Economic Valuation of Timber Production in Deodar and Ban Oak Forests in Selected Sites of Shimla, Western Himalaya

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Abstract:
Deodar (Cedrus deodara) forests at Jakhu Hill, Potter Hill, and Ban Oak (Quercus oblongata) forests at Tara Devi had their standing timber economically valued. With an estimated economic worth of ₹27.34 billion (₹2,734.34 crore), Jakhu Hill recorded a total wood volume of 105,154.26 m^3 (3,713,607.20 ft^3). With an estimated economic worth of ₹1.779 billion (₹177.92 crore) for domestic use and ₹2.353 billion (₹235.28 crore) for commercial usage, Tara Devi's 470 Ban Oak trees had a total growing stock volume of 56,671.82 m^3 and biomass of 2,210,201.14 quintals. With 506 Deodar trees and a total timber volume of 2,516,457.98 ft^3, Potter Hill was estimated to be worth ₹18.53 billion (₹1,853.12 crore). Differences in tree density, diameter distribution, height, and biomass buildup were the main factors linked to variation in timber value among quadrats. Overall, the results underscore the Deodar and Ban Oak forests' great economic significance as well as their important role in sustainable forest resource management and forest-based lifestyles.

Keywords: Tree, Forest, Timber, and Economic

Introduction:
Forest ecosystems provide valuable provisioning services, with timber being one of the most important resources supporting economic development and rural livelihoods. In the Western Himalayan region, Cedrus deodara and Quercus oblongata are ecologically and economically significant tree species that contribute substantially to timber production and forest-based livelihoods. Quantifying the economic value of standing timber is essential for sustainable forest management, resource planning, and informed policy decisions. This study evaluates the timber production potential and economic value of Deodar and Ban Oak forests across three representative forest sites—Jakhu Hill, Tara Devi, and Potter Hill—using forest inventory measurements, species-specific volume equations, and prevailing market prices. Biomass is the primary energy source for nearly half the global population (Karekezi & Kithyoma, 2006). In developing countries, wood biomass is a major renewable energy resource and makes up much of rural energy use (Hashiramoto 2007). While forest biomass supplies food, fodder, Timber, and fuel, its unsustainable use leads to resource loss, reduces forest ecosystem services, and degrades forests (Rawat & Nautiyal 1988). Destructive methods involve harvesting or cutting down trees to obtain direct biomass measurements. Non-destructive methods estimate biomass using variables such as tree height, basal area, and wood specific gravity without cutting trees. Remote sensing methods use satellite imagery or aerial photography

to indirectly assess biomass over large areas (Lu 2006). Absolute biomass measurements are only feasible during tree felling, a process that is not always possible (Murali et al., 2005).

Materials and Methods:

A) Sampling Design:

In this study, ten quadrants measuring 50 x 50 meters were laid at each of the three study sites. To estimate above-ground biomass, a total of 30 sample plots were evaluated. We selected these sites using Google Earth images and then navigated to them in the field with a GPS device (Garmin 72).

B) Observation:

This study focused exclusively on the tree component. Trees were considered as any trunk with a diameter at breast height (DBH; 1.37 m above ground) greater than 10 cm. Tree height was measured using a Blume Leiss Hypsometer, which employs a trigonometric method, and DBH was measured with a measuring tape. Trees were categorized by girth (m) and assigned to specific girth classes. For the economic evaluation, primary data were collected from the forest department and the Government wood depot, where the current timber prices were assessed.

C) Biomass Estimation:

A non-destructive allometric equation approach was used to assess biomass and carbon stocks. For each tree species, volume equations and species-specific gravity (the ratio of wood density to water density) are required. Tree volume was estimated using equations from the State Forest Departments, Forest Research Institute Dehradun, and Forest Survey of India (FSI 1996; Dadhwal et al., 2009). DBH and height were used in regression analysis to estimate biomass (Roy & Ravan 1996). Biomass was calculated as

Biomass = Tree volume × Species-specific gravity.

Volumetric equation for Cedrus deodara and Quercus oblongata:

Q. oblongata: (Pinaceae) = 0.014796+0.319061*(D^2) *H……………... (FSI 1996)

C. deodara: (Fagaceae) = 0.0789+0.2836*(D^2) * H……………………. (FSI 1996)

Specific gravity of Cedrus deodara and Quercus oblongata: (Rajput et al., 1985 and Sheikh et al., 2011)

Q. oblongata: (Pinaceae) = 0.87 ±0.32 (Wood classification – Heavy)

C. deodara: (Fagaceae) = 0.72±0.14 (Wood classification – Mod Heavy)

Result:

The assessment of timber resources revealed significant economic value in Deodar (Cedrus deodara) and Ban Oak (Quercus oblongata) forests across the sites. A systematic field inventory used 30 quadrats (10 per site) and measured each tree within a quadrat to estimate tree volume and timber potential. Measurements of girth at breast height (GBH) and total tree height provided parameters for volume estimation using species-specific allometric equations.

Deodar (Cedrus deodara):

$$V = 0.167174 - 1.735312D + 12.039017D^2$$

Ban Oak (Quercus oblongata):

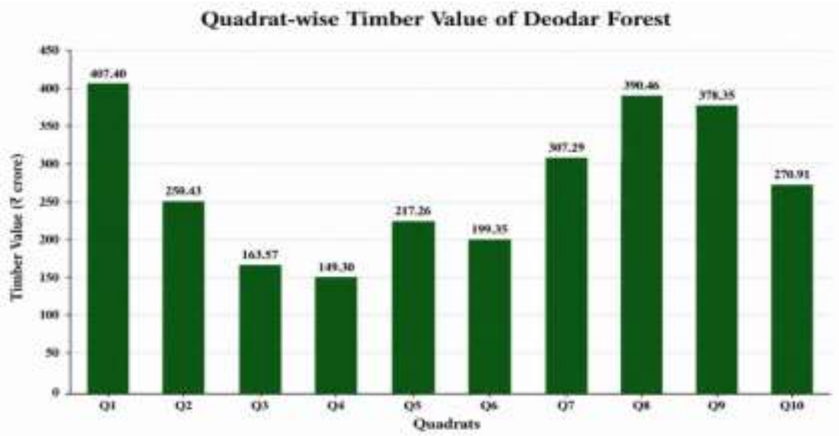
$$V = 0.682380 + 5.049937D - 2.770924D^2$$

The standing timber assessment of the Site- 1 Jakhu Hill (Cedrus deodara) revealed considerable variation among the ten sampled quadrats. The total estimated timber volume was 105,154.26 m^3, equivalent to 3,713,607.20 ft^3. Based on the prevailing timber rate of ₹7,364 per ft^3, the total economic value of standing Deodar timber was estimated at ₹27.34 billion (approximately ₹2,734.34 crore). Among all quadrats, Q1 recorded the highest timber value (₹407.40 crore) due to greater standing volume, whereas Q4 showed the lowest economic value (₹149.30 crore). The variation among quadrats was mainly attributable to differences in tree density, diameter distribution, and individual tree height.

Table 4.5.1 Quadrat-wise Timber Volume and Economic Value of Deodar Forest

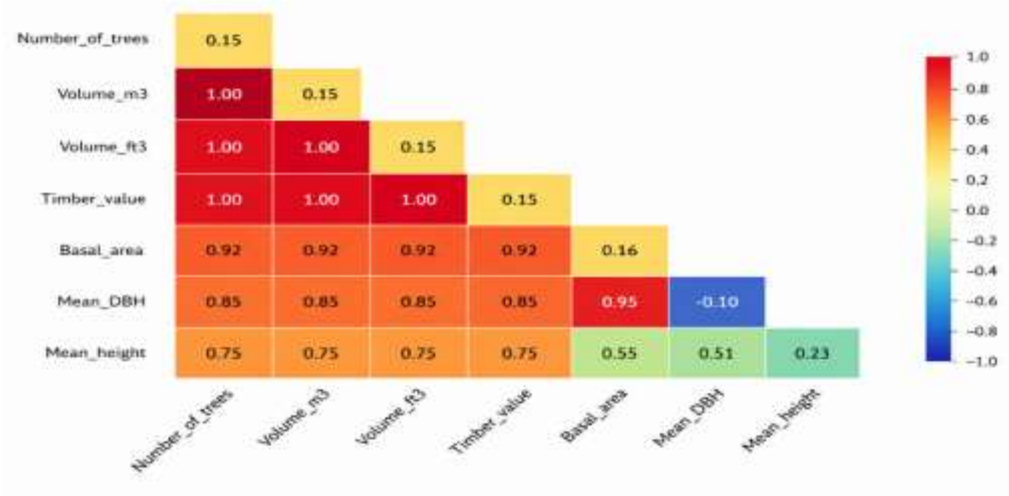
Quadrat	No. of Trees	Volume (m^3)	Volume (ft^3)	Timber Value @ ₹7364/ft^3 (₹)
Q1	26	15,668.32	553,375.20	4,074,045,973
Q2	28	9,629.61	340,079.80	2,504,347,267
Q3	22	6,289.27	222,073.70	1,635,741,503
Q4	25	5,739.20	202,742.20	1,492,994,360
Q5	27	8,354.00	294,981.60	2,172,644,102
Q6	26	7,667.12	270,711.50	1,993,519,306
Q7	27	11,814.38	417,287.50	3,072,930,550
Q8	23	15,017.43	530,339.70	3,904,621,151
Q9	27	14,553.58	514,000.90	3,783,497,652
Q10	27	10,421.34	368,014.80	2,709,102,487
Overall Total	**258**	**105,154.26**	**3,713,607.20**	**27,343,444,351**

Figure 4.5.1 Quadrat-wise Timber value of Jakhu Deodar Forest



Correlation analysis indicated that timber value in Deodar forests is primarily determined by stand volume and Tree dimensional characteristics, rather than tree density. Timber value exhibited a perfect positive correlation with standing volume ($r = 1.00$) and strong correlations with basal area ($r = 0.92$), mean diameter at breast height (DBH) ($r = 0.85$), and mean height ($r = 0.75$). The strong associations among DBH, basal area, and timber value underscore the importance of mature, large-sized trees in shaping forest productivity and economic potential. Conversely, the weak correlation between tree number and timber value ($r = 0.15$) suggests that tree quality and size are more influential than tree quantity. Overall, the heat map illustrates that the structural attributes of Deodar stand play a critical role in regulating timber production and economic valuation.

Figure 4.5.1 Pearson correlation matrix among Different parameters of the Jakhu Deodar forest

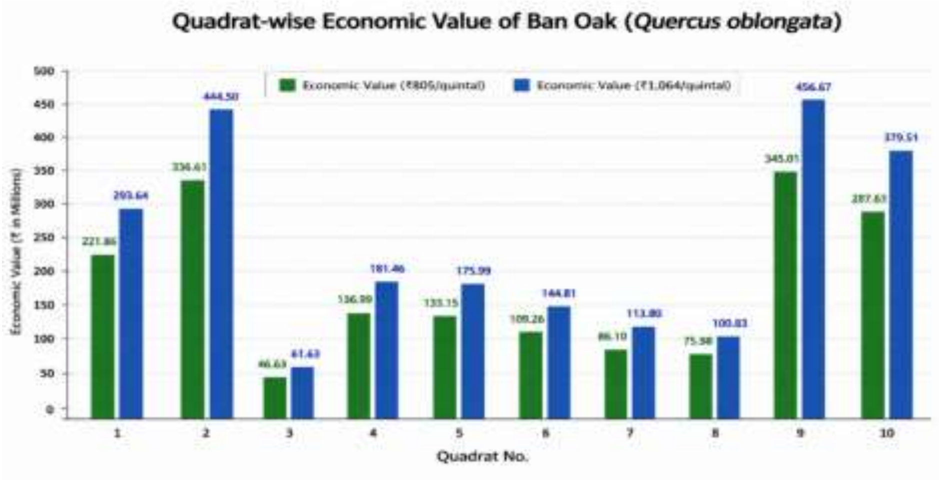


Site -2 Tara Devi Forest: a total of 470 Ban Oak (Quercus oblongata) trees were recorded across ten quadrats, yielding a cumulative growing stock volume of 56,671.82 m³ and an estimated biomass of 2,210,201.14 quintals. The estimated economic value ranged from ₹46.63 million to ₹345.01 million for domestic use and from ₹61.63 million to ₹456.67 million for commercial use across the quadrats. Quadrat 9 reported the highest economic value (₹345.01 million for domestic use and ₹456.67 million for commercial use), followed by Quadrats 2 and 10, attributable to their greater biomass stocks. Conversely, Quadrat 3 exhibited the lowest economic value due to its relatively lower volume and biomass. The total economic value of Ban Oak stands was estimated at **₹1.779 billion (₹177.92 crore)** for domestic use and **₹2.353 billion (₹235.28 crore)** for commercial use. These results demonstrate a clear positive relationship between growing stock volume, biomass accumulation, and economic value, underscoring the substantial contribution of Ban Oak forests to local forest-based resources and ecosystem services.

Table 4.5.2 Quadrat-wise Biomass and Economic Value of Tara Devi Forest (Ban-Oak)

Quadrat	No. of Trees	Volume (m³)	Biomass (q)	Value @ ₹805/q (₹)	Value @ ₹1064/q (₹)
1	57	7,066.789	275,604.77	221,861,839	293,643,477
2	51	10,721.640	418,143.96	336,605,888	444,503,573
3	48	1,485.333	57,927.99	46,631,031	61,629,378
4	39	4,363.346	170,170.49	136,987,742	181,461,806
5	44	4,241.046	165,400.79	133,147,637	175,986,440
6	42	3,480.097	135,723.78	109,257,639	144,810,103
7	51	2,742.402	106,953.68	86,097,712	113,798,719
8	41	2,420.281	94,391.00	75,984,758	100,832,024
9	57	11,005.210	429,203.19	345,008,567	456,672,193
10	40	9,145.680	356,681.52	287,628,624	379,507,537
Grand Total	**470**	**56,671.824**	**2,210,201.14**	**1,779,211,437**	**2,352,845,250**

Figure 4.5.2 Quadrat-wise economic value of ban oak (Domestic value and Commercial value)

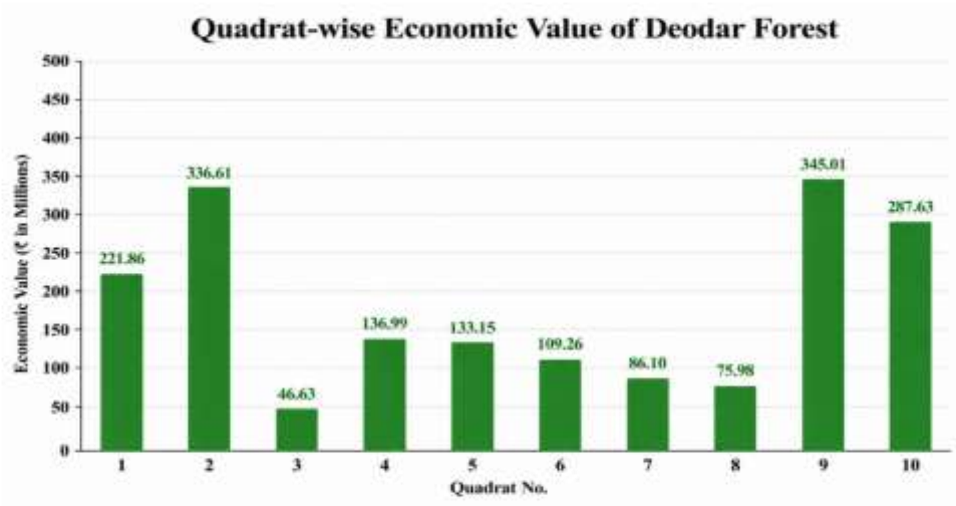


The Potter Hill Deodar forest contains 506 trees distributed across ten quadrats. The total timber volume is estimated at 2,516,457.98 ft³, corresponding to an economic value of **₹18.53 billion** (**₹1,853.12 crore**) based on the prevailing timber rate of ₹7,364 per ft³. Quadrats Q1, Q2, and Q3 recorded the highest economic values (₹3.65 billion, ₹3.10 billion, and ₹3.10 billion, respectively), while Q5 exhibited the lowest value (₹0.63 billion).

Table 4.5.3 Quadrat-wise Biomass and Economic Value of Potter Hill Forest (Deodar)

Quadrat No.	**No. of Trees**	**Total Volume (ft³)**	**Total Economic Value (₹)**
Q1	52	495,503.94	3,648,891,004
Q2	49	421,643.49	3,104,983,425
Q3	48	420,731.87	3,098,270,325
Q4	54	134,511.27	990,541,025
Q5	45	85,287.69	628,058,540
Q6	50	130,711.28	962,557,869
Q7	52	179,709.36	1,323,379,738
Q8	53	246,781.37	1,817,297,628
Q9	52	174,910.64	1,288,041,978
Q10	51	226,667.07	1,669,175,050
Grand Total	**506**	**2,516,457.98**	**18,531,196,580**

Figure 4.5.3 Quadrat-wise economic value of Potter Hill Forest



The difference between these values arises from the distinct pricing and utilization practices in commercial versus domestic markets for Ban-Oak. Overall, the studied forests are of high economic value. Deodar forests contribute the largest share of timber benefits. Sustainable management and conservation are essential to maintain these valuable resources while ensuring ongoing ecological and economic benefits.

Conclusion:

The current study shows that Shimla's Deodar (Cedrus deodara) and Ban Oak (Quercus oblongata) forests have a high standing wood value, underscoring their important economic contribution to forest resources. Tara Devi produced an estimated value of ₹1.779 billion (₹177.92 crore) for household use and ₹2.353 billion (₹235.28 crore) for commercial use. In comparison, Jakhu Hill and Potter Hill showed wood values of ₹27.34 billion (₹2,734.34 crore) and ₹18.53 billion (₹1,853.12 crore), respectively.

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