built-Up" emerged in 2020, with an initial area of 85,000 square meters, signifying human encroachment and infrastructure development within the reserve.

Table 2 presents the changes between 2020 and 2022. The water area continued to expand, with an additional 2,524,400 square meters, suggesting further growth in water bodies. The vegetation cover experienced a larger decline of 19,551,900 square meters, indicating significant changes in the vegetation composition and potentially highlighting ongoing threats to the ecosystem. The bare land area increased by 4,156,

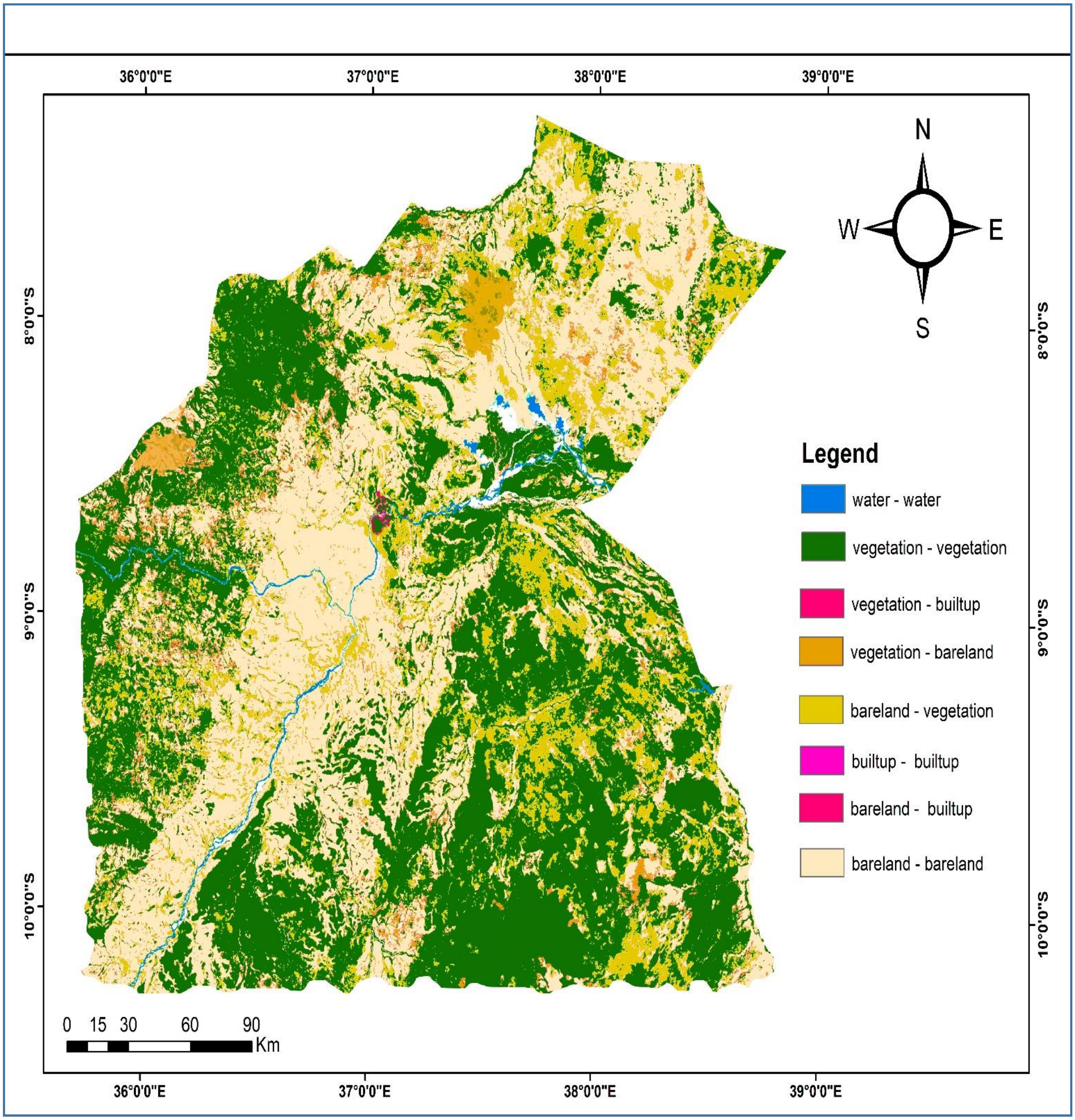

Figure 4.4 (2018-2020) Change detection Map

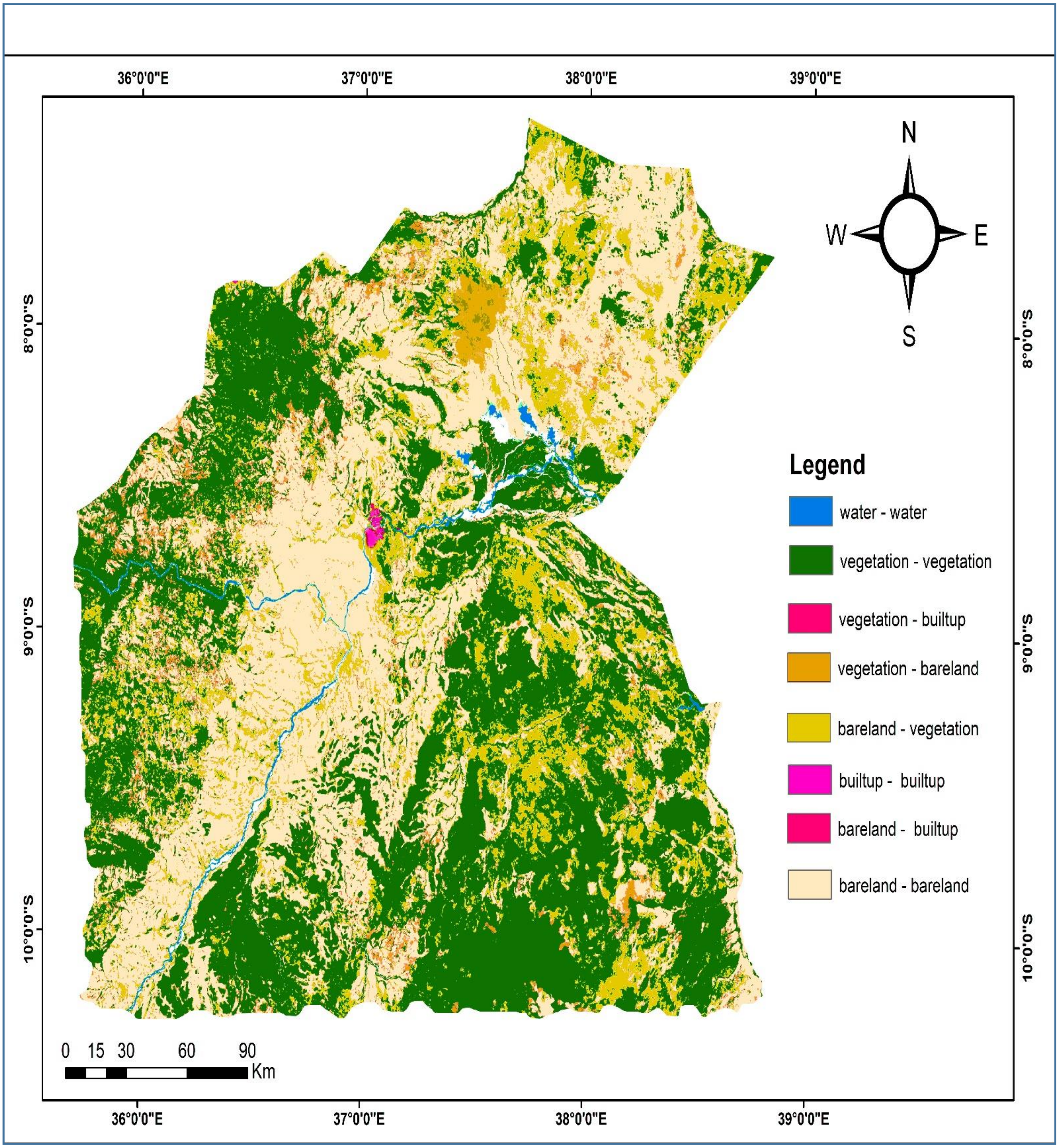

Figure 4.4 (2020-2022) Change Detection Map

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1Conclusion

In conclusion, the Nyerere National Park is facing significant challenges in terms of human activities and their impacts on wild dog habitat. The construction of the Stiegler's Gorge Dam, habitat fragmentation caused by road development, and the potential introduction of invasive species are all posing threats to the survival and well-being of African wild dogs in the reserve. These activities have the potential to disrupt their natural habitats, reduce their prey base, and increase the risk of poaching.

It is evident that the dam construction project has the potential to significantly affect the habitat of African wild dogs. The inundation of large areas of land, alteration of river flow patterns, and changes in vegetation cover can disrupt their movement patterns, hunting behavior, and breeding dynamics. The loss of suitable habitat and reduced prey availability may lead to the decline of the wild dog population in the Nyerere National Park.

5.2 Recommendations

- **Collaborative Research and Data Sharing**:

Collaboration between research institutions, conservation organizations, and government agencies is crucial for a comprehensive understanding of African wild dogs' habitat and effective conservation strategies. Encouraging data sharing and cooperation among stakeholders can lead to a more holistic approach to conservation. Sharing research findings, data sets, and best practices can enhance knowledge exchange and foster innovative solutions for the challenges faced by wild dogs in the Nyerere National Park. Collaboration also helps avoid duplication of efforts and maximizes the impact of limited resources.

- **Climate Change Adaptation**:

Climate change poses significant challenges to the conservation of African wild dog habitat. It is crucial to integrate climate change adaptation strategies into habitat conservation planning. This includes identifying areas that may serve as refugee for wild dogs under changing climatic conditions and ensuring their connectivity. Implementing adaptive management approaches that allow for flexible and dynamic conservation strategies can help mitigate the impacts of climate change on wild dog populations.

- **Long-term Monitoring and Evaluation**:

Continuous monitoring and evaluation of conservation efforts are essential to assess the effectiveness of implemented measures and adapt strategies as needed. Long-term monitoring programs should be established to track changes in wild dog populations, habitat quality, and threats over time. Regular evaluations can identify successes and challenges, allowing for adjustments and improvements in conservation strategies. Long-term commitment to monitoring and evaluation ensures that conservation actions remain adaptive and responsive to changing conditions.

- **Capacity Building**:

Strengthening the capacity of local communities, conservation organizations, and government agencies involved in wild dog conservation is vital for long-term success. Capacity-building initiatives can include training programs on habitat monitoring techniques, data analysis, conservation planning, and sustainable land management practices. Empowering local stakeholders with the necessary skills and knowledge creates a network of conservation champions who can actively contribute to the preservation of wild dog habitat.

- **Policy Support and Advocacy**:

Advocacy for policies that prioritize habitat conservation and protection is crucial. Engaging with policymakers, government agencies, and influential stakeholders can help shape conservation-friendly policies and regulations. This includes advocating for the inclusion of wild dog habitat conservation in land-use planning, environmental impact assessments, and development projects. Collaborating with local and international advocacy groups can amplify the voice for wild dog conservation and ensure that their habitat receives the necessary legal protection.

- **Public Engagement and Ecotourism**:

Engaging the public in wild dog conservation efforts is essential for generating support and raising funds for habitat conservation initiatives. Promoting ecotourism activities that offer opportunities to observe and appreciate wild dogs in their natural habitat can provide economic incentives for local communities to actively participate in their conservation. Educational programs, interpretive centers, and guided tours can help visitors understand the ecological significance of wild dogs and inspire them to become advocates for their conservation.

- **Adaptive Management Approach**:

Adopting an adaptive management approach allows for continuous learning and adjustment of conservation strategies based on feedback and new information. Monitoring the outcomes of conservation interventions and integrating that knowledge into future decision-making ensures that efforts are effective and efficient. Flexibility and openness to innovative approaches and emerging technologies enable adaptive management, leading to improved habitat conservation outcomes for African wild dogs.

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