TÍTULO

ASSESSING NATURAL REGENERATION OF PTEROCARPUS ERINACEUS IN KIANG WEST NATIONAL PARK, THE GAMBIA

AUTOR

Omar Sanneh

Esta edición electrónica ha sido realizada en 2023

Tutor	Dr. Alagie Bah
Instituciones	Universidad Internacional de Andalucía
Curso	*Máster CITES (2021-2022)*
©	Omar Sanneh
©	De esta edición: Universidad Internacional de Andalucía
Fecha documento	2023

INTERNATIONAL UNIVERSITY OF ANDALUCIA, BAEZA, SPAIN

MASTER'S DEGREE PROGRAM ON THE MANAGEMENT AND CONSERVATION OF SPECIES IN TRADE: The International Framework (14th edition) 2021-2022

MASTER'S THESIS SUBMISSION

On

Assessing Natural Regeneration of *Pterocarpus erinaceus* in Kiang West National Park, The Gambia

Submitted by
OMAR SANNEH

Supervisor
Dr. ALAGIE BAH
Associate Researcher, World Agroforestry, Senior Lecture University of The Gambia

March 2023

Table of Contents

LIST OF ACRONYMS

ANR	Assisted Natural Regeneration (ANR)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPA	Community Protected Area
DPWM	Department of Parks and Wildlife Management
EbA	Ecosystem-based Adaptation Project
FAO	Food and Agrculture Organization
FGD	Focus Group Discussion
KWNP	Kiang West National Park
SPSS	Statistical Package for Social Sciences
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
WABiLED	West African Biodiversity and Low Emission Development

ABSTRACT

Forests are a vital component of the earth's ecosystem, providing wide range of essential ecosystem goods and services that contribute to livelihoods, climate protection and biodiversity conservation. Over the past couple of decades, The Gambia has experienced drastic degradation of its forest cover, mainly due to illegal logging, wildfires, drought, overgrazing, and the spread of competitive species. *Pterocarpus erinaceus* is under severe threat due to illegal and unsustainable logging, leading to current suspension of its trade from The Gambia by CITES. In 2019, the Ecosystem-based Adaptation (EbA) project implemented Assisted Natural Regeneration (ANR) in a 900-ha area in Kiang West National Park (KWNP) as a low-cost alternative to natural forest regeneration. This study aims to determine the impact of ANR on stands of *Pterocarpus erinaceus* in KWNP. Vegetation data measurements showing growth of mother tree and wildlings were conducted in four subplots at the EbA project ANR implementation areas. Focus Group Discussion (FGD) was conducted with staff of KWNP and the management committees of communities adjacent to the park. The findings of the study revealed that on average *Pterocarpus erinaceus* tree density in the ANR plots increased by 100% from 36 trees/ha in 2019 to 72/ha in 2023. In contrast, wildlings density in ANR plots decreased by 44% from 64 trees/ha to 36 tree/ha. The findings also identified fire, overgrazing, illegal logging, termite infestation and drought as the main drivers of degradation in the park. The noticeable increment in the population of *Pterocarpus erinaceus* trees in the study plots implies the effectiveness of ANR as a low-cost landscape restoration strategy being implemented by the EbA project.

Keywords: CITES; *Pterocarpus erinaceus*; KWNP; ANR, Mother trees; Wildlings; Forest; Climate change;

DEDICATION

This work is specifically dedicated to my Mother Naba Kanyi and Father Imam Afang Sainey Sanneh for their prayers and roles as parents. It is also dedicated to my two sons and the entire family of Sanneh Kunda.

ACKNOWLEDGEMENT

All thanks and praise be to Allah, by Who's power this piece of work became a reality against all obstacles.

I would like to give special gratitude and sincere appreciation to the sponsor- United State Agency for International Development (USAID) through West African Biodiversity and Low Emission Development (WABiLED) for financing this CITES master's degree. I would like to thank the International University of Andalucía and lecturers particularly Dr. Margaritta Africa Clemente and Dr. Mercedes Munez for their support and guidance throughout the course.

Special thanks and appreciation also go the entire team of WABiLED for their invaluable support and guidance from the admission stage to this level. Thank you, team, WABiLED

To my able supervisor Dr. Alagie Bah, words are not enough to register my profound gratitude and sincere appreciation for your time and unconditional support all through the journey, without your invaluable support and guidance this work will not be completed. Together with Naffie Gaye – my Research Assistant; your contributions toward the success of this work are highly appreciated, thank you Dr. Bah and Naffie Gaye.

I would also like to express my gratitude to Dr. Abdul Aziz - WABiLED consultant, Madam Alima Koita WABiLED thesis coordinator and Madam Shelly Brend - Born Free for their reviews and input respectively.

Special thanks go to the Management and entire staff of the Department of Parks and Wildlife Management for the confidence to nominate me for the master's program and also for providing me the time and space to undertake this course.

Finally, huge thanks go to my wife Madam Hawa Sillah Sanneh for her moral support and understanding encouragement throughout the course of the program.

CHAPTER 1: INTRODUCTION

1.1 Background and Context

The Gambia is a small Sahelian country, bordered by Senegal and extending to the Western Coast of Africa between 13° and 15° N. It covers a total land area of approximately 10,689 km^2 with a length of about 400 km and a width varying between 24 - 50 km. According to the 2013 National Population and housing census, The Gambia's population is estimated at 1.9 million people with a population growth rate of 3.3% per annum (Gambia Bureau of Statistics (GBOS) and ICF International, 2014).

The Banjul declaration signed by the then president D. K Jawara in 1977 is a clear statement of acknowledgement by the government on the gravity of the situation with regard to wild species of fauna and flora in The Gambia. This declaration stated: "it is a sobering reflection, that, in a relatively short period of our history, most of our larger wildlife species have disappeared together with much of the original forest cover".

Land degradation is the biggest threat to forests worldwide. According to IUCN (2021), over half of the tropical forests worldwide have been destroyed since the 1960s, and a considerable amount of tropical forest hectarage is destroyed or drastically degraded. Land degradation affects humans in multiple ways, including social, political, cultural, and economic aspects. In The Gambia, land degradation is seriously affecting several sectors particularly agriculture, environment and health. It has aggravated the impact of climate change in the area of windstorms, heavy rainfall and flooding, among others. In fact, in July 2021, a heavy windstorm hit the entire country, with severe repercussions in North Bank Region (causing loss of lives and properties) because of the high level of deforestation in the region. The impact is so severe that some families have still not recovered.

The degradation and loss of forests are threatening the survival of many species and reduces the ability of forests to provide essential ecosystem services such as clean air and water, healthy soils for agriculture and climate regulation. According to Palo and Lehto (2003), tropical deforestation in Africa was estimated by FAO (1993, 2001) to have resulted in the loss of four to five million hectares annually during the 1980's and 1990's. The primary causes of forest degradation in Africa

are unsustainable exploitation (in the form of excessive harvesting of forest products), overgrazing, wildfires, and the spread of invasive species or pests (Asner et al., 2006; Asner et al., 2008; Murdiyarso et al., 2008; Hosonuma et al., 2012; Kissinger et al., 2012).

Land conversion and degradation in the Sahel have emerged as a primary concern, with more than two billion hectares of land degraded. The process leading to land conversion is sometimes because of multiple economic, social, cultural, and political issues (Maisharou et al., 2015). These have seriously affected the ecological equilibrium, resulting in natural resource degradation, and hence a decline in agricultural production. The Sahel region is largely dependent on agriculture as the main economic activity, with about 80-90% of the population actively engaged in agriculture (Doso, 2014). Land degradation is however a major environmental issue affecting the region, with negative consequences on agriculture.

The National Forestry Assessment report (2008-2010) indicated that The Gambia's natural forests are under increased pressure due to increasing rural population growth and subsistence farming. The Gambia lost about 97,400 ha of forest between 1997 and 2009. This is close to 8000 ha of forest lost every year. Bush fires, drought and illegal logging are major threats to forests. In The Gambia, the Ecosystem-based Adaptation Project (EbA) is spearheading efforts to restore degraded ecosystems through assisted natural regeneration to help contribute to build climate-resilient natural resource base in Community Protected Areas (CPAs) across four regions of The Gambia. The study was conducted at Kiang West National Park (KWNP) in Mansakonko Adminiative area, Lower River region.

According Winrock (1999), *Pterocarpus erinaceus* is an important legume species within its habitat: the species fixes atmospheric nitrogen through a symbiotic relationship with Rhizobium soil bacteria. The species is one of the main components within its wooded savannah habitat (Orwa, 2009) and can survive annual bush fires (Aubreville, 1950). The species is listed on CITES Appendix II, with the aim of protecting this important keystone species from unsustainable international trade.

Pterocarpus erinaceus is an important traditional source of animal leaf-fodder to pastoralist communities in West Africa, who lop wild trees to feed their livestock during the dry season.

Increasingly, this fodder is brought to urban and semi-urban markets for sale. Supply falls far short of demand, leading to increasing rarity of the species near to urban centres (Winrock, 1999). The species is also an important source of firewood and charcoal. The gum/resin of the species is blood-red in colour and is used in dyeing cotton. The species is an important source of traditional medicine: the leaves are used in abortifacient mixtures and as a febrifuge. Bark is used for ringworm of scalp, dressing for chronic ulcers, blennorrhagia and in a gargle for tooth and mouth troubles. Bark and resin used for urethral discharge and as an astringent for severe diarrhea and dysentery. The grated root is mixed with tobacco and smoked in a pipe as a cough remedy (Orwa, 2009). Timber of *Pterocarpus erinaceus* is extremely hard-wearing and has a beautiful colour; as a result, it has traditionally been used for production of local furniture, artisanal crafts, and traditional musical instruments such as xylophones (Winrock, 1999).

Kiang West National Park (KWNP) is the first and one of the biggest community protected areas in the country, covering an area of 23,621 hectares. It shares a boundary on one end with River Gambia, which is very rich in aquatic species such as fish, mammals, and reptiles (KWNPMP, 2012). KWNP has inadequate staff with limited infrastructures that are dilapidated, these conditions undermined the management system of the Park which led to the loss of ecosystem and biodiversity. Restoration of the ecosystem can help to enhance the original vegetative cover of the park, through adoption of effective and efficient management systems in the national reserve, to secure the biodiversity of the area (KWNPMP, 2012).

Assisted Natural Regeneration (ANR) is a blend of active planting and passive restoration, where local people intervene to help trees and native vegetation naturally recover by eliminating barriers and threats to their growth, leaning on their knowledge of the land and on ancestral traditions. In The Gambia, ANR is perceived to be a new concept. The ecosystem-based adaptation (EbA) project is the first to introduce ANR in KWNP to restore degraded forests. It is well known that climate change is exacerbating its effects on the ecosystems including forests and parks. Therefore, EbA is a significant part of a strategy to protect the environment and facilitate the development of the sustainable, natural resource-based economy to the benefit of local communities. It is in this context that this study entitled "Assessing Natural Regeneration of *Pterocarpus erinaceous* in Kiang West National Park" was undertaken.

1.2 Problem statement

Kiang West National Park is blessed with a diversity of tree species that provide important ecosystem goods and services to communities adjacent to the park, including collection of wild fruits, grazing, firewood resources, and bird watching for tourists. Previously, the park had a high density of *Pterocarpus* species, with high regeneration potentials. Recently, a rapid increase in the population of communities around the park has triggered increased interests to utilize forest resources for communities' livelihoods. This problem, coupled with other factors such as persistent droughts, bushfires, and increased wood utilization, are resulting in decline in ecosystem health, including the loss of *Pterocarpus erinaceous* from in the park.

The Gambia has been noted as a country with a high interest in the trading of timber products, although the resources are declining. The country has embarked on several initiatives including community forestry and Indigenous Community Conservation Areas practices as well as introducing improved restoration options. These efforts are seen as a way of increasing the forest resources of the country to benefit from improved international trade. *Pterocarpus erinaceus* is a highly valuable timber in international trade. It is listed on Appendix II of CITES which means that international trade is subject to regulatory measures. Gambia is currently under a recommendation to suspend trade in *Pterocarpus erinaceus* due to a lack of compliance with CITES,.ANR measures have the potential to enable The Gambia to sustainably manage *Pterocarpus erinaceus* and undertake legal international trade in the species.

Pterocarpus erinacous was previously in high abundance in Kiang West National Park since there was less impact from forest fire. The regeneration potentials were very high. Now there is lots of human activities in and around the park, which triggers occurrence of annual forest fire. This burns a significant number of wildlings, thus slowing regeneration of *Pterocarpus erinaceus*. The fires also burn the trunk of the mother trees, as well as the wildlings and seeds, thus leading to loss of species density. To address these challenges, Assisted Natural Regeneration can be viable option to allow natural regeneration to occur at a reasonable low cost. This contributes to revenue generation at the national level.

1.3 Research Questions and Objectives

1.3.1 Objectives

The overall objective of this research is to contribute to sustainable supply of rosewood from The Gambia for international trade in compliance with CITES.

Specifically, the study seeks to:

1. Assess the density of *Pterocarpus erinaceus* trees and wildlings in KWNP.
2. Determine the threats to ecological sustainability of *Pterocarpus erinaceus* trees in Kiang West National Park (KWNP).
3. Identify the effectiveness of ANR as an option for boosting available stocks of *Pterocarpus erinaceus* in the buffer zone of the park for consideration in national export quotas.

1.3.2 Research questions

The research questions of the study for *Pterocarpus erinaceus* are:

1. What are the drivers of its degeneration in KWNP?
2. Is ANR effective in the restoration and provision of ecosystem goods and services to communities around the park?
3. What enabling environmental factors support ANR in Kiang West National Park?
4. How can ANR enhance The Gambia's potential for sustainable supply of the species for international trade?

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of Tropical Forests

Forests cover nearly 30 % of the global land area (FAO and UNEP, 2020) and provide a wide range of essential ecosystem goods and services (Alcamo *et al*., 2003) that contribute to livelihoods (Lakerveld *et al.,* 2015, Brockerhoff et al., 2017), climate protection and biodiversity conservation. Studies have indicated that forests provide communities with a wide range of benefits and livelihood-related resources such as food, water, fiber, fuelwood (Langat et al., 2016; Alcamo, 2003; Vihervaara et al., 2012) and a host of other essentials. In Africa, forests occupy an area of 528 million hectares, most of it, 505 million hectares, are in the 40 countries of tropical Africa. Forest cover varies greatly by country and consists as an average of 23 % of land area in tropical Africa in 1995. Forests in tropical Africa are composed of moist and dry deciduous forests, rainforests, very dry forests as well as hill and montane forests (Palo and Lehto, 2003).

Despite the multiple benefits of forests, there is widespread concern that intensive and unsustainable exploitation of forest resources may lead to ecological problems such as degradation, reduction in the provisioning of services, etc. Therefore, crucial mitigation and/or adaptation measures need to be considered to help reduce climate-related impacts on ecosystems and livelihoods.

Tropical forest loss and degradation are the main drivers of the global biodiversity crisis and constitute a significant anthropogenic source of carbon dioxide to the atmosphere (Pan et al. 2011; Watson et al. 2018; Maxwell et al. 2019). Efforts to reverse biodiversity declines and mitigate climate change through large-scale reforestation of the tropics have gained global prominence through agreements and missions such as the Bonn Challenge and Paris Climate Accord (Lewis et al. 2019), and the ongoing UN Decade on Ecosystem Restoration (2021–2030).

Estimates show that global net forest loss accounted for 10 million hectares in 2015–2020, leading to degradation of vast areas of forest cover (FAO and UNEP, 2020). A recent edition on the State of the World's Forests (SOFO) by FAO and UNEP (2020) revealed that deforestation and forest degradation continue to take place at alarming rates, which contributes significantly to the ongoing loss of biodiversity. Recently, the Global Landscapes Forum (2021) organized a digital forum on Forest and Landscape Restoration (FLR) stated that over 40 %of the world's population is affected

by land degradation, costing the global economy around USD 6–10 trillion per year or roughly 10 percent of gross world product.

2.2 Causes of Forest Degradation

The Gambia is susceptible to the vagaries of the environment and climate change, e.g., droughts and flooding, which cause much damage to coastal ecosystems, farmlands, settlements, and livestock. The major issues affecting the environment sector are land degradation, coastal erosion, loss of forest cover, biodiversity loss, ineffective waste and pesticides management (National Development Plan, 2018 – 2021). The impact of Climate Change (CC) has emerged as one of the most significant external factors hindering the performance of the growth-driving sectors, especially agriculture, tourism, and industry, which have the greatest impact on the economy. The crisis of drought led to high exploitation of forest cover in the Gambia, because of the high dependency of natural resources for survival and socioeconomic development. The Gambia is highly vulnerable to the impacts of climate change because of the dependence of the country on rain-fed agriculture and the natural resource base, and a situation of increasing population, widespread poverty, and rapidly degrading environmental conditions (GNAP, 2015).

2.3 Assisted Natural Regeneration (ANR)

Assisted natural regeneration is a technique that involves protecting and nurturing vegetation such as mother trees and wildlings that are inherently present in an ecosystem. The practice is a cheaper alternative to reforestation aimed at accelerating natural successional processes by removing or reducing barriers to natural forest regeneration like soil degradation, competition with weedy species, and recurring disturbances (e.g. fire, grazing, and wood harvesting). ANR is also a faster way of allowing natural regrowth and can increase carbon sequestration and carbon sinks which contribute to climate change mitigation.

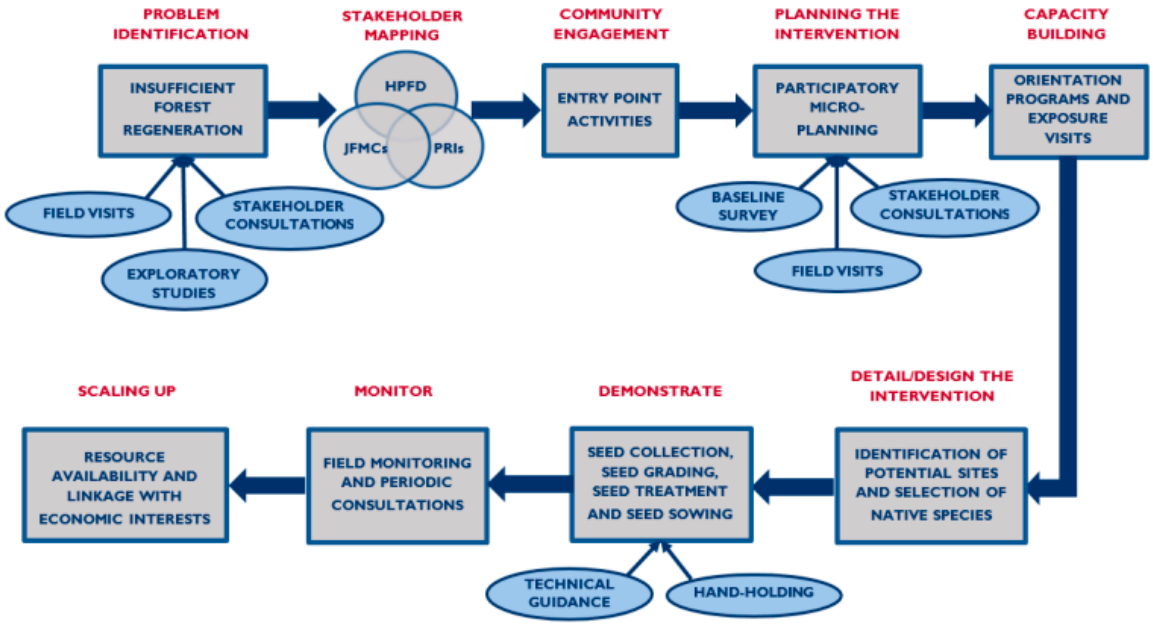

Figure 2.1: A schematic representation of the Management Strategy on community-based low-cost ANR. Source: USAID (2017)

Assisted natural regeneration is a blend of active planting and passive restoration, where local people intervene to help trees and native vegetation naturally recover by eliminating barriers and threats to their growth, leaning on their knowledge of the land and on ancestral traditions (Figure 2.1). According to Chazdom et al 2022, people can help the land and limit the frequency and severity of disturbances that can harm young trees and prevent them from growing. By preventing the spread of wildfires, people can build firebreaks and clear the forest floor of dry debris. To stop cattle from munching on saplings, they can build fences to keep them out. To give native trees enough room to grow, they can remove invasive grasses and shrubs. To encourage new vegetation to sprout from underground root systems, farmers can channel water into the soil and prune branches. And, if natural regeneration on its own does not increase tree cover quickly enough or the targeted species fail to pop up on their own, people can selectively plant trees to fill the gaps.

2.4 Where does ANR work best

ANR has been practiced for many decades in other countries under varied conditions, for different purposes and under different terminologies; in China it is known as the ‘mountain closure’ approach and in Vietnam it is part of the national strategy to reverse forest loss. ANR has also been

used in India and Sub-Saharan Africa to replenish fuelwood supply over thousands of hectares. This imitates conditions in the natural forest where many kinds of trees and plants of different ages all grow together. This is different from the appearance of forest plantations developed in conventional reforestation projects, which are typically composed of only one or a few species. With adequate rain and good implementation, impressive ANR results are usually evident in less than three years (FAO, 2019). In the Gambia ANR practiced was introduced by EbA project it was modeled in Kiang West National Park and replicated and upscaled in twenty-three Community Forest across the EbA intervention regions.

2.5 Advantages of ANR

ANR can be an important natural solution for mitigating and adapting to climate change that can also provide economic benefits for local farmers. ANR can enhance the supply of ecosystem services that have been depleted by land degradation, including through protection and rehabilitation of watersheds, increased carbon storage, and recovery of native biodiversity. Because of spatial variability in the ecological and social factors that influence natural regeneration outcomes, ANR provides a highly flexible and adaptive approach to restoration that is context- and site-specific.

A key advantage of ANR is the low requirement for infrastructure and capital investment and the significantly lower costs of implementation and maintenance compared to full tree planting. These qualities contribute to the effectiveness of ANR for household-, farm-, and community-based restoration activities. Enrichment planting and fencing add costs but can also increase financial and livelihood benefits. Because of the lower cost and infrastructure requirements, assisted natural regeneration can be an appropriate approach for large-scale forest restoration, particularly following major disturbances. ANR takes advantage of a natural successional process which ensures that the plant community that is established is well adapted to the site conditions. The naturally regenerating plant community typically comprises a mixture of species, resulting in more diverse, multilayered vegetative cover than from typical reforestation involving the planting of a limited number of species. This diversity enhances habitat quality for local wildlife and environmental stability.

ANR works with natural regeneration; it is most effective where natural regenerants are present at sufficiently high densities or when there is an adequate input of seeds from surrounding forest

areas. Compared to conventional reforestation, tree growth and stand development are slower, and commercial yields of timber and fiber are lower and less uniform than in intensively managed forest plantations. ANR is labor-intensive in early stages, particularly where naturally regenerating trees face heavy competition from weeds and grasses. ANR is poorly understood or advocated by policy makers who are focused on active tree planting approaches to reforestation.

Several benefits were attributed to ANR. For instance, Belem et al. (2017) reported that, in Burkina Faso, ANR is a viable technique that contributes to restoring vegetation beside the methods used for biodiversity conservation like tree planting during rainy season. Also, for land and vegetation restoration, natural regeneration approach is easier and lower cost as compared to plantation.

In The Gambia, ANR activities brought several benefits to the communities including: increased community resilience against climate change, increased biodiversity, reduced frequency of bush fire, cash for work initiatives-eg boundary clearing wages, priority tree ground clearing,, alternative livelihoods support (such as women's gardens), wildlife cropping etc. ANR can restore much more land, much more quickly than active planting, as it requires very little human intervention. According to a UN sustainable report, in Africa's dry Sahel region in Niger, farmers have used ANR to regenerate more than 200 million trees since the 1980s.

In areas where human pressure on the land is strong, especially from cattle grazing and agricultural expansion, ANR is the only way to ensure that the restored land effectively mimics the native habitat of local plants and wildlife. When ranchers manage their land more sustainably and graze their cattle more efficiently without degrading the land, they can fence off areas near biodiverse protected areas (or in areas along the borders of streams) to help nature regrow without hurting their bottom line. ANR is a cost-effective, nature-based solution for restoring thousands of hectares of land, while providing the ecosystem services like clean water and healthy soil, and carbon sequestration, that people need to thrive.

2.6 ANR Implementation in The Gambia

Assisted Natural Regeneration (ANR) is a blend of active planting and passive restoration, where local people intervene to help trees and native vegetation naturally recover by eliminating barriers and threats to their growth, leaning on their knowledge of the land and on ancestral traditions. In

the Gambia, ANR is perceived to be a new concept. The ecosystem-based adaptation (EbA) project is the first to introduce ANR in KWNP to restore degraded forests. It is well known that climate change is exacerbating its effects on the ecosystems including forests and parks. Therefore, EbA is a significant part of a strategy to protect the environment and facilitate the development of the sustainable, natural resource-based economy to the benefit of local communities. After successful initiation of the ANR practice in Kiang West National Park, it was replicated and upscaled in twenty-three Community Forests across EbA intervention region in The Gambia.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Study Area

The ANR assessment was carried out in KWNP in January 2023. Kiang West National Park is one of the largest and most important wildlife reserves in The Gambia. The park has an approximate area of 23,621 ha and was gazetted as a national park in 1987 (Figure 3.1). The park is under the management of the Department of Parks and Wildlife Management (DPWM), under the Ministry of Environment, Climate Change and natural Resources (MECCNAR).

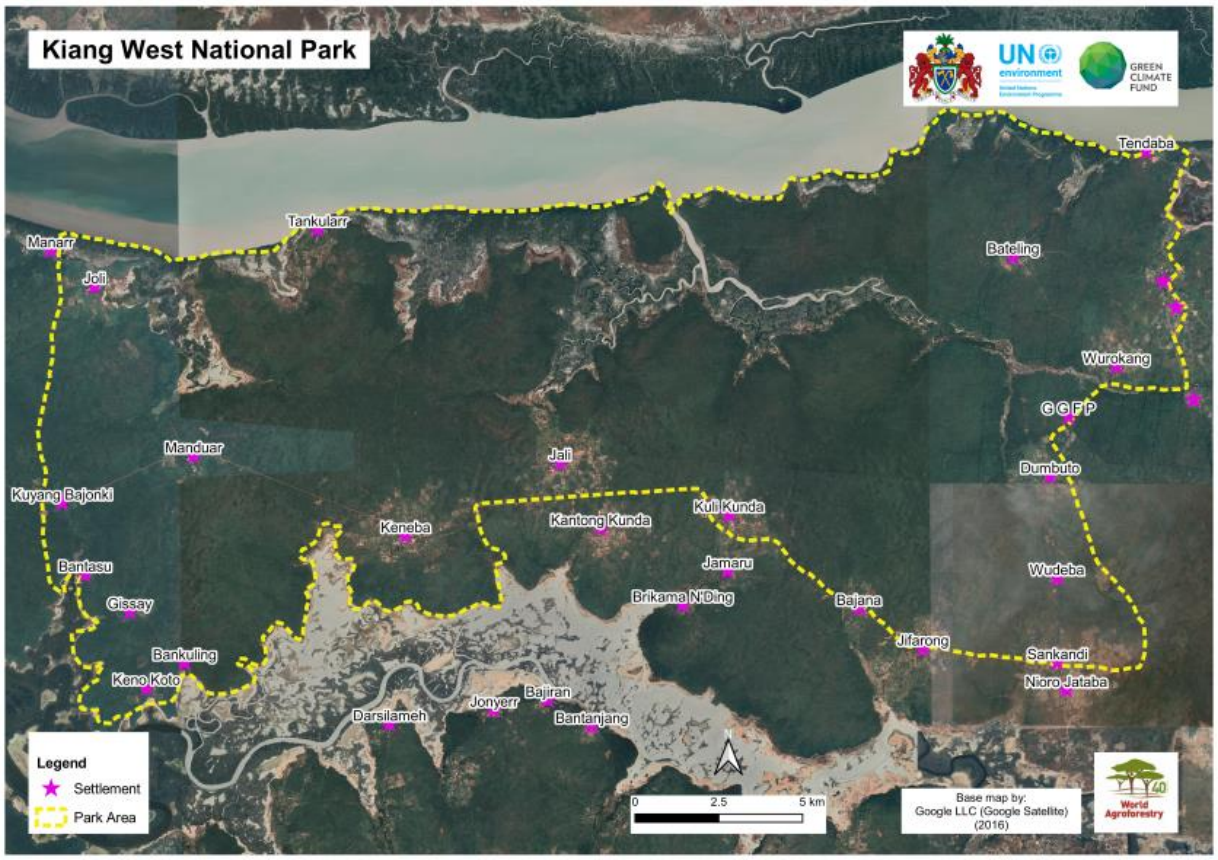

Figure 3.1: Map of Kiang West National Park (Source: ICRAF, 2019)

The park is in Kiang West District in the Lower River Region (LRR) of The Gambia. The park is adjacent to the bank of River Gambia and is 145 kilometres from the capital of Banjul. It is one of the largest protected nature reservations in The Gambia and has the largest and most diverse wildlife population. It is mainly made up of deciduous woodland and Guinea savannah. There are also extensive stretches of mangrove creeks, bolong tributaries, tidal flats, grasslands, forest and water (Figure 3.2).

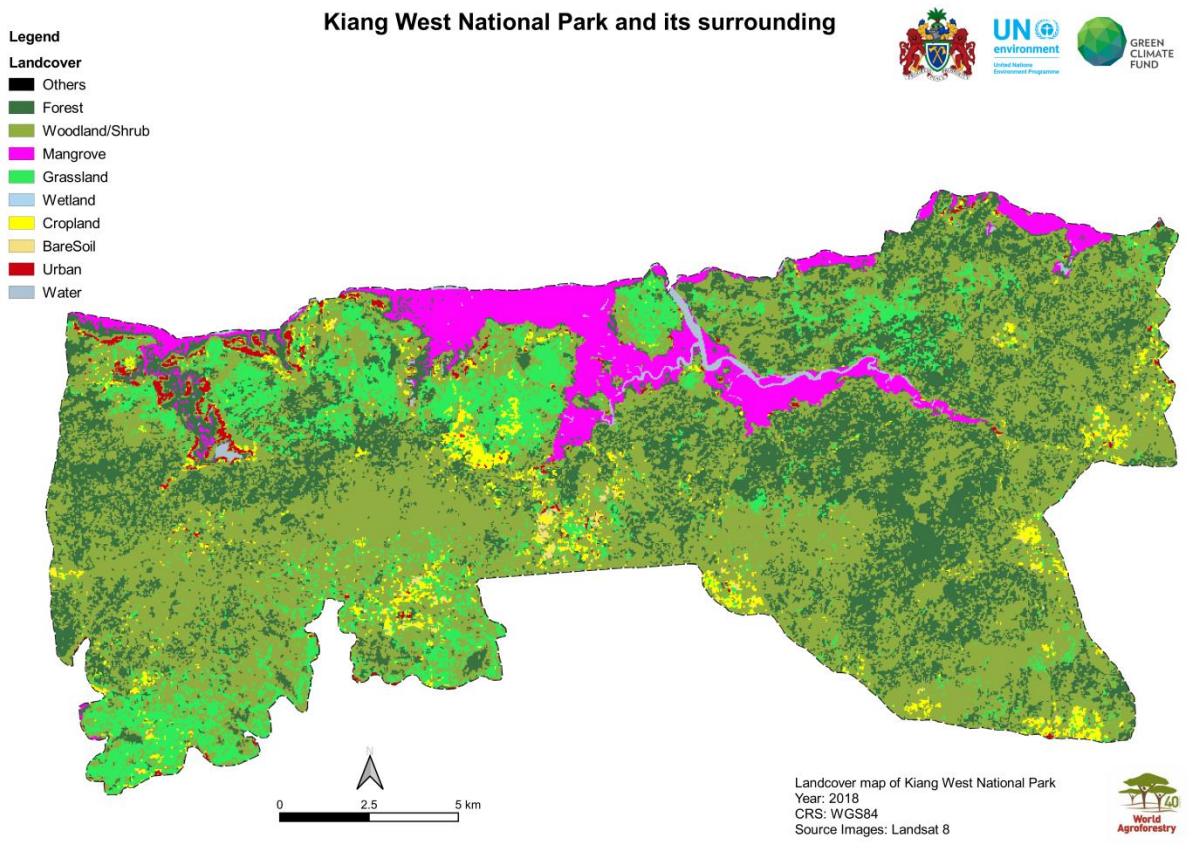

Figure 3.2: Land cover characteristics of Kiang West National Park (Source: ICRAF, 2019)

3.2 ANR implementation by EbA project

The state of degradation in Kiang West National Park is expanding and highly noticeable. To avert further degradation, the Ecosystem-based Adaptation (EbA) project decided to implement ANR in 2019, as a low-cost restoration initiative. First, spatial maps using both Google Earth and high-resolution ground cover assessment techniques were carried out to identify the severely degraded areas. As the park is managed by committee members from the five communities living in and around the park, an in-depth discussion was held with them to assess the drivers of degradation, the priority species (Table 4.1) they want to be restored in within the parks forest area and what management interventions are needed. Using the specified areas, plots were laid out in the park to delineate the restoration areas. Within the delineated areas, subplots were laid out to understand the state of the preferred tree species and the competitive species.

Figure 3.3: ANR plot 7 in KWNP covering 900 ha

The ANR plot (ANR Plot 7) was established by EbA project through technical support from World Agroforestry (ICRAF). The plot covers an area of approximately 900 ha of forest located between the communities of Batelling, Kwinella and Tendaba (Figure 3.3). Started in 2019, the ANR practice is a yearly event involving management of the priority species through the establishment of a 10-m fire belt around the ANR plot and clearing of fire load in a 4-m diameter. The fire belts had a 10-m width where any fuel load that exacerbates fire was cleaned and removed. Ground clearing is important to reduce competition between shrubs/grass and existing mother trees/wildlings to promote natural regeneration.

Table 3.1: Priority species in KWNP identified by the communities

Local name	Botanical name
Jalo	*Khaya senegalensis*
Keno	*Pterocarpus erinaceus*
Netto	*Parkia biglobosa*
Wulakono duto	*Cordyla pinnata*
Wolo	*Terminalia macroptera*
Kukuwo	*Diospyros mespiliformis*
Santangho	*Daniellia oliveri*
Tomborongho	*Ziziphus jujuba*
Kutufingho	*Vitex doniana*
Jambakatangho	*Combretum glutinosum*
Bunkungho	*Bombax costatum*

3.3 Location of ANR Study Plots

The assessment was conducted in ANR Plot 7 in four subplots measuring 25 m x 25 m each. The coordinates of the subplots have been established since 2019. In each sub-plot, five coordinate points (P1 – P4 and center) were marked in 2019 to help track their locations (Table 3.2). The coordinates will continue to be useful for monitoring purposes.

GPS device (Garmin etrex 10) was used to track the sub-plots. In each of the plots, both hard copy and Kobo Collect were used to collect data on priority species, wildlings density, fire incidence, signs of illegal logging and overgrazing. Table 3.2 shows the four corner and center points of the subplots used in ANR plot 7.

Table 3.2: Coordinates of subplots in ANR plot 7

ANR	**Center Point**		**Point 1**		**Point 2**		**Point 3**		**Point 4**	
Plot 7	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**
Sub Plot 1	13.410766	15.836645	13.410666	15.836666	13.410866	15.836783	13.410933	15.836556	13.410733	15.836433
Sub Plot 2	13.411883	15.831083	13.411733	15.831316	13.411937	15.831216	13.083333	15.831066	13.411916	15.830966
Sub Plot 3	13.409266	15.826016	13.409235	15.826216	13.409383	15.826233	13.409383	15.826865	13.409151	15.826016
Sub Plot 4	13.407423	15.820083	13.407332	15.820183	13.407483	15.820233	13.407533	15.823689	13.407316	15.819933

3.4 Data Collection

3.4.1 Vegetation assessment of *Pterocarpus erinaceus*

Vegetation assessment of *Pterocarpus erinaceus* species was performed on the experimental plots in January 2023 (Figure 3.4). The data was compared with the baseline results of 2019 and the subsequent monitoring results of 2021 and 2023 by the EbA project to understand the changes over time. In total 4 square plots, each with 25m by 25m were assessed within the delineated areas.

Figure 3.4: Tree circumference measurement

In each of these plots, the following measurements were done:

- Wilding density count
- Mother tree density count
- Circumference at breast height using measuring tape (in cm)
- Tree height of the preferred tree species using clinometer (in m)
- Tree canopy size (in m)

- Visual observation of damage extents due to termites, wildlife, fire, cutting or pest infestation

3.4.2 Key Informant Interviews and Focus Group Discussion

Questionnaires were developed and administered in the form a Focus Group Discussion (FGD) to regional wildlife Officers in KWNP and other relevant stakeholders such as local park management committee from Dumbuto, Batelling, Bajana, Kulikunda and Jali. Two respondents per community participated in the FGD to gather relevant information about the research questions. The discussion also assessed the effectiveness of ANR that was implemented in the park by the EbA project in 2019. The total number of participants in the FGD was twelve (12).

Figure 3.5: Focus Group Disscusion

3.4.3 Secondary data

Secondary data were used to support the primary data, and this was achieved through documentary research, publication, and reports. Weather data (rainfall and temperature) was obtained from the Department of Water Resources from 1988 to 2017.

3.5 Data Analysis

SPSS (Statistical Package for Social Sciences) and excel software were used to analyze the data from the field. Simple descriptive analytical methods such as frequency table and bar chart were used.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Climatic Conditions

Kiang West National Park is in the Lower River Region of The Gambia. The study area has a subtropical climate characterized by rainfall and temperature variability throughout the year. Figure 4.1 presents results of mean annual rainfall and temperature at the study site from 1988 to 2017. The rainfall peaks in the years 2012 (1338 mm) and 2017 (1422 mm), while lowest rainfall was recorded in 2002 (383 mm). The highest mean annual maximum temperature was recorded in 1996 (37°C) and 20017 (38°C).

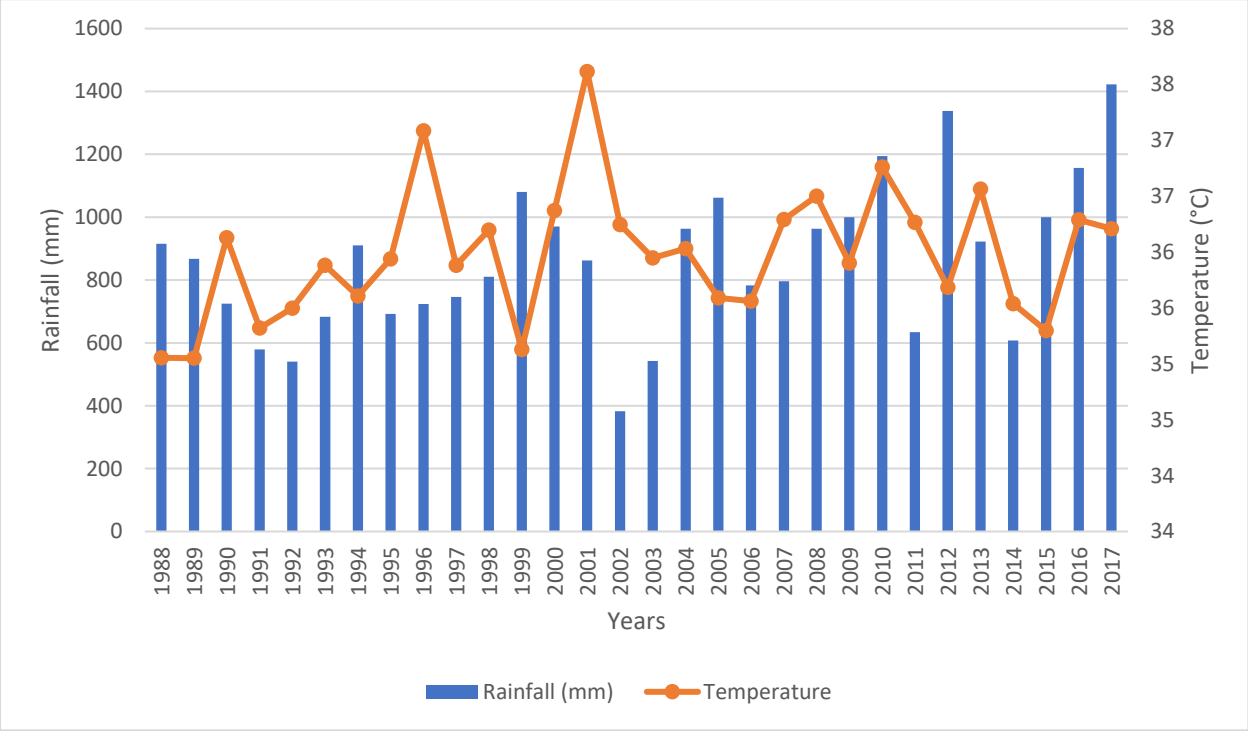

Figure 4.1: Average yearly rainfall and temperature trends in the study area

A recent baseline report by World Agroforestry (Duguma et al., 2020) for the Ecosystem-based Adaptation Project indicates that The Gambia receives more than 90% of its annual rainfall from May to October in a unimodal rainfall pattern. In general, the Gambia experiences a Sahelian climate, characterized by a long, dry season (November to May) and a short, wet season (June to October). Average temperatures in Gambia range from 18°C to 30°C during the dry season and 23°C to 33°C during the wet season. All these fluctuations have grave consequences on the ecosystem function in the study area. Several reports have indicated that climate change adversely impacts food security, terrestrial ecosystems, land degradation, and land use (Smith et al., 2020; Sunderland and Rowland, 2019).

4.2 Location and Ecosystem of the Study Area

Kiang West Nation Park is one of the biggest community protected areas (CPA) and wildlife reserves in The Gambia. It was declared a national park in 1987 and is managed by the Department of Parks and Wildlife Management (DPWM). It is located in the middle of Kiang West district and jointly managed by five communities including Dumbuto, Batelling, Bajana, Kulikunda and Jali. As per the 2013 population census of The Gambia, the population of the five settlements is summarized as follows (Table 4.1):

Table 4.1: Settlement community population of Kiang West National Park

Settlement	Households	No. of male	No. of female	Total population
Dumbuto	92	324	376	700
Batelling	43	108	111	219
Kulikunda	85	413	388	801
Bajana	45	208	202	410
Jali	131	469	586	1055
Total	396	1522	1663	3185

Source: (GBoS, 2013)

The headquarters of KWNP is at Dumbuto parks and wildlife office which oversees all management activities within the park. The area of the park was initially 11,000 ha which was later extended to 19,051 ha.

Kiang West National Park ecosystem is composed of varieties of trees, wildlife, watersheds and mangroves. In addition, the river ecosystem covers about 4 - 6 km length of the park along the North-western border. The park is adjacent to a couple of farming communities with farming being their principal livelihood strategies. The main tree species in the park include *Khaya senegalensis*, *Pterocarpus erinaceus*, *Combretum spp*, *Terminalia spp*, *Bombax custatum*, *Parkia biglobosa*, *Afvizilia a*fricana, *Rhizophora spp* and *Antiaris Africana*. The vegetation along the river is predominantly mangroves. Common wildlife found within the area includes antelopes, wild pigs, monkeys, baboons, hyenas, snakes, birds, rats, squirrels, monitor lizards, monkeys, wild pigs, baboons, squirrels, rats and birds.

4.3 Observed Changes in Vegetation Cover of ANR Plots

4.3.1 Tree density of *Pterocarpus erinaceus*

Kiang West National Park is home to a variety of various species of trees including *Pterocarpus erinaceus*. The management Committee of the park have identified ten priority species that are important for both their livelihood. In the park, *Combretum glutinosum* is among the most dominant species in the park. It is also very resistant to fire.

The percentage changes of mother trees density in Plots 1-4 are presented in Figure 4.2. In Plot 1, it was observed that the density of *Pterocarpus erinaceus* trees increased significantly by 117% from 2019 to 2023, while that of Plot 2 increase by 33% during the same period. Plots 3 and 4 showed insignificant changes in density of *Pterocarpus erinaceus* trees. The average tree density registered in 2019 ANR plots was 32 trees/ha. A significant increment was recorded in 2023 with an average density of 72 trees/ha.

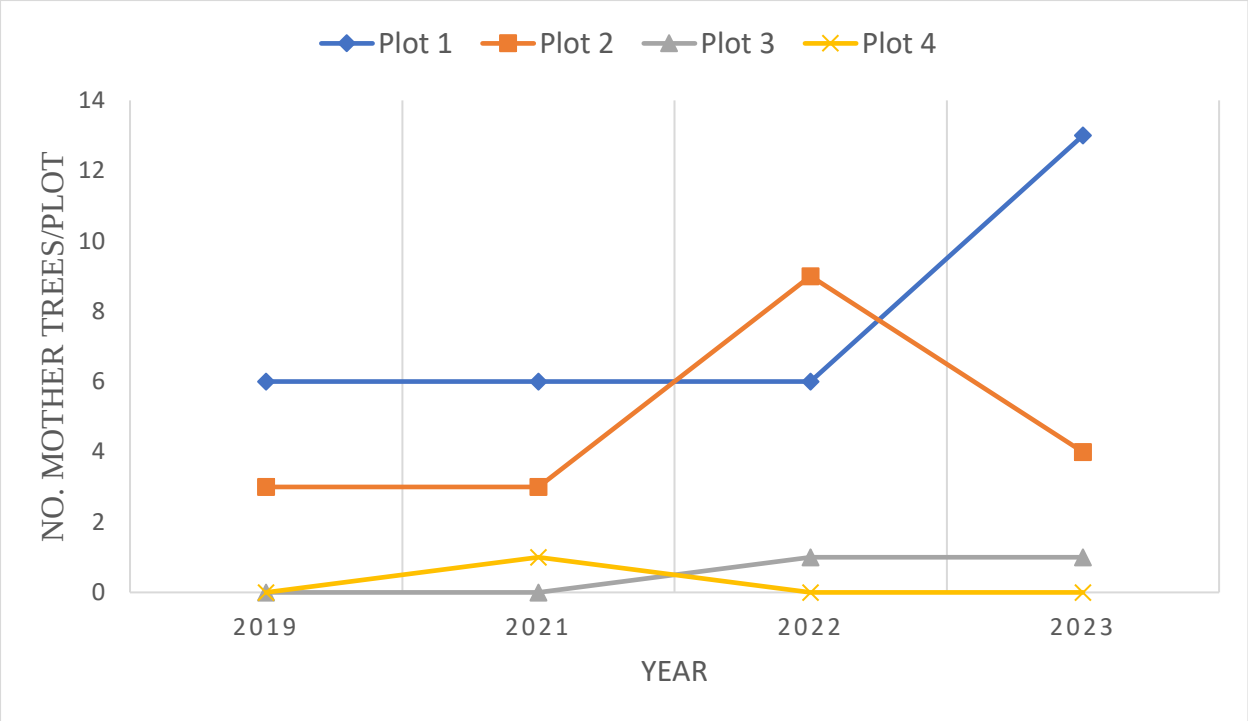

Figure 4.2: Changes in *Pterocarpus erinaceus* tree density in ANR plots in KWNP

The increment in the population of *Pterocarpus erinaceus* trees in the study plots implies the potential of ANR in the restoration of KWNP. The benefits could be realized more in the long run. Restoration of the forest have a positive impact on the environment for it increases rainfall, reduces extreme temperatures, serves as carbon sink, recreation, and cultural activity centres as well. According to the focus group discussion, the environmental benefit of the forest is beyond what we mentioned above; forest helps to regulate the climate, it maintains the oxygen level at the atmosphere to facilitate breathing for humans and other animals; it helps the soil to absorb water during floods, which consequently protects the soil property by slowing the flow. In addition, it can improve soil fertility, reduce soil and water erosion, and minimise desertification as well.

ANR influences carbon storage through changes in the growth of aboveground and below-ground tree biomass and changes in wood end use. In most cases, improved natural

regeneration could result in increased landscape and biodiversity improvements. Through proper management of the forest, ANR effects could also result from increased mixed species stands and higher tree density in KWNP. However, these benefits could be constrained by environmental damages that could emanate from biotic and abiotic factors such as forest fires, drought, illegal logging and termite infestation. Studies have shown that the growth of secondary forests can be strongly affected by fire frequency (Zarin *et al*. 2005).

The current trend in the improvement of the vegetative growth of the park could yield several economic benefits from increased timber production and other ecosystem goods and services. For example, increased density of *Pterocarpus erinaceus* could culminate in sustainable timber production, improved forest cover leading to increased carbon sequestration in the long-term.

4.3.2 Wildlings Density *Pterocarpus erinaceus*

The wildling densities recorded in 2019, 2021, 2022 and 2023 averaged 4, 6, 3 and 2/plot, respectively (Figure 4.3). In general, from 2019 to 2021, the wildling count increased by 36% in Plot 1, 33% in Plot 2, 100% in Plot 3 and 200% in Plot 4. The average wildling density in 2019, 2021, 2022 and 2023 were 64, 96, 48 and 36 tree/ha, respectively. The population of *Pterocarpus erinaceus* wildlings decrease in most of the plots. This could be attributed to incidence of fire in the ANR plots in 2021. Subplot 2 accounted in 2019 6 species and 12 wildings. In 2021, the total number of plants registered in the subplot was 26.

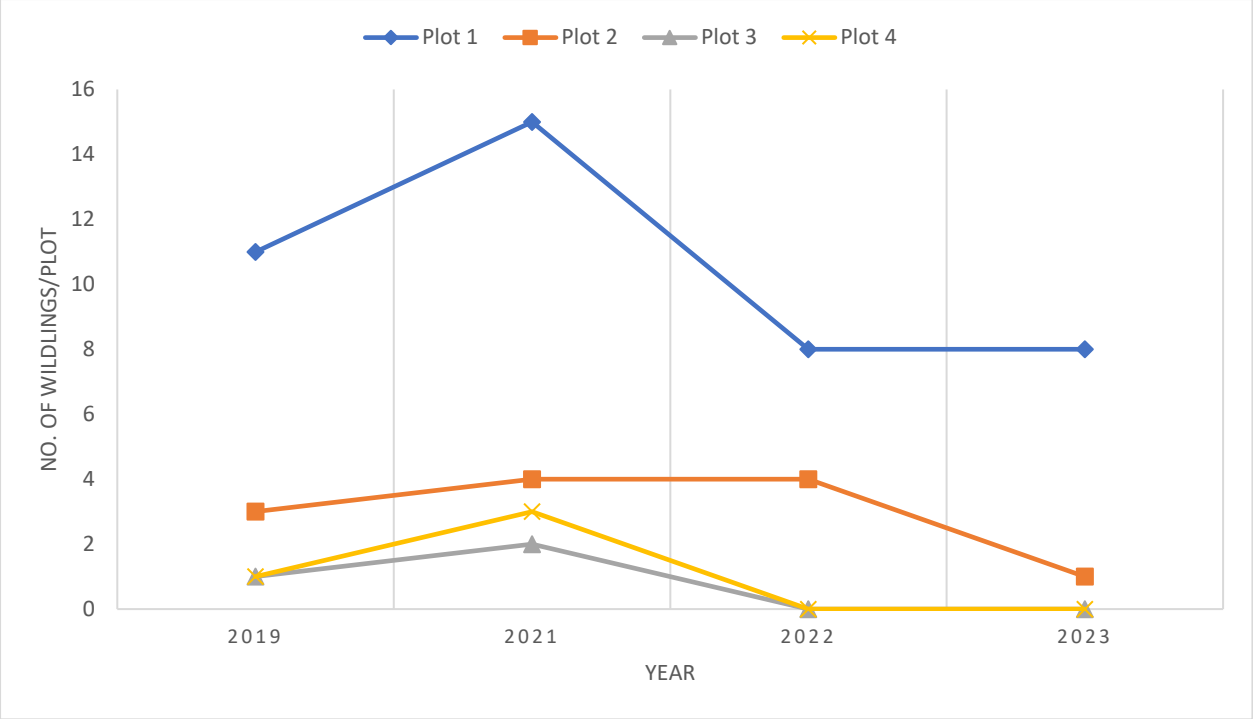

Figure 4.3: Changes in *Pterocarpus erinaceus* wildling density in ANR plots in KWNP

The noticeable changes in wildling density could be attributed to the incidence of fire in the park, particularly in 2021. Fire events are common disturbances in the study region (Lower River Region) and the park (KWNP) is mostly affected. The fires tend to impact the wildlings more compared to the mature trees. The vegetation recovery mechanisms are mostly slow. In general, ecosystems submitted to frequent fires tend to be more resilient. Forest fires contribute to global greenhouse gas emissions and can negatively affect public health, economic activity, and provision of ecosystem services (Tyukavina et al., 2022). In boreal forests, fires are a part of the ecosystem dynamics, while in the humid tropics, fires are largely human-induced and lead to forest degradation. Increasing global temperatures and more prolonged and severe droughts over the past decades are creating favorable wildfire conditions (Jolly et al., 2015).

4.3.3 Tree Growth Parameters

Overall, tree canopy sizes were different among plots. Plot 3 had noticeably higher canopy size (3.25 m), as opposed to Plot 1 (2.03 m), Plot 2 (0.81 m) and Plot 4 (0.40 m) (Figure 4.4). The average canopy cover was 1.6 m. In general, canopy cover could play a role in explaining variation in seedling and species densities, and species composition, across plots.

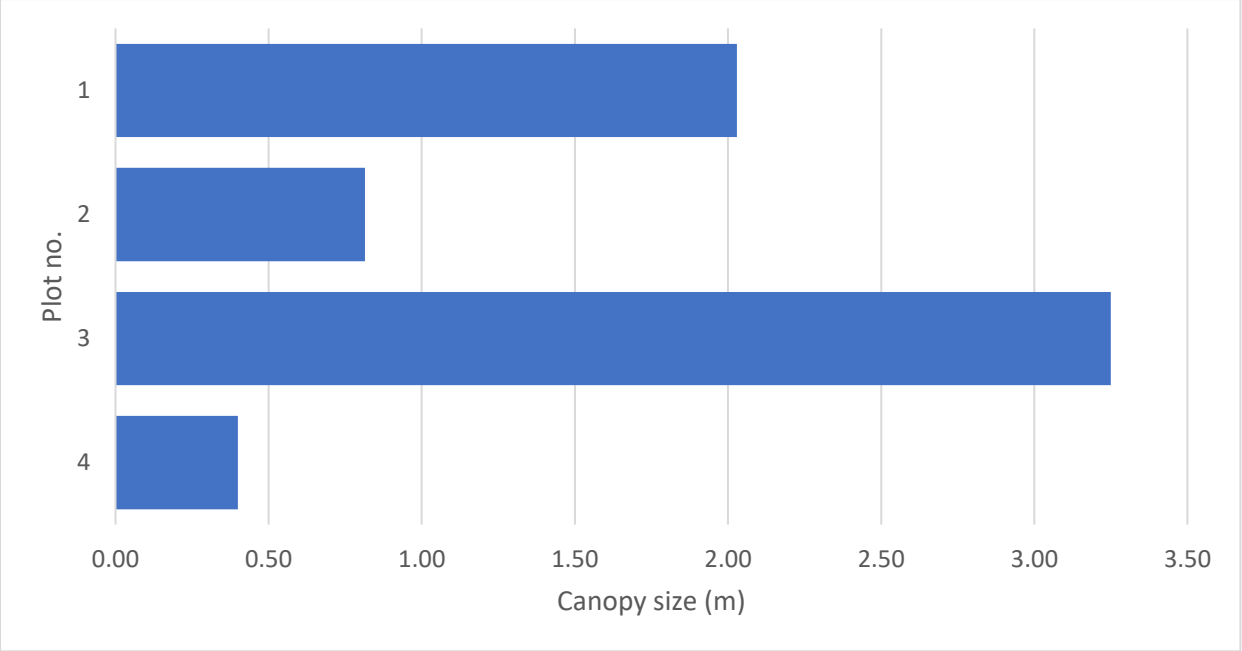

Figure 4.4: Characteristics of canopy size in ANR plots

Our study of average canopy dimensions of *Pterocarpus erinaceus* trees in the ANR plots showed potential for greater tree regeneration in the ecologically restored park. Our findings suggest that the positive effects of ANR can be extended to cover nationwide forest areas. Our findings support the hypothesis that increasing canopy cover can facilitate rainforest recovery by creating favorable microhabitats for tree regeneration (Holl et al., 2000; Ashton et al., 2014) and biodiversity. A recent study by Anand et al. (2021) suggest that canopy cover contributed to explaining patterns of seedling density, diversity, and composition across plots, and was positively associated with regeneration of late successional species, but not early successional species. This is corroborated by the nursery experiment, which showed a positive influence of shade on seed germination and early survival, particularly for two late-successional species. Apart from altering microhabitats to favor seed germination and survival, overstory trees can influence animal-mediated processes such as seed dispersal and predation that shape natural regeneration in tropical forests (Terborgh et al., 2008; Paine et al., 2016).

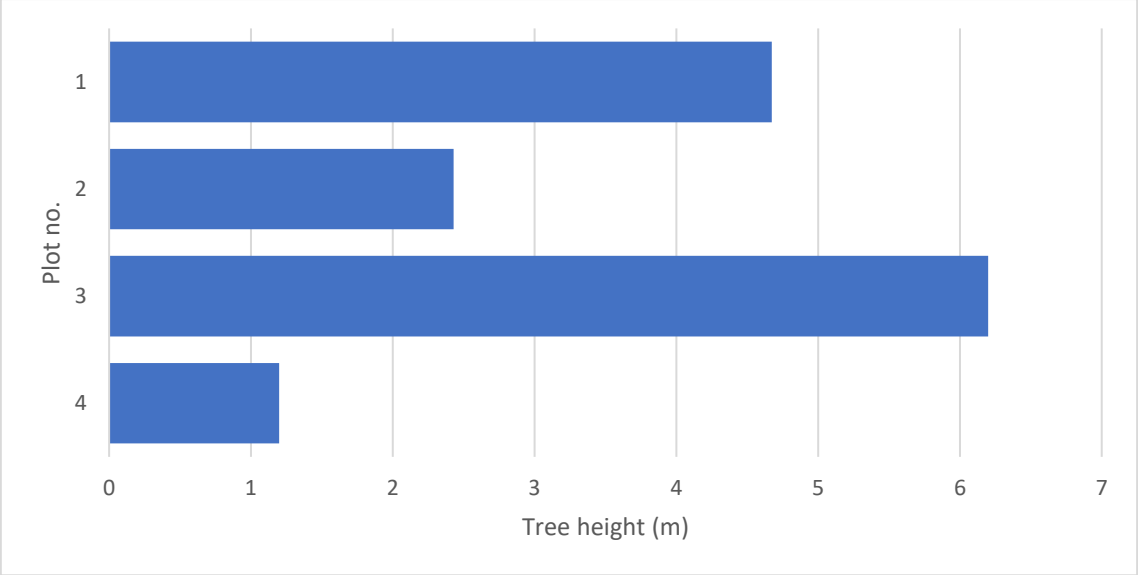

Figure 4.5: Tree height in ANR plots

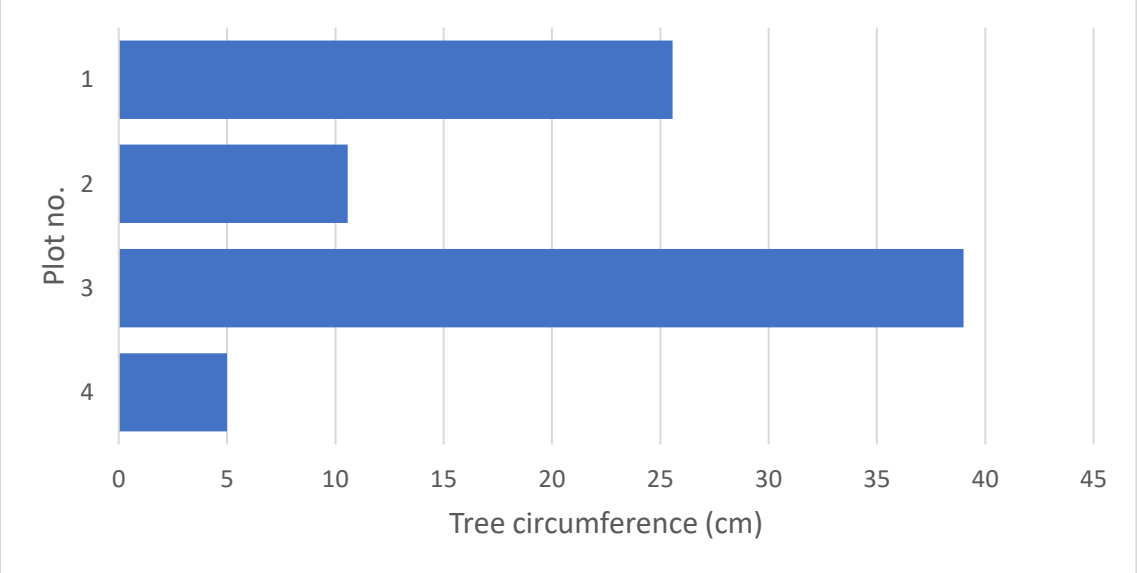

Figure 4.6: Tree circumference in ANR plots

Results on plant height and tree circumference are presented in Figure 4.5 and Figure 4.6, respectively. Tree height varied among ANR plots. Plot 3 had noticeably higher tree height (6.2 m) than Plot 1 (4.67 m), Plot 2 (2.43 m) and Plot 4 (1.2 m). Similarly, tree circumference was higher in ANR Plot 3 (39 cm), followed by Plot 1 (26 cm), Plot 2 (11 cm) and Plot 4 (5 cm). Forest height is a fundamental parameter in forestry. Tree height is widely used to assess a site's productivity both in forest ecology research and forest management. Thus, a precise

height measure represents a necessary step for the estimation of carbon storage at the local, national, and global scales.

Pterocarpus erinaceus is very important in an ecosystem. It belongs to the Fabaceae (legumes) family and Papilionaceae subfamily. Adult specimens are medium sized trees (12-15 m high) with a trunk diameter averaging between 1.2 and 1.8 m. The species we found in KWNP are still at the juvenile stage of growth. The height ranged from 1.2 m – 6.2 m, while the circumference ranged from 5.0 cm – 39 cm.

4.3.4 Observed Condition of the Trees

The health condition of *Pterocarpus erinaceus* trees in each ANR plot was assessed (Table 4.2). Generally, between 75-79% of trees were observed to be healthy in Plots 1 and 2. In contrast, all assessed *Pterocarpus erinaceus* trees in Plot 3 exhibited unhealthy status. In terms of apparent wounds, between 50-100% of the assessed trees showed signs of physical injury on either the bark or branches. Also, most of the trees in the ANR plots (75-100%) are free from pest infestation.

Table 4.2: Observed parameters on tree condition

Observed parameters	Tree condition	Plot 1	Plot 2	Plot 3	Plot 4
		% occurrence			
Tree health status	Healthy	79	75	0	n/a
	Unhealthy	21	25	100	n/a
Apparent wounds	Yes	29	50	0	n/a
	No	71	50	100	n/a
Pest infestation	Yes	14	25	0	n/a
	No	86	75	100	n/a

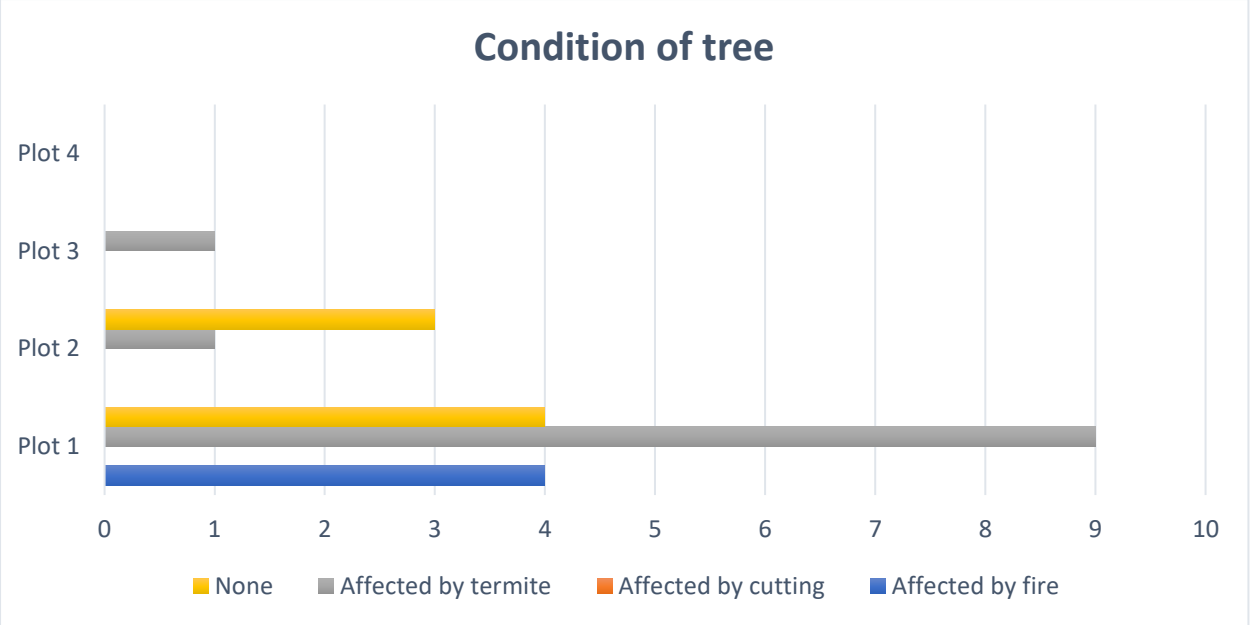

Figure 4.7: Tree circumference in ANR plots

The physical condition of the *Pterocarpus erinaceus* trees in each ANR plot was assessed on visible signs of termite infestation, cutting and fire (Figure 4.7). The observation focused mainly on the tree trunk and branches for the signs. Trees in Plot 1 were the most affected by termites (69%) followed by Plot 2 and Plot 3. In terms of signs of fire on tree trunk or branches, 31% of assessed trees in Plot 1 have been affected. This is probably due to the 2021 fire incidence in the park in 2021 (Figure 4.8).

The impact of fire on the ecosystem could be huge. In terms of climate change, burning of the vegetation by fire both adds carbon dioxide to the air and removes the ability of trees to absorb existing carbon dioxide. Bush fires pose a major threat to the ecosystem, biodiversity and environmental sustainability as well. Forest fires can lead to significant decline in forest biomass, as well as changes in species composition. Lower River Region is one of the most affected in terms of forest fires. Development of comprehensive fire management system is fundamental in addressing fire related challenges in the region.

Figure 4.8: Signs of fire burning tree trunk in ANR plots

Figure 4.9: Tree bark recovering from fire impact in ANR plots

Fire is a common occurrence in landscapes adjacent to KWNP. In 2021, the ANR plots were ravaged by fire, leading to extensive damage to the wildling and tree trunks. As a survival mechanism, trees in fire-prone areas develop thicker bark, in part, because thick bark does not catch fire or burn easily. It also protects the inside of the trunk. Although the *Pterocarpus erinaceus* trees were affected by fire and radiant heat, most of the trees have shown potential to recover through their barks (Figure 4.9).

4.4 Threats and Drivers of Degradation in KWNP

The Focus Group Discussion (FGD) held with the park management committee and technical staff of Department of Parks and Wildlife Management (DPWM) established that indeed there is evidence of degradation in the park. *Pterocarpus erinaceus* being one of the priority species identified by the community is under threat due to human-induced factors such as fires and illegal logging. Some of the observed changes in the park over the past couple of years during the FGD included reduction of tree density and tree cover, reduction in wildlife animal species, decrease in water areas such as ponds, river tributaries. Wild fruits are also observed to be decreasing, thus lowering food variety for the community as well as the wildlife. A case in point was that of baboons that have resulted into feeding on tree barks and consequently causing trees and their wilding to die, a factor that was attributed to reduced variety of wild fruits.

The communities established that there are several sources causing degradation in the area, leading to endangering the growth of *Pterocarpus erinaceus* in the park. These included:

- Bush fires especially during the dry seasons.
- Lack of clear fire belts and boundaries to reduce fire movements.
- Insufficient human capacity and equipment to fight fire once there is a fire outbreak.
- Illegal activities such as logging, poaching and honey harvesting which contribute to degradation.
- Animal activities such as termites and baboons feeding on the bark of trees.
- Soil erosion during the rainy season.
- There was no sign of illegal logging, overgrazing or transhumance.

Fire as a persistent cause of degradation is a major concern. The discussion revealed that fire incidents remain one of the key challenges facing the effective management of the park. The community members established the causes and control measures of the fire incidents as part of the ANR strategies. Some of the common sources of fire incidents include:

- Honey collection process that uses fire to scare away the bees.
- Hunting exercises.
- Smoking in the forest during the dry season.
- Charcoal production around the landscapes adjacent to the park.
- Malicious fires caused by the outsiders.
- Farmlands clearing process.
- Cross-border fires that come from adjacent lands.

The establishment of a 10-m boundary fire belt around ANR plot 7 is meant to prevent entry of fire into the plot. Unfortunately, in 2021, the ANR plot was affected by fire. In the park, the presence of native *Andropogon gayanus* potentially contributes to an increased risk of a wildfire. Invasion by such species can greatly increase fuel loads, resulting in rapid spread of fires. Therefore, the greater flammability of *Andropogon gayanus* contribute to the explanation of why fire is more frequent in those areas.

The participants also established that most of the fires emerge from the East side of the park with two fire incidences recorded in the past one year – one in the riverside area and the other in Kwinella side. Several interventions are already in place to control fire incidences within Kiang West National Park. The park manager established that early-controlled burning on the fire hotspot regions was the most common exercise that is implemented by the parks and Wildlife Department with community support. The Ecosystem-based Adaptation (EbA) project has been very supportive in the protection of the park through the establishment of 10-m fire belts around the park. Further, since 2019, the project has supported the implementation of ANR covering at least 900 ha. The initiative is led by the communities.

4.5 Effectiveness of ANR and Implication of *Pterocarpus erinaceus* Conservation in KWNP for CITES

Pterocarpus erinaceus (African rosewood) is a multipurpose tree species indigenous to semi-arid and Guinean-savanna woodlands of Africa. It is a leguminous woody perennial of the family Fabaceae and grows naturally in West and Central Africa (Ouédraogo et al. 2006; Orwa et al. 2009). The multiple use benefits of *Pterocarpus erinaceus* account for the high pressure on populations of this species. Internationally, pressure comes from particularly China, which is the largest importer of rosewood from Africa due to increased demand for rosewood furniture (Winfield et al. 2016). Logging of the species is currently done without proper regulations, making exploitation unsustainable. According to Duvall (2008), the leaves are an important source of fodder for livestock in the dry season. Locally, various parts of the tree are important in traditional medicine. The wood is highly preferred for charcoal production, for carving mortars and pestles, manufacture of musical instruments (such as xylophones, guitars, violins), and for furniture making and building construction (Duvall 2008; Bosu 2013; Dumenu and Bandoh 2016). Ecologically, it is important in traditional agroforestry systems by forming symbiotic relations with Rhizobium to fix nitrogen into the soil (Bonkoungou, 1999).

Ptercocarpus erinaceus is on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This means that international trade in the species is subject to strict regulatory measures. In The Gambia, there has been dramatic increase in trade of *Pterocarpus erinaceus* timber to key destinations such as China. This explosive trend in exports of rosewood timber is compounded by rises in illegal and unsustainable harvesting practices to meet this growing demand in the Chinese markets. These activities are happening despite the existence of specific local and international regulations.

At the 74th meeting of the CITES Standing Committee (SC74, March 2022), the Standing Committee requested the Secretariat to open an expedited compliance procedure for *Pterocarpus erinaceus*, pursuant to Article XIII of the Convention. The 16 range States, including The Gambia, were requested to either: 1) provide their non-detriment finding (NDF) and legal acquisition finding (LAF), or 2) request the Secretariat publish a voluntary zero export quota. As a result of this process, in June 2022, The Gambia was subject to a recommendation to suspend commercial trade in *Pterocarpus erinaceus* by CITES. This was as a result of violation of CITES through rapid illegal exploitation and large-scale smuggling of the *Pterocarpus erinaceus* along Gambia's southern borders.

To address this situation, it is essential that the species can be sustainably managed, enabling the publication of a Non-Detriment Finding and Legal Acquisition Finding for Gambia. There is, therefore, a need to consolidate efforts geared towards restoration of degraded landscapes. This can be principally achieved through enrichment planting, ANR and protection of the forest from bushfires. In the case of KWNP, both the EbA project and the Department of Parks and Wildlife Management (DPWM) have adopted and implemented intervention measures to protect biodiversity in park, including the *Pterocarpus erinaceus* species that are considered one of the most endangered. The intervention measures include ANR and early controlled burning. Natural regeneration on the KWNP is being hampered by fire occurrence and climate change. Therefore, more monitoring activities and stiff penalties should be put in place to avert incidence of bush fires and illegal logging. Although, demand for timber from *Pterocarpus erinaceus* species on the international market is on the rise, raising conservation concerns has led to enforcement of more stringent measures and efforts to protect forest ecosystems in The Gambia.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

African rosewood (*Pterocarpus erinaceus*) is a multi-purpose woody species threatened by human-induced factors such as forest fires and illegal logging. This study assessed the regeneration of *Pterocarpus erinaceus* in Kiang West National Park from 2019 to 2023. It also investigated the vegetative characteristics of *Pterocarpus erinaceus* and identified drivers of degradation in the park.

In general, the survival regeneration rate of *Pterocarpus erinaceus* in most of the ANR plots was quite impressive. The findings of the study revealed that on average *Pterocarpus erinaceus* density in ANR plots increased by 100% from 36 trees/ha in 2019 to 72/ha in 2023. In contrast, wildlings density in ANR plots decreased by 44% from 64 trees/ha to 36 tree/ha. The decrease in wildling density could be explained by the fact that those wildlings could have grown to be adult trees (3 m and above). Further, the noticeable changes in wildling density could be attributed to the incidence of fire in the park, which occurred in 2021. Fire events are common disturbances in the study region (Lower River Region) and the park (KWNP) is mostly affected. The fires tend to impact the wildlings more compared to the mature trees.

The findings also identified the main causes of land degradation, eventually endangering the growth of *Pterocarpus erinaceus* in the park. These included fire, overgrazing, illegal logging, termite infestation and drought.

It was shown that, the increment in the population of *Pterocarpus erinaceus* trees in the study plots implies the effectiveness of ANR in the restoration of KWNP. The ANR approach can be a useful intervention within the overall landscape restoration strategy as a cost-effective method. There is currently momentum building on ANR in the EbA intervention sites as it can provide many benefits, including habitat restoration, conservation of biodiversity, watershed protection, climate change mitigation and provision of a range of products and services.

5.2 Recommendation

To achieve success in ANR implementation, the growth limiting factors such as competition from weeds, fires, overgrazing and illegal logging should be controlled. Under favorable soil and climatic conditions, regeneration can begin to occur naturally. In the long-term, *Pterocarpus erinaceus* has the potential to be sustainably managed and traded internationally, in compliance with CITES requirements. However, for ANR to be effective, the following ecological, socio-economic, and regulatory conditions are essential:

1. It is essential to prevent or at least minimize human induced disturbances, including fires, grazing and unsustainable and illegal harvesting.
2. Local communities should continue to be sensitized and incentivized to participate in forest restoration through ANR and enrichment planting.
3. There should be a favorable policy and regulatory environment, as well as political will to promote and upscale ANR initiatives throughout the country.
4. There should be awareness at all levels of government that only sustainably managed forestry can lead to CITES compliance and legal international trade.
5. Public institutions and civil society organizations should be capacitated and supported both technically and financially to conduct research on ANR.
6. Regular monitoring and evaluation is essential to assess the progress and effectiveness of ANR in forest restoration projects. It enables adaptive management based on feedback data and informs the effectiveness and impact of ANR activities implemented.
7. Farmer Managed Natural Regeneration (FMNR) should be introduced in agricultural landscapes to minimize pressure on the park.
8. Creation of fire belts around the park perimeters through community support.
9. Creation of an open boundary and buffer zone along the park perimeter to manage spread of fire.
10. Increased awareness creation on fire management and control measures.
11. Enhanced law enforcement exercises.
12. Development of a comprehensive fire management system is fundamental in addressing fire related challenges in the region.

REFERENCES

1. Alcamo, J., Hassan, R., Scholes, R., Ash, N., Carpenter, S., Pingali, P., Bennett, E., Zurek, M., Chopra, K. and Leemans, R., 2003. Ecosystems and Human Well-Being: A Framework for Assessment. A Report of the Conceptual Framework Working Group of the Millennium Ecosystem Assessment. Island Press, Washington. DC,245 p.
2. Arbonier, M. Arbres, arbustes et lianes des zones sèches d'Afriques de l'Ouest, deuxième édition, CIRAD/MNHN/UICN, Paris.
3. Ashton MS, Gunatilleke CVS, Gunatilleke IAUN, Singhakumara BMP, Gamage S, Shibayama T, Tomimura C (2014) Restoration of rain forest beneath pine plantations: a relay floristic model with special application to tropical South Asia. Forest Ecology and Management 329:351–359.
4. Asner, G.P.; Broadbent, E.N.; Oliveira, P.J.C.; Keller, M.; Knapp, D.E.; Silva, J.N.M. Condition and fate of logged forests in the Brazilian Amazon. *Proc. Natl. Acad. Sci.* 2006, *103*, 12947–12950.
5. Asner, G.P.; Hughes, R.F.; Vitousek, P.M.; Knapp, D.E.; Kennedy-Bowdoin, T.; Boardman, J.; Martin, R.E.; Eastwood, M.; Green, R.O. Invasive plants transform the three-dimensional structure of rain forests. *Proc. Natl. Acad. Sci.* 2008, *105*, 4519–4523.
6. B.Belem, F. Kaguembega-muller, R. Bellefontaine, J.P. Sorg, U. Bloesch & E. Graff. 2017
7. Bonkoungou E. 1999. Semi-arid lowlands of west Africa Programme, BP 320, Bamako, Mali. https://www.winrock.org/ factnet-a-lasting-impact/fact-sheets/pterocarpus-erinaceusan-important-legume-tree-in-african-savannas/. Accessed 6 Marh 2023.
8. Bosu, D. 2013. Draft Report on the Dynamics of Harvesting and Trade in Rosewood (Pterocarpus erinaceous) in Bole, Central, West and North Gonja Districts of the Northern Region. Analysis of the international trade in Pterocarpus Erinaceus and its consequences in West Africa.
9. Brockerhoff, E.G., Barbaro, L., Castagneyrol, B. et al. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodivers Conserv 26, 3005–3035 (2017).
10. Brockerhoff, E.G., Barbaro, L., Castagneyrol, B. et al. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodivers Conserv 26, 3005–3035 (2017).
11. Doso, S. Jnr. 2014. Land degradation and agriculture in the Sahel of Africa: causes, impacts and recommendations. J. Agric. Sci. Appl. Volume 3, Issue 3.
12. Dumenu, W.K. and Bandoh, W.N. 2016. Exploitation of African rosewood (Pterocarpus erinaceus) in Ghana: a situation analysis. Ghana J For 32: 1-15.
13. Duvall, C.S. 2008. Pterocarpus erinaceus Poir. https://www.prota4u.org/database/protav8.asp?g=pe&p=Pterocarpus+erinaceus+Poir. Accessed 8 Marh 2023.

14. FAO and UNEP. 2020. *The State of the World's Forests 2020. Forests, biodiversity and people*. Rome. .https://doi.org/10.4060/ca8642en.

15. FAO. 2019. Restoring Forest landscapes through assisted natural regeneration (ANR) – A practical manual. Bangkok. 52 pp. License: CC BY-NC-SA 3.0 IGO.

16. Gambia Bureau of Statistics (GBOS) and ICF International. 2014. The Gambia Demographic and Health Survey 2013. Banjul, The Gambia, and Rockville, Maryland, USA: GBOS and ICF International.

17. Gambia Bureau of Statistics. (2013). Population and Housing Census report.
18. Holl KD, Loik ME, Lin EHV, Samuels IA (2000) Tropical montane forest restoration in Costa Rica: overcoming barriers to dispersal and establishment. Restoration Ecology 8:339–349.

19. Hosonuma, N.; Herold, M.; De Sy, V.; De Fries, R.S.; Brockhaus, M.; Verchot, L.; Angelsen, A.; Romijn, E. An assessment of deforestation and forest degradation drivers in developing countries. *Environ. Res. Lett.* 2012, *7*, 44009.

20. IUCN, 2021. Deforestation and forest degradation. In Matti Palo and Erkki Lehto 2003. African deforestation: causes and 10542-B1.

21. Jolly, W. M., Cochrane, M. A., Freeborn, P. H., Holden, Z. A., Brown, T. J., Williamson, G. J., et al. 2015. Climate-induced Variations in Global Wildfire Danger from 1979 to 2013. *Nat. Commun.* 6, 7537. doi:10.1038/ncomms8537.

22. Kissinger, G.; Herold, M.; De Sy, V. 2012. *Drivers of Deforestation and Forest Degradation: A Synthesis Report for REDD+ Policymakers*; The Government of the UK and Norway: Vancouver, BC, Canada.

23. Lakerveld, R. P., Lele, S., Crane, T. A., Fortuin, K. P. J., and Springate-Baginski, O. 2015. The social Distribution of Provisioning Forest Ecosystem Services: Evidence and Insights from Odisha, India. Ecosystem Services 14: 56–66.

24. Langat, D. K., Maranga, E. K., Aboud, A. A.,and Cheboiwo, J. K .2016. Role of Forest Resources to Local Livelihoods: The Case of East Mau Forest Ecosystem, Kenya. International Journal of Forestry Research 2016.

25. Lely, H. V. 1925. The useful trees of northern Nigeria. Crown Agents for the Colonies, London.

26. Maisharou, A., Chirwa, P.W., Larwanou, M., Babalola, F., and Ofoegbu, C. 2015. Sustainable land management practices in the Sahel: Review of Practices, Techniques and Technologies for Land Restoration and Strategy for Up-scaling. The International Forestry Review. Vol. 17, Supplement 3: Special Issue: Climate change and forestry in Africa (2015), pp. 1-19 (19 pages).

27. Maxwell SL, Evans T, Watson JEM, Morel A, Grantham H, Duncan A, et al. (2019) Degradation and forgone removals increase the carbon impact of intact forest loss by 626%. Science Advances 5:eaax2546.

28. Murdiyarso, D.; Skutsch, M.; Guariguata, M.; Kanninen, M. Measuring and monitoring forest degradation for REDD: Implications of country circumstances. *Cifor Infobriefs* 2008.

29. Orwa C, A Mutua, Kindt R , Jamnadass R, S Anthony. 2009 Agroforestree Database: a tree reference and selection guide, version 4.0. available at http://www.worldagroforestry.org/treedb/AFTPDFS/Pterocarpus_erinaceus.PDF, accessed 20th Sept 2022.

30. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. 2009. Agroforestree Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/treedb/AFTPDFS/ Pterocarpus_ erinaceus.pdf. Accessed 5 Mar 2023.

31. Ouédraogo A, Thiombiano A, Hahn-Hadjali K, Guinko S. 2006. Diagnostic de l'état de dégradation des peuplements de quatre espèces ligneuses en zone soudanienne du Burkina Faso. Sécheresse 17: 485-491. French.

32. Paine CET, Beck H, Terborgh J (2016) How mammalian predation contributes to tropical tree community structure. Ecology 97:3326–3336.

33. Pan Y, Birdsey RA, Fang J, Houghton R, Kauppi PE, Kurz WA, et al. (2011) A large and persistent carbon sink in the world's forests. Science 333:988–993.

34. Smith, P., Calvin, K., Nkem, J., Campbell, D., Cherubini, F. and Nkonya, E.M. 2020. Which practices co-deliver food security, climate change mitigation and adaptation, and combat land-degradation and desertification? Global Change Biology 26(3): 1532-1575.

35. Sunderland, T. C. and Rowland, D. 2019. "Forests, land use, and challenges to climate stability and food security," in Sustainable Food and Agriculture, Elsevier, pp. 95-116.

36. Terborgh J, Nuñez-Iturri G, Pitman NCA, Valverde FHC, Alvarez P, Swamy V, Pringle EG, Paine CET (2008) Tree recruitment in an empty forest. Ecology 89:1757–1768.

37. Tropicultura,2017,35, 2, 73-86.

38. Tyukavina A, Potapov P, Hansen MC, Pickens AH, Stehman SV, Turubanova S, Parker D, Zalles V, Lima A, Kommareddy I, Song X-P, Wang L and Harris N. 2022. Global Trends of Forest Loss Due to Fire From 2001 to 2019. *Front. Remote Sens.* 3:825190. doi: 10.3389/frsen.2022.825190.

39. USAID. 2017. COMMUNITY-BASED LOW-COST ASSISTED NATURAL REGENERATION A Management Strategy based on Lessons Learned from Rampur landscape, Himachal Pradesh.

40. Vihervaara, P., Marjokorpi, A., Kumpula, T., Walls, M.,and Kamppinen, M. (012) Ecosystem Services Of Fast-Growing Tree Plantations: A case Study on Integrating Social Valuations with Land-Use Changes in Uruguay. Forest Policy and Economics 14: 58–68.

41. Watson JEM, Evans T, Venter O, Williams B, Tulloch A, Stewart C, et al. (2018) The exceptional value of intact forest ecosystems. Nature Ecology and Evolution 2:599–610.

42. Winrock. 1999. A quick guide to multipurpose trees from around the world: Pterocarpus erinaceus: an important legume tree in African savannas. Forest, Farm and Community Tree Network (FACT Net) FACT Sheet, FACT 99-03, June 1999.

43. Zarin D.J, et al. Legacy of fire slows carbon accumulation in Amazonian forest regrowth. *Front. Ecol. Environ.* 2005;3: 365–369.