ASSESSMENT OF FUEL WOOD CONSUMPTION AND ITS EFFECT ON FOREST DEPLETION IN DRY DECIDUOUS FOREST OF HALIYAL TALUK, UTTAR KANNADA DISTRICT

Abstract:

Forest plays a significant role in extending wood and non-wood resources around the world,Forests provide ecosystem services, such as timber, food, fuel, fodder, non-wood products and shelter, which are essential for human well-being. however the increasing demand and pressure on forest resources majorly like fuel wood lead to degradation of forests. Hence it is important to assess the fuel wood consumption pattern and its impact on the forest for sustainable management of resources. In the present study,Haliyal taluk was selected, the area which is under rapid urbanization, surrounded by dry deciduous forest and the people living in that area depend on forest for fuel wood consumption.The study examined fuel wood collection among different farmer categories: large, medium, small, and landless. Results from the semi structured questionersurvey revealed that medium farmers collected the most fuel wood. The total fuel wood consumption in Haliyal taluk was 5232.2 tonnes, with an average household consumption of 2.60 quintals of fuel wood per year. Major preferred tree species for fuel wood were *Xylia xylocarpa*, *Terminalia tomentosa* and *Lagerstroemia lanceolata*, which are valued for their high energy content, favourable burning characteristics and availability. For estimation of forest degradation Randomized Block Design was used and the study classified the forest vegetation into four crown density classes: Very Dense Forest (T_1), Moderately Dense Forest (T_2), Open Forest (T_3), and Scrub (T_4). Data was collected from 20 plots (20 x 20 m each) across these classes to measure forest depletion. The results showed that statisticallysignificant differences in degradation levels, with the highest depletion (31.56 m³/ha) in very dense forests followed by moderate depletion (6.75 m³/ha) in moderately dense forests and the lowest (2.4 m³/ha) in scrub forests. This pattern reflects greater anthropogenic pressures and higher fuel wood availability in more dense forest types.

Key words: Forest depletion, forest types, fuel wood, farmers, landholding

1: INTRODUCTION

Forests are one of the most important components of the terrestrial ecosystems. They are the storehouse of biological diversity. Crown canopy is a significant regulator of forest, affecting microclimate, soil conditions and having an undeniable role in a forest ecosystem. Dry deciduous forest is a biome dominated by deciduous trees which shed their leaves seasonally during dry winter and spring month. These are most wide spread forests of India. Found in Madhya Pradesh, Maharashtra, Andra Pradesh, Karnataka, Tamil Nadu, Gujarat and Rajasthan. These forests are categorized by extremely variable climates, low rainfall, 5-6 dry months within the annual cycle and nutrient poor soil. Dry Deciduous Forests receives the rainfall between 70 to

100 cm commercially important tree species like Teak, Sal, Sandal, Bamboo, Terminalia, Acacia species are found are found(Yadav, 2006).

Forest canopy density refers to the proportion of an area in the field/ground that is covered by the crown of trees and is expressed in percentage of the total area. For the better management of forest, changes of canopy density should be considered. Forest canopy density is one of the useful parameter to consider in the planning and implementation of rehabilitation program. It is possible that there isn't any change in the area of forest during the time but the density of forest canopy is changed. Crown density is used to estimate the percentage of crown volume that contains biomass.The classification of the cover into dense and open forests is based on internationally adopted norms of classification. Trees with below average crown densities are expected to have reduced growth compared to trees with full, symmetrical crowns(Indian state of forest report, 2021).

Western Ghats, an orographic feature extending from Kanyakumari in the South to Tapti in the North, cover six states in the Western India. The Western ghats of Uttara Kannada district is known for their dense forests which cover about 80% of the area of the district. The total forest of Uttara Kannada is about 8, 29,151 ha. And the per capita forest is about 0.77 ha**.** The forests of Uttara Kannada can be classified into 3 categories based on density as partially open forest (20-40% density), Medium density forest (40-80% density) and closed forest(above 80% density**).** Based on this classification Uttara Kannada district has about 1388.89 km^2 of partially open forest, 1646.16 km^2 of medium density forest and 714.55 km^2 of closed forest.Depending on phenological conditions and other ecological factors, the forests of Uttara Kannada are broadly divided into two types namely Moist and Dry types. The moist type may be sub-divided into evergreen, semi evergreen and moist deciduous. The dry type can be divided into dry deciduous and thorny forest.(Banavasi and Koppad, 2018).

Depletion of forest on the extensive scale was carried out in the colonial period (1840). The beginning and expansion of railways during this period led to the destruction of huge chunks of forests (1852). Around 3 billion people (40% of the population) across the world are dependent on fuelwood (WBA, 2016) and the majority of them use fuelwood as the major source for cooking fuel (IEA, 2006).In independent India, clearing of forest land for the purpose of cultivation has also led to the depletion of forest cover in country. Timber has become an important commercial resourcedue to its strength properties and used for railway line construction. It is used for building and making of furniture, ship building, door making etc., The felling of trees for the purpose of obtaining timber is important causes of reduced forest cover in India. Many forests have been cleared for building large scale dams in country. Rapid industrialization, urbanization and expansion of cite has also led to the destruction of forest cover in country. Animal grazing, collection of fire wood in rural areas are some of reason of forest depletion.In developing countries, about 2.5 billion people (52% of the population) are reported to rely on biomass, such as fuelwood, charcoal, agricultural waste, and animal dung to meet their household energy needs for cooking and heating, etc. purpose and majority of the users are from rural areas. These resources account for over 90% of household energy consumption in many countries. Around 10 percent of world primary energy demand (~1090M.toe) of fuelwood is used in households in developing countries (IEA, 2006). In India, out of 1.21 billion population [4], 853.88 million people (70.57%) are dependent on fuelwood for cooking or heating purposes (FSI, 2011).The practise of shifting cultivation also a reason of destruction of forest cover. Keeping these points in view, the present study on Assessment of forest depletion and its causes in dry deciduous forest was carried out with following objectives: **a) Assessment of fuel wood consumption patternand; b) Assessment of forest degradation**

2: MATERIALS AND METHODS

2.1: Study area

The investigation on assessment of forest depletion and its causes in dry deciduous forest was carried in the dry deciduous forest of Haliyal taluk in Uttar Kannada district, Karnataka(Figure 1).The experimental site is situated at 15° 16' N latitude and 76° 37' E longitude, with an average elevation of 473 m above mean sea level. The area experiences south west monsoon.The average mean annual rainfall is 2500 mm. The climate of Haliyal region is moderate except during the rainy season. The mean maximum temperature varied from 25 °C to 33 °C. The soils of Haliyal area aremixed lateritic soils. The forest types like evergreen to semi evergreen and moist deciduous to dry deciduous forest type are present.(Anon, 2024)

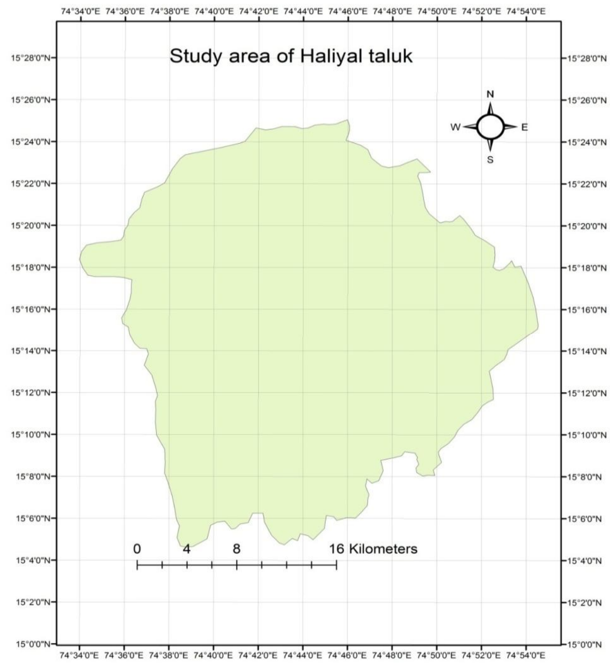

Figure 1. Study area map

2.2: Methodology

a. Assessment of fuel wood consumption pattern

In order to assess the fuel wood consumption pattern in Haliyal taluk a semi structured questioner survey was prepared. Questioner survey was carried to total 40 farmers which were classified based on the land holding into large (>8 acre) medium (4-8 acre) small (<4 acre) and landless farmers.The information like name of the farmer, landholding, and quantity of fuel wood collected from forest, major tree species preferred by farmer/local for fuel wood etc. were collected.

b. Assessment of Forest Degradation

The forest vegetation was classified based on the crown density classes. Very dense forest, moderately dense forest, Open forest and Scrub. The total treatments are 4 based on crown density classes and 5 replication (Table 1). In each forest type 5 plots of 20x20m each were laid (Figure. 2). Total 20 plots were laid in total forest area and following parameters were recorded. The Randomized Block Design (RBD) was followed to reduce systematic error. The data obtained from each of the experiments for all the parameters were subjected to analysis of variance (ANOVA) using OPSTAT statistical packages as described by Jayaraman (2001)to assess the effectiveness of the various treatments. The level of Significance was calculated as F test at p=0.05.

Table 1. Classification of forest types based on canopy classes

Treatments	**Forest types**	**Canopy density (%)**
T_1	Very Dense Forest	Canopy density of 70% and above
T_2	Moderately Dense Forest	Canopy density between 40% to 70%
T_3	Open Forest	Canopy density between 10% and 40%
T_4	Scrub	Having canopy density less than 10%

Forest Survey of India(2021)

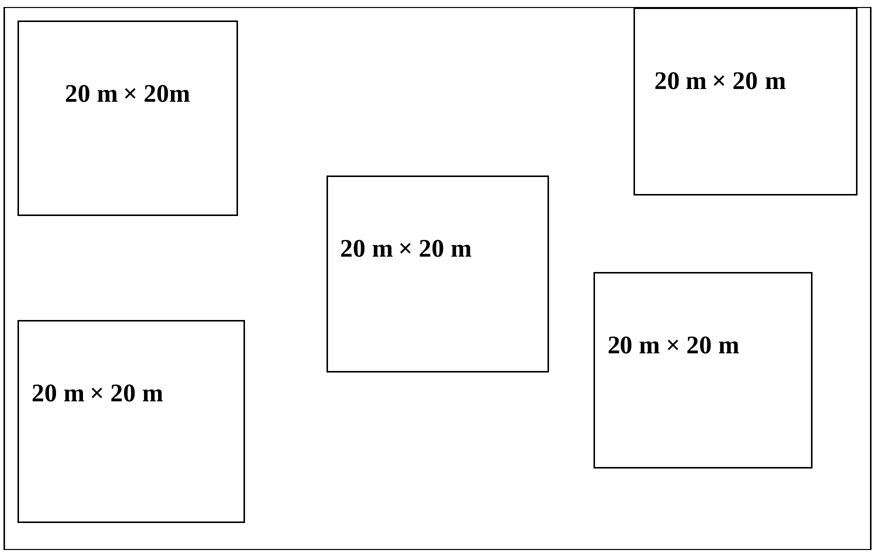

Fig 2. Layout of plot in forest area

Observations recorded:

Fallen, dead and cut trees are estimated and following measurement were recorded

Table 2. Parameter recorded for estimation forest degradation and instruments used

Si no	Observation recorded	Instrument used
1	Stump diameter (cm)	Measured by using measuring tape
2	Length of cut stumps (m)	

3	Length of cut branches (cm)	
4	Length of fallen /dead wood (m)	

Volume of stumps: Volume was calculated by using formula

Volume (m^3) = B.A (m^2) × H (m) × F.F

Where,

F.F = Artificial Form Factor: It is known as breast height form factor.in this basal area is measured at breast height

B.A = Basal Area ($g^2/4\pi$)

H = Height of fallen/cut stump (m).

Field observation photos:

Plate: 1 Lying of plots and recording field observations

Plate: 2 Questionnaire survey with forest officials and household owners

3: RESULTS AND DISCUSSION

3.1: Fuel wood consumption pattern

The quantity of fuel wood collected by the different category of farmers from the different forest area is represented in the (Table 3). The results shows that among the four categories of farmers the average fuel wood per family fuel wood collected was highest by medium farmers (3.21 quintal) followed by small farmers (2.63 quintal) quintal), landless farmers(2.40 quintal) and large farmers(2.15quintal).This variation in fuel wood collection across farmer categories may be due to underlying socio-economic and land use dynamics of the local people. The medium farmers collected the most fuel wood can be attributed to their relatively larger landholdings. These results are in line with Sunderlin*et al*., 2005 these category of farmers typically has more access to forest areas compared to small and landless farmers. Larger landholdings provide these farmers with greater opportunities to gather fuel wood from their own land or nearby forested areas. Medium farmers often have better resources and infrastructure to manage and exploit their land effectively, which can enhance their capacity to collect and utilize fuel wood. Small farmers, while having less land compared to medium farmers, still collect a substantial amount of fuel wood. Similar results were reported by Chambers *et al*., 1989 farmers ability to collect fuel wood is influenced by the proximity of their land to forest areas and their need to supplement their energy requirements. The lower amount of fuel wood collected by landless farmers could be due to additional challenges such as limited means to transport or gather fuel wood effectively. Large farmers, despite their significant landholdings, collected the least amount of fuel wood(2.15 quintal). This might be due to better access to alternative energy sources, reducing their dependence on fuel wood. Additionally, the efficiency of large-scale agricultural practices might make large farmers less reliant on traditional fuel wood collection(Kour *et al*, 2020).

Table 3: Quantity of fuel wood collected by different category of farmers

Category of farmers	Total fuel wood collected (quintal)	Average fuel wood per family (quintal)
Large farmers (>8 acre)	21.5	2.15
Medium farmers (4-8 acre)	38.5	3.21
Small farmers (<4 acre)	21	2.63
Landless farmers	24	2.40

The result depicted in the table 4 shows the total amount of fuel wood consumption pattern in Haliyal taluk. The fuel consumption pattern was assessed through the semi structured questioner survey. The results revealed that the average fuel wood consumption per household was found to be 2.60 qt/yr. The total fuel wood consumption in Haliyal taluk was found to be 5232.2 tonnes and the total volume of dead wood was found to be 6, 64,261.89 m^3/ha.The settlement of local people adjacent to forest area could be the major driving force for the fuelwood consumption. These lines are in agreement with Sharma *et al*., 2009 reported that Forest dependent rural and tribal communities were reported to collect fuelwood from forest land as well as from private land.

People of hilly regions are more dependent on forest land for fuelwood collection as compared to people living in plains which could be due to easy and free accessibility of fuelwood and unavailability of sufficient areas of private and community lands.

Table 4: Total fuel wood consumption pattern in Haliyal taluk

Average fuel wood consumption per household	2.60 qt/yr
Total no of households in Haliyal	20124
Total fuel wood consumption in Haliyal	52322.4 qt/yr
	5232.2 tonnes
Total area of Haliyal taluk (ha)	85840
Percent of forest area	68.33
Area under forest (ha)	58654.472
Total volume of dead wood (m^3/ha)	664261.895

The result in the table 5 represents major tree species preferred by different category of farmers for fuel wood consumption. All the category of farmers preferred *Xylia xylocarpa* (Jambe), followed by *Terminalia tomentosa* (Kari matti) and *Lagerstromia lanceolata* (Nandi). The widespread preference for *Xylia xylocarpa* suggests that this species is highly valued for its fuel wood properties. Jambe is known for its high energy content, which makes it an efficient and effective choice for fuel. Its wood burns slowly and produces a lot of heat, making it a reliable source of energy (Banavasi and Koppad, 2018). Additionally, Jambe wood is dense and durable, which may contribute to its preference as it lasts longer and provides sustained warmth. *Terminalia tomentosa* is also a popular choice, likely due to its favourable burning characteristics. Kari matti is known for its good combustion properties, producing steady heat with minimal smoke. Its availability and ease of collection might also make it a convenient option for farmers. This species is commonly found in many forested areas, which makes it accessible and a practical choice for fuel wood.Sharma *et al*., 2009. Similarlythe sustainability of these forests depends greatly on their productivity, resilience and human activities (Awasthi et al 2003). Scientific studies suggest that the plant community structure is greatly influenced by disturbances in the forests (Yadav and Gupta 2006).

Table 5: Major tree species used for fuel wood consumption in Haliyal taluk

Large farmers (>8 acre)	**Medium farmers (4-8 acre)**	**Small farmers (<4 acre)**	**Landless farmers**
1) *Xylia xylocarpa*(jambe)	1) *Xylia xylocarpa*(jambe)	1) *Xylia xylocarpa*(jambe)	1) *Xylia xylocarpa*(jambe)
2) *Lagerstromia lanceolata* (nandi)	2) *Terminalia tomentosa* (karimatti)	2) *Terminalia tomentosa* (karimatti)	2) *Terminalia tomentosa* (karimatti)
	3) *Lagerstromia lanceolata* (nandi)	3) *Lagerstromia lanceolata* (nandi)	
	4)*Albizia lebbeck*		
	5) *Bauhinia purpurea*		

3.2: Forest degradation

The results presented in the (Table 6)shows the quantification of forest degradation in different crown density classes (m^3/ha). The statistical significant difference was observed among the T_1 and other treatments *i.e*,T_1(31.562)was found to bestatistically significant over T_2, T_3 and T_4 whereas T_2, T_3 and T_4 are on for each other.The results indicates that degradation and deforestation of forest is higher in very dense forest with 31.562 m^3/ha fallowed by degradation of forest with 6.755 m^3/ha in moderately dense forest and least degradation was found in scrub forest 2.433 m^3/ha. This may be due to the availability of more fuel wood the in adjacent forest area and the more anthropogenic activities (Koppad and Tikhile, 2012). Several studies have highlighted that dense forests are particularly vulnerable to degradation due to their higher ecological and economic value, which often makes them prime targets for deforestation and exploitation (Geist and Lambin, 2002). Similar results were also reported by Ramachandra *et al.,* 2000,Availability of bioresources in hilly zone is the main reason for fuel wood consumption and degradation of the forest resources.Dense forests typically possess a complex structure and high biodiversity, making them more susceptible to disturbances that lead to significant degradation. The high level of degradation observed in very dense forests could be attributed to factors such as illegal logging, land conversion for agriculture, and infrastructure development, which are often more prevalent in these areas (Nepstad *et al*., 2006).Moderately dense forests, while still experiencing some level of degradation, are less affected compared to very dense forests. This could be due to their relatively lower economic value and possibly better management practices compared to more intact, dense forests. The intermediate level of degradation (6.755 m^3/ha) in these forests may reflect a balance between ecological pressure and conservation efforts. It is also important to consider that moderately dense forests might still support a significant amount of biodiversity and ecosystem services, though less than very dense forests.In contrast, scrub forests, characterized by the lowest level of degradation (2.433 m^3/ha), exhibit the least amount of forest degradation. Scrub forests generally have a lower canopy cover and reduced biodiversity compared to more dense forest types, which may result in less pressure from human activities and lower rates of deforestation (Rimal*et al*., 2019).

The preference for these species reflects their practical benefits in terms of energy efficiency, availability, and ease of use. The choice of tree species for fuel wood is influenced by their burning quality, the convenience of collection, and their abundance in local forest areas. Farmers tend to select species that offer the best balance between energy output and resource availability.

Table 6: Quantification of forest degradation in different crown density classes (m^3/ha)

Treatment	Replication					Average
	R_1	**R_2**	**R_3**	**R_4**	**R_5**	
T_1	17.664	34.621	23.593	19.529	62.403	**31.562**
T_2	9.725	1.186	8.769	8.246	5.851	**6.755**
T_3	4.469	9.309	1.479	4.065	3.439	**4.552**
T_4	3.442	4.981	2.958	0.698	0.088	**2.433**
					CD @ 5%	**12.803**
					SEm (±)	**4.2**

4: CONCLUSION:

Forest depletion is more in very dense forest due to human intervention and anthropogenic activities. farmers the average fuel wood per family fuel wood collected was highest by medium farmers (3.21 quintal). Major tree species used for fuel wood consumption were *Xylia xylocarpa*,*Lagerstroemia lanceolate*, *Terminalia tomentosa*. The widespread preference for *Xylia xylocarpa* for fuel wood consumption suggests that this species is highly valued for its fuel wood properties. Jambe is known for its high energy content, which makes it an efficient and effective choice for fuel.Higher fuelwood consumption is mainly due to lack of unconventional energy sources. Extensive farming for firewood could be the only alternative to bridge the gap between the demand and supply. It has also been observed that the firewood consumption also differs according to family size and small families have more firewood consumption than those of medium and large families.

5. FUTURE SCOPE

Establish long-term monitoring programs to track changes in fuel wood consumption patterns and forest health over extended periods. Evaluate. The adoption and impact of alternative energy sources (e.g., Liquefied Petroleum Gas (LPG), biogas, solar cookers) on fuel wood consumption and forest health that will help to determine the effectiveness of these alternatives in reducing dependency on fuel wood. The effectiveness of existing policies related to forest management and fuel wood collection needs to be regulated based on current scenario.Protecting very dense forests from further degradation should be a priority due to their critical role in biodiversity conservation and carbon sequestration.Overall, the data reinforces the need for targeted conservation strategies that address the specific needs of different forest types.

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