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**HABITAT PREFERENCE AND DISTRIBUTION PATTERNS FOR
HELICHRYSUM SPECIES IN RWANDA.**



A thesis submitted in partial fulfilment of the requirements for the degree of Master in Biodiversity Conservation and Natural Resources Management.

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Kigali, October 2024

DECLARATION

I, Enock Ndayishimiye declare that this master's dissertation "**Habitat preference and distribution patterns for Helichrysum species in Rwanda**" is the result of my own work in partial fulfilment of the requirements for the award of a master's degree in Biodiversity Conservation and Natural Resource Management at the University of Rwanda, College of Science and Technology and has not been submitted for any other degree at the University of Rwanda or any other institution. All sources that I have used or quoted have been indicated and acknowledged in the references.

Date: 22nd October, 2024

Signed by:

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APPROVAL

I certify that this research project entitled "**HABITAT PREFERENCE AND DISTRIBUTION PATTERNS FOR HELICHRYSUM SPECIES IN RWANDA**" was done under my supervision and has been submitted for examination with my approval.

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DEDICATION

I dedicate this work to:

- The Lord God, The Lord Jesus Christ, and The Lord Holy Spirit.
- To my parents, sisters and brothers.
- To my Supervisor, Professors, and Fellow Students.
- To my friends.

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LIST OF ACRONYMS

RBD: Rwanda Development Board

REMA: Rwanda Environment Management Authority

SDM: Species Distribution Modelling

ENM: Ecological Niche Modelling

MINAGRI: Ministry of Agriculture and Animal Resources

NHR: National Herbarium of Rwanda

GBIF: Global Biodiversity Information Facility

GPS: Global Positioning System

ABSTRACT

Rwanda as a country located in the East Africa has different areas which are the hotspot of endemic plants species including *Helichrysum* species. The mountainous forests of the country are most areas in which *Helichrysum* species are diverse and distributed. The habitats of *Helichrysum* in Rwanda are located in the protected areas and non-protected areas. The habitats of *Helichrysum* in the non-protected areas have been experiencing destruction and fragmentation of habitat, which has been identified as a serious danger to biodiversity. Nevertheless, earlier research on plant conservation in East Africa disregarded unprotected areas in favour of protected ones. Understanding the distribution patterns and preferred habitats of plants in Rwanda will be crucial for developing future conservation plans for small plant species like *Helichrysum*. The locations can exhibit distinct characteristics in terms of its climate and ecology. To obtain the information on the characteristics of areas and habitats occupied by *Helichrysum* species in Rwanda, we carried out a field study in three National Parks (Nyungwe National Park, Volcanoes National Park, and Gishwati-Mukura National Park). To obtain crucial information on the chorology, species richness and habitats of *Helichrysum*, we examined numerous specimens from Global Biological Information, National Herbarium of Rwanda, and different literature which facilitated the identification of *Helichrysum* species occurred in the four climatic zone (the Eastern zone, the Western and Northern Highland zone, the Central Plateau zone, and the Lake Kivu side zone) of Rwanda. The results of the study showed that *Helichrysum* species are distributed in all the climatic zones and in both protected and non-protected areas of the country with 31 species. The protected areas (Nyungwe National Park and Volcanoes National Park) characterized with high mountainous forests and wet climate, and ericaceous belt at the top, are the most dominated areas with more than 20 *Helichrysum* species by each. The Akagera National Park has a lowest number of *Helichrysum* species with one species. In this study, non-protected areas were considered by district as their administrative units. The high number of *Helichrysum* occurred in non-protected areas are located in Huye and Nyamagabe districts with 10 species each, followed by Nyamasheke district with 10 species. Huye district has a part in the Central Plateau climatic zone which were found to be the third climatic zone in rich of *Helichrysum* species with 9 species after the Western and Northern High Lands with 31 species and 15 species in the Lake Kivu side. *Helichrysum forskhalii* was found the most distributed species in all the parts of Rwanda, while *Helichrysum newii* was found to be dominant in the high mountain areas of the Volcanoes National Park. The areas of Rwanda have a diverse of ecosystems in which *Helichrysum* species can have suitable habitats. The results showed that the ecosystems including forests, shrub lands, marshlands, supraforestral ericoid belt and savannah are the preferable and suitable habitats for *Helichrysum* species. Forest lands had 28 species, shrub lands had 23 species, while the rocky slope areas had a lowest number of *Helichrysum* with 9 species. The conservation initiatives in the future should focus on the scattered forest lands which are not protected and the shrub lands around the roadsides where small plants like *Helichrysum* have more suitable and preferred habitats. The further researches should consider the determination of the phytochemical and biological activities of *Helichrysum* species in Rwanda. This study will be helpful in the planning of strategies toward the conservation of *Helichrysum* in Rwanda.

Key words: habitat preference, distribution patterns, ecosystems, climatic zones, *Helichrysum* species, adaptation.

CHAPTER 1. INTRODUCTION

1.1. Background

A comprehensive knowledge of diversity of species, preferred habitats, and pattern of distribution within an area facilitate in developing effective conservation plans. The evaluation of the habitat and occurrence patterns of species goes origins from the early 1700s. It has been highlighted that from the Equator to the Pole, there is a variety of species and their distribution ranges (Forster et al., 1778). The distribution of plant species in different areas is influenced by different factors including the environmental conditions (rainfall, soil type, and temperature) of the area and habitat preference of the species (Humboldt, 2005). Plants could prefer diverse habitat depending on its survival ability in the habitat (Comita et al., 2007). In Rwanda, plants show exhibit a variation in locations due to many factors of geographical areas. The climate, topography, soils and biological richness of Rwanda facilitate many plant species to adapt in Rwanda (Gatwaza and Xiangrong, 2021). The basic influencing environmental factors of plant distribution are temperature and rainfall. It is very crucial to consider these environmental factors in the study of plant species distribution. In Africa; the afro-montane and afro-alpine regions are the known for having a high diversity of plants. Rwanda is located in these regions, and is one of the hotspot of biodiversity and their natural habitats maintain many natural populations of different species that *Helichrysum* species are included in. *Helichrysum* species are native to many regions around the world, including Europe, parts of Asia, and Africa. According to a first research in Flore d'Afrique Centrale and several herbarium databases, many *Helichrysum* species occur in the Volcanoes National Park, Nyungwe National Park, Gishwati-Mukura National Park and their surrounding areas. These areas of Rwanda host a big diversity of plants and animals which play different ecological functions, and provide various ecosystem services. *Helichrysum* species contribute to various ecosystem service such as soil stabilization, pollinator support, and nutrient cycling in their natural habitats. There is a limited information on the habitat preferences of these species in Rwanda, and how they are spatially distributed in the country as well as their adaptabilities into their environment. This study was aimed to determine the habitat preference and distribution patterns of *Helichrysum* species in Rwanda. This information will make it easier to define future conservation goals for the *Helichrysum* species in Rwanda based on their occurrence and habitats.

1.2. Problem Statement

Helichrysum is a flowering plant genus from the sunflower family (Asteraceae). The genus *Helichrysum* has roughly 500-600 globally distributed species (Hillard, 1983). The term *Helichrysum*

refers to the generally brilliant yellow cluster or group of blooms seen on various species within the genus, originates from the Greek word “helios,” which means sun, and “chryos,” which means gold. These species are classified as xerophytes (plants which have evolved to be capable to withstand severe drought). Several kinds of *Helichrysum* are utilized in traditional treatments in South Africa (Lourens et al., 2008). Several species of the *Helichrysum* genus were utilized in conventional health care in Rwanda and Burundi to cure diarrheal illness. *Helichrysum forskhalii* was found to treat bacteria (Kajangwe et al., 2008). However, specific habitat and spatial distribution information for these species in Rwanda would require further research. This research was aimed to fill the information gap on the *Helichrysum* species existing in Rwanda.

1.3. Objectives

1.3.1. Main objectives

The main objective of this study was to determine the habitat preference and spatial distribution of *Helichrysum* species in Rwanda.

1.3.2. Specific objectives

The specific objectives of this research were:

1. To study the chorology and specie richness of *Helichrysum* species occurred in Rwanda.
2. To characterize the distribution patterns and habitat preferences of *Helichrysum* based on their occurrences, altitudinal ranges and ecosystem features.

CHAPTER II. LITERATURE REVIEW

2.1. Brief morphological description of *Helichrysum* species.

There are about 600 *Helichrysum* species largely in Africa and Madagascar, but also in Europe, Asia and Australia. In southern Africa there are 245 species which are widely distributed. There is a considerable variety of form and habit in this genus which includes annual herbs, perennial herbs, sub-shrubs, and shrubs. They all bear the glossy, papery flowers, that are found in a wide range of colours (white, yellow, red, and gold) and in single and double forms. *Helichrysum* species in Rwanda have adapted in all climatic zones of the country.

2.2. Technics of studying habitat preferences and distribution patterns of species

The study of species distribution has a long history. This study involves the description, comprehending and forecasting of geographical locations and environmental requirements of species (Sutherst R.W, 2014). Different techniques for modelling distributional locations based on associations between observed occurrences and environmental factors have been designed (Seberon & Nakamura, 2009). The species distribution modelling (SDM) has different terminologies (Heads, 2015) including ecological niche or environmental modelling (its goal is to predict the species' ecological niche by using factors that exist its environment); predictive habitat distribution modelling (they use metrics to correlate the geographical location of species or population with their current habitats) (Barbosa et al., 2012); habitat modelling (they evaluate whether a species is suitable for a given habitat).

2.2.1. Ecological niche or Environmental modelling

In the field of ecology, Niche modelling also called ecological niche modelling (ENM) is a potent technique for comprehending the distribution of species and environmental requirements (Elith & Leathwick, 2009). By studying the interaction between a species' biological requirements and environmental variable, niche modelling makes predictions about a species' possible distribution basing on the species' known occurrence and environmental variables (Franklin, 2010; Peterson et al., 2011; Barbosa et al., 2012; Guisan et al., 2017). Because it makes it possible to forecast and comprehend species distribution patterns based on environmental variables; niche modelling is essential to ecological study. The possible effects of habitat loss, climate change, and other environmental stressors on species survival and biodiversity are evaluate with the use of this predictive tool (Gengping et al., 2013. Niche modelling aids in the development of efficient conservation plans and habitat restoration initiatives by clarifying the ecological requirements of species. It offers insightful information about the suitability of a species' habitat, influencing

decisions about land management and setting priorities for conservation (Guisan et al., 2017). Niche modelling promotes a greater knowledge of complex ecological systems by helping to research species interactions, community dynamics, and ecosystem resilience (Peterson, 2006). Niche modelling is important for epidemiology in wildlife and veterinary medicine. By taking into account both biology of the pathogen and the uncertainty of the data that is currently accessible, it enables us to anticipate disease distribution (Escobar, 2020).

2.2.2. Predictive habitat distribution modelling.

It is a technique of using statistics and probability in nature to produce models which interrelate the distributions of species with their current habitat characteristics. Most statistical methods such as Generalized Linear Models (GLM) and Ordinary Multiple Regression are applied to perform the models of species distribution in geographic locations. The predictive habitat distribution modelling is based on the quantification of the interconnection between the species and their environment. These models are very important in ecology to study the effects of climate on plants and animals within their habitats. The models are also applied in the evaluation of land uses and environmental alterations on species distribution and habitat patterns (Guisan et al., 2017; Barras et al., 2021).

2.3. Factors to consider in species distribution modelling

2.3.1. Occurrences of plant species

2.3.2. Environmental factors.

Environment factors such as rainfall, temperature, topography, and soil characteristics are the major drivers of plants species distribution in geographic areas where species could find its habitat (Elith & Leathwick, 2009). The suitability of the species in habitats is greatly influenced by the annual rainfall, geographic features and ecology. The habitat suitability of the plant species reads to different patterns and spatial arrangement of plants (Majeed et al., 2021).

2.3.3. Biome of an area

To choose appropriate locations for species to live, they take into account surroundings including vegetation, terrain, and climate (Guisan & Zimmermann, 2000); Bioclimatic envelope modelling (they estimate the surroundings in which a species is likely to exist using data on climate. They produce a “envelope” of climate that is ideal for the species) (Thuiller et al., 2005) and Climate envelope modelling (they highlight how the distribution of species can be predicted using climatic data) (Araújo et al., 2012). SDM has been extensively utilized in key biogeographic fields such as studying species distribution, diversity trends, historical biogeography, eco-regional classification, conservation evaluation, and estimating the implication of future world change.

2.4. Importance of studying the plant species distribution.

Given its numerous role in affecting the functioning of ecosystems and the protection of biodiversity (van der Plas, 2019), the study of plant species distribution is essential to ecological studies and conservation initiatives (Guissan et al., 2013). It serves as a basis for well-informed decisions about conserving biodiversity, management of ecological systems, and efficient utilization of resources, all of which improve the sustainability and health of the natural environment (Villero et al., 2017). Developing knowledge about the spatial distribution trends among plant species can help with the following important topics such as conservation, restoration, biodiversity assessment, species interaction, and climate change impact (Elith & Leathwick, 2009). Conservation actions may decide critical locations for ecosystem preservation and rehabilitation by considering plant species distribution (Peterson et al., 2011). Developing techniques to protect endangered species and maintain areas of high biodiversity is made easier when one is aware of the location of particular plant species (Guissan et al., 2013). Initiatives aimed at restoring ecosystems require and understating of distribution of plant species. By reintroducing native plant species to places where they have disappeared, rehabilitation activities can be more precisely managed ad strategically planned, improving the resilience ad performance of ecosystems. Studies on the distribution of plant species are crucial for determining the extent of biodiversity in an environment. Tracking shifts in the distribution of plant species over time assists in identifying possible threat to biodiversity and offers important insights into the health of ecosystems. The distribution of plant species can provide information about the interactions between different species in an environment. It is useful for exploring pollination networks, food systems, and other ecological connections that support the equilibrium and function of ecosystems. Information on the distribution of plant species are additionally useful to evaluate how ecosystems are being affected by climate change. Distribution shifts of plants may serve as a sign of changing climate regions and the need for responsive management approaches to reduce the impact of climate change on biodiversity.

Chapter 3. MATERIALS AND METHODS

3.1. Study area

This study carried out in Rwanda, a country of African continent in the central-east region of the continent. Rwanda is located between the latitude 2°00 S and the longitude 30°00 E. Rwanda has a tropical climate that is tempered by its mountainous landscape, which varies from 900 to 4507 m and extends from the east to the west, considering its closest position to the equator (Muhire et al., 2015).

The places concerned in this study are the areas of plant species hotspot in Rwanda which include Nyungwe, Volcanoes, and Gishwati-Mukura National Parks. These parks are known for having biodiversity hotspot in the East African region where Rwanda is located (Kalisa et al., 2019). The existence of remote mountains and high ridges is the cause for this abundance of biodiversity (Wang et al., 2020). Rwanda's habitats and ecosystems (Figure 4) are broad, comprising tropical mountain forests to savannahs, streams, lakes, and wetland ecosystem all of that sustain a variety of animals and plant species (REMA. 2018). Plants species in Rwanda are diverse with over 3,000 species of plants hailing across different bio-geographical areas (Fischer and Killmann. 2008). Most of these plants are rare to the Albertine Rift, with over 280 of them classified endemic in Rwanda (Fischer & Killmann, 2008). Rwanda boasts 56 native endemic flowering species, 47 of that belong to Nyungwe National Park (REMA, 2008). Nyungwe National Park is the one of the afro-montane areas of Rwanda along with Volcanoes and Gishwati-Mukura National Parks, and other tiny forestlands located in the Congo-Nile Ridge. These areas provide a niche for diverse and abundant plant species. Among plant species found in different areas of Rwanda, *Helichrysum* species are distributed in the Afromontane and diverse ecosystems include wetlands, grasslands, shrublands including the ericoid supraforestral belt, forest edges and hillsides, and savannah in Rwanda. According to a first research in Flore d'Afrique Centrale and several herbarium databases, many *Helichrysum* species occur in the Volcanoes National Park, Nyungwe National Park, Gishwati-Mukura National Park and their surrounding areas.

3.1.1. Nyungwe National Park

Nyungwe National Park (Figure 1) is located in the highlands of southwest region of Rwanda (Musabe. 2002) about 2°15' South, and about 2°30' and 29°29' East, at an elevation ranging from 1600 m to 2950 m (Plumptre et al., 2002).

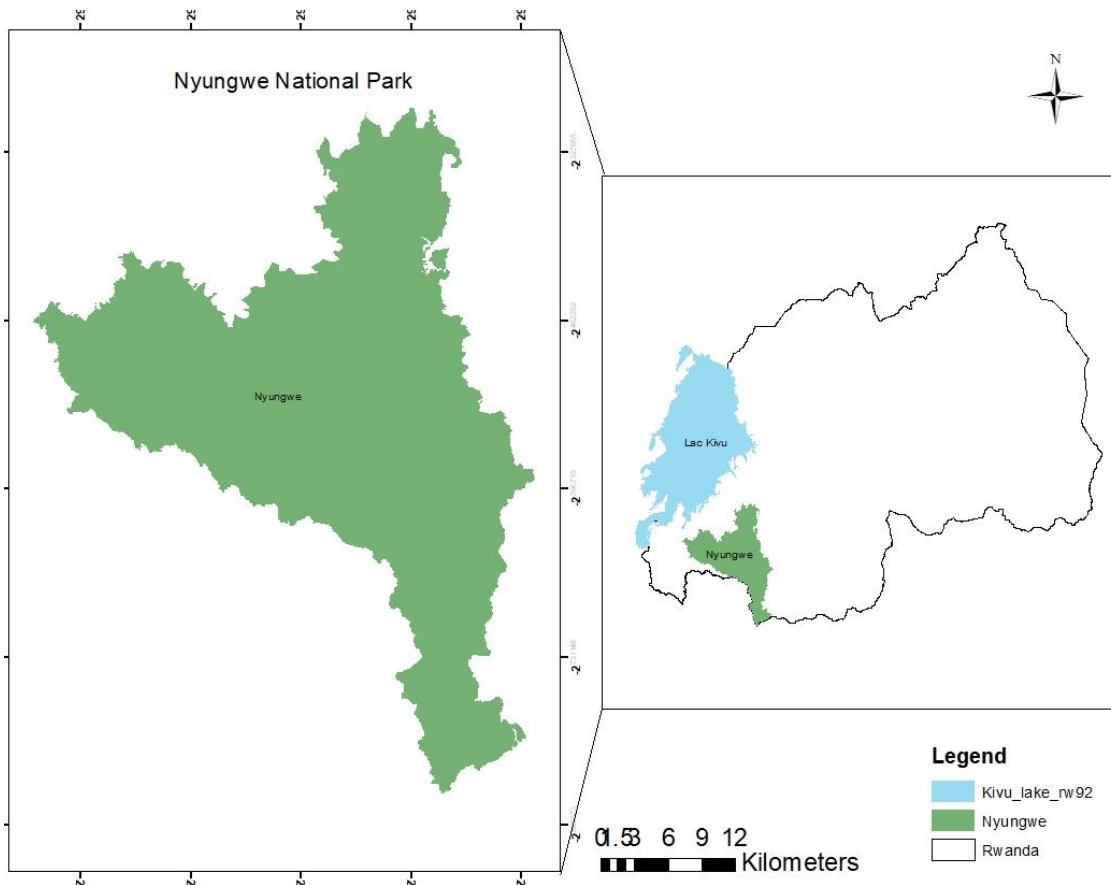


Figure 1: Map of Nyungwe National Park

Nyungwe National Park is a vast and varied highland rainforest made up of a combination of forests that are both primary and secondary. This park is known for being more diverse in biodiversity along with other mountain rainforests in central part of Africa (Plumptre et al., 2002). Nyungwe includes one of the greatest units of lower mountain forest in Africa along alongside the continuous forest in Kabira National Park, Burundi (Weber, 1989; Vedder et al., 1992). Massive areas of forest between 1,600 and 2,950 meters of elevation can be found in Nyungwe; not many other woodland regions in Africa do the same (Butynski et al., 1997). Nyungwe National Park plays an important role in the central region of Africa for the conservation of the rainforests because of its size and location at these elevations. Nyungwe is home to a diverse range of wildlife and plants, although being less species abundant than a few other forests in the Albertine Rift (Butynski et al., 1997; McNeilage et al., 1998, Omari et al., 1999). According to Dowsett (1990), Nyungwe is home to around 260 species of plant species, at least 24 of which are thought to be indigenous to the Albertine Rift. Nyungwe has a diverse range of flora and wildlife because to animal migration and seed dissemination. Given that it serves as the home to numerous species of both animals and plants, any action that is properly carried out in this geographical region should take biological variety preservation into account. This study was carried out in this forest to identify the distribution patterns and habitat preference of *Helichrysum* species believed to be found in Nyungwe forest as it is a geographic area characterized by

environmental factors (high rainfall, high altitude, and low temperature) which favors the survival of *Helichrysum* of afro-montane regions.

3.1.2. Volcanoes National Park

Volcanoes National Park (Figure 2) is located in northern to western parts of Rwanda, one each side of Congo-Nile about 1600-2900 meters of elevation, and to the south on the crest line of volcanic cones around 2300 meters to 4500 meter of elevation.

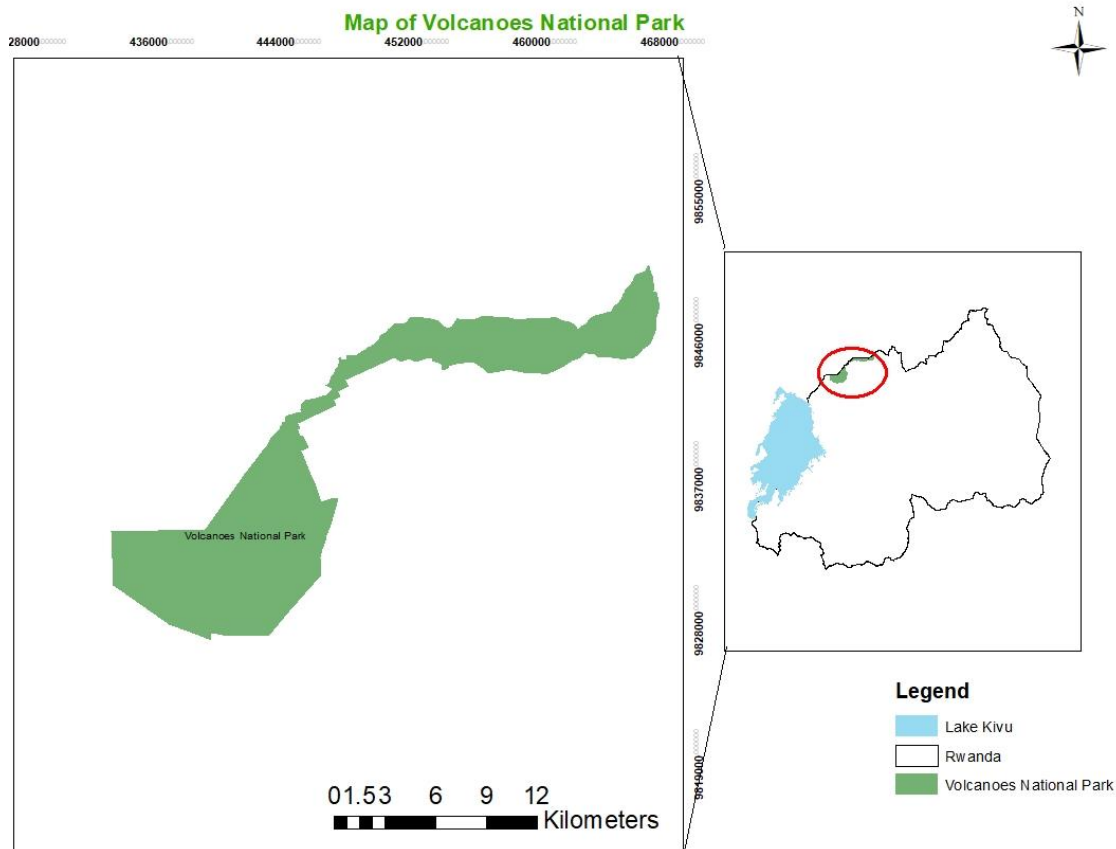


Figure 2: Map of Volcanoes National Park

Volcanoes National Park is placed in the Albertine Rift, a region known for having a hotspot to biological diversity along many indigenous and endangered species of plants and animals (Plumptre et al., 2007). This area is particularly important since it has the world's only population of the mountain gorillas surviving in the wild (Weber and Vedder, 1983). Due to the mountainous terrain, the study area's annual warmth (11-18°C) and precipitation (1700-1800 mm), these locations are more temperate than the hot and humid equatorial regions nearby despite having comparable annual cycles (Seburanga et al., 2014). The plant life found in Volcanoes National Park includes mountain forests, grasslands, bushes, marshes, wetlands, and humid forests that are distributed over various altitudinal levels. At 3300 meters of elevation, the average annual rainfall can reach 2000 mm. The weather of this area is cooler and more humid than other areas in Rwanda such as the capital city of Kigali

experiences an average yearly temperature of 19°C, with variations in temperature depending on the terrain of the country. The Volcanoes National Park has a chain of five Quaternary volcanic mountains, ranging in elevation around 3500 to 4500 meters. They are Mount Kalisimbi, Mount Bisoke, Mount Muhabura, Mount Sabyinyo, and Mount Gahinga, which are also a component of the catchment that separates the Nile and Congo River basins.

3.1.3. Gishwati-Mukura National Park

Gishwati-Mukura National Park is a disconnected highland rainforest in Rutsiro and Ngororero districts in Rwanda's western province (Figure 3). Its coordinates are latitude -1.821307°, longitude 29.356296°, and latitude -1.982464°, longitude 29.504869°. Its elevation ranges from 2000 to 2700 meters above sea level. The park is made up by two distinct forests, the larger is Mukura with area of 19.8 square kilometres) and the smaller is Gishwati with area of 15.7 square kilometres. The park has a total size of 35.5 squared kilometres.

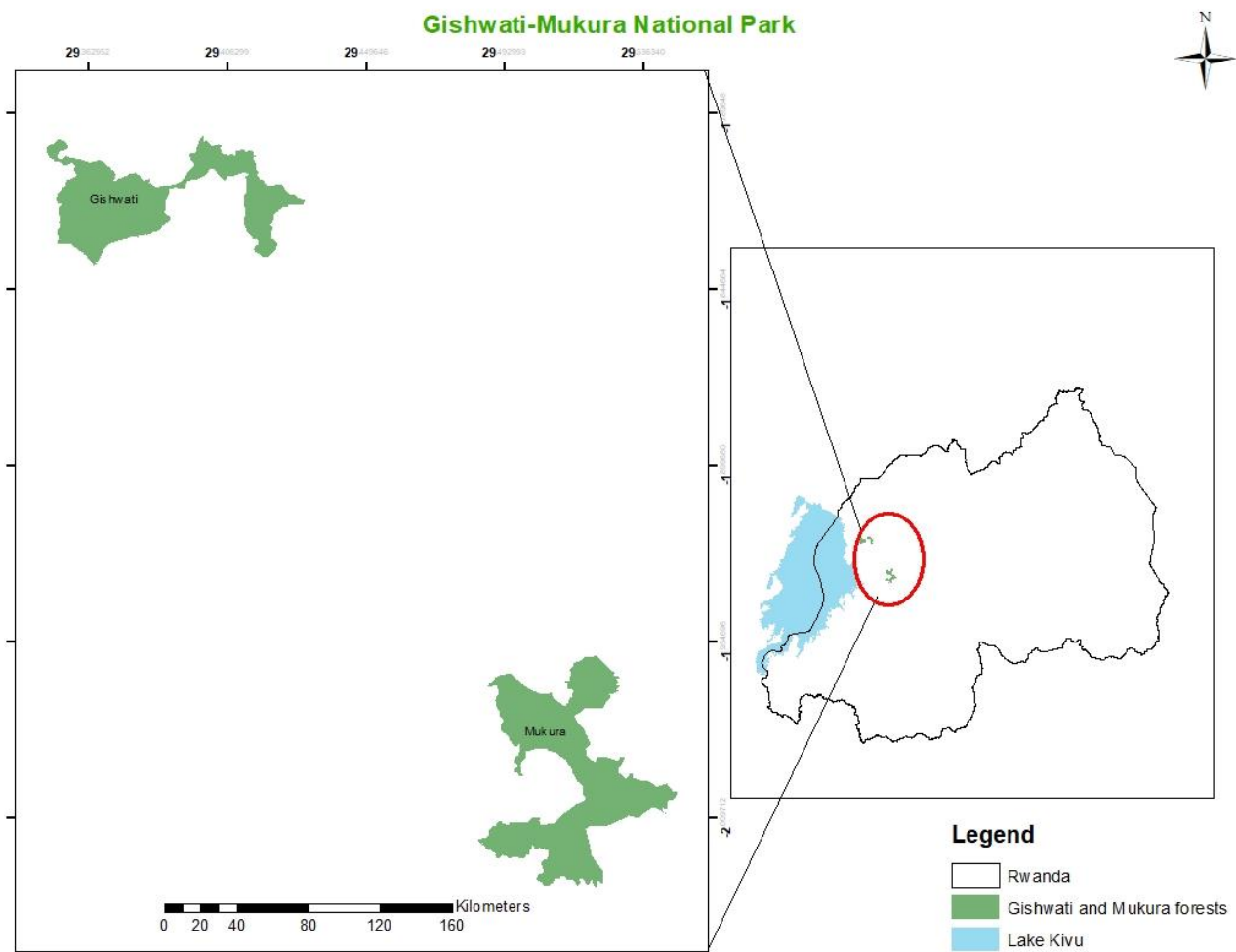


Figure 3: Map of Gishwati-Mukura National Park

The park is located in the tropical Afrotropical part of the East African region. Gishwati-Mukura National Park is among the hotspots of biodiversity found in the Albertine Rift region which has

different habitats for several species that are endemic to the region (Plumptre et al., 2004). Before the 1980s, the park was covering a landscape of around 25.3 thousand hectares. However, because of various human operations, such as illicit mining, crop cultivation, livestock raring, and habitations, the landscape of the park has dropped to around 3.6 thousand hectares (Arakwiye et al., 2021).

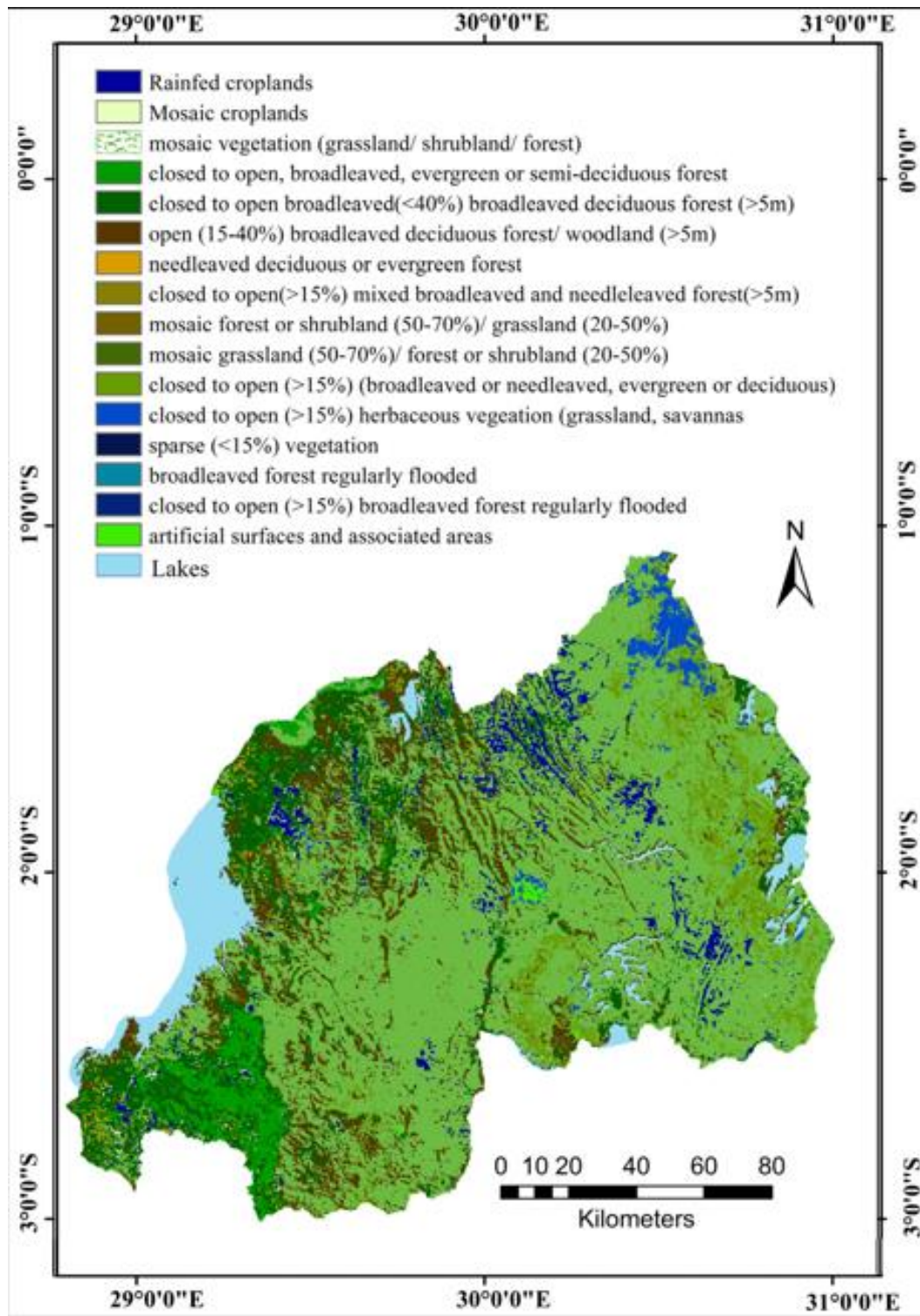


Figure 4: Spatial distribution of different vegetation types in Rwanda

Source: Ndayisaba et al, 2016

3.2. Methods

3.2.1. Data collection

All *Helichrysum* species detailed in the Flora of Tropical East Africa (Thulin, 1984), Knox and Pócs (1992) and Knox and Palmer (1998) which are distributed in Rwanda were described in this study. To gather the information on the habitat and distribution areas of each species, we dug into the previous surveys (Mabberley 1975; Thulin 1984; Knox and Pócs 1992; Agnew and Agnew 1994; Beentje et al. 1994; Knox and Palmer 1998; Knox et al. 2004; Zhou et al. 2017; Zhou et al. 2018), voucher specimens in the National Herbarium of Rwanda, and voucher specimens from the online herbaria Global Biodiversity Information Facility. Field data of *Helichrysum* species were collected in natural areas of Nyungwe National Park, Volcanoes National Park and Gishwati-Mukura National Park. During field data collection, a direct observation of species was purposely used to collect specimens of species along parks' trails and roads toward visited national parks (Figure 5)



Figure 5: Occurrence points of *Helichrysum* species during field observation

For each species collected, its specimen has been deposited to the National Herbarium of Rwanda. The specimens should be used in the future to further identification and exploring the difference in morphological features of the species. The Collection of data on the habitat, distribution area, and altitudinal range of *Helichrysum* species. Based on the field observations, different searches in herbaria online data bases, and literature search, we provided detailed information on habitat preferences, distribution patterns, and altitudinal range of each studied species. A total number of 250 *Helichrysum* specimens have been used to gather the information on their habitat preference and distribution patterns in Rwanda. The information has been collected from the specimens downloaded from GBIF (with 124 specimens, 66 specimens from field, and 60 from NHR (Figure 6)

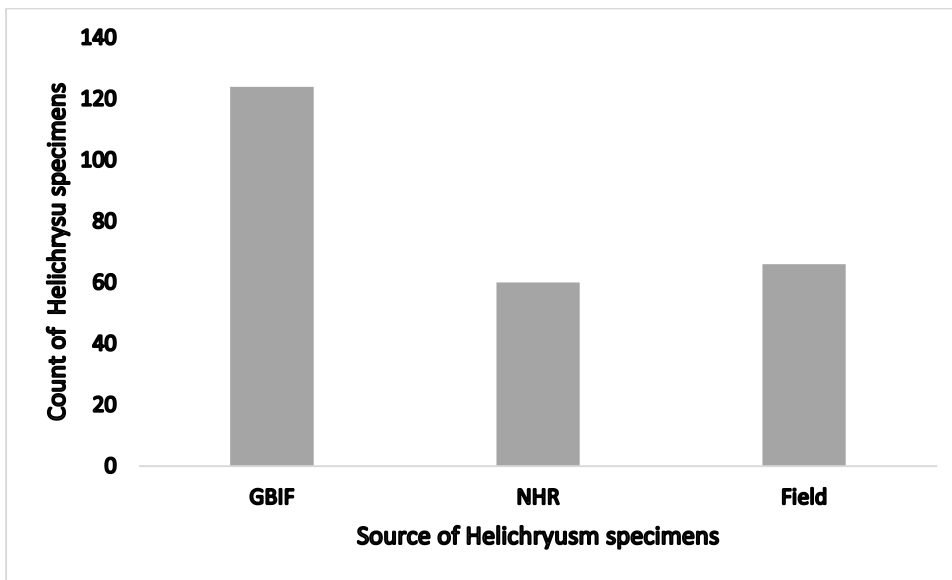


Figure 6: Counts of collections of specimens

3.3. Materials

Pruning shears to collect the plants. Plant presses to dry the plants and prepare herbarium specimens. GPS to get coordinates and altitude of collection sites. Photographic camera to take pictures of the plant specimens collected and their habitat. Books and online herbaria platforms have been used to check and to maximize the habitat and distribution data of *Helichrysum* species in Rwanda.

3.4. Data analysis

Data recording and preparation were done using Microsoft Excel. Data visualization was helped by R-studio to determine the diversity, richness, habitats, distribution and altitudinal range of *Helichrysum*. Google map was used to check the localities of retrieved voucher specimens from visited herbaria.

CHAPTER 4: RESULTS

4.1. Diversity of *Helichrysum* species found in Rwanda

Helichrysum species are represented by 31 species (Table 1) and distributed in mostly in Protected areas of Rwanda. The results showed that the three protected areas (Nyungwe National Park, Volcanoes National Park, and Gishwati-Mukura National Park) provide diverse habitats (table 1) to 55 species of *Helichrysum* species (Table 2). *Helichrysum* species have different biological forms including herbs, shrubs and sub-shrubs. Based on the rainfall patterns and the landscape of Rwanda, Rwanda has four climatic zones which include the Eastern plains zone, the central plateau zone, the western and northern highland, and the Lake Kivu side zone (Table 1). The most widely distributed *Helichrysum* is *Helichrysum forskahlii* (J.F. Gmel.) Hilliard & Burt due to that it can grow in areas with altitudinal range of 1000-4200 m (Table 1).

4.2. Characteristics of climatic zones of Rwanda and their richness of *Helichrysum* species.

The climatic zones of Rwanda have distinct characteristics including the temperature range, rainfall patterns, altitudinal ranges, topographic features, and vegetation types which greatly read to the existence of diverse habitats in which different *Helichrysum* species can adapt. These climatic zones are the Eastern plains, the Central Plateau, the Western and Northern highland, and the Lake Kivu side zone. The results of this study showed that the climate and the land uses of have contributed on the distribution of some *Helichrysum* species in more than one climatic zones of Rwanda.

1. The Eastern plains which has an altitudinal range of 1000-1500 m. The Eastern plain zone is very warm and moderate dry. The annual average temperature varies in 20° C to 22 ° C, while the annual rainfall ranging from 700 mm to 1100 mm. The Eastern plain zone comprises various habitats which support the life of different plant species. Those habitats in this zone are corridor woodlands; savannah with grasses, bushes, and trees; forests surrounding lakes along with other bodies of water (Twarabamenye and Gapusi 2000 in MINITERE 2003a). These forests are home to 66 different species of plants, including *Acacia kirkii*, *Teclea nobilis*, *Erythrina absyssiica*, *Albizia gummifera*, *Dombeya burgessia*, *Newtonia buchananii*, *Cordia Africana*, and *Dombeya kirkii* (MINAGRI. 1998). Additionally, there are a few endangered or rare species such as *Eulophia guineensis*, *Pterygota mildbraedii*, *Impatiens irvingii*, and *Markhamia lutea* (MINAGRI 1998). With these climatic factors and habitat types of the Eastern plains, a few number of *Helichrysum* species have adapted in this area. *H.mechowianum* var. *ceres* (S.Moore) Beentje, *H. nudifolium* var. *oxyphyllum* (DC.) Beentje, *Helichrysum coriaceum* Sond, and *H. nudifolium* var. *nudifolium*. Mount Kibwara, fallow land on defland, shrubs around Gashikiri hill provide the habitat for *Helichrysum coriaceum*.

H. mechowianum var. *ceres* (S.Moore) Beentje inhabit in grassy savannah on almost deep ground, shrubby savannah on rocky soil, roadside embankment, and summit of Gafumba hill, fallow land and stony ground. *H. nudifolium* var. *oxyphyllum* (DC.) Beentje, and *H. nudifolium* var. *nudifolium* are mostly grow in marsh's buffer zone with *Erica spp*, savannah with *Acacia* species, forest on hillside, clearings in *Erica/Philippia* and *Hypericum* thicket (up to 4-5 m tall) with broadleaved small trees, open shrub land of *Erica /Philippia* and *Helichrysum* species, *Alchemilla* and grasses.

2. The central plateau zone has the average annual temperature which varies from 19°C to 20°C, while its rainfall is in the range of 1000 and 1200mm. The altitudinal range of the central plateau is 1500-2000m. *Helichrysum odoratissimum* (L.) Sw, *Helichrysum nitens* subsp. *robynsii* (De Wild.) Lisowski, *Helichrysum panduratum* O.Hoffm., *Helichrysum ruandense* Lisowski, *Helichrysum schimperi* (Sch.Bip. ex A.Rich.) Moeser, and *Helichrysum foetidum* var. *microcephalum* A.Rich. The central plateau of Rwanda is more characterized by a variety of habitats such as shrubland, woodland, savannah, marshlands, and forest highland in which *Helichrysum* species may adapt. *Helichrysum foetidum* var. *microcephalum* A.Rich, *Helichrysum nitens* subsp. *robynsii* occur in bambusetum and mountain forests in the central plateau. *Helichrysum odoratissimum* (L.) Sw grows in different habitats of the central plateau such as marshland with *Erica* and Cyperaceae, mountainous forest, Mwendu hill, runway edges, rocky sloppy areas. *Helichrysum ruandense* Lisowski has a habitat preferences found in fallow land, the bushes around side of the road, and few inhabited areas. *Helichrysum panduratum* O.Hoffm and *Helichrysum schimperi* (Sch.Bip. ex A.Rich.) Moeser are scattered in the areas of the central plateau with various habitats comprising with different ecosystem types. These species can be found in areas around rivers; of grassy savannah; mountainous forests; in rocky soils around the roads; clearings in *Erica / Philippia* and *Hypericum* thickets (up to 4-5 m tall); with broadleaved trees and small trees rainforest edges in swampy areas; Gatovu hill; fallow land on the bottom of the valleys; evergreen broadleaved mixed forest (*Lauraceae*, *Hagenia*, *Acanthus pubescens*, and shrubs) edge with climbing species; shrubs on lithosol in *Myrica*; fallow at the bottom of the valley. *Hypericum* thicket (up to 4-5 m tall) with broadleaved small trees; and open shrub land of *Erica / Philippia* and *Helichrysum* species, *Alchemilla* and grasses. Within these types of habitats and the climatic factors of the Central plateau zone, there are other *Helichrysum* species which can adapt in them while they can grow in the other climatic zones of Rwanda. These *Helichrysum* species are *Helichrysum cymosum* (L.) D.Don; *Helichrysum foetidum* (L.) Moench; *Helichrysum globosum* A.Rich., 1848; *Helichrysum keilii* Moeser; *Helichrysum luteoalbum* (L.) Rchb.; *Helichrysum nudifolium* (L.) Less.

3. The Western and Northern highland region (the Congo-Nile peak and Birunga region) between 1800 m and 4507 m Rainfall is abundant and always above 1200 mm. In this region there are mountainous forests and wetlands which are the habitat preference of these *Helichrysum* species: *Helichrysum newii* Oliv. & Hiern; *Helichrysum nandense* S. Moore; *Helichrysum mildbraedii* Moeser; *Helichrysum leptothamnus* Moeser *Helichrysum stenopterum* DC.; *Helichrysum maranguense* O.Hoffm. *Helichrysum setosum* Harv.; *Helichrysum longiramum* Moeser; *Helichrysum helvolum* Moeser; *Helichrysum helothamnus* var. *helothamnus* Moeser; *Helichrysum helothamnus* Moeser; *Helichrysum guilelmi* Engl.; *Helichrysum goetzeanum* O.Hoffm.; *Helichrysum glutinosum* A. Braun; *Helichrysum gaharoense* Moeser & Schltr; *Helichrysum forskahlii* var. *forskahlii*; *Helichrysum forskahlii* (J.F.Gmel.) Hilliard & Burt; *Helichrysum formosissimum* var. *guilelmii* (Engl.) Mesfin; *Helichrysum formosissimum* Sch.Bip; *Helichrysum ellipticifolium* Moeser; *Helichrysum argyranthum* O.Hoffm; *Helichrysum brunioides* Moeser; *Helichrysum brunioides* subsp. *brunioides*. *Pseudognaphalium* spp.
4. The Lake Kivu side region (1500-2000 m). This region is warm and moderately dry but temperatures are moderate on the lakeside. Rainfall significantly decreases with altitude. Briefly, as the altitude increases, temperature decreases and rainfall increases. *Helichrysum cymosum* (L.) D. Don; *Helichrysum foetidum* (L.) Moench; *Helichrysum foetidum* var. *foetidum*; *Helichrysum helothamnus* Moese.

4.3. Influence of altitudinal ranges on the distribution of *Helichrysum* in Rwanda.

The results of this study showed the distribution patterns of *Helichrysum* in Rwanda in its distinct areas which are topographically different from their altitudinal ranges. In Rwanda, 32 species of the *Helichrysum* species (Table 1) are dominant in the highland areas which are mostly characterized by highland forests and ericaceous supra-forestal belt where these species mostly have their habitats. The highlands areas are mostly found in the Western and Northern parts of the country. The results also revealed that the eastern plain of Rwanda have 9 species which is too small compared with other regions of the county. This small number of species of *Helichrysum* is influenced by the low altitudinal range (100-1500 m) and lowland topography of the region. The eastern plain region is dominated by shrubs and grasslands in Rwanda. The region provides a very large habitat for different animals and plants. The habitats in the eastern plains are rich in thickets and thorny bushy plants. This region is characterized by habitats which are distinct with the habitats of regions of Rwanda. There some *Helichrysum* which prefer the habitats of eastern plain and the others such as the central plateau and western and northern highland.

Table 1: Distribution of species of *Helichrysum* in the climatic regions of Rwanda.

Climatic region of Rwanda	Altitudinal range (m)	Species
The Eastern plain	1000-1500	9
The Central plateau	1500-2000	8
The Western and Northern highland	1800-4507	32
The Lake Kivu side	1500-2000	15

4.4. Influence of the land use and landscape patterns on the distribution of *Helichrysum* in Rwanda.

The distribution patterns of *Helichrysum* species are more influenced by environmental factors, land uses, and landscape patterns. In Rwanda, the results of this study showed that the protected areas (national parks) provide tremendous habitats to the *Helichrysum* species. Nyungwe National Park and Volcanoes National Park are the most to host many species of *Helichrysum* in Rwanda with 24 and 22 species respectively. These parks are one of the natural montane forests found in Africa and known to be the hotspots of biodiversity. In this study, other areas were considered in their districts of location. In these districts, mostly *Helichrysum* species were found on the forestlands, agricultural lands, river banks, mountains, and alongside the roads. Huye and Nyamagabe districts were found to have 10 species of *Helichrysum* each (Table 2).

Table 2: Distribution areas of *Helichrysum* species in Rwanda

Distributional area	Number of Species
Protected areas	
NNP	24
VNP	22
Gahinga	14
Muhabura	12
Bisoke	10
Kalisimbi	9
Sabyinyo	5
GMNP	9
ANP	1
Other areas (District)	
Huye	10
Nyamagabe	10
Karongi	9
Nyamasheke	7
Rutsiro	6
Kirehe	4
Muhanga	4
Rubavu	4
Bugesera	3
Burera	3
Nyabihu	3
Rusizi	3
Nyaruguru	1

4.5. Diversity of habitats preferred by *Helichrysum* species in Rwanda.

Habitat preference of plants species have a great influence on their geographical distribution and abundance (Zheng et al., 2020). In Rwanda, the climatic regions exhibit different habitats composed by trees, shrubs, and grasses. The results of this study showed that *Helichrysum* species found in Rwanda prefer mostly forestlands with 28 species, shrub lands with 23 species (Table 3). The results

also revealed that every *Helichrysum leptothamnus* prefers one type of habitat (shrub land), while other species adapt in diverse habitat types (Annxe 1). The abundance of *Helichrysum* species in forests, shrub land and marshlands are caused by the fact that these species are located in protected areas and less disturbed landscapes such as savannah, and grasslands. These habitats preferred by *Helichrysum* are characterised by open places dominated by diversity of plants species such as *Erica* thickets, *Phillipia* species, and crops.

Table 3: Habitat preferences of *Helichrysum* species.

Habitat	Helichrysum species
Forest	28
Shrub land	23
Marshland	19
Grassland	16
Savannah	12
Herbaceous patches	9
Roadsides	7
Rocky sloppy areas	6

4.6. Characteristics of habitat preferences of *Helichrysum* in Rwanda.

Forestlands and shrub lands are the most habitats where *Helichrysum* species grow with other plant species. The results showed that the plants species which grow mostly in the montane areas are dominant characteristics of the habitats preferred by *Helichrysum* species. The annex 2 illustrates the characteristics of the occurrence of *Helichrysum* species visited during the field survey. *Helichrysum argyranthum* are found in habitats of clearings in *Erica / Phillipia* and *Hypericum* thicket (up to 4-5 m tall) with broadleaved small trees, open shrub land of *Erica / Phillipia* and *Helichrysum*, *Alchemilla* and grasses. *Helichrysum ellipticifolium* prefers swampy area dominated by *Carex*, *Helichrysum globosum* and *Alchemilla*. *Helichrysum formosissimum* prefers habitat having *Hagenia* forest, big trees with plenty of epiphytes, and *Lobelia giberroa*, thicket of *Dendrosenecio* (4 m tall) and *Lobelia* spp, *Hypericum revolutum* and some *Phillipia*. *Helichrysum forskahlii* were found being distributed in herbaceous patches among crops and dispersed *Alnus acuminata* trees, clearings in *Erica* thicket, on rocky soils, herbaceous patches among *Eucalyptus* plantations and crops, evergreen broadleaved mixed forest (Lauraceae, *Hagenia*, *Acanthus pubescens*, etc) edge with clearings, clearings in *Erica / Phillipia* thicket (up to 4-5 m tall) with broadleaved trees and small trees, and *Hypericum* thicket (up to 4-5 m tall). In the margins of agricultural land of *Pyrethrum* crops, other

habitats are grasslands in road margin, grassland grazed by cattle, and swampy area. *Helichrysum gaharoense* adapts in habitats along a stream in clearings of a *Hagenia* forest with *Hypericum revolutum*.

CHAPTER 5: DISCUSSION

5.1. Distribution patterns for *Helichrysum* in Rwanda

The aim of this study was to determine the characteristics of locations and habitats in which *Helichrysum* species are adapted in Rwanda. The map of the vegetation of Rwanda shows the locations covered by the *Helichrysum* species in Rwanda. The results showed that these locations are distributed in the climatic zones of the country where they are mostly dominated by diverse ecosystems of highlands, shrub lands, marshlands, mountains and savannah land. The *Helichrysum* in the four zones have 32 species which are represented mostly herbs or subshrubs. The highlands of Western and Northern zone of Rwanda are the most dominated by *Helichrysum*. These species are commonly occurred in high mountains of the country in different landscape patterns (Daba et al., 2023).

These types of species which can adapt in mountainous or high-altitude areas may find their ranges widened and their access to resources boosted when the environment are affected by the climate change caused by the melting of glaciers and snowfall. The habitats in high elevation areas were inhabited mostly by *H. newii* in Volcanoes National Park, while the habitat with low elevation areas in the Eastern part of Rwanda were mostly inhabited by *H. mechowianum* var. *ceres*. The distribution of *Helichrysum* in diverse altitudinal ranges could be caused by their habitat preferences and their adaptability changes (Chen et al., 2015). The high altitude mountains of Rwanda were formed by volcanic eruptions and they are among the East Africa Mountains referred as the Sky islands (Hedberg 1969). The vegetation of these mountains are very different compared with the vegetation of the lowlands in terms of species richness, growth characteristics, and the habitat types. The species richness of *Helichrysum* in Rwanda is very different as the Western and Northern parts has 32 species, Lake Kivu sides with 15 species, the Eastern parts has 9 species, and the Central Plateau zone has 8 species. The study has found that in all climatic zone of Rwanda, there is more than one *Helichrysum* species which can adapt to their rainfall, temperature and altitude.

5.2. Characteristics of habitats preferred by *Helichrysum* species in Rwanda

The distribution patterns and habitats of *Helichrysum* in Rwanda are huge in the protected areas of the country. The most key factors which should be taken into account to ensure the protection and restoration of species are the climatic factors, suitability of species in a habitat, and the occurrence in the species in a geographic area (Préau et al., 2020). The models of habitat suitability enhance the knowledge on the ecology of a species to be protected and play a great role in the planning of land uses. *Helichrysum* species were found to be suitable in less disturbed ecosystems such as the highland forests, savannah, shrub lands around roads, marshlands, and shores of rivers. These ecosystems need be focused in the preparation of conservation initiatives as they provide suitable habitats for both plants and animals of different kinds. The study has revealed that *Helichrysum* species can grow in diverse ecosystems with plants of herbaceous, shrubs, and tree forms. The protection and restoration measures of a considerable ecosystem can support the conservation of the small plants in which *Helichrysum* are belonged.

The conservation of biological diversity need to consider all types of living organisms in the current increasing threats to biodiversity. These threats are mostly caused by land use changes related with deforestation, and land degradation which influence the habitat destruction and climate change in Easter Africa (Maitima et al., 2009). The forests of afro-montane areas are forming fragments of forest lands and being isolated in the mountainous ecosystems. Without the current man-made activities, these forests would probably have been formed as unseparated habitat (Hedberg 1969). The fragmentation of habitats hamper threatens the distribution patterns of different indigenous species, for example, *L. giberroa* (Kebede et al. 2007). Therefore, the fragmentation and loss of habitat could be a threat to *Helichrysum* species which prefer their habitats in forest ecosystems (Dong et al., 2019). Both climate change and habitat destruction will continue to affect the distribution patterns of species, causing shifts in ranges, decrease, and extinctions of species in their native places (Kipkoech et al., 2019). Additionally, the high mountainous forests and their environments in Rwanda as in Eastern Africa have invasive plant species which pave another threat to these places (Obiri, 2011; Hulme et al., 2013). In the most mountainous areas of Rwanda, there is a rise of ecotourism activities. To help the undergo of these touristic activities, roads and trails within the mountainous areas have been established. The invasive species could get the way to get into the areas of different altitudes (Muchuku et al., 2020; Pauchard et al., 2009).

CHAPTER 6: CONCLUSION AND RECOMMENDATION

The results of this study showed that *Helichrysum* are distributed in all climatic zones of Rwanda. The Western and Northern zone is the highest dominated area with a big diversity of *Helichrysum* species. The protected areas mostly Nyungwe and Volcanoes National Parks are found to be the host of a high number of *Helichrysum* species at more than 20 species per each park. This big number of species living these two national parks is attributed to the high altitudinal range, wet climate, and less human activities and disturbances. The *Helichrysum* have adapted in all types of ecosystems around the country due that they are perennial plants which can grow in open areas, farmlands, roadside shrub land, and marsh land. The mountain forest and shrub land ecosystems are the most preferable and suitable habitats for *Helichrysum*. With the distribution patterns of these species in both protected and non-protected areas, it is very important consider the best management of the fragmented and scattered forest plantations around the country to sustain the conservation of *Helichrysum* and other small plant species. The conservation in the future for the *Helichrysum* species should take account on their preferred habitats. Other researches in the county should focus on the phytochemical components and bioactivities of *Helichrysum* distributed in Rwanda.

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ANNEX

Annex 1: Diversity, habitats and distribution of Helichrysum in Rwanda.

Scientific Name	Altitude range (m)	Distribution area	Habitat	Biological form and growth height (cm)	Conservation status	Sources of data
<i>Helichrysum argyranthum</i> O.Hoffm	2000-3700	VNP-Muhabura and Gahinga volcanoes. Nyabihu district-along Rambura-Rubavu road, around Lake Karago. Rutsiro district-along Gakoma-Karongi road, Track to Congo-Nile.	Shrub land. Grassland	Shrub, 100-180	NE	GBIF, NHR, Field data.
<i>Helichrysum brunioides</i> Moeser		NNP-Rwasenkoko, Pindura and Mugasare. Nyamagabe district-Birara	Marshland	Herb, 30-100	Threatened	GBIF

		valley, Rugeera forest. GMNP-Gisunzu.				
<i>Helichrysum brunioides</i> subsp. <i>brunioides</i>		NNP-Pindura and Mugasare, Nyamagabe district-Rugeera forest, GMNP-Gisunzu	Wet slope on brown soil.	Herb, 40-80	EN	GBIF
<i>Helichrysum coriaceum</i> Sond.	1200-1500	Bugesera district-Biharagu. ANP-Kibwara mount.	Grassland, shrubland, savannah.	Perennial herb, 75	NE	GBIF, NHR.
<i>Helichrysum cymosum</i> (L.) D.Don		NNP. Huye district. Muhanga-Karongi road. Karongi District-Ruhumiro near Gisovu	Forest highland, grassland.	Shrub, 100	NE	GBIF, NHR.
<i>Helichrysum ellipticifolium</i> Mooser	2000-3500	NNP-Uwasenkoko, Mugasre, and Rutovu.	Savannah trees, grassland in forest margin, marshland	Shrub, 30-100	VU	GBIF, NHR, Field data.
<i>Helichrysum foetidum</i> (L.) Moench	1350-2700	Karongi district-Gisovu, Huye district, Nyamasheke district, GMNP-Mutura.	Savannah, highland forest.	Perennial herb, 30-115	NE	GBIF, NHR.
<i>Helichrysum foetidum</i> var. <i>foetidum</i>	1500-2500	Karongi district-Gisumo and Gisovu. Rutsiro district-Gikungu-Gisovu. along	Marshland, forest highland. Shrubland.	Perennial herb, 30-100	NE	NHR

		Huye-Rusizi road. Huye-district. NNP-Uwinka, Uwasenkoko and Cyaruyoga. Nyamasheke district- Rangiro, Gatare to Muzimu mount. Nyamagabe district- Bunyambiriri and Bitandara.				
<i>Helichrysum foetidum</i> var. <i>microcephalum</i> A.Rich.	1500-2500	NNP-along Huye-Rusizi road, Huye district	Shrub land, bambusetum.	Perennial herb, 30–150	NE	GBIF
<i>Helichrysum formosissimum</i> Sch.Bip.	1800-4700	VNP-Kalisimbi, Gahinga, Sabyinyo Bisoke volcanoes, NNP-Uwinka and Uwasenkoko. Rutsiro district-Gikunku	Forest highland, shrub land, grassland.	Perennial herb, 100-150	LC	GBIF, NHR, Field data.
<i>Helichrysum formosissimum</i> var. <i>guilelmii</i> (Engl.) Mesfin	1800-4200	NVP-Muhabura and Gahinga volcanoes.	Forest planted on hill, sloppy dryland, shrub land.	Annual shrub, 30-200	LC	GBIF, NHR
<i>Helichrysum forskahlii</i> (J.F.Gmel.) Hilliard & Burt	1000-4200	VNP- Kalisimbi, Bisoke, Muhabura, Sabyinyo, and Gahinga volcanoes. NNP-Uwasenkoko,	Marshland , forest highland, rocky areas,	Perennial herb, 20-100	LC	GBIF, NHR, Field data.

		Uwinka, Mugasare and Kamiranzovu. Along Huye-Rusizi road. Nyamasheke district-Rangiro and Kirambo. Along Muhanga-Karongi road. Huye district-INRS.	savannah with acacia spp, grassland. Evergreen broadleaved forests.			
<i>Helichrysum forskahlii</i> var. <i>forskahlii</i>	1050-4700	NNP-Uwasenkoko	Marshland with herbs and Erica.	Erect herb, 30-100	NE	GBIF
<i>Helichrysum gaharoense</i> Moeser & Schltr.	2000-3500	VNP-Kalisimbi volcano.	Along stream, marshland.	Herb, 150	Threatened	Field data
<i>Helichrysum globosum</i> A.Rich., 1848	1000-3500	Kirehe district, Huye district, VNP-Bisoke, Gahinga. Kalisimbi volcano and around Bikwi river. Burera district, Nyamasheke District-Impala. GMNP.Gishwati forest. Kirehe district. Huye District, Astrida. Uwinka. Karongi district-Karongi hill. Nyamasheke district-Rangiro and Impala.	Savannah, grassland, marshland, forest highland, shrub land, herbaceous patches.	Perennial herb, 20-100	NE	GBIF, NHR, Field data.

<i>Helichrysum glutinosum</i> A. Braun	2000-2500	VNP-Gahinga volcano. NNP-Uwasenkoko. GMNP-Gishwati forest.	Herbaceous patches, grassland.	Perennial herb, 30–150	NE	Field data
<i>Helichrysum goetzeanum</i> O.Hoffm.		VNP-Kalisimbi volcano, around Bikwi river.	Savannah with Acacia species.	Perennial herb, 200-300	Not threatened	GBIF
<i>Helichrysum guilelmi</i> Engl.	3000-4000	VNP-Gahinga, Kalisimbi, Muhabura and Bisoke volcano.	Shrubland.	Annual shrub, 30-200	LC	Field data
<i>Helichrysum helothamnus</i> Moeser	2000-3500	NNP-Uwasenkoko, near Mugasare, VNP-Kalisimbi near Bukomane, Sabyinyo. Rutsiro district-along Gakoma-Karongi road. Karongi district-Kibuye hill.	Grassland, marshland, forest highland. Shrubland.	Erect herb, 30-100	NE	NHR
<i>Helichrysum helothamnus</i> var. <i>helothamnus</i> Moeser	2000-4000	VNP-Gahinga, Kalisimbi and Bisoke. NNP- along Kamiranzovu hiking trail	Marshland, shrubland.	Perennial herb, 100-150	NE	Field data
<i>Helichrysum helvolum</i> Moeser	1800-2500	NNP-Uwinka and Pindura. Rutsiro district-Gikunku, Muhanga district-Muhanga mount.	Forest highland, savannah, grassland.	Herb, 100- 150	VU	GBIF, NHR
<i>Helichrysum keilii</i> Moeser	2000-2500	Nyamagabe district-Kisake and	Forest highland,	Perennial herb, 30-50	NE	GBIF, NHR

		Nyabisindu hill. Nyagatare district- Gabiro	herbaceous patches.			
<i>Helichrysum leptothamnus</i> Moeser	3000- 3500	VNP-Gahinga and Kalisimbi volcano.	Shrub land.	Herb	NE	Field data
<i>Helichrysum longiramum</i> Moeser	2000- 2500	NNP-Pindura, Bigugu, Kamiranzovu, Uwinka, Rutovu, and Mugasare. VNP- Bisoke, Gahinga, Sabyinyo, Muhabura. Huye district-Rubona. Nyamasheke District-Impala and Muzimu mount. Nyamagabe district-Kisake mount. Along Muhanga-Karongi road. Karongi district-Gisovu, Kibuye mount and Ruhumiro. Rubavu district.	Marshland , shrub land, forest highland.	Shrub, 80-100	LC	GBIF, NHR, Field data.
<i>Helichrysum luteoalbum</i> (L.) Rchb.		GMNP-Mutura, Huye district- Rubona, Astrida. Nyabihu District- Lake Karago.	Shrub land, sloppy grassland, rocky	Perennial herb, 70	NE	GBIF

			forest highland.			
<i>Helichrysum maranguense</i> O.Hoffm.	1500- 3600	NNP-Uwinka and Bunyangurube hill. Along Rusizi-Huye road	Marshland , shrub land.	Herb, 200-350	NE	GBIF, NHR
<i>Helichrysum mechowianum</i> <i>var. ceres</i> (S.Moore) Beentje	1500- 2200	Bugesera district- Birenga near Akagera valley. Kirehe district. Huye district- Maraba	Marshland , shrub land on road edges, forest hills.	Perennial herb, 50	NE	GBIF
<i>Helichrysum mildbraedii</i> Mooser	1500- 3700	VNP-Muhabura, Bisoke, Gahinga, and Sabyinyo volcanoes. NNP- Uwinka, Bigugu, Uwasenkoko, Mugasare and Rukuzi. Nyamasheke district-Bizimu mount.	Rocky grassland, shrub land, forest highland.	Perennial herb, 65	VU	GBIF, NHR, Field data.
<i>Helichrysum Mill.</i>		Rusizi district, Busoro forest. VNP-Bisoke. Huye district	Forest highland, savannah, grassland, marshland, rocky grassland, shrub land.	Perennial herb, 30-60	NE	GBIF

<i>Helichrysum nandense</i> S. Moore	2000-3200	VNP-Gahinga and Muhabura volcano	Herbaceous patches, shrub land.	Shrub, 100-200	NE	Field data
<i>Helichrysum newii</i> Oliv. & Hiern	3000-4500	VNP-Bisoke and Muhabura volcanoes.	Savannah, forest highland, shrub land.	Shrub, 15-100	NE	GBIF, NHR, Field data.
<i>Helichrysum nitens</i> Oliv. & Hiern	2000-2300	Karongi district-Karongi mount. Nyamagabe district-Nshili hill and Nyabisindu hill.	Marshland . Shrub land.	Perennial herb, 20-80	Not threatned	GBIF, NHR
<i>Helichrysum nitens subsp. robynsii</i> (De Wild.) Lisowski	1800-2300	Huye district-Bunazo mount	Forest on hillside.	Perennial herb, 20-100	NE	GBIF
<i>Helichrysum nudifolium</i> (L.) Less.	1000-2000	Nyabihu district-Nkuli, Huye district-Rubona. NNP-Mugasare	Savannah. Patches on roadsides.	Herb, 80-150	NE	GBIF, NHR
<i>Helichrysum nudifolium</i> var. <i>nudifolium</i>	1200-1500	Bugesera district. Nyagatare district-Mimuri.	Savannah.	Perennial herb, 10-45	NE	GBIF
<i>Helichrysum nudifolium</i> var. <i>oxyphyllum</i> (DC.) Beentje	1200-1500	Kirehe district-Rusumo. Nyagatare district-Mimuri and Rusumo. Huye district-Huye mount	Marshland , savannah.	Perennial herb, 60	NE	GBIF, NHR
<i>Helichrysum odoratissimum</i> (L.) Sw.	1200-3500	Huye district-Rubona, Gihandamuyaga, INRS, Maraba, Tare, Huye mount, Runyinya, and	Forest highland, marshland, savannah.	Perennial herb, 50	NE	GBIF, NHR, Field data.

		<p>Ruhande Alboretum. NNP- Uwinka. Nyagatare district-Mimuri. Nyamagabe district-Muko. Kirehe district. VNP-Muhabura volcano. Ngoma district-Kibaya hill. Rutsiro District- Track to Congo Nile crete. Ngoma district-Birenga hill and Kibaya hill. Rubavu district- Gisenyi-Busoro track.</p>				
<p><i>Helichrysum panduratum</i> O.Hoffm.</p>	<p>1500- 2700</p>	<p>Nyamasheke district. Huye district-Ruhande Alboretum. NNP- Kamiranzovu, Uwinka, Banda river and Bunyangurube hill. Nyagatare district- Nyakagege hill. Nyamasheke district-Gatare- Muzimu mount. Burera district- Mukungwa.</p>	<p>Shrub land, forest lowland, forest highland, marshland, herbaceous patches.</p>	<p>Perennial herb, 100</p>	<p>NE</p>	<p>GBIF, NHR, Field data.</p>

<i>Helichrysum ruandense</i> Lisowski	1500-2500	Huye district-Rubona and Gatovu hill. NNP. GMNP-Gisunzu. Rubavu district-Rwerere. VNP-Bisoke volcano.	Forest highland, grassland, herbaceous patches on roadsides.	Perennial herb, 120	EN	GBIF, NHR
<i>H. schimperi</i> (Sch.Bip. ex A. Rich.) Moeser	1500-3200	Huye district-Kigembe, Mbazi, and Ngoma hill. Nyagatare district-Mimuri. Nyaruguru district. Rulindo district-Gihuke. Nyanza district-Kagunga. Nyamagabe district-Mushubi. VNP-Muhabura. NNP-Bigugu summit. GMNP-near the park office.	Shrub land, grassland, marshland.	Perennial herb, 200-300	NE	GBIF, NHR, Field data.
<i>H. setosum</i> Harv.	1700-2500	VNP-Muhabura and Gahinga volcanoes. Nyamagabe district-Muko, Bitandara region, Kigeme, Kibeho and Bunyambiliri. Along Huye-Rusizi road Rwanda. NNP-near Rukuzi, Uwinka	Shrub land, marshland, herbaceous patches, forest highland	Herb, 60-100	NE	GBIF, NHR, Field data.

<i>H. stenopterum</i> DC.	1800- 2700	VNP-Muhabura volcano. NNP- Uwasenkoko. Nyamagabe district- Bunyambiliri and Kanyege	Forest highland, grassland, herbaceous patches on roadsides.	Perennial herb, 200	Not threaten ed	NHR
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Annex 2: Characteristics of habitats preferred by Helichrysum species in Rwanda

Species	Habitat characteristics
<i>H. argyranthum</i>	Clearings in <i>Erica/Philippia</i> and <i>Hypericum</i> thicket (up to 4-5 m tall) with broadleaved small trees.
<i>H. ellipticifolium</i>	Swampy area dominated by <i>Carex</i> , <i>Helichrysum globosum</i> and <i>Alchemilla</i> .
<i>H. formosissimum</i>	Swampy area dominated by <i>Carex</i> , <i>Helichrysum globosum</i> and <i>Alchemilla</i> .
<i>H. forskahlii</i>	Herbaceous patches among crops and dispersed <i>Alnus acuminata</i> trees; clearings in <i>Erica</i> thicket, rocky soils herbaceous patches among <i>Eucalyptus</i> plantations and crops, evergreen broadleaved mixed forest (Lauraceae, <i>Hagenia</i> , <i>Acanthus pubescens</i> , etc) edge with clearing in <i>Erica / Philippia</i> thicket (up to 4-5 m tall) with broadleaved trees and small trees; in <i>Pyrethrum</i> crops margins grassland in road margin; grasslands grazed by cattle; swampy area.
<i>H. gaharoense</i>	Along a stream in clearings of a <i>Hagenia</i> forest with <i>Hypericum</i> .
<i>H. globosum</i>	Swampy area dominated by <i>Carex</i> , <i>Helichrysum globosum</i> and <i>Alchemilla</i> ; grasslands grazed by cattle; herbaceous patches among crops and dispersed <i>Alnus acuminata</i> trees.

<i>H. glutinosum</i>	Herbaceous patches among crops and dispersed <i>Alnus acuminata</i> trees; grasslands between Eucalyptus plantations and the non-paved road; grasslands in road margins.
<i>H. guilelmi</i>	Clearings in the <i>Hypericum</i> and <i>Hagenia</i> forest; restricted to a gully; thicket of <i>Dendrosenecio</i> (4 m tall) and <i>Lobelia</i> spp. With some <i>Philippia</i> ; open thicket of <i>Dendrosenecio</i> with <i>Alchemilla</i> .
<i>H. helothamnus</i> <i>var. helothamnu</i>	Clearings in the <i>Hypericum</i> and <i>Hagenia</i> forest; open Thicket of <i>Dendrosenecio</i> (4 m tall), <i>Lobelia</i> spp. and <i>Helichrysum</i> ; swampy area dominated by <i>Carex</i> , <i>Helichrysum globosum</i> and <i>Alchemilla</i> ; open <i>Hypericum</i> thicket with <i>Lobelia</i> spp. And <i>Pteridium aquilinum</i> ; rainforest clearings in swampy areas.
<i>H. leptothamnus</i>	<i>Erica</i> , <i>Dendrosenecio</i> and <i>Lobelia</i> thicket, in Sphagnum bog swampy area dominated by <i>Carex</i> , <i>Helichrysum globosum</i> and <i>Alchemilla</i> .
<i>H. longiramum</i>	Grassland in road margin clearings in <i>Erica / Philippia</i> and <i>Hypericum</i> thicket (up to 4-5 m tall) with broadleaved small trees; grasslands in road margins.
<i>H. mildbraedii</i>	On rocky wet soils where water runs along a stream in clearings of a <i>Hagenia</i> forest with <i>Hypericum</i> ; thicket of <i>Dendrosenecio</i> , <i>Lobelia</i> and <i>Philippia</i> , in small ravine where water flows rocky steep humid road margins.
<i>H. nandense</i>	Herbaceous patches among crops and dispersed <i>Alnus acuminata</i> trees, clearings in <i>Erica / Philippia</i> and <i>Hypericum</i> thicket (up to 4-5 m tall) with broadleaved small trees.
<i>H. newii</i>	Open shrub land of <i>Erica / Philippia</i> and <i>Hypericum spp</i> ; open shrub land of <i>Erica / Philippia</i> and <i>Helichrysum newii</i> , <i>Alchemilla</i> and grasses; open thicket of <i>Dendrosenecio</i> (4 m tall), <i>Lobelia spp</i> . Open thicket of <i>Dendrosenecio</i> with <i>Lobelia</i> , large patches of <i>Alchemilla</i> , grasses and <i>Helichrysum helothamnus</i> .
<i>H. odoratissimum</i>	Clearings in <i>Erica / Philippia</i> thicket (up to 4-5 m tall) with broadleaved trees and small trees
<i>H. panduratum</i>	Rainforest edges; in swampy areas.
<i>H. schimperi</i>	Evergreen broadleaved mixed forest (<i>Lauraceae</i> , <i>Hagenia spp</i> , <i>Acanthus pubescens</i> , etc) edge with clearing in <i>Erica</i> thicket; climbing species grassland in road margin.
<i>H. setosum</i>	Herbaceous patches among crops and dispersed <i>Alnus acuminata</i> trees.
<i>H. stenopterum</i>	Herbaceous patches among Eucalyptus plantations and crops, grasslands in road margins.



Photo 1: Helichrysum gaharoense

Source: Field data.



Photo 2: Helichrysum species in marshland of Kalismibi Volcano

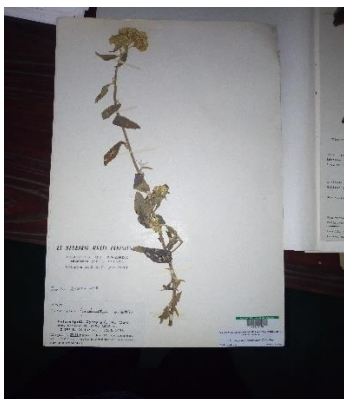


Photo 3: Specimen of Helichrysum panduratum from NHR

