Ethnobotany Survey of Medicinal Plants in Home Gardens around Volcanoes National Park, Rwanda

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Abstract

Home gardens show evidences of medicinal plant use and are good places to provide information about plant health practices and biocultural knowledge transfer. In Rwanda there no enough information related to home gardens of medicinal plants. This ethnobotanical study of medicinal plant in home gardens was conducted in that perspective to document medicinal plants in domestic gardens. The study was conducted in home gardens around Volcanoes National Park (VNP) in Musanze and Burera Districts of the Northern Province of Rwanda. The study was conducted in Kinigi Sector in Musanze District, and Cyanika and Gahunga Sectors in Burera District. The objective of the study was to document medicinal plants used to treat human diseases in home gardens around VNP. This is fruitful for biodiversity conservation as domestication of medicinal plants found inside the park, reduces park encroachment and local communities and park manager conflicts. Data were collected by using stratified sampling method, semi-structured interview, and field observation. About 200 households were surveyed and adult household members, men or women, interviewed. A total of 40 medicinal plant species existing in the VNP and belonging to 22 plant families were recorded in home gardens in study area. Lamiaceae, Asteraceae, Rubiaceae and Euphobiaceae were most frequent plant families. Regarding used plant organs, leaves were the most plant organ used whereas barks, roots and fruits were the least used plant organs in study area. *Maesa lanceolata* was the medicinal plant species for which all stated plant organs are used. The medicinal plants recordee in home gardens in the study area were found to play a vital role in treatment of human diseases include malaria, kidney diseases, stomach diseases, aches, liver diseases, skin diseases, Influenza, gonorrhea, diarrhea and asthma and more others.

Keywords: Ethnobotany, Medicinal plants, Home gardens and Volcanoes National Park

https://dx.doi.org/10.4314/rjeste.v6i1.5

1. Introduction

Since the beginning of recorded human history, people have used plants to treat illnesses and ease physical suffering. It has been noted that in many instances, indigenous people use plants as the source of important pharmaceuticals (Wondimu et al., 2007). Again, medicinal plants are just one of the many ways that plants' authentic products or byproducts benefit people. Long ago, as soon as the first person fell ill, plants were used for medicinal purposes. Humanity was well aware of some of the nearby plants' medicinal qualities around 3000 B.P (Wondimu et al., 2007). Addition to that, it is well known that traditional medicines are frequently used, particularly in the rural areas of the country with low incomes. Since the beginning of civilization, medicinal plants have played a significant role in the provision of healthcare to humans. The demand for medicinal plants is rising in both developing and developed nations, and the majority of their trade in goods still comes from wild plants that have been harvested. People are becoming more interested in using safe, efficient, and affordable indigenous remedies, especially in developing nations where access to modern health services is limited (Andarge et al., 2015; Kanta et al., 2018).

Local communities around protected area depend on their natural forest products for better health and livelihood benefits, through collection of plants for their remedies and nutritional function. However local communities are restricted from direct access to the protected area for biodiversity conservation (Idolo et al., 2010; Newmark, 2008). As population continues to increase, food scarcity, lack of employment, climate change and lack of an alternative of non-timber forest product like medicinal plant drives local community to increase pressure to protected areas (Wellnitz, 2003). The poorest households are the highly dependent on the forest product from protected areas, while the wealthier households are less dependent to parks (Mukul et al., 2016; Wellnitz, 2003). Home gardens as alternative source of plant products both medicinal and edible plant species can be a functional approach in management of protected areas and sustainable livelihood of local community around protected area for biological conservation (Salafsky and Wollenberg, 2000; Wellnitz, 2003). Home gardens can play an important role in conservation of medicinal plant species as they contain very large number of species which are often absent or uncommon and through this method of plant domestication it can be used as appropriate approach for community around protected areas to get herbal product (medicinal plant in this case) without entering in the park (Mekonen et al., 2015). Home gardens contain cultivated mixture of perennial and annual plant species with specific arrangement and structure managed by house hold members for subsistence production (González-Ball et al., 2022; Mekonen et al., 2015; Torquebiau, 1992). Home gardens show an evidence of medicinal plant use and are good places to provide information about plant's health practices and biocultural knowledge transfer (Finerman and Sackett, 2003; González-Ball et al., 2022; Mekonen et al., 2015).

The government of Rwanda in last decades has been encouraging Rwandans households to have kitchen garden in each house hold across the country especially in rural areas in response to food insecurity and infant mortality resulted from malnutrition in young children below 5years old. The kitchen gardens were only dominated by edible vegetables, spice and other plant species with nutritional functions (Devereux et al., 2019; Hasselskog, 2016). Medicinal plant was ignored so home garden can be important in Rwandan households especially those

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found near protected areas like volcano National Park and other protected areas in Rwanda to reduce the park encroachment and conflict between park managers and local community around protected areas. Though effective biodiversity conservation should consider better health of local community around conservation areas through different strategies (Chowdhury and Koike, 2010) including ecotourism, allowing extraction of non-timber forest products, providing primary education and establishing long-term research stations (Chapman et al., 2015). This delivers multi-fold benefits to protected areas as well as the local communities, governments, and private agencies (Larson 2003).

Local communities around Volcano National Park were formally use plants as herbal remedies and nutritional benefits. But nowadays using these plants products is difficultly due to lack of access to the park and this is the main driver of park's encroachment. And due to lack of access to some of the medicinal plant mainly found in the park. Also, the knowledge about the use of these plants is losing because the elders who know how these plants are used are dyeing without transferring of that knowledge to young generation (Study et al., 2020). The current study assessed medicinal plants in home gardens around VNP to understand how park management and local communities work together to promote both biodiversity conservation and public health. The study was conducted in two districts of Northern part of Rwanda in the sectors surrounding VNP; it aims at documenting ethnobotanical information related to medicinal plants. This will be fruitful for biodiversity conservation, park encroachment reduction as well as conflict resolution among local communities and park manager, through encouraging people living around volcano national park to domesticate the most needed medicinal plant commonly found inside the park. The study specifically analyzed the diversity of medicinal plants in home gardens and the diseases that they treat, identified medicinal plant organs most used in the treatment, and documented the methods of preparation.

2. Materials and Methods

2.1. Study Area

The study was conducted in two districts of Northern part of Rwanda in the sectors surrounding the VNP. The latter is situated in the North West part of Rwanda, close to Nyagahinga National Park in Uganda and Virunga National Park in the Democratic Republic of the Congo. It is a distinctive, high-altitude portion of the Albertine lift, which is regarded as one of the most important ecosystems for the preservation of biodiversity worldwide. It is surrounded by 12 densely populated administrative sectors, with two of them, Gahunga and Cyanika, having a population density of over 900 people per square kilometer(Munanura et al., 2018). The majority of the locals living close to the park are subsistence farmers who suffer from extreme poverty and frequently rely on illegally harvesting forest resources to support their way of life (Munanura et al., 2018). The park regulates water infiltration and release, which is crucial to the agricultural productivity of nearby communities (Nahayo et al., 2010). The survey was carried out in Kinigi, sectors in Musanze district, and Cyanika and Gahunga in Burera district (Figure 1).

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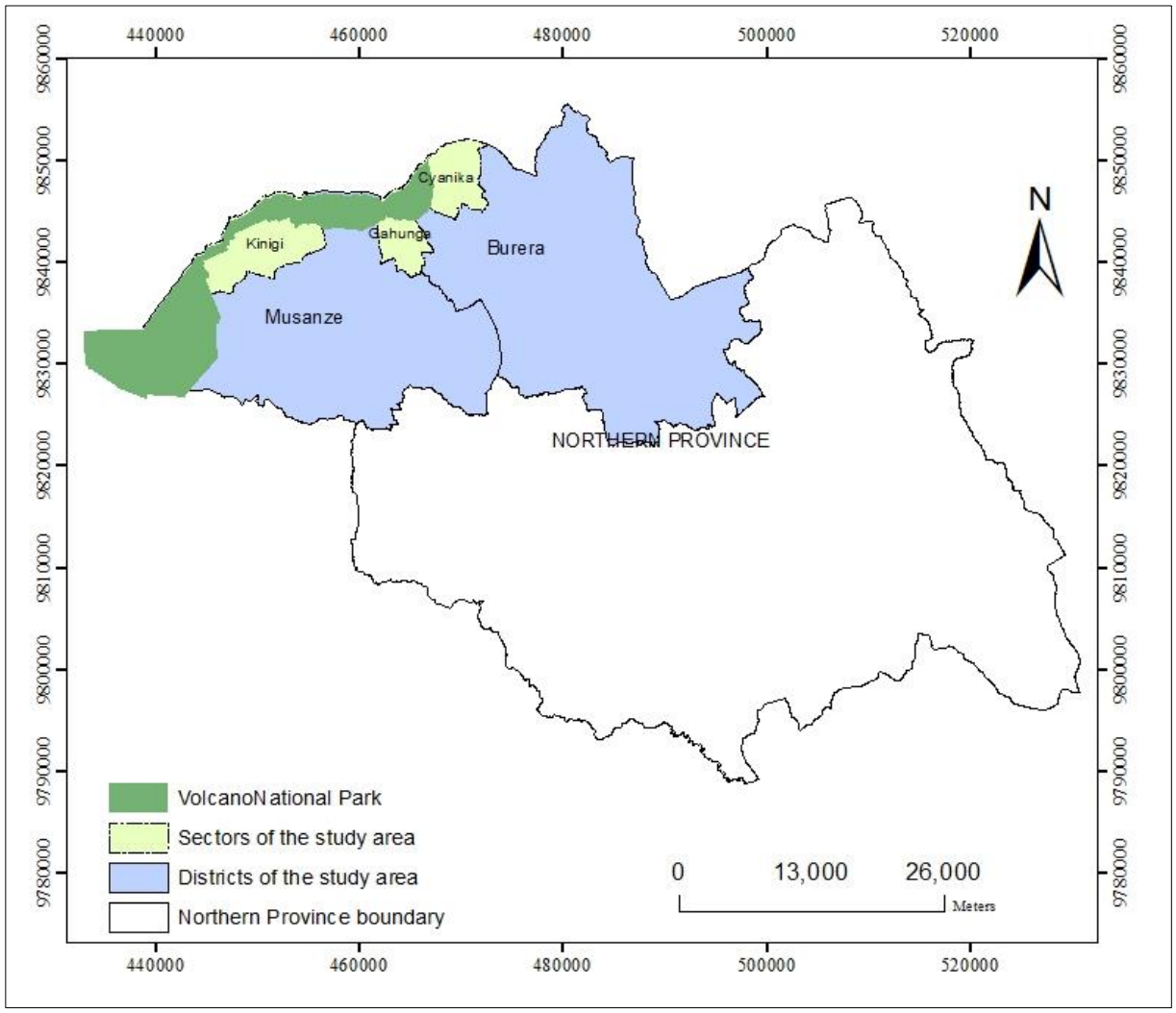

Figure 1**:** Study areas around VNP in the Northern province of Rwanda

2.2. Ethnobotanical data collection

Ethnobotanical survey was carried out to collect data on medicinal plants used to treat human disease in home gardens around VNP. Data was collected from February to June 2023. The stratified sampling method was used to select study sectors and cells. To collect ethnobotanical data including, the semi-structured interview and field observation methods were used. The collected ethnobotanical data include the local name of plants, the organs used, the disease treated, the dosage, the preparation methods, the adverse effect, other uses than medicinal purposes, and the preservation techniques were all recorded during the interview (Paulos, 2020).

The minimum sample size was calculated using the published tables generated based on the desired precision, confidence level and variability (p). In these tables, the sample size reflects the number of obtained responses to take part in the study. The sample size level, the

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confidence level and the variability for this study were ± 7 %, 95% and 0.5 respectively (Muyembe et al., 2023). The used table is that one adopted from Yamane formula (1967) as follows:

$$n = \frac{N}{(1+(N*e)\text{^}2)} \quad \text{Equation 1}$$

The study area had 6790 households and the taken sample was 200 households. In total, 200 households were surveyed and adult household's member either man or woman were sampled. The following Table 1 shows the distribution of respondents per district, sector and cell

Table 1: Distribution of respondents and proportion of sampled households

Districts	Sectors	Cells	Number of households	Taken stratified sample size	Proportion (%)
Musanze	Kinigi	Nyabigoma	1095	32	16.1
		Bisoke	976	29	14.3
Burera	Gahunga	Gisizi	1127	33	17
		Nyangwe	1042	30	15.3
	Cyanika	Gasiza	1335	39	20
		Nyagahinga	1215	36	18
Total			6790	200	100%

Interviews were done based on checklist questions prepared before the field work. As informants do not know English, the survey questions written originally in English, were translated into Kinyarwanda.

In each of the 200 households, home gardens were visited and information on medicinal plants such as names, abundance, used plant organs, preparation methods, and treated diseases were collected. Vernacular names of medicinal plants were obtained from the informants and local field assistants. Some plants were immediately scientifically identified at the field or base on local plant name from the field and the corresponding scientific names were obtained from published literature. Photographs and specimen of non-identified plants on field were taken and used later for plant identification at the National Herbarium in Huye.

2.3. Data analysis

In the study area, the species richness of medicinal plants, the most frequent plant families, the most used plant organs, and the proportion of indigenous and exotic species were determined using Excel Microsoft. The diversity of medicinal plants was calculated using the Simpson index that considers the both species richness and relative abundance of each species with the community (Das et al., 2012). The Simpson index and evenness are performed using the following equations 2 and 3 respectively:

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$$Simpson\ index\ (H) = -\sum_{i=1}^{S} p_i\ ln\ p_i \qquad \text{Equation 2}$$

where p is the proportion of individuals belonging to a specific species (i) relative to the total of individuals in the sample (N). It is calculated by dividing the number of individuals of species i (n) by the total number of the individuals in the sample. "ln" is the natural logarithm and S the total number of found in the sample. High Shanon index (H>3) indicate a community with no dominant single species (Das et al., 2012). The medium diversity is characterized by the Simpson index values varying from to 3 (1≤H≤3) whereas the low diversity is found under the Simpson index less than 1 (H < 1) (Das et al., 2012).

The Shanon evenness is calculated using the following equation 3:

$$Shanon\ eveness\ (H'_e) = \frac{H}{H'_{max}} \qquad \text{Equation 3}$$

where H is the Shanon index and H' max is the maximum possible value of H for a given number of species (S) in the community. H'max is calculated by the following equation 4 by Magurran 2021):

$$H'_{max} = \ln(S) \qquad \text{Equation 4}$$

The Simpson evenness values range from 0 to 1. The values closer to 0 indicate that few species dominate the sample; the evenness equal to 1 indicates a perfect evenness (Magurran, 2021).

$$H'_{max} = \ln(H) \qquad \text{Equation 4}$$

The medicinal plant preparation methods were classified in the following classes: crushing and squeezing, pounding and powdering, burning and roasting, and chewing (Paulos, 2020). The medicinal plant species combined to treat one human disease were classified as mixed medicinal plants. All the time, the frequency and percentage of different classes of medicinal plants and preparation method were calculated and compared and their differences statistically tested w at confidence level of 5%.

3. Results

3.1. Diversity of medicinal plant species and families

A total of 40 medicinal plant species and 22 plant families were recorded in home gardens in study area. The diversity of medicinal plants was high and the evenness indicated a clumped distribution of medicinal plant individuals (See Table 2). The most abundant medicinal plants were *Brilliantasia cicatricose*, *Tithonia diversifoli*, *Maesa lanceolate*, *Mitragyna rubrostipulata Plantago palmate*, *Clutia abyssinica*, *and Rumex usambarensis.*

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Table 2: Diversity and evenness of medicinal plants in the study area

Plant diversity	Evenness
Shanon index	3.3
Eveness	15.1

The most frequent medicinal plants were *Brilliantasia cicatricosa (*25%), *followed by Maesa lanceolata (20.81%), Rumex usambaransis (18.32%), Clutia abyssinica* (16.51%), *Ocimum urticifolium* (15.12%)*,* and *Crassocephallum vitellinum* (13. 23%) *(*Figure 2*).*

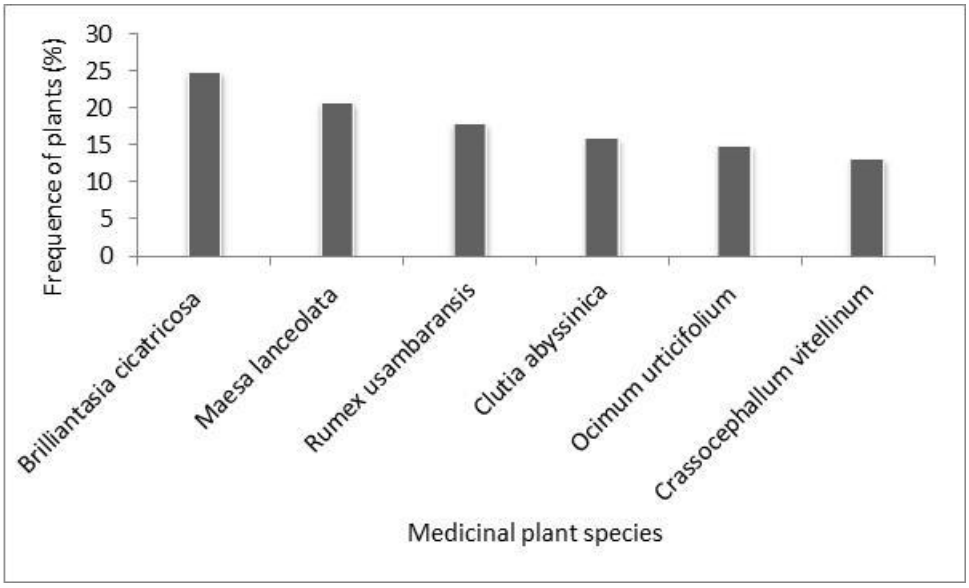

Figure 2: Top 5 common medicinal plants in the study area

80% of the recorded medicinal plants are native of VNP; the remaining 20 % are only non-native. The native species include *Blumea brevipes, Clutia abyssinica, Coleus kilimandschari, Crassocephalum vitellinum, Gynandropsis gynandra, Leucas martinicensis, Lobelia giberroa, Lysimachia ruhmeriana, Maesa lanceolate, Markhamia lutea, Mitragyna rubrostipulata , Ocimum urticifolium, Phytolacca dodecandra, Plectranthus barbatus, Rumex bequaertii , Acanthus pubescens, Aloe vera, Brilliantasia cicatricose, Chenopodium procerum, Dodonaea viscosa, Erythrina abyssinica, Gynura scandens, Leonotis nepetifolia, Mitragyna rubrostipulata, Plantago palmate, Ranunculus bequaertii, Rumex usambarensis, Senescio manii, Tetradenia riparia, Urtica dioica, Urtica massaica, and Verinonia amygdalina.* The non-native medicinal plant species recorded in the study area are *Triumfetta rhomboidea, Tropaeolum majus, Rubia cordifolia, Euphorbia schimperian, Carica papaya, Galinsoga parviflora, Chenopodium ugandae, Tithonia diversifolia.*

Regarding the diversity of plant families, Lamiaceae and Asteraceae were most frequent plant families with 7 medicinal plant species each. Other most represented plant families are Rubiaceae and Euphobiaceae with4 and 3 medicinal plant species respectively, and the Euphobiaceae with 3 medicinal plant species (Figure 3).

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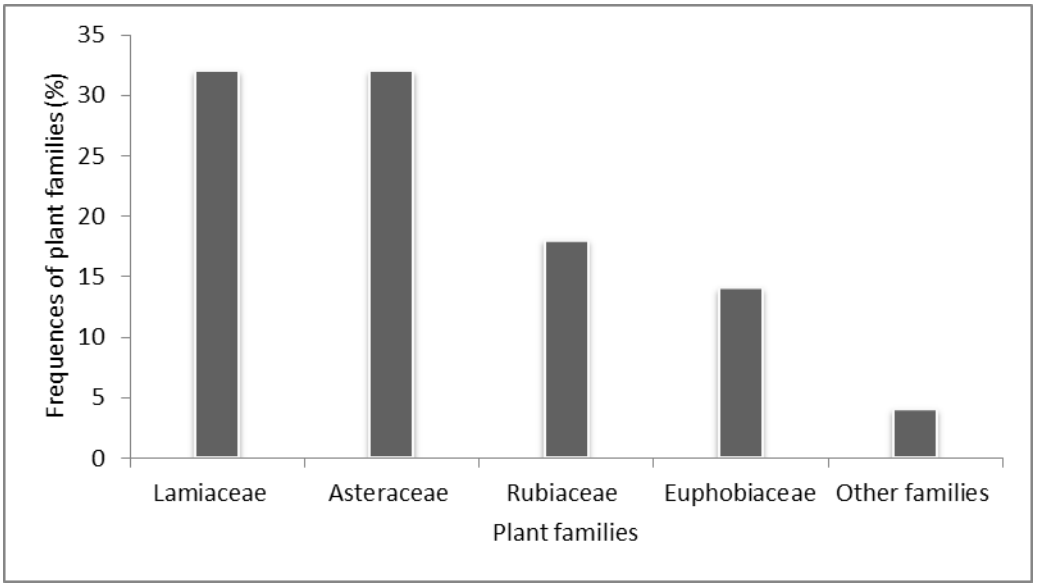

Figure 3: Five most frequent plant families in home gardens of study area.

3.2. Treated diseases within study area

Different disease and infections were recorded within study area and classified into nine categories with their percentage frequencies as follow: intestinal disease with 31.05%, respiratory and infectious, skin and poisoning diseases were found with no percentage frequency difference and abortion, cardiovascular, liver diseases, and burn were the least observed with less than 10%.

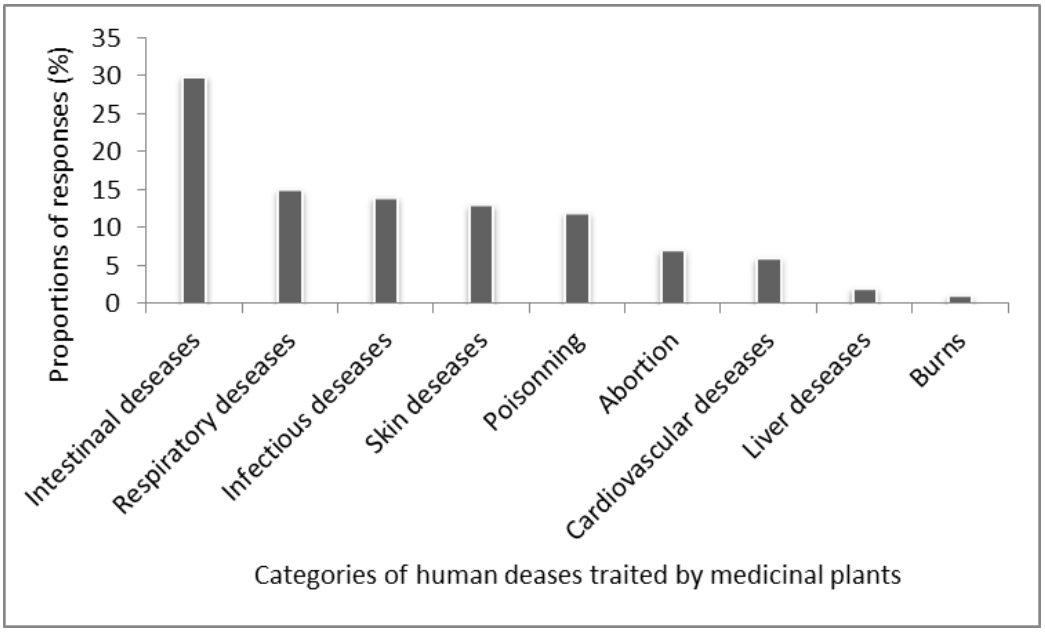

Figure 4: Most frequent categorized diseases and their percentage frequencies in study area.

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3. 3. Use of plant organs in traditional remedies

The leaves were the most plant organ used in traditional medicine in the study area with 82.79%. The roots and fruits bark showed no percentage frequency different and were almost less than 10%. *Maesa lanceolata* was noted as the medicinal plant species that use all plant organs i.e., leaves, roots, bark and fruits.

3.4. Ways of medicinal plant preparations

The study found that communities around VNP use different ways of medicinal plant preparation to treat illnesses in humans. The plant preparation was mostly with one single plant or with two or more combined plants. The mixed medicinal plants preparations were only 7.52%. The most frequent preparation method was crushing and squeezing with 48.95%, followed by pounding and powdering with 31.05%, cooking and boiling with 14.77%, burning and roasting (5:30%), and chewing (2.22%) (See Figure 5).

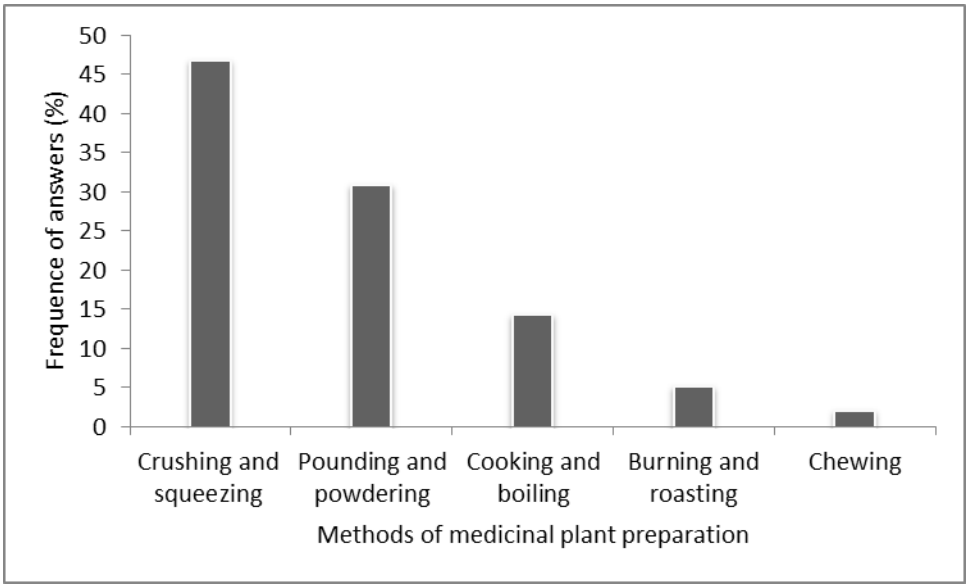

Figure 5: Categorized preparation methods of medicinal plants in study area

4. Results Discussion

4.1. Lamiacea and Asteraceae are the most frequent medicinal plant families in the study area

Asteraceae and Lamiaceae were the most families that contain more plant species where each of the two has 7 medicinal plant species but Asteraceae was the family with high frequency within study area. This is due to the fact that Asteraceae family is known to be found in agricultural area and most of its species are contains numerous species that can be incorporated into the a healthy diet (Rolnik and Olas, 2021). We have found the similar results with Ndahayo et al. (2010) who carryied out ethnobotanic study around VNP and also found that Lamiaceae and Asteracea are most diverse plant families among medicinal plants.

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4.2. Native medicinal plant species were most diverse in study area

The native medicinal plant species were noted as most diverse medicinal plant species within study area with 32 medicinal plant species out of 40 plant species recorded in whole study area and only 8 plant species were exotic. Local community and traditional healers in study area stipulated that they mostly use native plant species because there the most familiar with and the knowledge about its use were gained from their elders who did not expose to the exotic plant species hence high diversity of native medicinal plant in study area. As it is supported by assessment of traditional ecological knowledge and beliefs in the utilization of important plant species by (Irakiza et al., 2016). Non-native medicinal plant species to the VNP in study area home gardens were less frequent compared to native ones. The respondents indicated that getting seedlings: to grow medicinal plants in their home gardens is the main issue to the community around VNP. The local community around the park, except registered traditional healers, is not allowed to enter the forest. And even for authorized traditional healers, collecting native plant species from the park requires permission from RDB and it takes a lot of time and its long journey to reach to the point.

4.3. Most observed diseases and plant organs used to treat human within study area

People in study area were mostly affected by intestinal diseases and uses *Tithonia diversifolia* to treat these disease (Dewole and oni, 2013). The intestinal diseases are due to lack of sufficient hygiene consequent mostly to lack of proper latrines and drinking water (Izere et al., 2021). Fresh leaves are the good recipe for the most of plant since they contain more curative chemicals and can be extracted easily. This idea supports our results showing that leaves are most used plant organ in traditional medicine and it is an appropriate way in medicinal plant conservation.

4.4. Methods of preparation and the dosage required for diseases treatment in the study area

Crushing and squeezing were the most preparation method because it is primary way of preparation in such way that other method like powdering, they first crushed and then undergo the next step of preparation as observed in other ethnobotanical literature of (Waweru et al., 2017). They noted that, the crushing of medicinal plants is the primary mode of preparation. Again, in our study we have found a combination of different medicinal plants species to treat one or more disease. The traditional healers told us that they use crushed and dried plants organ and mix with clay where can be kept for long period and commonly used by pregnant women and other female diseases treatment. Different measurements are used by traditional healers when prescribing dosages (Paulos, 2020). The precise amount, however, might not be able to be determined using these measurements but the most mentioned by local people in study area were one spoon 3 time a day, and glass per day as mentioned (Ramathal et al., 2008).

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5. Conclusions

The study on medicinal plants in home gardens around VNP indicated that the cultivation of medicinal plants by local communities can satisfy their needs of traditional medicine, a mean of biodiversity conservation. Medicinal plants were highly diverse but their distribution remains clumped. The medicinal plants recorded are used to treat various diseases especially intestinal diseases due to lack of hygiene in the study area. Among the recorded medicinal plants, the most abundant plants are the native plants to the VNP. This is good for the park managers because the local community can satisfy to its needs in terms of traditional medicine. More effort is however needed to avail medicinal plant seedlings for sustainable biodiversity conservation and local community livelihood. Also, further research is needed to identify active substances of the recorded medicinal plants for the purpose of drug discovery.

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