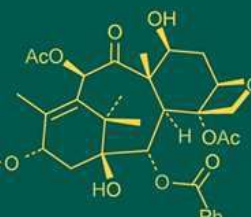
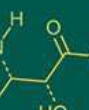
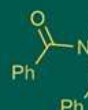


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## Quantification of forest degradation in different forest types of Yellapur forest division of Uttara Kannada district, Karnataka

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**Abstract**

This study examines the annual degradation in tree height, basal area, form factor, number of stems, volume, biomass and carbon stock across three forest types - dry deciduous, moist deciduous and semi-evergreen - in the Yellapur forest division during 2023-24. The results reveal varying degrees of degradation across all parameters, with dry deciduous forests experiencing the most significant declines. Tree height decreased by 0.34 m in dry deciduous forests, 0.487 m in moist deciduous and 0.15 m in semi-evergreen forests, though these reductions were statistically non-significant. The basal area degraded by 2.38 m<sup>2</sup> ha<sup>-1</sup> in dry deciduous forests, 1.33 m<sup>2</sup> ha<sup>-1</sup> in moist deciduous and 1.11 m<sup>2</sup> ha<sup>-1</sup> in semi-evergreen forests, with dry deciduous forests showing the most significant degradation. Similarly, stem numbers dropped by 33, 25 and 15 in dry deciduous, moist deciduous and semi-evergreen forests, respectively.

Volume degradation followed the same trend, with a 12.95 m<sup>3</sup> ha<sup>-1</sup> reduction in dry deciduous forests, compared to 8.84 m<sup>3</sup> ha<sup>-1</sup> in moist deciduous and 1.49 m<sup>3</sup> ha<sup>-1</sup> in semi-evergreen forests. Biomass declined by 13.03 t ha<sup>-1</sup> in dry deciduous forests, 7.13 t ha<sup>-1</sup> in moist deciduous and 4.91 t ha<sup>-1</sup> in semi-evergreen forests. Corresponding carbon stock losses were 6.14 t ha<sup>-1</sup>, 3.30 t ha<sup>-1</sup> and 2.45 t ha<sup>-1</sup>, respectively. The highest degradation across all metrics occurred in the dry deciduous forests, with statistically significant differences observed in basal area, volume, biomass and carbon stock compared to the semi-evergreen forests. The primary causes of tree mortality were disease, cutting and natural factors, with dry deciduous forests recording the highest number of dead trees. This study highlights the urgent need for forest management interventions to mitigate degradation and preserve the ecological integrity of these forests.

**Keywords:** Degradation, moist deciduous, dry deciduous, semi-evergreen forest

**Introduction**

Forest biomass, encompassing all living and dead organic material within these ecosystems - such as trees, shrubs, roots and soil organic matter is a indicator of forest health and productivity. It plays a crucial role in global carbon cycles by acting as a significant reservoir for carbon, thereby helping to mitigate climate change through the absorption and storage of atmospheric carbon dioxide. Beyond carbon storage, forest biomass supports vital ecosystem functions like nutrient cycling, soil formation and providing habitats for diverse species. Understanding the dynamics of forest biomass is essential for evaluating carbon sequestration potential and assessing the impacts of deforestation and forest degradation on climate change mitigation efforts.

Forest degradation, driven by human activities such as deforestation, logging, unsustainable practices, infrastructure development and climate change, leads to a decline in forest health and quality (Hosonuma *et al.*, 2019) [8]. This degradation negatively impacts forest-dependent communities, exacerbates socioeconomic inequalities and threatens cultural heritage and indigenous knowledge. Degraded forests are more vulnerable to natural disasters, which can affect human settlements, infrastructure and biodiversity. Between 1990 and 2020, the global forest area decreased by 3%, from 4.24 billion to 4.06 billion hectares (Anon., 2020) [1]. Deforestation and encroachment, driven by population growth and increasing land demand, are key contributors to this decline (Capistrano and Kiker, 1995) [5].

In India, forest quality declined by over 74,457 sq. km between 2015 and 2021, with significant losses in Karnataka and the northeastern states, highlighting the urgent need for strengthened conservation efforts (Anonymous., 2021) [2].

Forest degradation is a critical environmental issue that affects the ecological balance, biodiversity and the ability of forests to sequester carbon. It refers to the gradual deterioration of forest structure, function and species composition, often driven by human activities such as logging, agricultural expansion, infrastructure development and unsustainable forest management. Unlike deforestation, which results in the complete removal of forest cover, degradation leads to the decline in forest health, resulting in reduced biomass, carbon stocks, tree density and changes in forest dynamics.

Tropical and subtropical forests, in particular, are highly susceptible to degradation due to their rich biodiversity and complex ecological interactions. Forest degradation can also be exacerbated by natural factors such as climate change, wildfires and diseases. These changes not only compromise the forest's ability to provide ecosystem services, such as carbon storage, water regulation and habitat for wildlife, but they also diminish the livelihoods of local communities that depend on forest resources.

The assessment of forest degradation is a critical endeavour in environmental monitoring and conservation efforts. It involves the systematic evaluation of changes in forest

structure, biodiversity and ecosystem functions over time. This often entails the use of standardized methodologies and remote sensing techniques to quantify alterations in forest cover, biomass and carbon stocks. By employing standardized protocols and metrics, researchers and conservationists can effectively monitor the extent and severity of forest degradation, identify hotspots of degradation and develop targeted interventions to mitigate its impacts (Zhuravleva *et al.*, 2013) [24]. Accurate assessment of forest degradation is essential for informing sustainable forest management strategies, enhancing biodiversity conservation efforts and combating climate change.

## Materials and Methodology

### Study area

The present study was focused on various forest types within the Yellapur Forest Division in Uttara Kannada District. Located in the eastern part of the district, the Yellapur Forest Division covers a total area of 168,986.66 hectares, including Betta lands (protected forests), which represents 86.97% of the division's geographical area (1,902.28 km<sup>2</sup>). The division is bounded by longitudes 74°25' to 75°6' East and latitudes 14°44' to 15°7' North. The study area is depicted in Figure 1. The Yellapur Forest Division encompasses three distinct forest types *viz* dry deciduous, moist deciduous and semi-evergreen.

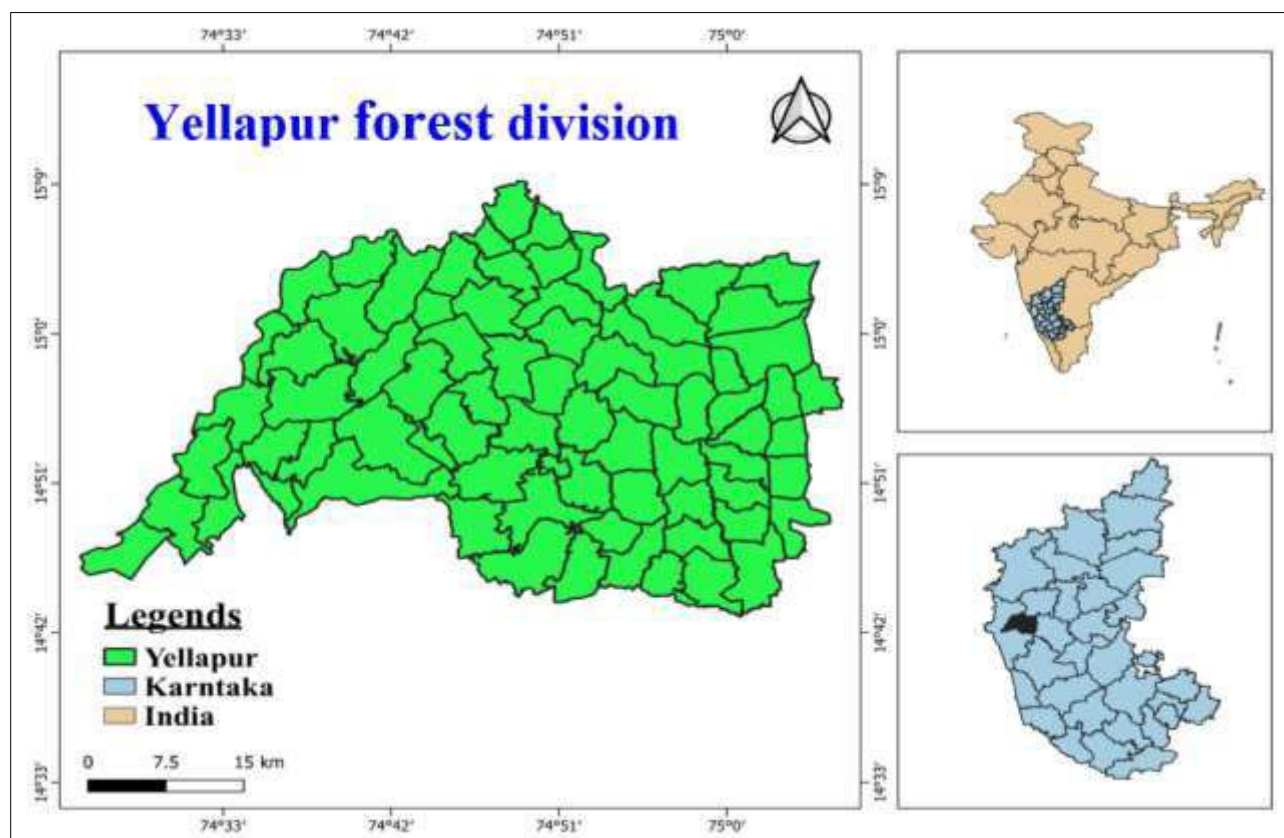


**Fig 1:** Study Area map

### Experimental Details

Three permanent plots were established in each of the forest types in the Yellapur division and trees were numbered serially in each plot. The permanent plot was made into 9 subplots (Fig. 2) each having 33.33m x 33.33m indicating a total 27 plots in each forest types. among them, 7 subplots in

each forest type were selected for enumeration for assessing the forest degradation. Growth parameters such as girth at breast height, tree height and girth at the base of numbered trees in each plot are recorded. Volume is estimated using the standard formula. An overview of all types of forests.

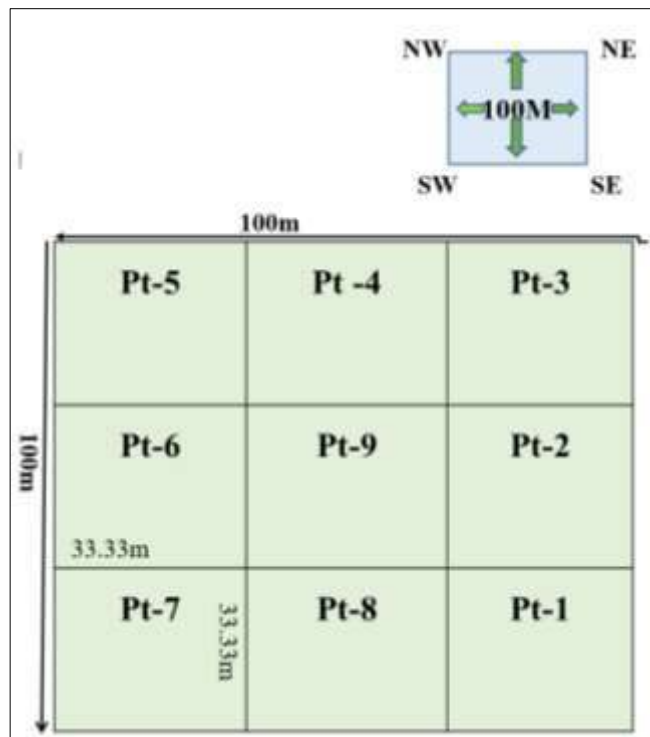


**Fig 2:** Layout of permanent plot

After one year, the same plot is reassessed to record any tree loss, which may have occurred naturally, been caused by human activities, or resulted from other anthropogenic factors. The degradation within the plot is estimated and these findings are then used to assess the total degradation across different forest types based on the area of forest.

#### Field Data Collection

Observations on various growth parameters is recorded and enumeration is done in the experimental site.

#### Tree height

The height of the trees was measured from the ground level to the tip of the tree. Ravi altimeter was used for measuring the height of the trees. The tree height was expressed in meters.

#### Girth at breast height

The girth of the tree was measured at 1.37 m height from ground level. The tape was used to measure the girth. The girth of the tree was expressed in meters.

#### Girth at the base (GAB)

Girth at the base typically refers to the circumference

measurement of the base of a tree taken at 10 cm above ground using tape.

#### Recording the tree parameter and dead trees

Geographical conditions of the locations, including latitude, longitude and altitude, are recorded using GPS. Additionally, tree parameters are documented and any dead trees present in the field are identified and recorded.

#### Calculation

##### Calculation and computation of data

- Basal area =  $G^2 / 4\pi$  Where G is the girth at breast height and expressed in centimeters (cm).
- Total volume of tree ( $m^3$ ) = Basal area ( $m^2$ )  $\times$  Height (m)  $\times$  Form factor
- Form factor =  $(\text{Girth at breast height})^2 / (\text{Girth at base})^2$
- Estimation of above ground biomass (AGB): Biomass of trees obtained from each quadrat is used to estimate total AGB ( $t\ ha^{-1}$ ).

AGB = Volume  $\times$  Specific gravity  
("db.worldagroforestry.org")

- Estimation of below ground biomass (BGB): IPCC (2007) suggest that below ground biomass is close to 27% of the total above ground biomass

$$BGB\ (t\ ha^{-1}) = AGB \times 0.27$$

$$\text{Total Biomass} = AGB + BGB\ (t\ ha^{-1})$$

- Carbon stock estimation:** The total carbon stock was determined by multiplying the total tree biomass with a factor of 0.47 as suggested by IPCC (2007) and expressed in  $t\ ha^{-1}$ .

$$\text{Carbon stock} = \text{Total biomass} \times 0.47$$

#### Experimental results

##### Annual degradation in tree height

The result pertaining to degradation with respect to tree height has been presented in Table 18. The Dry deciduous forest had a height of 10.36 meters in 2023 slightly decreased to 10.18 meters in 2024 with a degradation of 0.34 meters. The Moist deciduous forest showed a more significant reduction, from 14.34 meters in 2023 to 13.86 meters in 2024 resulting in a degradation of 0.487 meters. The Semi-evergreen forest height decreased from 12.05 meters in 2023 to 11.92 meters in 2024, with a degradation of 0.15 meters. The statistical test indicated that the height degradation in all the forests was non-significant (Table 1).

**Table 1:** Annual degradation in tree height, basal area and form factor in the different forest types of Yellapur forest division during 2023-24

| Forest Types    | Height (m) |       |             | Basal area ( $m^2\ ha^{-1}$ ) |       |             | Form factor |      |             |
|-----------------|------------|-------|-------------|-------------------------------|-------|-------------|-------------|------|-------------|
|                 | 2023       | 2024  | Degradation | 2023                          | 2024  | Degradation | 2023        | 2024 | Degradation |
| Dry deciduous   | 10.36      | 10.18 | 0.34        | 26.99                         | 24.61 | 2.38        | 0.76        | 0.65 | 0.11        |
| Moist deciduous | 14.34      | 13.86 | 0.487       | 26.41                         | 25.09 | 1.32        | 0.72        | 0.65 | 0.06        |
| Semi-evergreen  | 12.05      | 11.92 | 0.15        | 76.50                         | 75.39 | 1.11        | 0.746       | 0.71 | 0.02        |
| SEm ( $\pm$ )   | 0.96       | 0.88  | 0.12        | 4.97                          | 5.05  | 1.06        | 0.02        | 0.05 | 0.02        |
| CD @5%          | 3.01       | 2.76  | NS          | 15.47                         | 15.74 | NS          | NS          | 0.05 | NS          |

#### Annual degradation in basal area

The basal area representing the cross-sectional area of tree stems at breast height shows a decline across forest types. In

dry deciduous forests, the basal area decreased from  $26.99\ m^2\ ha^{-1}$  in 2023 to  $24.61\ m^2\ ha^{-1}$  in 2024 indicating a  $2.38\ m^2\ ha^{-1}$  degradation. In moist deciduous forest, it dropped

from 26.419 m<sup>2</sup> ha<sup>-1</sup> to 25.093 m<sup>2</sup> ha<sup>-1</sup>, resulting in a 1.326 m<sup>2</sup> ha<sup>-1</sup> degradation. Semi-evergreen forests saw a decrease from 76.509 m<sup>2</sup> ha<sup>-1</sup> to 75.394 m<sup>2</sup> ha<sup>-1</sup>, marking a degradation of 1.114 m<sup>2</sup> ha<sup>-1</sup>. The statistical analysis revealed that the extent of basal area degradation in dry deciduous forests is significantly greater than semi-evergreen forests. However, the level of degradation between dry and moist deciduous forests, as well as between moist and semi-evergreen forests, is comparable with each other (Table 1).

Annual degradation in the number of stems

The data indicates a notable decline in the number of stems across all forest types in the Yellapur forest division from 2023 to 2024. In dry deciduous forests, the number of stems decreased from 690.56 to 657.13 showing a degradation of 33 stems. Moist deciduous forests reduced from 398.65 stems in 2023 to 372.93 in 2024 indicating a degradation of 25 stems. Semi-evergreen forests experienced a decline from 1,195.95 stems to 1,180.52, marking a degradation of 15 stems. The highest degradation in the number of stems is observed in dry deciduous forests, with a reduction of 33 stems (Table 2). The statistical analysis indicated that the

quantity of degradation in dry deciduous forests is significantly higher as compared to semi-evergreen forests however the quantity of degradation between dry and moist deciduous forests and moist and semi-evergreen forests are on par with each other at a 5 per cent level of significance.

Annual degradation in volume

The volume degradation in cubic meters per hectare (m<sup>3</sup> ha<sup>-1</sup>) for different forest types in the Yellapur forest division from 2023 to 2024. The dry deciduous forests show a decrease in volume from 239.626 m<sup>3</sup> ha<sup>-1</sup> in 2023 to 226.68 m<sup>3</sup> ha<sup>-1</sup> in 2024, resulting in a degradation of 12.95 m<sup>3</sup> ha<sup>-1</sup>. The moist deciduous forests' volume decreased from 322.323 m<sup>3</sup> ha<sup>-1</sup> to 313.479 m<sup>3</sup> ha<sup>-1</sup> indicating a degradation of 8.84 m<sup>3</sup> ha<sup>-1</sup>. In semi-evergreen forests, the volume slightly declined from 855.926 m<sup>3</sup> ha<sup>-1</sup> to 854.44 m<sup>3</sup> ha<sup>-1</sup> marking a minimal degradation of 1.49 m<sup>3</sup> ha<sup>-1</sup>. The statistical analysis showed that the volume of degradation is notably higher in dry deciduous forests compared to semi-evergreen forest and the degradation of volume between dry and moist deciduous forests as well as between moist and semi-evergreen forests is similar (Table 2).

Table 2: Annual degradation in the number of stems, basal area and volume in the different forest types of Yellapur forest division during 2023-24

| Forest Types    | No. of stems |         |             | Volume (m <sup>3</sup> ha <sup>-1</sup> ) |        |             |
|-----------------|--------------|---------|-------------|-------------------------------------------|--------|-------------|
|                 | 2023         | 2024    | Degradation | 2023                                      | 2024   | Degradation |
| Dry deciduous   | 690.56       | 657.13  | 33          | 239.62                                    | 226.68 | 12.95       |
| Moist deciduous | 398.65       | 372.93  | 25          | 322.32                                    | 313.47 | 8.84        |
| Semi-evergreen  | 1195.95      | 1180.52 | 15          | 855.92                                    | 854.44 | 1.49        |
| SEm (±)         | 121.29       | 120.66  | 4.23        | 47.68                                     | 47.26  | 2.91        |
| CD @5%          | 377.87       | 375.90  | 13.18       | 148.56                                    | 147.23 | 9.05        |

Annual degradation in biomass

The table indicates a decline in total biomass across all forest types in the Yellapur forest division from 2023 to 2024. For dry deciduous forests, the total biomass decreased from 222.13 t ha<sup>-1</sup> in 2023 to 209.077 t ha<sup>-1</sup> in 2024, indicating a 13.038 t ha<sup>-1</sup> degradation. In moist deciduous forests, the biomass decreased from 276.251 t ha<sup>-1</sup> to 269.137 t ha<sup>-1</sup>, resulting in a degradation of 7.139 t ha<sup>-1</sup>. Semi-evergreen forests saw a decrease from 627.787 t ha<sup>-1</sup> to 622.87 t ha<sup>-1</sup> indicating a degradation of 4.913 t ha<sup>-1</sup>. The statistical analysis revealed that biomass degradation is significantly higher in dry deciduous forests compared to semi-evergreen forests. The degree of biomass degradation between dry and moist deciduous forests as well as between moist and semi-evergreen forests appears to be comparable (Table 3).

Annual degradation in carbon stock

The carbon stock represents the amount of carbon stored in the forest biomass. In dry deciduous forest, the carbon stock decreased from 104.394 t ha<sup>-1</sup> in 2023 to 98.249 t ha<sup>-1</sup> in 2024, indicating a 6.146 t ha<sup>-1</sup> degradation. In moist deciduous forests, the carbon stock reduced from 129.844 t ha<sup>-1</sup> to 126.549 t ha<sup>-1</sup>, showing a degradation of 3.296 t ha<sup>-1</sup>. Semi-evergreen forests saw a slight decline in carbon stock from 295.061 t ha<sup>-1</sup> to 292.614 t ha<sup>-1</sup>, marking a degradation of 2.447 t ha<sup>-1</sup>. The degradation among different forest types is statistically significant and the highest degradation in carbon stock is observed in dry deciduous forests. The statistical analysis found that the loss of carbon stock is much higher in dry deciduous forests compared to semi-evergreen forests. At the same time, the loss of carbon stock between dry and moist deciduous forests as well as between moist and semi-evergreen forests is fairly similar (Table 3).

Table 3: Annual degradation in total biomass and carbon stock in the different forest types of Yellapur forest division during 2023-24

| Forest Types    | Total biomass (t ha <sup>-1</sup> ) |        |             | Carbon stock (t ha <sup>-1</sup> ) |        |             |
|-----------------|-------------------------------------|--------|-------------|------------------------------------|--------|-------------|
|                 | 2023                                | 2024   | Degradation | 2023                               | 2024   | Degradation |
| Dry deciduous   | 222.13                              | 209.07 | 13.03       | 104.39                             | 98.24  | 6.14        |
| Moist deciduous | 276.25                              | 269.13 | 7.13        | 129.84                             | 126.54 | 3.29        |
| Semi-evergreen  | 627.78                              | 622.8  | 4.91        | 295.06                             | 292.61 | 2.44        |
| SEm (±)         | 35.80                               | 35.44  | 2.11        | 16.82                              | 16.65  | 0.97        |
| CD @5%          | 111.54                              | 110.41 | 6.59        | 52.42                              | 51.89  | 3.03        |

Number of dead Tree status in different forest types of Yellapur Forest Division

The dead tree status in the Yellapur Forest Division varies across different forest types including Dry Deciduous, Moist

Deciduous and Semi-Evergreen forests. It is categorized by factors such as Cut, Uprooted, Diseased, Standing Dead (Snags) and Natural Causes (Table 4). In the dry deciduous forest out of the 33 recorded dead trees 10 (30.33%) were

cut, 9 (27.77) were diseased and 7 (21.21%) were snagged trees (Plate 1). In the moist deciduous forest among the 25 dead trees recorded per hectare 9 (36%) were cut, 8 (32%) were diseased and 4 (16%) snagged trees (Plate 2). In the semi-evergreen forest, the highest number of dead trees were due to natural causes 6 (40%) trees followed by 5 (33.33%) diseased trees, 2 (13.33%) uprooted trees and 2 (13.33%) cut trees (Plate 3) Across all forest types, the most common cause of tree mortality was disease accounting for

22 dead trees followed by cutting (21 trees) and natural causes (14 trees). Statistical analysis indicated that the number of dead trees was significantly higher in the dry deciduous forest compared to the semi-evergreen forest. However, there was no significant difference in the number of dead trees between the dry deciduous and moist deciduous forests, nor between the moist deciduous and semi-evergreen forests (Table 4 and Fig. 3).

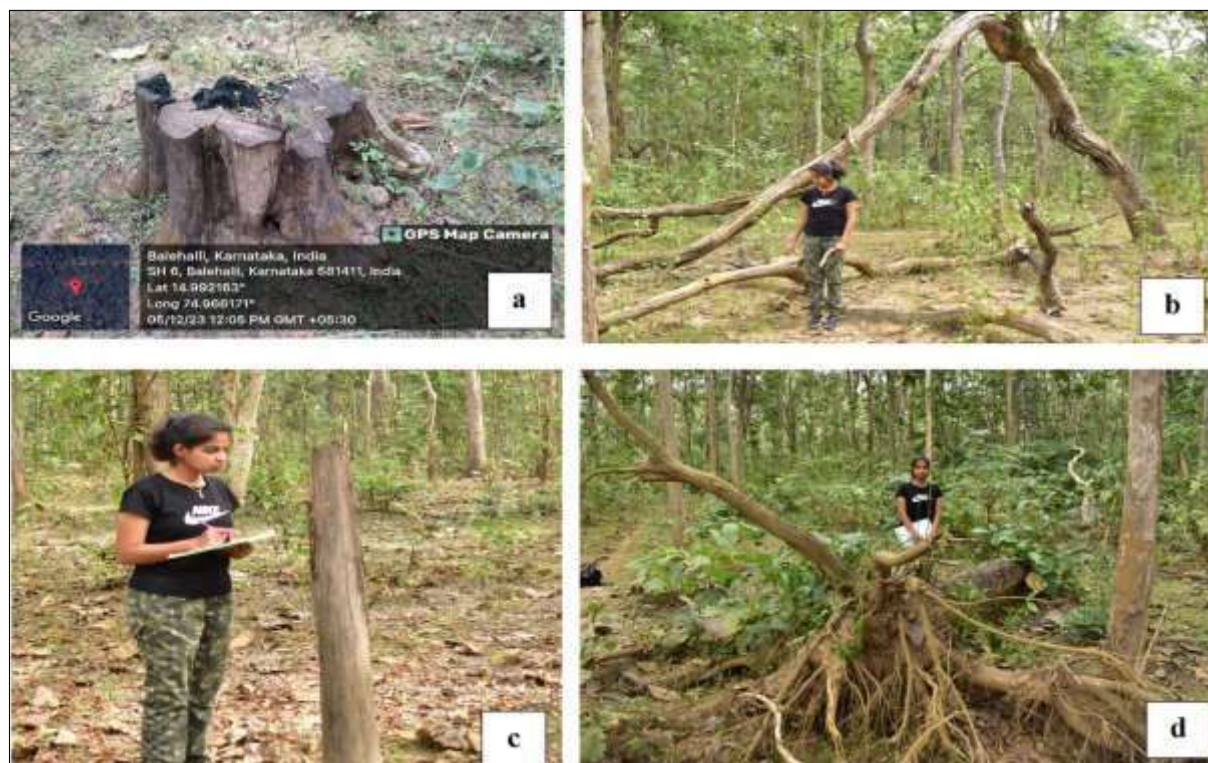


**Plate 1:** Degradation observed in Dry deciduous forest (a. Cut b. Natural cause c. Diseases attack d. Uprooted).



**Plate 2:** Degradation observed in Moist deciduous forest (a. Cut b. Termite attack c. Logs cut d. disease and pest attack)



**Plate 3:** Degradation observed in Semi evergreen forest (a. uproot b. natural cause c. Cut d. Disease and pest attack)

**Table 4:** The number of dead trees status in different forest types of the Yellapur forest division

| Sl. No. | Dead tree Status | Dry deciduous |          | Moist deciduous |          | Semi-evergreen |          | Total by category |
|---------|------------------|---------------|----------|-----------------|----------|----------------|----------|-------------------|
|         |                  | Number        | Per cent | Number          | Per cent | Number         | Per cent |                   |
| 1       | Cut              | 10            | 30.30    | 9               | 36.00    | 2              | 13.33    | 21                |
| 2       | Uprooted         | 2             | 6.06     | 1               | 4.00     | 2              | 13.33    | 6                 |
| 3       | Diseased         | 9             | 27.27    | 8               | 32.00    | 5              | 33.33    | 22                |
| 4       | Snag trees       | 7             | 21.21    | 4               | 16.00    | 0              | 0.00     | 11                |
| 5       | Natural cause    | 5             | 15.15    | 3               | 12.00    | 6              | 40.00    | 14                |
|         | Total            | 33            | 100      | 25              | 100      | 15             | 100      |                   |
|         | SEm ( $\pm$ )    | 4.233         |          |                 |          |                |          |                   |
|         | CD @5%           | 13.187        |          |                 |          |                |          |                   |

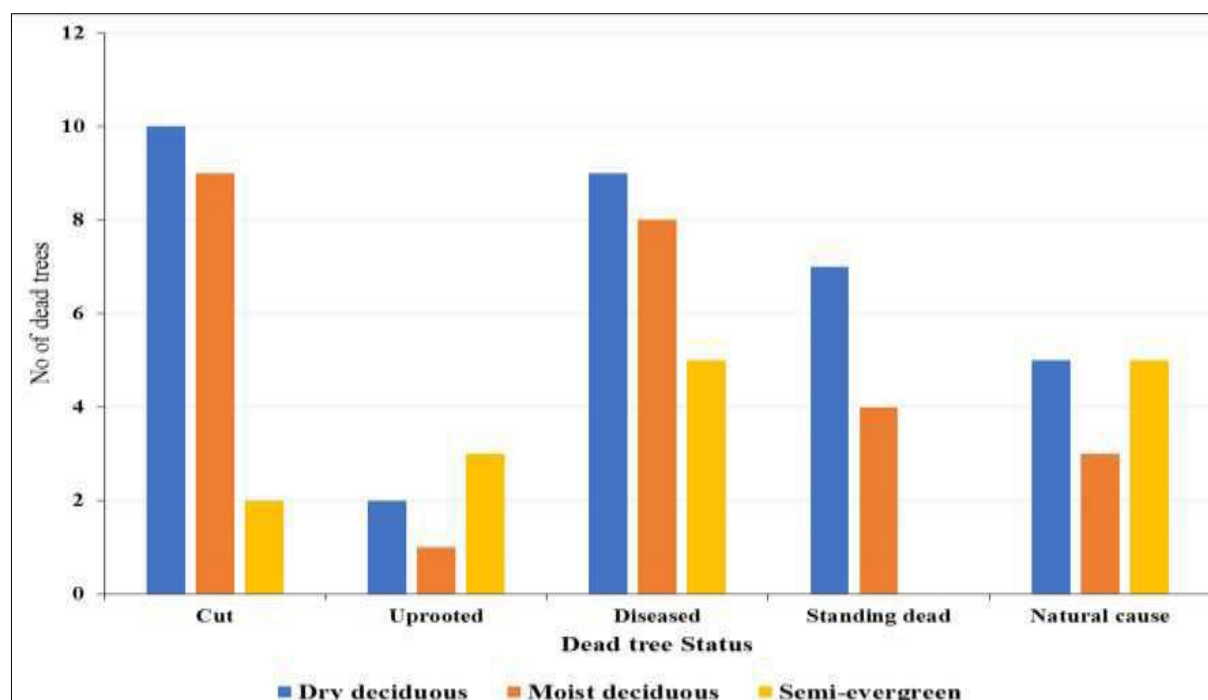


**Fig 3:** Dead tree status in different forest types of Yellapur forest division

## Discussion

The degradation in the Yellapur Forest Division is primarily driven by factors such as disease, cutting, standing dead trees (snags), uprooting and natural causes, with the dry deciduous forest being particularly affected. Disease is a major cause of tree mortality especially in the dry deciduous forest where environmental conditions create a favorable habitat for disease spread. Cutting is widespread in dry deciduous forest due to their proximity to human settlements making them more accessible for harvesting fuelwood and timber. Snag trees are often the result of pest attacks that weaken the trees over time. Uprooting in the dry deciduous forest is primarily caused by high winds and intense rainfall, which destabilize trees. Natural causes such as lightning strikes, overgrazing and damage from animals further contribute to tree decay and death. These factors are key drivers of forest degradation and tree mortality across the Yellapur Forest Division majorly in the dry deciduous forest. Sundaram and Parthasarathy (2002) [22] reported that 84 trees died across four study sites between 1996 and 1999 with an annual mortality rate of 0.73 per cent for the entire forest stand though mortality rates varied among the individual sites.

Mueller *et al.* (2005) [14] predicted that drought frequency and severity would increase across many continental interiors. Their analysis of the impacts on dominant plants identified several major causes of degradation. These include heightened anthropogenic activities, such as logging and land conversion, as well as natural disturbances like droughts and pest infestations. Additionally, changes in land use and insufficient forest management practices have likely intensified the loss of stem density and basal area.

According to a study by Ciais *et al.* (2008) [7], increased frequency and severity of droughts can lead to substantial losses in forest biomass and carbon stock due to reduced tree growth and increased mortality rates. Furthermore, anthropogenic pressures, such as logging and land conversion, can exacerbate these effects by removing large amounts of biomass and disrupting the forest ecosystem. Inadequate forest management practices, as highlighted can also contribute to the decline in biomass and carbon stocks by failing to adequately address the impacts of environmental stressors and human activities on forest health.

Long-term observations in the Uttara Kannada district of the Western Ghats have shown that forest areas closer to human settlements and with easier access experience declines in tree density, basal area, biomass and carbon stocks. The increased removal of trees in smaller diameter classes indicates a high demand for these trees by local communities. In less disturbed areas, the higher mortality of smaller trees is due to their inability to compete with taller, canopy trees for resources such as light, moisture and nutrients. Despite natural disturbances and tree harvesting, certain forest plots have seen increases in basal area, biomass and carbon stocks due to the enhanced growth of surviving trees. The resultant canopy gaps have supported new tree recruitment, leading to a restoration of tree density, above-ground biomass and carbon stocks, which partially mitigates CO<sub>2</sub> emissions (Bhat and Ravindranath, 2011) [4]. Joshi and Dhyani (2019) [9] are pertinent to my research as their findings reflect how forest structure and human activities influence carbon storage. Variations in carbon stocks are attributed to differences in tree density, basal

area, species diversity and both biotic and abiotic factors affecting tree growth. The proximity to mining operations, human disturbances and development projects has resulted in the loss of mature, large trees, thereby affecting forest structure and carbon sequestration. Larger-diameter trees have been identified as key carbon reservoirs. Their work underscores the need to protect mature, large-diameter native trees and offers critical insights for forest managers to create effective management strategies for tropical dry deciduous forests.

## Summary and conclusion

In the Yellapur forest division, there was a notable decline in stem numbers from 2023 to 2024 across all forest types. Dry deciduous forests saw the highest reduction of 33 stems, decreasing from 690.56 to 657.13. Moist deciduous and semi-evergreen forests also experienced declines of 25 and 15 stems, respectively. The basal area decreased across all forest types from 2023 to 2024, with dry deciduous forests showing the greatest reduction of 2.386 m<sup>2</sup> ha<sup>-1</sup>. Moist deciduous and semi-evergreen forests experienced smaller declines of 1.326 and 1.114 m<sup>2</sup> ha<sup>-1</sup> respectively. Volume loss varied across forest types in the Yellapur division, with dry deciduous forests experiencing a decrease of 12.95 m<sup>3</sup> ha<sup>-1</sup>, moist deciduous forests losing 8.84 m<sup>3</sup> ha<sup>-1</sup> and semi-evergreen forests showing a minimal decline of 1.49 m<sup>3</sup> ha<sup>-1</sup>. The total biomass declined across all forest types in the Yellapur division, with dry deciduous forests showing the highest decrease of 13.038 t ha<sup>-1</sup>. Moist deciduous and semi-evergreen forests experienced reductions of 7.139 and 4.913 t ha<sup>-1</sup> respectively. Carbon stock declined across all forest types, with dry deciduous forests showing the greatest reduction of 6.146 t ha<sup>-1</sup>. Moist deciduous and semi-evergreen forests experienced smaller decreases of 3.296 and 2.447 t ha<sup>-1</sup> respectively.

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