

**IDENTIFYING THE SOCIAL AND ECOLOGICAL CONSTRAINTS TO
RESTORE BONNET MACAQUES (*MACACA RADIATA*) INTO THE
FORESTED LANDSCAPE, CENTRAL WESTERN GHATS, SHIMOGA
DISTRICT, INDIA.**

**A thesis TO BE submitted to
THE UNIVERSITY OF TRANS-DISCIPLINARY HEALTH SCIENCES AND
TECHNOLOGY**



**FOR THE AWARD OF THE DEGREE OF
M. Sc by Research (CONSERVATION FUTURES)**

**BY
--SAMARTHA P--**

UNDER THE GUIDANCE OF

NAME OF MENTOR/S

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DECLARATION BY THE CANDIDATE

**I declare that this thesis entitled “IDENTIFYING THE SOCIAL AND ECOLOGICAL CONSTRAINTS TO RESTORE BONNET MACAQUES (*MACACA RADIATA*) INTO THE FORESTED LANDSCAPE, CENTRAL WESTERN GHATS, SHIMOGA DISTRICT, INDIA.” submitted for the award of Master Science to THE UNIVERSITY OF TRANS-DISCIPLINARY HEALTH SCIENCES AND TECHNOLOGY, Bengaluru is my original work, conducted under the supervision of my guide Dr. Chetan HC, Associate Professor. I also wish to inform you that no part of the research has been submitted for a degree or examination at any university. References, help, and material obtained from other sources have been duly acknowledged
I hereby confirm the originality of the work and that there is no plagiarism in any part of the dissertation.**

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SUMMARY

The Western Ghats, celebrated for its diverse biodiversity, faces a critical paradox as the most densely populated global biodiversity hotspot. Mounting human activities has triggered habitat loss, leading to a surge in human-wildlife conflicts. Unplanned human-centric development compounds the issue by causing habitat fragmentation, hindering eco-centric solutions. This results in wildlife encroaching upon human settlements, intensifying conflicts and fostering the emergence of zoonotic diseases, posing threats to both human and wildlife populations.

This study, centered in the Malnad region of Shimoga district, specifically Thirthahalli, Hosanagara, and Sagara taluks, scrutinizes the Macaque conflict. It extensively examines land use, land cover changes, and the local community's perceptions of macaques, conflicts, underlying causes, measures taken by respondents, and their recommendations to alleviate the conflict situation.

We have used GIS and remote sensing tools to understand the land use and land cover change from 2000 to 2021. This reveals that a decline in natural forest cover and a rise in degraded forests are aligned with increased agricultural lands, monoculture plantations, and urbanisation. The second objective delves into the intersection between community perspectives on Macaque conflict, their livelihoods, and their views on Macaque behavior and habitat.

Through a comprehensive community perception survey with over 144 respondents, employing both qualitative and quantitative methods, the study explores the community's perceptions of macaques, the root causes of conflicts, measures implemented by residents to minimize conflicts, and their suggestions for government intervention. Analysing data on respondents' land, sources of income, cultivated crops, local wildlife, conflict experiences, and annual economic losses provides a nuanced understanding of community perspectives.

Despite variations in opinions, a prevailing concern emerges among respondents regarding macaques and the imperative for effective conflict management. This research not only illuminates the intricate dynamics between human activities and biodiversity but also provides essential insights for developing strategic interventions to harmonize human-wildlife coexistence in the region.

1. INTRODUCTION

We face the enormous challenge of reversing the trend of global forest fragmentation. It is estimated that 30% of global forest land has been completely cleared and 20% has been degraded (WRI, 2011). The proportion of intact forest landscapes varies enormously across the globe, with the environmental and ecological implications varying from region to region. A major threat is faced by arboreal mammals due to the large-scale forest fragmentation and narrowing down of forest corridors caused by many developmental activities such as roads, dams, mechanized agricultural and forest encroachments for agriculture, urbanization, and expansion of urbanizations, etc. As a consequence, many wildlife species, especially bats and primates, which are major hosts for many zoonotic diseases, are getting closer to human settlements than ever before (Chetan et al., 2023). Human-primate conflict has become common in many parts of the world and even in India, in the form of crop raiding in human-dominated landscapes. This is very common in many parts of the Western Ghats and also in other tropical forests worldwide (FAO 2006).

However, only 9.8% of the entire tropical forest biome lies within strictly protected areas (Schmitt et al. 2008), and the long-term viability of the existence of those reserves is strongly influenced by human activity in adjacent human-dominated landscapes (Wittemyer et al. 2008). Therefore, the future priority for conservation and sustainable management lies outside the PAs to meet the demand of humans from the mosaics of forest-agricultural landscapes (Harvey et al. 2008; Perfecto & Vandermeer 2008). However, such mosaics of the forest-agricultural landscape and its associated small mammals and arboreal mammals and their ecological services such as seed dispersal, pollination, and seed predation are important in sustaining the biological diversity of the landscape (Ganesh and Davidar 2001; Chetan and Ganesh 2012).

As the local human populace is a major stakeholder in the mosaic of the forest-agricultural landscape, it is important to understand their perception of forests and the wildlife that surrounds them. It largely helps us to know the current state of a landscape, which in turn gives a clear idea about human and wildlife coexistence and their interactions. Taking local communities into conservation or management would have maximum wildlife conflicts avoided and plan a proper conservation framework that benefits both people and wildlife with a coexisting approach.

There has been an increasing intolerance towards macaques in many parts of Karnataka. Its serious issues require forest managers and wildlife experts to solve this problem. The district of Shimoga has the second-highest population of Bonnet macaques after Chamarajnarag (Chetan et al., 2023). Since the majority of the district falls under the Western Ghats, it is home to many wildlife species. As the district has undergone massive natural forest cover loss from human activities over the years, wildlife is increasingly frequenting human settlements. The Bonnet macaque, which is endemic to south India, is a least-concerned primate species that is increasingly coming into contact with humans, triggering conflict situations and leading to intolerance towards the species. Macaque activities such as crop raiding, house raiding, and infrastructure damage are not the only causes of this intolerance; also, an emerging zoonotic disease like Kyasanur Forest Disease (KFD), also known as monkey fever, is adding more to this intolerance by increasing the conflict between humans and macaques in the region.

With this background, our study was carried out in the central-Western Ghats landscape of Shimoga district, which includes a mosaic of forested and agricultural landscapes and has been rapidly dwindling recently with changes in agricultural practices (Sinu et al. 2012, Chetan et al 2023). These practices also vary; marginal farmers follow intensive agricultural practices and also prefer economy-oriented crops compared to progressive farmers. So, the small landholders, to maximize their economic yield, prefer monoculture crops such as betel nuts, rubber, pineapples, and ginger, and in some parts, ash gourd seasonally in the region. These changes in crop and monoculture practices may attract wildlife into agricultural fields, and often there are incidences of crop raids and human-wildlife conflict.

About the Bonnet Macaque Species:

The Bonnet macaque (*Macaca radiata*) is a species of primate endemic to southern India. It belongs to the Cercopithecine group, which includes approximately 71 species of primates such as baboons, vervet monkeys, and macaques. Bonnet macaques are exclusive to the Peninsular region of the Indian Subcontinent and inhabit a variety of ecological environments. Despite this, much remains unknown about their ecology, demographics, and behavior (Sinha, 2001). The Rhesus macaque, a closely related species, is widely distributed in the northern regions and is a significant counterpart to the Bonnet macaque (Singh et al., 2008).

Both species of macaques have a commensal nature and have coexisted with humans in India for an extended period. Macaques, including Bonnet macaques, exhibit a remarkable ability to

adapt to human-altered environments (Priston and McLennan, 2013). They maintain close proximity to humans across South and Southeast Asia (Beisner et al., 2015). Due to habitat loss and easy access to food sources, macaques are recognized for their tendency to encroach on agricultural lands. They frequently damage crops and disturb human habitats, posing challenges in both urban and rural agrarian areas throughout India (Roonwal and Mohnot, 1977).

An interesting observation about Bonnet macaques, highlighted by various researchers, is their inclination to inhabit human settlements and associated niches, often becoming more terrestrial than remaining exclusively arboreal (Nolte, 1955; Simonds, 1965; Sugiyama, 1971; Krishnan, 1972; Kurup, 1981; Pirta et al., 1981; D'Souza & Singh, 1992; Sinha, 2001). Previously, the species was distributed widely across southern India, but now its range has significantly contracted. With the continually growing human population, the Bonnet macaque faces increasing challenges. Consequently, it has become imperative to develop strategies that minimize conflicts and ensure the long-term survival of the species (Sinha, 2001).

Crop raiding by macaques is a notable source of conflict between humans and macaques across Asia (Regmi, 2009), and it is currently prevalent in the Shimoga region. Nonetheless, macaques also hold significant religious and cultural value in India, as they are considered living representations of Lord Hanuman (Sinha, 2015). Attitudes and perceptions towards crop-raiding macaques vary among individuals. In a case study focusing on crop raiding by Rhesus macaques in Himachal Pradesh, northern India, respondents in five interviewed villages exhibited mixed opinions and ambivalent attitudes toward macaque management (Sinha and Radhakrishna, 2015). In the effort to mitigate human-macaque conflicts, it is crucial to consider the perspectives of farmers from conflict-prone areas before making management decisions (Sinha and Radhakrishna, 2015).

Study Rationale for the Bonnet Macaque

It has been observed that the Shimoga District holds the second-highest population of Bonnet Macaques after the Chamarajanagar District in Karnataka (Kumara et al., 2010). Over the years, there has been a growing human-macaque conflict in the Shimoga region (Kumara and Diandra, 2018). In response, farmers from Shimoga District have organized multiple protests urging the government to address the monkey menace in the area (The Hindu, 2018). To

mitigate this conflict, the government, in collaboration with the forest department, proposed establishing a monkey park, considering locations such as the isolated Islands of Sharavathi backwaters (Deccan Herald, 2019). However, local residents vehemently opposed this initiative, fearing potential zoonotic diseases like Kyasanur Forest Disease (KFD) and ecological imbalances in densely populated monkey parks (The Hindu, 2019). In the 2020–21 Karnataka budget, Rs. 6.25 crores were allocated solely for managing the monkey menace in the Shimoga region (TOI 2021). Some politicians have even advocated for granting permission to locals to cull Bonnet Macaques, citing their role in both conflicts and potential KFD transmission (TOI, March 2021).

Bonnet macaques are not only held responsible for crop raiding in the Western Ghats region of south India but are also identified as significant carriers of the zoonotic Kyasanur Forest Disease. These macaques serve as the primary amplifying hosts for the KFD virus, posing a severe threat to humans and other primate species in affected areas (Dobler, 2010). Research estimates indicate that around 400 to 500 people are affected by KFD annually in the Western Ghats (Babu et al., 2018). Moreover, a high mortality rate is observed among Bonnet macaques and Gray Langurs, which are definitive hosts of KFD (Babu et al., 2018). Scientific studies underscore that deforestation is a major driver of KFD and similar zoonotic diseases (Walsh et al., 2019). This not only impacts humans but also devastates local monkey populations (Walsh et al., 2019). The distribution and density of the tick species of the genus *Haemaphysalis*, a key reservoir and vector for KFD, are more prominent in fragmented and degraded forests (Babu et al., 2018). Factors such as environmental degradation substantially affect local wildlife, elevating the likelihood of tick transmission and thereby the spread of KFD (Ajesh et al., 2016).

To address the complexities of the region, we have formulated the following broad objectives:

1. Assessing the land use and land cover changes over the last two decades and classifying the potential habitats associated with bonnet macaques' in the Shimoga district of selected talukas of Thirthahalli, Hosnagara, and Sagara.
2. Assessing how the community perceives the bonnet macaque conflicts over the habitat gradients within these talukas
3. Assessing the community perceptions of change in habitats over the last two decades
4. Identifying possible solutions in the mosaics of human-dominated landscapes to minimize human-bonnet macaque conflicts

2. STUDY AREA

Geographic Context

The district of Shimoga is located in the central western region of Karnataka State (Fig. 2.1). Encompassing a land area of 8,435 sq km, the district consists of seven talukas. It is a landlocked region featuring two major ecozones—the Malnad region to the west and the Maidan region to the east. This study specifically focuses on the Malnad region, which is associated with a higher incidence of human-macaque conflict. The Malnad region is situated entirely within the Central and Western Ghats. Comprising four distinct forest types—deciduous forest, moist deciduous forest, semi-evergreen forest, and evergreen forest—the Malnad landscape is characterized by a mosaic of features, including forests, rivers, dam backwaters, human settlements, and agricultural areas. The highest point in the area is Kodachadri Hill, standing at an elevation of 1343 m asl, while the mean altitude across the region is approximately 640 meters above sea level.

Scope

This study was conducted within three talukas of Shimoga district, covering an area of 4,617 sq km, which constitutes 54.3% of the district's total land (Fig. 2.1). These three talukas Thirthahalli, Hosnagara, and Sagara—are situated in the Malnad landscape of the central Western Ghats. This area features a diverse range of landscapes, including forests, mountains, rivers, dam backwaters, and a mixture of human-influenced environments. Notably, the dam catchment areas of rivers such as Sharavathi, Varahi, Chakra, and Savehaklu encompass 2,605 sq km of the total area covered by these three talukas, contributing to 56.4% of the overall district landscape (Sathyaprakash et al., 2020)..



Fig. 2.1 – Shimoga district forest type map (*Source: Karnataka Forest Department*)

History of Land Use

Historical trends indicate a significant reduction in natural forest cover across the Shimoga region, particularly since 1973. The forest cover has dwindled from 43% to 23%, primarily due to the expansion of agriculture, horticulture, and forest plantations, as well as the construction of roads and high-tension power lines through forested areas (Roy et al., 2011; Rawat et al., 2013). Additionally, the creation of dams has led to the submergence of land under water. Over recent decades, the district has seen the denotification of a substantial portion of forest-owned land for alternative purposes. Reportedly, more than 70% of forest-owned land has been denotified, primarily for activities like timber cultivation (New Indian Express, 2018). A notable instance is the case of Mysore Paper Mills Ltd. (MPM), a government enterprise that has leased around 70,000 acres of forest department land for monoculture *Acacia* plantations, a lease that was renewed in February 2020 (Bennett et al., 2021).

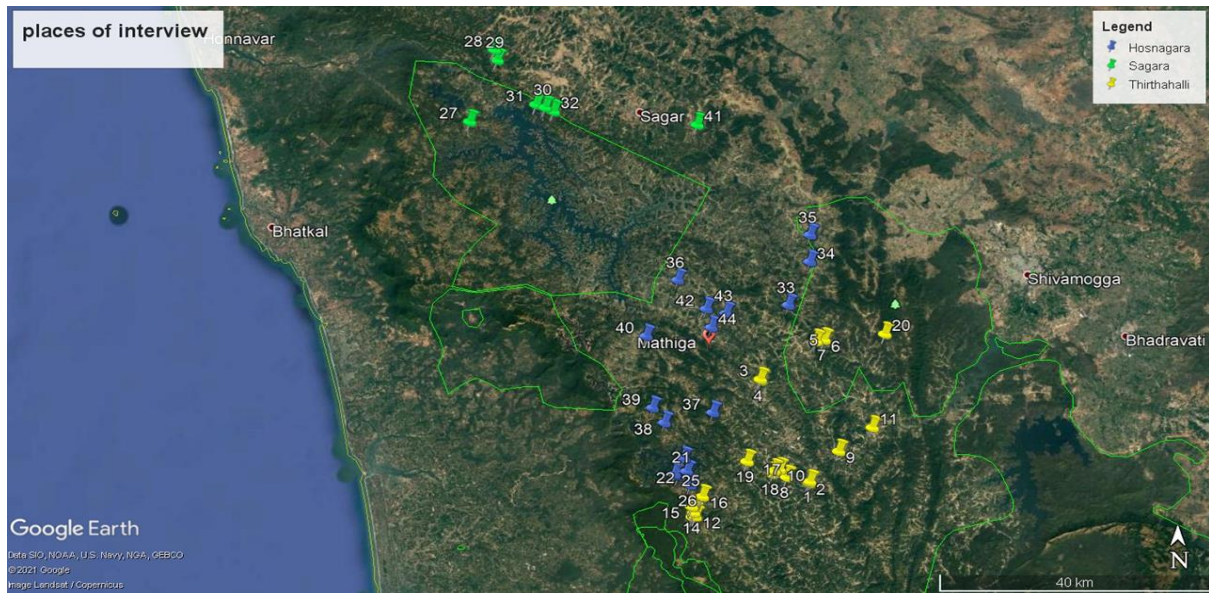


Figure 2.2 Sampling locations within the Malnad region of Shimoga region (Google Earth image)

3. METHODS

3.1. Land Use and Land Cover Classification (LULC)

The sampling was carried out in the Shimoga region of Malnad, with a specific focus on three talukas: Thirthahalli, Sagara, and Hosangara. The LULC studies used satellite images from both Landsat 7 (2000, 2015) and Sentinel 2 (2021). The LULC was classified into evergreen and deciduous forests, agricultural land, urban and built-up areas, shrublands, and water bodies. The GEE script-based approach was used to categorize changes over a period of time (2000, 2015, 2021). This cloud-based platform implements the three major steps outlined below: (i) image selection; (ii) collection of training samples; and (iii) running the classifier.

With the help of Google Earth Engine (GEE), the accuracy of both LULC classification maps was checked. This matrix contrasts the LULC linked to the validation points with the classifications that were produced (2000, 2015, 2021). The overall accuracy can be calculated with the help of a confusion matrix.

Finding Changes and Making Predictions: The cellular (MOLUSCE) plugin of Quantum GIS 2.18.0 software was used to find LULC changes and make predictions about them. A change in area was computed between the initial year (2000) of the LULC, the mid-year (2015), and

the final year (2021) of the LULC. The steps taken for this study are shown in the methodology flow chart (Figure 3.1).

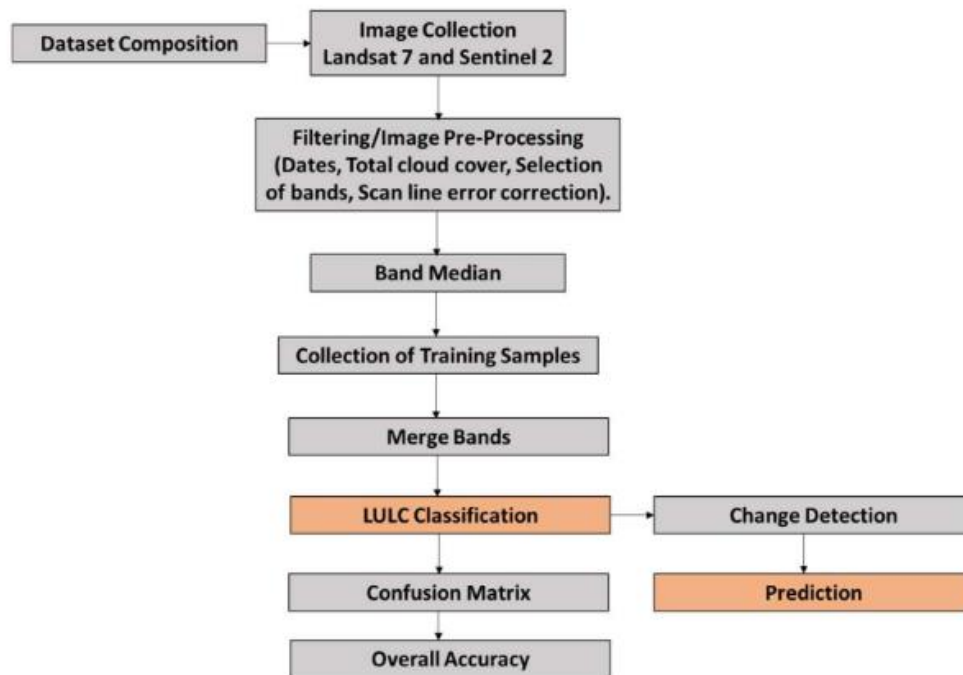


Figure. 3.1 Schematics steps followed for generating LULC maps

The two-decade LULC maps were verified through ground truth observations, where we adapted canopy cover and density (FSI classifications), direct evidence of human disturbance, and primary ground observations. Based on this, we have classified the results into three major categories.

1. Less degraded (LD) habitats: These habitats are characterized by minimal disturbance and continuous natural forest connectivity corridors in the landscape, which sustain biodiversity and gene flow.
2. Moderately Degraded (MD) Habitats: These habitats consist of mosaics of degraded evergreen and deciduous forests with narrowing contiguous forest corridors and mosaics of agriculture habitats.
3. Highly Degraded (HD) Habitats: These habitats have experienced significant disruption due to exotic plantations (such as *Acacia*, *Eucalyptus*, and Pine) and agricultural encroachments. They also include remnant degraded forest habitats that are not connected to natural forest corridors, as classified based on ground observations.

Community Perception Study

The perception study was carried out at two levels, namely, the semi-structured questionnaire interview approach and the second Focused Group Discussion (FGD) method, to get a consolidated perception of human-macaque conflicts and the history of causation and LULC changes within the Thirthahalli, Sagara, and Hosangara talukas.

The Questionnaire Method:

The sampling was performed based on LULC classification (Objective 1) within three major LULC habitats: highly disturbed (HD), moderately disturbed (MD), and less disturbed (LD), covering an area of approximately 100 to 150 hectares for each habitat. The detailed descriptions are provided below.

- I. **Highly Disturbed (HD) Habitats:** These areas have undergone severe landscape alterations over the past two decades, transitioning from native to non-native monoculture plantations. Encroachment is evident through the establishment of Areca orchards or other forms of commercial agriculture. These regions might be integrated into a mosaic of forested agricultural areas and monoculture exotic plantations, such as Acacia landscapes or human-dominated environments.
- II. **Moderately Disturbed (MD) Habitats:** These landscapes are characterized by a significant proportion of scrub forests, often featuring isolated trees with less canopy cover. Elements of agriculture, like paddy fields and Areca orchards, create mosaics within this landscape. Monocultural landscapes are absent in these areas.
- III. **Less disturbed (LD) habitats:** In these landscapes, the original forest species persist with a healthy canopy of mature trees, interspersed with agricultural mosaics. These areas are well-connected with continuous forests, and monocultural exotic plantations are notably absent from this landscape.

To collect information from respondents, a semi-structured questionnaire (Appendix 1) was designed. Each household was considered a sampling unit, and formal interviews were conducted with one respondent per household. The family head provided the majority of the responses, occasionally in company with other family members or by themselves, particularly when they were out in the field. Additionally, informal interviews were conducted with other

members of the household and local farmers in the area, who would often gather at each sampling unit out of curiosity. This approach allowed interviewees to raise topics not covered in the questionnaire and share their personal experiences. All unique inputs and experiences were documented during focused group discussions.

Community perspectives regarding historical and current land use and its impact on Macaque behavioral changes, troop size, and interactions with locals (including conflicts) were assessed using the semi-structured questionnaire method. Furthermore, inquiries were made at the household level (Annexure 1) to understand if there has been any instance of zoonotic disease transmission from wildlife in the area, along with the community's viewpoints on this matter.

Focused Group Discussion (FGD) Method:

We added to the information we got from the questionnaire with information from the Focused Group Discussion (FGD). This is because we asked questions in the village groups that weren't covered in the questionnaire. However, frequently, the discussion revolves around topics such as future perceptions of macaque conservation and its habitats. The gathered information is utilized to chart a path forward for wildlife habitat conservation and the development of a management plan.

DATA ANALYSIS

A total of 154 respondents were interviewed from 44 villages in the 3 taluks, viz.: Thirthahalli taluk; 90 respondents from the 20 villages (village names: Lakshmipura, Shuntikatte, Agalabagilu, Hisana, Hullatti, Keshavapura, Hitlusara, Thirthmuttur, Chibbalagudde, Kasaravalli, Hedduru, Tumbinkuli, Tumbinkone, Avaremane, Dasanakodige, Naluru, Heggodu, Ramkrishnapura, Kodlu, Alse); Hosanagara Taluk, 40 respondents in the – 18 villages (Taorolli, Temmemane, Malliki, Nidhagodu, Mavinkoppa, Huruli, Humchadkatte, Heddaripura, Baruve, Seegekoppa, Bhimagodu, Achumane, Mathiga, Nagara, Nellunde, Nivane, Mathiga), and; Sagara Taluk, 24 respondents in the 7 villages (Mandavalli, Korlakai, Adukatta, Baligere, Gubbagodu, Hebbabaylu, Ullur).

The information obtained from the Focused Group Discussion (FGD) was used to validate the questionnaire responses and to validate them with the local communities within the respective landscapes. Each respondent was analysed for recurring perceptions and differences in experiences related to changes in land use and land cover. This data was summarized and statistically presented for all close-ended questions. Responses that were not originally included in the questionnaire were separately recorded to gain a comprehensive understanding of the respondents' viewpoints. Subsequently, the comments were categorized and represented numerically. Furthermore, the unique opinions and personal experiences of the respondents were also documented to provide context to the quantitative results, following the methods outlined by Ogra (2009) and Dixon et al. (2009).

4. RESULTS AND DISCUSSION

4.1. LAND USE AND LAND COVER CHANGE:

The intervals reveal that there have been significant changes in land cover since 2000 (Table 4.1, Fig. 4.1). In 2015, habitat classification showed that shrublands and evergreen forests had declined. By 2021, drastic changes were observed, with approximately 25% of the land shifting to shrub forests, a 10% decrease in evergreen forests, and a 27% increase in agricultural landscapes over two decades from 2000. This transformation is particularly evident in the landscapes of the Thirthahalli and Sagar regions, where many forest mosaics have been converted into Areca orchards and monocultural plantations, such as Acacia species. The second largest conversion of land was into urban and human-built areas, accounting for about 5% of the land since the year 2000.

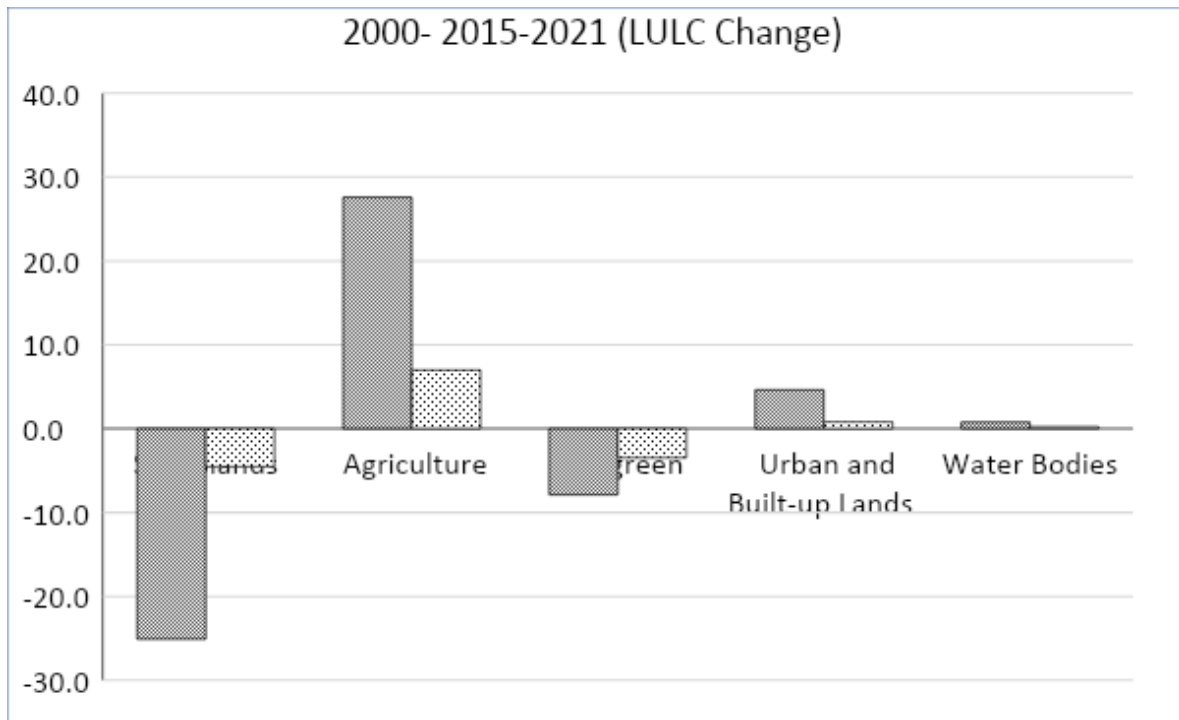


Fig. 4.1. Land use and land cover change analysis

The landscape has been undergoing significant changes since 2000 due to mechanization in agricultural practices, leading to the use of heavy earthmovers and JCBs even in the remotest villages of the talukas. This could be a reason for the sudden changes observed in land use practices in the region. Additionally, commercial crop preferences have reshaped the landscape, and extensive forest clearing began around 2010, with clear reflections between 2015 and 2021. Furthermore, large-scale development activities such as dam construction and the spreading of water due to backwater have altered the landscape and habitats.

Fig 4. Ground truth observation photos



Photo: 4.1. Monoculture plantation



Photo:4.2. Scrub forest



Photo: 4.3.Evergreen Forest

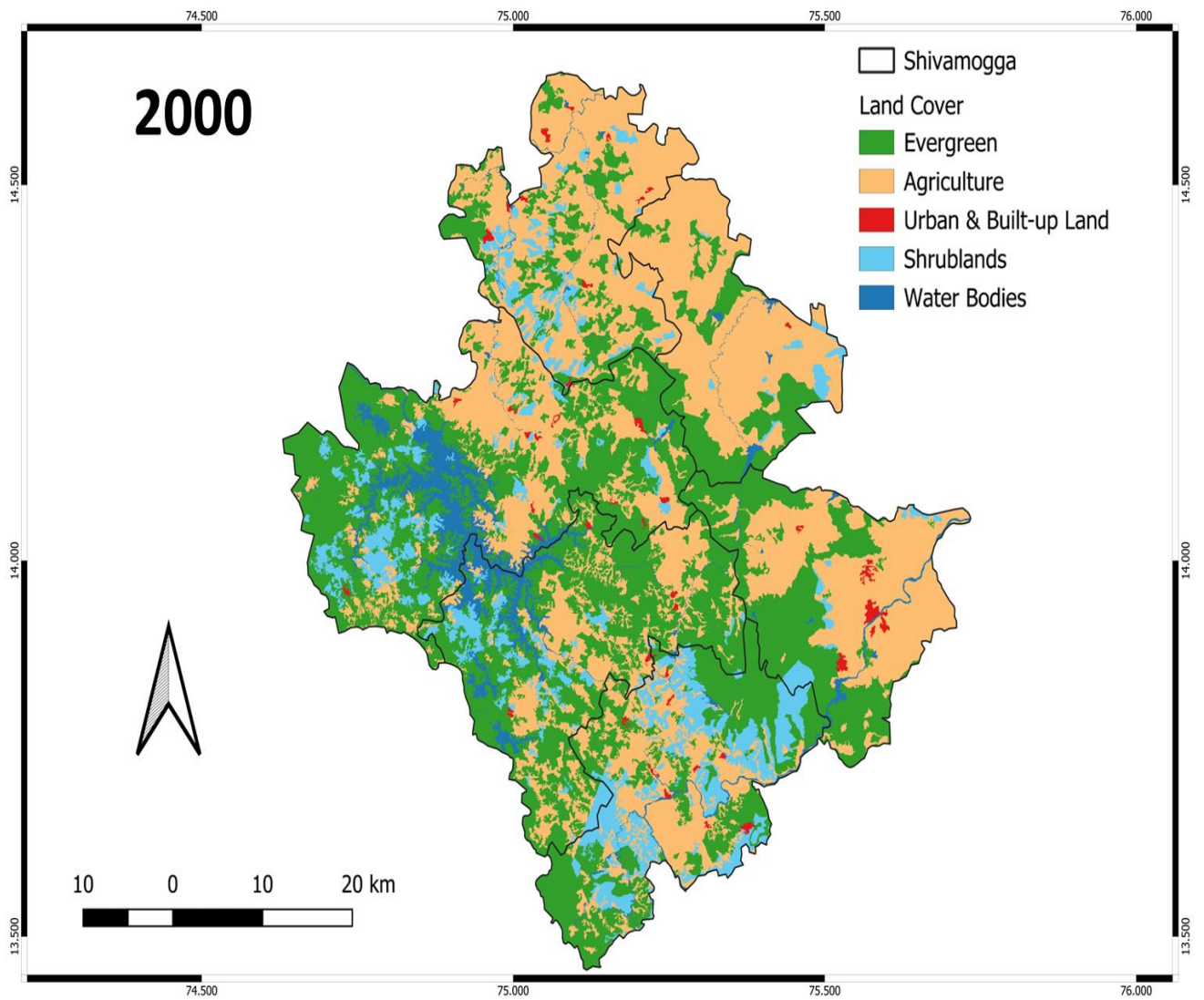


Fig. 4.2. Land use and Land Cover change image 2000

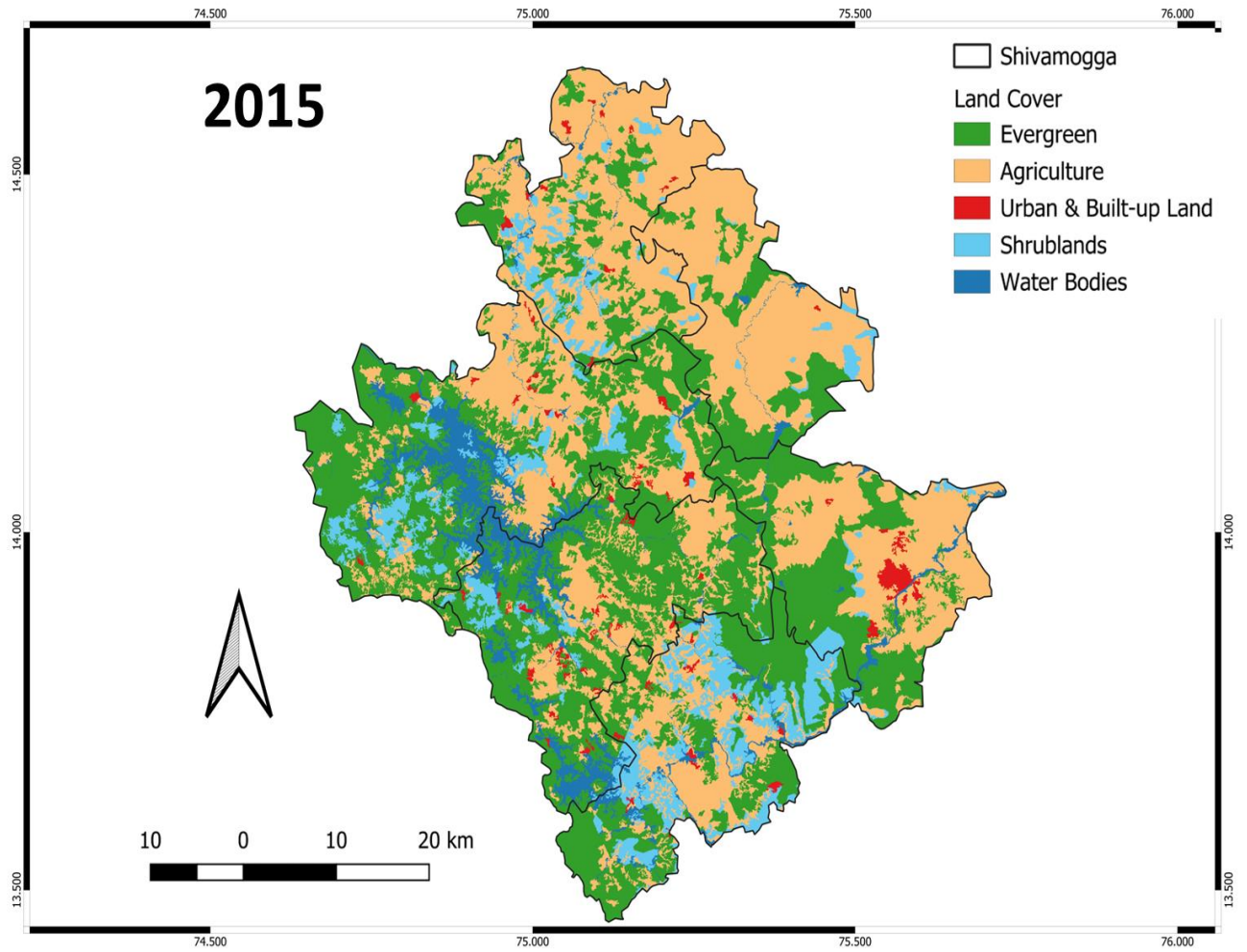


Fig. 4.3. Land use and Land Cover change image of 2015

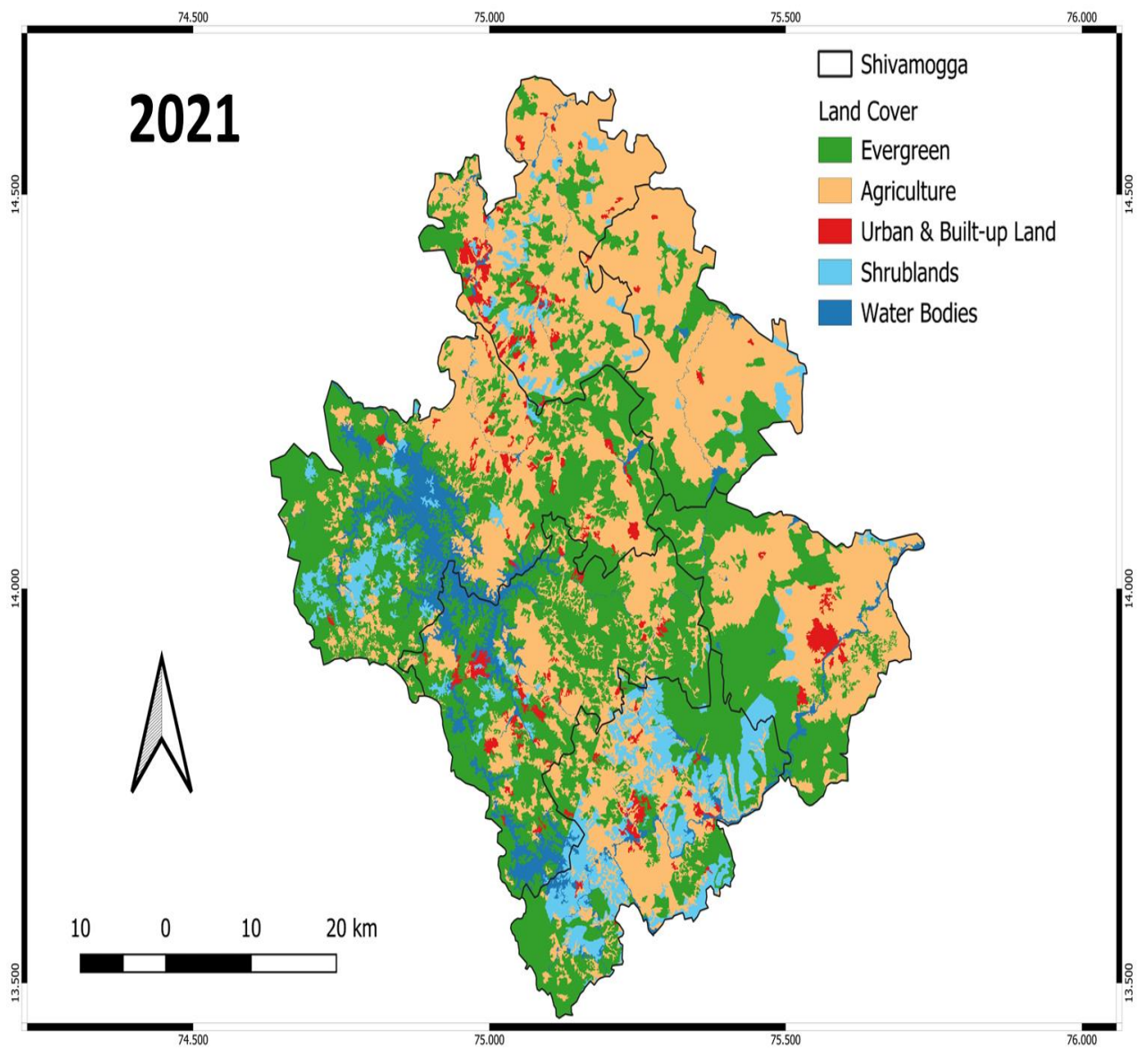


Fig. 4.4. Land use and Land Cover change of 2021 image

Table. 4.1. Percentage of land-use and land cover changes over period of time and shift over (talukas – Thirthahalli, Sagara, and Hosanagara)

Category	2000	%	2015	%	2021	%
Shrublands	697.63	49.5	633.83	45.0	346.5	24.4
Agriculture	394.52	28.0	492.98	35.0	788.77	55.6
Evergreen	255.14	18.1	206.28	14.6	144.94	10.2
Urban & Built-up Lands	28.75	2.0	39.85	2.8	94.66	6.7
Water Bodies	32.5	2.3	35.6	2.5	43.67	3.1

This shows that habitat loss is the root cause of the increase in human-macaque conflicts as well as KFD outbreaks. For instance, since 1973, Shivamogga has witnessed a drastic decline in natural forest cover due to encroachment for agriculture, horticulture, monoculture plantations, and development activities. The district tops the list of de-notified forest lands by the government. Over 70 percent of forest land has been denotified for purposes like growing timber and generating revenue. In 1980, Mysore Paper Mill Ltd. (MPM) alone leased 28,000 hectares in the Shivamogga district from the forest department for up to 40 years for monoculture plantations of species like acacia, eucalyptus, and pine. In 2020, the lease was extended until 2026, despite opposition from locals and environmentalists. Mysore Paper Mill (MPM) Ltd. alone has leased 28,000 ha from the forest department for monoculture plantations like acacia, eucalyptus, and pine-like species. In 2020, its lease will be renewed for another 20 years. The ecological restoration of such degraded forests seems to be the only sustainable and ethical solution to mitigate the situation. This is very much possible in the landscape based on selective interventions at LD (less disturbed), MD (moderately disturbed), and HD (highly disturbed) (Fig. xx).

4.2. COMMUNITY PERCEPTION

4.2.1. Wildlife conflicts

Based on the questionnaire data analysis, macaque conflicts are more pronounced in highly disturbed (HD) habitats, followed by moderately disturbed (MD) habitats, and then less disturbed (LD) habitats

(Fig 4.3). The macaque conflicts are most commonly observed in agricultural and household settlements (90% and 80%, respectively) in HD, which is not the case in LD habitats. However, contrary to that, other nocturnal wildlife such as wild boars and Indian gaurs are more prevalent in LD habitats where there are significant conflicts with the agricultural landscape (Fig. 1). The Kruskal-Wallis *chi*-squared test shown across the three habitats is also significant (KW Chi-square = 108.02, $df = 2$, p -value < 0.0001).

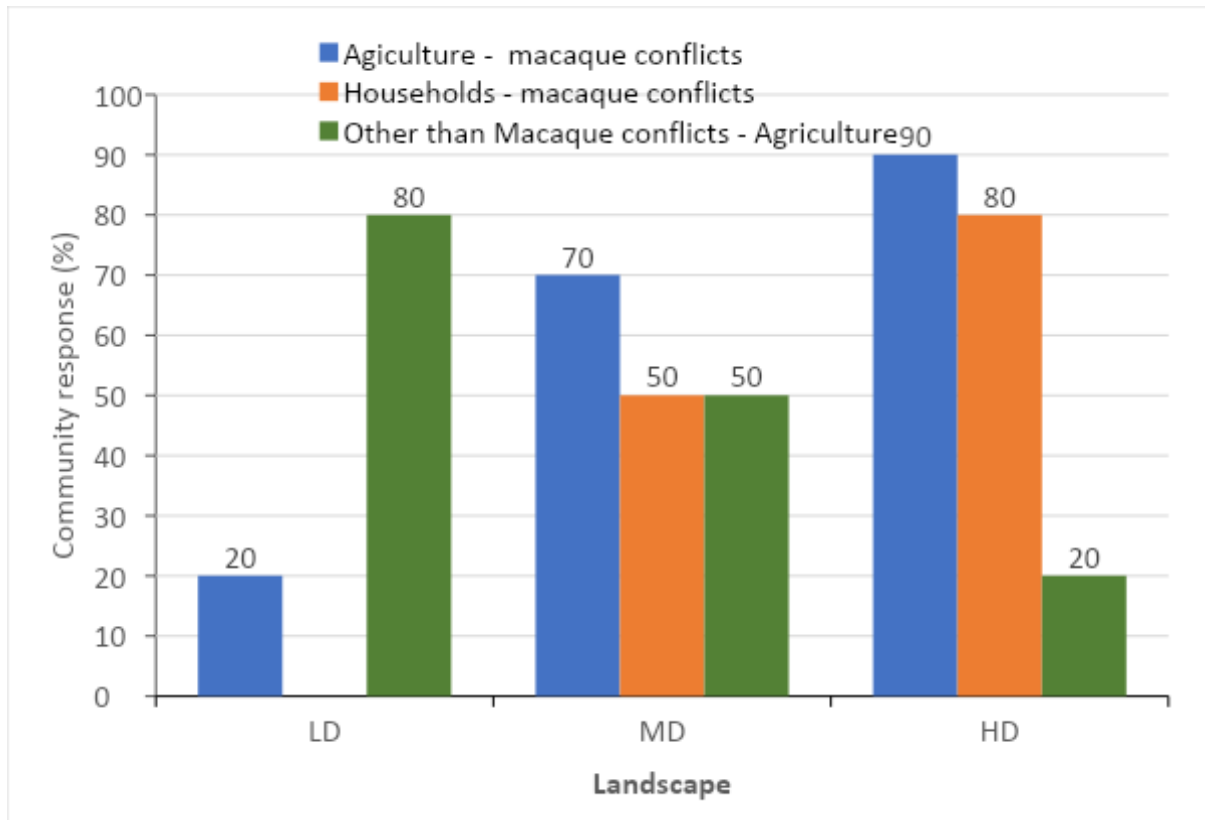


Fig. 4.3. Community response on bonnet macaque conflicts within their agricultural and households than other wildlife conflicts represented in the LD, MD, and HD landscape (NOTE: LD – Less Disturbed, MD – Moderately Disturbed, HD – Highly Disturbed)

4.2.2. Habitat Change

The local community's response revealed a significant change in land use and land cover observed in highly disturbed (HD) and moderately disturbed (MD) habitats (Fig. 4.4). This change has historical underpinnings, as the Shimoga district has undergone substantial habitat transformation since 1973, resulting in a decline from 43% to 23% (Ramachandra et al., 2019). This decrease in the Malnadu region could be attributed to factors such as the expansion of agriculture, horticulture, and monoculture exotic plantations by Mysore Paper Mill Pvt. Ltd. Additionally, local-to-regional demand and agricultural

encroachment by the local community are clearly evident in our ground-truth observation. Furthermore, the government's de-notification of forest lands has further contributed to the reduction in natural forest cover (as reported by The New Indian Express, 2018; and The Hans India, 2021). Last 15 years macaque conflict has increased evidently, and this revealed in HD habitats has become increasingly common. The area has witnessed a drastic decline in natural forest cover since 1973, with forest cover decreasing from 43% to 23% (Ramachandra et al., 2019). The expansion of agriculture, horticulture, and forest plantations has been a major driver of this decline (Ramachandra et al., 2019). Additionally, local people have encroached upon forest lands, and the government has denotified a significant portion of forest lands for other purposes like timber growing and revenue generation (New Indian Express, 2018; The Hans India, 2021). Monoculture practices involving the cultivation of non-native trees such as acacia, eucalyptus, and pine have further degraded the land and surrounding forests (Vijaya Kumara and Lewis Diandra, 2018). These non-native trees absorb nutrients and water from the surrounding forest, hindering the growth of other plants and causing ecological imbalances (Rascher et al., 2011).

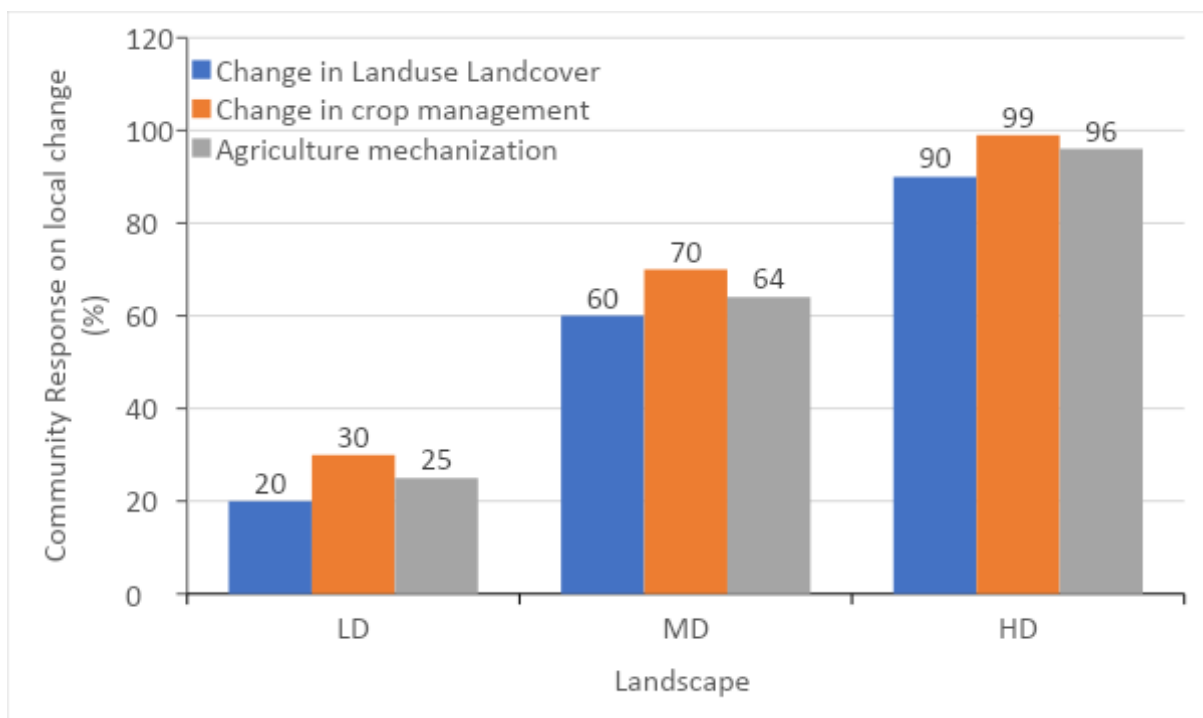


Fig. 4.5. Community response towards local land use and land cover change in the LD, MD and HD landscape (NOTE: UD – Less Disturbed, MD – Moderately Disturbed, HD – Highly Disturbed) The landscape in the "Less Disturbed" category is located near the Hosanagara region and the nearby Shettihalli Wildlife Sanctuary, both of which are partly protected under buffer areas and communities are under the Eco-development Community where they are beneficiaries of the EDC committee.

Highly disturbed habitats have been significantly impacted by major drivers such as non-native plantations including Acacia, eucalyptus, and pine. These non-native tree species have played a major role in degrading the land and surrounding forests (Vijaya Kumara and Lewis Diandra, 2018). Moreover, these non-native trees hinder the growth of native plants and create empty forests due to the absence of native faunal foraging opportunities (Rascher et al., 2011).

The altered landscape and loss of natural forest cover have led to negative impacts on the local communities and native flora and fauna (Hartemink, 2003). To address these issues, there is an urgent need to reclaim and restore denotified and leased forest lands, focusing on restoring native floral diversity (The Hindu, 2021; PR Kumar et al., 2018). While the forest department has initiated some restoration efforts by planting native fruiting trees, these initiatives are currently limited in scale (Vijaya Kumara and Lewis Diandra, 2018). A more sustainable and long-term solution would involve converting revenue-generating forest plantations into native forests through large-scale restoration and the planting of native fruiting trees (PR Kumar et al., 2018).

Consequently, the region is facing negative consequences. Arboreal mammals, like bonnet macaques, are attempting to venture out from these habitats and are moving closer to human settlements and agricultural fields. This proximity to human activities also leads to direct contact with humans, increasing the risk of zoonotic diseases such as the Kyasanur Forest Disease and wildlife conflicts (Ramachandra et al., 2020).

There are many anecdotal statements from senior citizens during the FGD discussion between the age groups 80 to 85: -

- Before the monkeys were coming very rarely to the fields, only during rice harvest time to eat grains and it was nothing in terms of loss. - 81-year-old lady from Tairolli village, Hosanagara.
- Before monkeys were never damaging Areca nuts, only now they are plucking. It seems like they don't have food left in the forest. - 83-year-old respondent from Temmemane, Thirthahalli taluk.
- The monkey population was very low before, but now it's risen up so much - an 89-year-old lady from Agalabagilu, Thirthahalli taluk.

- Before there were no ticks in the forest now the forest is full of ticks and unwanted plants. - 85-year-old man from Mandavalli village, Sagara taluk.
- Before the forests were very lush and rich in plant diversity including many fruiting trees like Sampige Hannu (*Flacourtia montana*), Hebbalasu (*Artocarpus hirsutus*) Uppage hannu (*Garcinia* sp.), Nerale hannu (*syzygium cumini*), Kouli hannu (*Carissa carandas*), Halage hannu (*Elaeagnus conferta*), Challe hannu (*Aporosa lindleyana*), Mullu hannu (*Ziziphus oenoplia*) and so many other varieties of fruits. But now they have become very rare in forests and I can only see Acacia and Nilgiri plantations and degraded forests. - 85-year-old Man from Keshavapura, Thirthahalli.

The community perception gives a clear perspective on the current scenarios. Primates are protected under wildlife laws in many countries, such as India, which prevent humans from capturing, injuring, or killing them (Claudio Sillero-Zubiri and David Switzer, 2001). People feel that the government or forest department should take responsibility for providing solutions for the conflicts with macaques (Kumara and Diandra, 2018). Of the many solutions that are described in scientific literature, growing primate-favorable crops next to economically important crops could decrease the issue of crop raiding by macaques (Naughton-Treves et al., 1998). The farms that are closer to forests have a greater chance of macaques raiding the field (Baranga et al. 2012). Though many measures are described to prevent macaques from raiding crops, it is impossible to completely deter macaques from the land as the species is highly adaptive to the changes (Kumara and Diandra, 2018). Some observations made by the researchers include that monkeys from urban areas left in villages cause more damage to crops by increasing conflict situations in villages (Yeo and Neo, 2010).

A study was conducted in Hosanagara taluk of Shimoga that quantified the impact of the human-macaque conflict situation. The majority of the farmers owned less than 10 acres of land. And the most common measure taken by the people to deter monkeys from their land was keeping dogs. About 86% of people interviewed saw B. macaques as pests, with 38% conjuring them as scared. Conflict situations like crop raids, house raids, and infrastructure damage were reported in the region caused by Bonnet Macaques. Many interesting innovations taken by people to deter monkeys were observed. Many respondents believed that there was no solution but to live with it. The study found that the attitude of farmers don't want to cause harm to the macaques, but the rising population and crop raiding are concerning them, which is worsening

the relationship of people with macaques. Some official perspectives from the Forest Department say that restoring the forests with native fruiting trees is being done. But since the MPM plantations lease has been renewed, it means that it's happening only on a small scale. Other official perspectives, such as reducing encroachment, putting up rehabilitation centers for monkeys and castration for monkeys, and creating awareness among the people, are looked upon for implementation. However, they say, these methods may not be feasible and are bound to be time-consuming. So, it is important to know the further views of people on macaques in the Malnad region of Shimoga, as it is more prevalent now as the government is engaging in making decisions on the issue. A further study that encompasses the cause and suggestions of the people in mitigating the conflict situation with correspondence to land cover changes is necessary. Shimoga is a district that has a high occurrence of both crop raiding, which is leading to conflict (Kumara and Diandra, 2018), and victims of Kyasanur viral forest disease (Kavi and Bhargavi, 2017). So it's important to consider this region to mitigate the human-bonnet macaque conflict in a careful manner. In mitigating human-macaque conflict, it is important to consider the views of farmers from conflict areas before making any management decisions (Sinha and Radhakrishna, 2015).

4.3. Way forward

Habitat conservation and sustainable management

Based on the results of Objectives 1 and 2, it is clear that in Shimoga district, including Thirthahalli, Sagar, and Hosanagara talukas, a large-scale modification of the landscape from forested to non-forested purposes has occurred. The Land Use and Land Cover (LULC) data, supported by community perceptions, also reveal that the transformation of the landscape into non-native monocultural plantations directly affects macaques, forcing them out of their natural habitat. Currently, many of these macaques reside closer to human settlements, leading to serious issues such as macaque-human conflict as well as an increased risk of zoonotic diseases, as supported by recent publications (Chetan et al 2023). We have proposed an interventional framework based on our primary findings. The landscape is classified into three gradients, viz., highly degraded, moderately degraded, and less degraded habitats. Each habitat needs special attention to bring back macaque-friendly habitats. Which is the only solution to reduce human-macaque conflicts in the region?

Less Disturbed (LD) Habitat Interventions:

As the name suggests, these landscapes boast luxuriant, original forest habitats, providing year-round food availability under a mature canopy (fig. 4.6). This setting creates an ideal habitat for sustaining macaque troops within the landscape. These habitats are considered remnant native patches within the study area. Assessing the plant species in these habitats may provide insights into the HD and MD habitats. Furthermore, studying these habitats (namely: part of Hosanagara and Shettihalli WLS) will help us restore other degraded habitats. Variables such as plant species and life history may aid in ecological interventions in HD and MD habitats. These landscapes necessitate a high level of awareness for those who leave them.

Moderately degraded habitat interventions:

The habitat is characterized by a significant proportion of degraded scrub forests, often featuring isolated trees with less canopy cover, interwoven with a mosaic of agricultural patches such as paddy fields (Fig. 4.6), Areca orchards, and human settlements. This setting resembles a mosaic of forested, degraded, and agricultural landscapes. The wildlife in these landscapes is highly vulnerable, with only bonnet macaques managing to coexist with human settlements (Priston and McLennan, 2013). Our two-decade-long Land Use and Land Cover (LULC) analysis clearly shows this degradation. It may be due to large-scale forest area conversions for agricultural encroachment and the transformation of forest land into timber-growing monocultural plantations (Meera Bhardwaj, 2018). The MPM alone has leased 70,000 acres of forest land from the forest department (Satish, 2021).

Interventions for this habitat need to consider the community as a major stakeholder. Planting suitable species that have been reported in less degraded habitats is crucial. Additionally, community-level awareness is necessary to encourage voluntary participation in the afforestation program. Further efforts to improve soil health and protect native species are essential to restoring macaque-friendly habitats in the MD habitat.

Highly degraded habitat intervention:

These landscapes are highly vulnerable, and the causes of land degradation need to be thoroughly understood before initiating any ecological interventions (Fig.4.6). These causes could be social, cultural, and ecological. Local stakeholders such as the local Biodiversity Management Committee (BMC) and the local panchayats/forest department should participate and drive ecological interventions, such as introducing the appropriate native species for the

afforestation program and ensuring their protection. Frequent monitoring, including weeding, manuring, and watering, is required until the saplings are established in the habitats. There is a significant opportunity to involve the social forestry department and establish possible islands of native forest within the monocultured landscape, as suggested by Chetan et al. in 2023 .

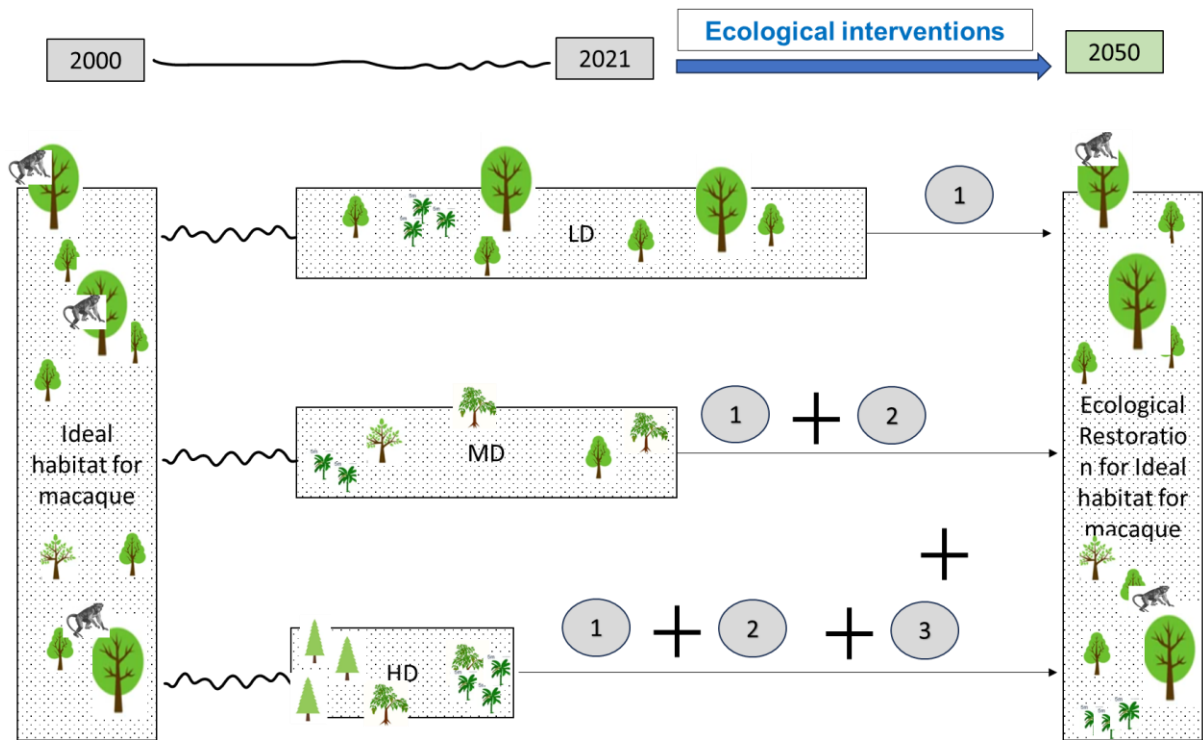


Fig. 4.6. Framework for next 30 years: Conservation and mitigation measure for macaque habitats restoration. Note: LD – *Less disturbed*, MD - *Moderately disturbed*, HD - *Highly disturbed*. **Ecological interventions** viz. (1). *Environmental Awareness and Conservation Measures*. (2). *Soil Health, Livestock Grazing, and Fodder Collection Protection*. (3). *Active Ecological Restoration and Protection Measures through Social Forestry*; 2021 to 2050 intensity of ecological restoration in respective habitat gradients.

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Appendix 1. Semi structured questionnaire used for community interviewed across HD, MD and LD habitats in the study area.

Name: _____ Age: _____ M/F: _____
Village Name : _____ Taluka: _____
Family member: _____ Native/Non Native _____
Y/Generation _____
Livestock's number: _____ Wildlife conflicts: Y/N : _____ if, Yes, what are _____
Forest type nearby: Natural/ Disturbed /Plantation _____
Forest dependency: Grazing / Fodder / firewood/ NTFP or _____

1. How much land do you own?

2. What crops have you grown?

Major source- _____

Medium source - _____

Minor source - _____

3. Are there any wild trees in your land? If yes, can you identify them and if possible, can you guess how much of your land it covers?

4. Do you have any fruiting trees in your land? If yes, can you specify which season / months it yields and how do you use it?

5. Have you noticed any forest cover change ? YES OR NO

1. . If Yes, Please explain how forest cover has been changing.

0. Do you believe that forests are degrading day by day? If yes, what could be the reason?

0. What would be major reason for forest degradation
1. forest land used for agricultural encroachment, 2. cut for timber 3. Forest Plantations 4. Other ?

0. Have you made any changes in agricultural practices over the past decades? No change or if yes, can you specify the crops?

6. Do you know or have you encountered any wildlife in your area? Can you name them?

7. Are there any wildlife conflicts on your crops or house recently?

1. No,
2. If Yes, what are those wildlife names _____ Cr
ops _____ & which seasons _____

8. Are there any monkeys in your area? If yes, Can you name those species?

9. In a year, any specific month/seasons you find (more wildlife issues in your village)?

1. All throughout the year
2. Seasonally: Monsoon / Summer / Winter
3. In the case of Bonnet macaque - Monsoon / Summer / Winter ?

10. Do you think that any wildlife species population is increasing in recent decades from last 50 year?

1. No
2. Yes ; if Yes. Explain which species and why _____

11. Do you have bonnet macaques in your area? If possible do you know how many groups reside in your proximity?

12. What is your opinion on macaques?

1. Forest dwellers
2. Forest keepers
3. Gods
4. Pests

13. Do you have any idea about the role of macaques in the forests or ecosystem?

1. Seed dispersal, 2. Seed predator, 3. Pollinator, 5. pest controller 6. No idea.

14. What would be the reason for Bonnet Macaques becoming a nuisance in villages? What could be the reasons?

1. Due to forest degradations
0. Lack of food availability / roosting places
3. They like human crops than forest food
4. No idea

15. What type of macaque conflicts do you deal with on a day to day basis and what is that which affects your tolerance level?

1. Crop damage
2. House raids
3. Infrastructure damage
4. Physical attack

16. What percentage of economic loss is happening due to macaque raids?

1. <10000
 2. <50,000
 3. >50000
 5. > 1 Lakh
-

17. Do you think there is a change in macaque's behavior due to change in land use and land cover in this region?

1. I don't think so
 2. Yes, behavior has also changed
- If Yes, what could be the reasons? _____
- _____
- _____

18. Do you think the forest is lacking wild fruiting trees and do you believe this might be one of the reasons for macaques to get closer to human settlements?

Yes; or if no, can you specify another reason?

19. What all measures have you taken to deter monkeys away from your land?

1. Keeping dogs
2. Crackers or large sounds
3. Guns, catapult or other long distance weapons
4. Electric fencing

5. Cutting trees

20. What are your sociocultural beliefs/perspectives on the Bonnet macaque? Do you have any place of worship dedicated to Lord Hanuman?

:

21. Do you have any suggestions to minimize the Macaque conflicts in the area?

1. Macaque habitat improvements in degraded patches and respected forest areas.
2. Capture and release in dedicated Monkey Park
3. Capturing and sterilizing them, so that no more next progeny
4. Kill them at one time.

22. Do you know about the spread of Kyasanur forest disease (KFD) spread?

1. Yes or No;
2. Does your family consist of any victims in the past or present?
Yes or No;

0. What might be the cause?

4. What is your opinion on the spread of KFD?

1. Macaques accelerating the spread of KFD'
2. Macaques' presence helps as an indicator of the disease outbreak
3. Increase in tick density
4. Forest degradation

5. In your opinion, what might be the possible solution to eradicate KFD?

APPENDIX 2 – FIELD PHOTOS

INTERVIEWS WITH LOCAL COMMUNITY

Figure 1: A Respondent pointing at crop damages caused by macaques in his field



Figure 2 : Interviewing with the respondent in his field. An action taken according to their preference, to make sure their routine was not interrupted.



Figure 3: Interviewing in the respondents house front yard.



Figure 4: Conducting Focused group discussion.



Figure 5: Interview with a senior citizen



LANDSCAPE PHOTOS

A. THIRTHAHALLI TALUK

MPM's Pine plantation in Forest department's leased land



Private Rubber plantation



Areca trees planted in paddy fields



Areca and pepper orchards



Degraded forest



Natural forest



Agricultural lands converted to layouts



Coffee Plantation



Paddy fields



River Tunga



B. HOSANAGARA TALUK

River Varahi Dam Backwaters- Mani



Eucalyptus plantation



Rubber plantation



Areca plantation



Chopped Acacia plantation



New Acacia plants regrowing from roots



Forest cleared for Agriculture



Natural forest



C. SAGARA TALUK

New Areca saplings planted by clearing natural forest



Eucalyptus plantation



High Tension wire poles cutting through forest



Railway track cutting through forest



Trees chopped for road widening



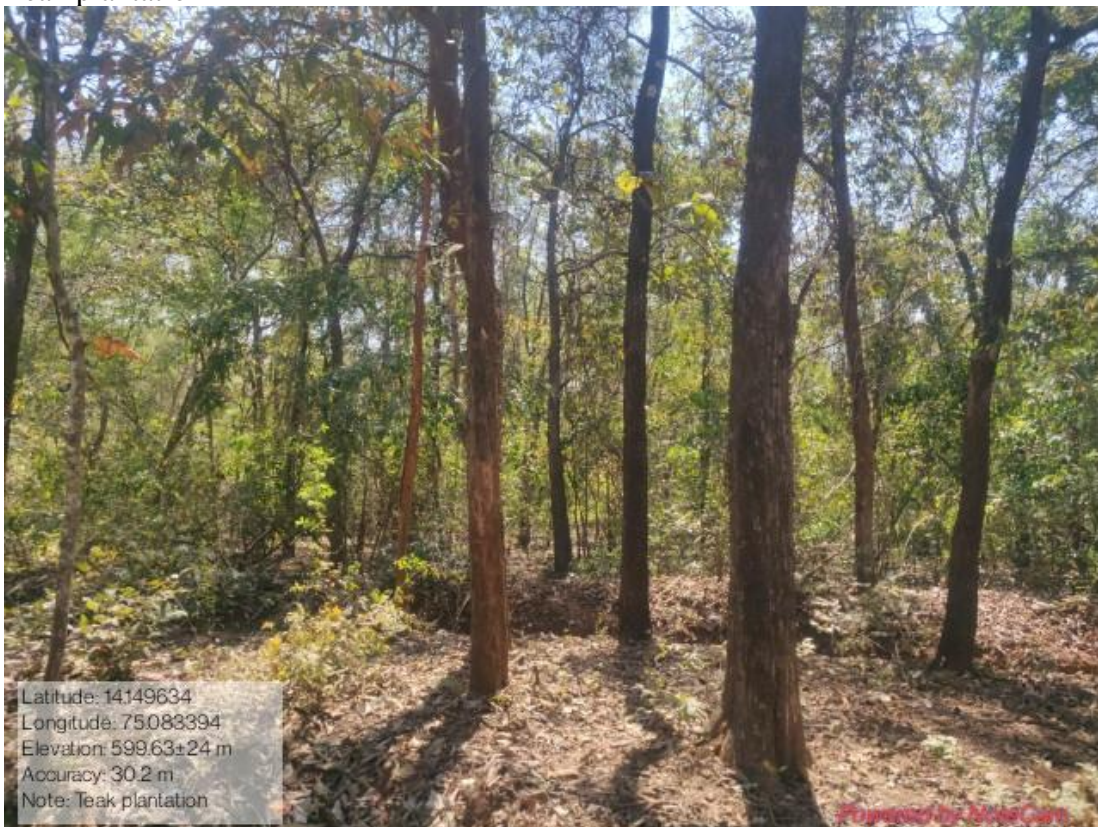
Ginger fields



Acacia becoming invasive



Teak plantation



CONFLICTS AND MITIGATION MEASURES TAKEN BY RESIDENTS

Figure 1: B.Macaques raiding houses



Figure 2: B.Macaque seen on roof top



Figure 3: Macaque on coconut trees



Figure 4: Macaque on roof tiles



Figure 5: Bonnet macaque entering house premises



Figure 6: Bonnet macaque in areca plantation



Figure 7: A respondent with his home-made sound making PVC pipe gun



Figure 6: Stone pelting gun made with metal pipe to hurt monkeys



Figure 7: KFD diseased dead macaque



Figure 8: House dog eating KFD diseased monkey which is seen as a potential carrier of the disease

