Timber Production Potentials in Nepal: A Critical Review on Projected Estimates

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Abstract

This paper delves into historical efforts to enhance timber production in the country. It examines the influence of spatial dynamics, public infrastructure facilities, processing industries, timber taxes, and timber export duty in timber production and supply. It contends that it must consider the critical constraints outlined in the policy documents and practiced standards when examining forecasted timber production potentials. The paper concludes that the aggregate annual timber supply in the market will likely reach 2.7 million m^3, which will meet the demand for domestic timber and replace imported timber in the market.

Keywords: Harvest, Forest tax, Formal trade, Nepal, Potential forests

INTRODUCTION

The land cover map of 2000 and 2019 shows that forest is the primary land use followed by cropland with 41.6 per cent and 24.21 per cent coverage, respectively (FRTC 2022). Forest cover is around 44.8 per cent of the country, while other woodlands are included. Despite this extensive forest cover, its contribution to the national economy is considered less than potential. The supply and use data available for fiscal years 2004/05 and 2010/11 estimates contribution of 3.2 and 1.4 per cent respectively (CBS 2013; CBS 2018).

A study by the Department of Economics, Tribhuvan University, reveals that the informal economy contributes about 42 per cent of the national economy, and agriculture, forestry, fishing, real estate activities, accommodation, and food services have a significant share (TKP 2024). Many forest products are harvested and directly consumed by local households for free or subsidized fees or through informal trade. Such activities remain excluded from the national account, and the estimated figure misleads the economic value of forests.

After the political transition to a multi-party system in the 1990s'; the country followed structural reform to increase private sector investment, particularly in the manufacturing and service sectors. The government promulgated laws and bylaws to implement those reforms, which also had spillovers in forestry. The government imposed legal restrictions on timber exports and exercised high export duties. Export restriction measures effectively reduced timber exports and made them readily available for domestic industries. The availability of high-value hardwoods, road access, and electricity facilities offered business opportunities in the Terai. As a result, the timber industry grew faster in this region. At the same time, the hilly region stayed behind due to poor access and the minimum distance threshold enforced by the government in establishing wood-based industries from the nearby forests.

To increase revenue, the government endorsed an annual round timber harvesting target of 3.2 million cubic meters (m^3) of the Master Plan for Forestry Sector (MPFS). The operational forest management plans (OFMP)

were prepared and implemented in 20 Districts covering 493,379 ha of forests (DoF 2015). However, these plans failed to achieve timber production targets and prematurely expired.

Forest Sector Policy 2000 (HMGN 2000) envisioned the "No green tree felling" that negatively impacted timber production and supply chain. Timber production grew slowly in Community Forests (CF) and reached 1.7 million m3 in the fiscal year 2010/11. The media had perceived such a surge in production as illegal harvesting. Consequently, the government formed three investigative committees to investigate it. The Commission for the Investigation of Abuse of Authority (CIAA) also intervened in timber harvesting-related matters. The investigation committee submitted a report highlighting the lapses in timber production and supply in general, particularly in CF. The CIAA also directed the Ministry of Forests to regulate timber harvesting in Terai. The private forests had the slightest disturbance, filling the timber supply gap for CF.

There was an attempt to enhance timber production and supply by declaring Forest Decade (2014-2023), implementing the Scientific Forest Management Guideline (SFM) in 2014, and endorsing the Forestry Sector Strategy (2016-2025). The government set an annual timber production target of 10 million m^3. As a result, SFM gradually gained momentum. Unfortunately, another investigation committee was formed in 2020 to investigate timber produced by SFM implemented CF. Similar to past investigations, there was a disturbance in timber production throughout the country.

Past efforts to reduce raw timber exports to foster domestic industries resulted in mixed outcomes. It helped establish sawmills and veneer industries in the Terai and small and medium-sized wood-based industries in the hills. Despite those positive results, the production process remained the same. Timber-exporting countries use modern technology to produce quality products at low prices. As a result, timber imports started to grow in Nepal, risking the reduced demand for domestic raw timber in the market.

The Government of Nepal (GoN) has recently decided to reduce export duty on timber, the outcomes of which are yet to be experienced. However, there might be increased demand for raw timber export, leading to increased competition among the existing industries for accessing domestic raw timber. If that holds, it may put domestic industries under pressure to switch to imported input products instead of domestic raw timber. If processing firms have other wood-based firms, such as sawmills, that complement furniture making, they may face exit barriers. In that situation, sawmills would have no better choice than to operate at a price that covers variable costs. It will impact the economy by reducing employment opportunities from value addition locally.

Timber production trends show that the current market supply is manifold less than the predicted potential. Such poor performance indicates that Nepal's complex topography and fragile mountain ecosystems only allow some forests to produce timber profitably. Looking back to such limiting factors, we only accept the projected timber production potentials obtained by multiplying available forest area by estimated annual growth by considering the harvesting costs associated with the limiting factors. We have projected Nepal's timber production potential, taking note of the impact of demographic changes, public infrastructure, processing facilities, stumpage prices, and timber export duty on timber production and supply decisions.

ECONOMIC CONSIDERATION OF FORESTS

The value of farmland in rural areas is a function of the farm-gate price of farm-produced products. That means farm produce gets a reasonable price when the local market is nearby, and transportation costs are minimal. Intuitively, agricultural land value declines along with increasing distance. In our conceptual framework, Va represents the land value of farming in use. A downward slope implies decreasing value with increasing distance from the villages (Figure: 1). The land owner invests cost to maintain property rights as described by cost function (Ca), and the owner has an incentive to manage this land up to a point (B) where cost equals the return. Land beyond point B (B-B') is underutilised land (UUL), which is used in an activity that provides short-term returns at minimum capital and labor inputs- such as nurturing natural trees or multi-purpose tree planting. It provides forest products till the harvested product's value function Vf lies underneath the value function Va in rural villages.

Since agriculture is labor intensive, if labor migration is high, then cost function shifts left (Ca'), making less area available for profitable agro-practices. Thus, tree planting takes place left to B. The migration activity increases the cost of agro-activity, and land Bo-B' is left as underutilised land (UUL), where low-labor-intensive activity is preferred. As a result, farmers either plant trees or nurture natural tree species on such land, which explains why the forest is expanding in UUL in rural villages of Nepal.

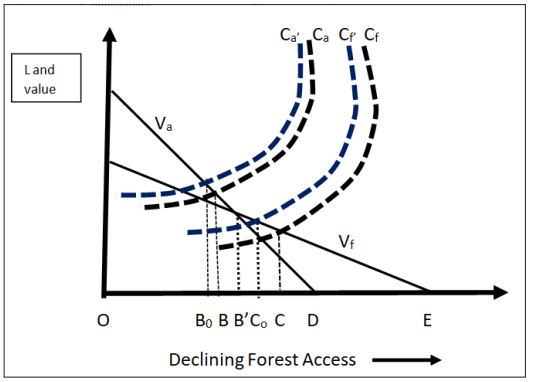

Figure 1: Impacts of spatial dynamics in timber production potentiality

The Terai belt is the country's food basket and has excellent access to market and food processing industries. The value function for agriculture Va can be drawn parallel, and its effect on value functions can be interpreted using the same logic above.

Demographic changes in rural areas have impacted forestry as they have affected agro-activity due to increased forest management costs. As a result, forest users respond by extending underutilised and under-managed forests (Co-C). Forest beyond point Co has the potential to produce a positive return. However, the anticipated cost does not allow commercial harvesting, especially in those areas where migration of the working population is high. The forest beyond points C to E remains an unmanaged natural forest, and forest users may visit for specific purposes till the time value (cost) recovers the product value.

Such observations are widespread in mid-hills, where demographic change has occurred recently. We observed similar trends

in the Kabhre and Sindhupalchowk districts during the forestry module household survey administered by the National Statistics Office (NSO) in the year 2023. This observation implies that local households have been collecting forest products from their private trees and partly relying on community forests (Co-C) for specific products. This framework model supplements the earlier statement that all forests have biological potential but may not qualify as financially viable to produce timber.

TIMBER PRODUCTION POTENTIAL FORESTS

Timber production sources refer to the different categories of forest lands under the definitions of the Forest Act in 2019. Based on the ownership, there are two broad timber producers: national forests and private forests. The national forests include different forest regimes based on management responsibilities, viz. protected, government-managed, community, collaborative, religious, and leasehold forests.

The forest land with unique environmental, ecological, scientific, or cultural values and critical watersheds or biodiversity hotspots are declared protected forests (PrF) and managed under a unique management plan to promote eco-tourism and protect forests. The timber produced in the religious forests (RF) cannot be sold or distributed. Similarly, leasehold forests (LhF) do not contribute to the timber markets. Therefore, CF, Government-Managed Forests (GMF), and collaborative forests (CoF) are three major timber producers of national forests. Besides, industrial plantations established in the national forests and nurtured or planted trees in private lands (PF) also contribute to timber production.

There are different estimates that Nepal's timber production potential ranges from 5.88 to 25.8 million m^3 annually (refer to Annex-1). These estimates rely on different base years. The extraction level is estimated to be 3.4 million m^3 in the recent past, as measured from stumps in the forests, and the total annual drain of wood is estimated at 12 to 14 million m^3 (DFRS 2015) cited in (MSFP 2016). This data indicates that different authors have adopted different values in estimating production potential forest area, annual growth rate, and harvesting intensities.

Terai forest is known for much greater commercial value than forests elsewhere in Nepal. The green growth model estimates 2.89 million m^3 of timber production from 1.45 million ha of forests by 2030 (World Bank 2019). Likewise, the Chure Master Plan includes the most accessible potential production forests, which recommends limited-use management in all types of forests above 19 degrees slope and strict protection above 31 degrees slope (GoN 2017). According to this plan, forests below 19 degree slopes would qualify to implement production-oriented management activities. CFs with more than 100 ha in size and above 19 degrees slope will not qualify for commercial timber production under this plan.

The mid-hills and high-hills forests are fragmented and extended over remote topography. Therefore, these forests have low potential for timber production due to high extraction costs. The Community Forestry Users Groups - Management Information System (CFUG-MIS) data set was used to identify CFs with over 100 ha of forest area and slopes under 19 degrees, classifying them as potential SFM forests. Accessibility constraints were considered using sources like MPFS (1989), FRA (2015), and the Chure

Master Plan (GoN 2017). We estimated less than 50 per cent CF are likely suitable for commercial timber production.

2.02 million ha national forests, which is less than 30 per cent, are viable for commercial timber production. Thus, the potential timber production area under the SFM-scenario in Government Managed Forest (GMF) and Community Based Forest Management (CBFM) will be 1.12 million ha and 0.88 million ha, respectively. No limitations are considered in CoF, block forests, and planted forests due to their distribution in the Terai landscape.

A precise estimate of the PF is needed. Nevertheless, one study estimates 54,890 ha of compact forests (Amatya and Lamsal 2017) and a registered PF of 2902 ha (CFD 2017). Since forest areas reported by the FRA include national and private forests, we consider trees nurtured along the forest fringes and planted forests constitute about 15 per cent of the total national forests, covering about 0.74 million ha.

EXAMINING THE MAI VALUES USED IN NEPAL

The condition of the tree is determined by its size and volume. Every year, living trees in the forest experience growth in height and girth until they are over-mature. Such growth contributes to stem volume increment in the corresponding year. When the diameter growth of a tree dramatically drops, it signifies the tree is leading toward the maximum biological age.

Measuring the annual growth rate of the height and diameter to calculate the growth rate, also known as current annual increment (CAI), is challenging due to immense measurement efforts. Since the annual increment is so small, precise measurement to estimate growth accurately is challenging. Alternatively, foresters adopt periodic tree growth measurements at every 5- and 10-year interval. The average annual growth rate is calculated by dividing the total stand volume by the interval period. When the average annual growth, also called mean annual increment (MAI), is maximum, the corresponding year is called the rotation age. The timber produced at this age is the Maximum Sustained Yield (MSY). Therefore, MSY is the maximum volume of timber production potential; before and after can only provide a little.

The calculation of MAI is more complex than explained above. It is particularly challenging in irregular natural forests where foresters have to make the best estimates of stand age, which are not readily available in the field. Therefore, stand age is based on judgment, and for stand volume, foresters rely on forest surveys and inventory work. The average annual growth is calculated by dividing the total stand volume by stand age and then by the total area, which gives MAI in m^3 or ft^3 per hectare per year. The MSY, therefore, represents the rotation age at which MAI is maximum, also called Biological rotation. However, MSY does not consider the cost and return factors; this concept often opposes financial rotations in forestry literature.

Recalling the shape of the biological growth curve (the famous S-shaped curve), the MAI increases along with the increase in age up to a particular stage. Then, it starts declining due to a diminishing growth rate, which indicates that trees have approached the mature stage. When trees become over matured, tree growth starts to culminate, and the volume of dead dying branches starts falling. Thus, MAI is diminishing in over-mature forests, and CAI eventually turns negative.

This concept fits well if CAI and MAI estimates represent annual and average increments measured in the field. However, we use conservative MAI in practice, so there is room to argue on theoretical grounds. To simplify our analysis, we assume our estimated MAI value is close to the measured values. On that ground, Should forest owners harvest timber by multiplying Growing Stock (GS) by estimated MAI values in over-mature forests? The simple answer is no because such stands do not add additional increments.

While raw timber was exported to India, selected large timber trees were cut in Terai forests, leaving inferior timber trees behind. Such high-grading practices led to many forest patches becoming low-quality forests over time. These forests now exist as less commercial-value forests dominated by over-mature trees. In such forests, MAI-based harvesting decisions are counterproductive to financial return and forest health.

The Chure Master Plan suggests an MAI of 5.0 m^3/ha/yr for forests (< 19-degree slope) if managed under suitable silviculture systems (GoN 2017). The estimated MAI for the mid-hill is 7.5 m^3/ha/yr for the middle mountain broadleaved plantations (MSFP 2016). The CF Inventory Guideline suggests average annual growth for good, medium, and slow-growing species of medium-quality forest as 4 per cent, 3 per cent, and 2 per cent of total growing stock, respectively.

The data from the Department of Forest and Soil Conservation (DoFSC) for CF-produced raw timber for 27 Districts in the fiscal year 2014/15 reveals that harvesting was almost 50 per cent below what was approved by the community forest operational plan (CFOP). This validates that the underutilisation of CFs has increased in recent years. Considering CFs are underutilised for timber production, we presume annual growth has compounded in the growing stocks. Thus, we have used the MAI value for CBFM as 3.0 m^3/ha/yr and 2.0 m^3/ha/yr for GMF.

We acknowledge that the MAI value varies for the different topography and site quality; employing the same MAI value everywhere risks serious errors. Considering this, we have adjusted values based on those used by the government to avoid such risks, such as the Chure Master Plan, CF Inventory Guideline, the Master Plan (MSFP), and National Silviculture Workshop Proceedings. Furthermore, MAI for nurtured trees and planted trees also varies widely. Because MAI should be higher in PF due to the edge effect and timber stand improvement inputs. However, using separate MAI for each tree species was challenging due to the complexity of species composition and tree distribution. We have used an estimated 4.0 m^3/ha/yr value for all trees planted or nurtured on private lands.

TIMBER PRODUCTION AND SUPPLY TREND

The value of raw timber is determined by the market demand for input products used to produce finished products for end uses. If there is a high demand for raw timber from the pulp, paper, and furniture industries, then the price of small-diameter round timber in the market will increase. On the other hand, industries producing veneer and saw timber require big-sized round timber. This indicates that demand determines the value of standing trees, which drives timber producers to decide when to harvest trees and how much to produce at prevailing prices. In countries like Nepal, where wood pulping industries do not exist, there is no reason to harvest small-sized trees; instead, wait till large-size round timber is ready for sawmills and veneer industries.

National forest covers 4.93 million ha area and its production trend for the last fifteen years (Figure 2) supports the findings of under-utilisation of forests (Khanal 2002; Dangi *et al.* 2007; DoF 2017; Poudyal *et al.* 2023). Timber supply trend shown in Figure 2 could be smoother; it is irregular and distorted by various external and internal factors- such as administrative hurdles, weak governance, and capacity gaps. Due to administrative hurdles, such distortions are at two points, marking supply shocks in 2008/09 and 2019/20, which caused a profound fall in timber production in respective years. Such disturbance was particularly noticeable in the CBFM and GMF of Terai, Chure, and inner Terai districts over the next few years.

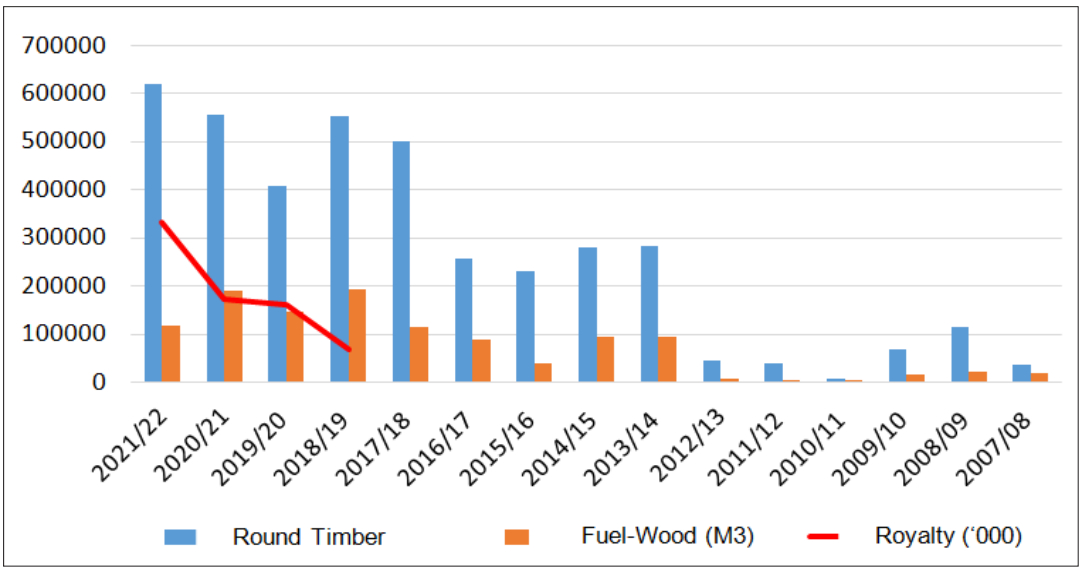

Figure 2: Trend of wood production (15 years) and royalty collection (4 years)

Source: MoF 2022; FCGO 2021, 2023

TIMBER PRODUCTION AND SUPPLY POTENTIAL

We have estimated gross timber volume using adjusted forest area for areas reduced from deforestation. We also adjusted the productivity lost from forest degradation from 2014 to 2022. We know climate change-related catastrophic risks such as forest fires, hurricanes, and landslides may damage forests and enhance timber supply to some extent. However, we have not considered them because such catastrophic shocks are unpredictable, and data is unavailable for growing stock damages.

Realising the site quality impacts the proportion of timber and fuel-wood production, we considered the average site quality for all types of forests. Thus, we estimate net round timber volume by multiplying the Gross timber volume by the Timber Recovery Factor (TRF). We have used the formula below to estimate the country's projected net timber harvesting potential (aggregate) and the summary result is presented in table 1.

Formula (1)

$hn_{(t)} = Area_{j(n)}) * (1- deforestation\ rate_{j(n)})^{t-n} * MAI (1- degradation\ rate_{j(n)}^{t-n} * TRF_{(t)}$

Where,

J represents the five types of forest regimes (Community forest, collaborative forest, block forest, government managed forest and planted forest)

$hn_{(t)}$ = Net Timber harvesting potential in m^3/year from national forests in year t (year 2022);

Forest $Area_{j(n)}$) = Timber Production potential forest Area for forest regime j in year n;

Deforestation $rate^1_{j\ (n)}$ = estimated deforestation rate for forest regime j in year n (base year 2014);

Degradation $rate^2_{j\ (n)}$ = estimated degradation rate for forest regime j in year n (base year 2014);

$MAI_{j\ (n)}$ = Estimated Mean Annual Increment in m^3/ha/year for forest regime j in year n;

$TRF_{j\ (t)}$ [3] = assumed 60 per cent of gross volume is net timber harvest in forest regime j in year t;

Formula (2)

Annual net timber harvesting potential from PFs ($hp_{(t)}$) in year *t (2022)* can be estimated:

$hp_{(t)}$ = Forest $Area_{private\ (n)}$ * $MAI_{private(t)}$ * Yield factor (timber) $_{private(t)}$

Where,

$hp_{(t)}$ = Net timber harvesting potential in m^3/ year from private forests in year (year 2022);

Forest $Area_{private\ (n)}$ = Estimated area under tree cover in private land (in ha) in year n;

$MAI_{private\ (t)}$ = Estimated Mean Annual Increment in m^3/ha/year of respective Private forests;

TRF (timber)[4] $_{private\ (t)}$ = Coefficient for net timber harvest in private forests in year t;

Based on the literature review, we considered 20 per cent of timber from government and community-managed forests is traded without official records. Thus, adjusting for unrecorded trade the net annual timber harvesting is estimated using Formula 3 below the result is presented in table 1.

Formula (3)

$H_{(t)} = (hn_{(t)} - 0.2(hn_{(t)}) + hp_{(t)}$

Where,

J represents the five types of forest regimes, viz. Community forest, collaborative forest, block forest, government managed forest and planted forest.

$H_{(t)}$ = Annual net timber harvesting in year t;

$hn_{(t)}$ = Annual timber harvesting potential from forest regime j in year t (2022);

$0.2(hn)_{(t)}$ = assumed 20 per cent illegal harvesting and trade in national forests;

$hp_{(t)}$ = *Annual net timber harvesting from Private forests in year t (2022);*

According to the data from DoFSC for FY 2017/18 of 29 Districts, 58 per cent of the total Annual Allowable Harvest (AAH) was harvested in CF, of which 38 per cent was sold in the market. Adjusted timber production for 2022/23 is estimated at 2.93 million m^3, aligning with the World Bank's 2030 green growth scenario (World Bank 2019). Of this, adjusting 60 per cent consumed internally,

[1] Assumed deforestation rate for GoN and CBFM is 0.25 and 0.06 per cent per year respectively.
[2] Degradation for GoN and CBFM forests is 0.4 and 0.07 per cent per year respectively.
[3] Estimated coefficient is 0.6 for conversion of Gross timber volume to net timber volume.
[4] Estimated coefficient is 0.75 for conversion of Gross timber volume to net timber volume

1.66 million m^3 is expected to enter the market. This data shows underperformance in GMF and CBFM, contributing less than 3 per cent and 17 per cent of their supply potentials, respectively (For detail, See Table 1)

Table 1: Timber supply potential versus actual supply in F.Y. 2022/23 under scfm scenario

Forest Regime	Forest Area in m. ha	ScFM Area in m. ha[5]	Estimated[6] Yield in m. m^3	Adjusted[7] Yield in m. m^3)	Actual Yield[8] in m. m^3	Percent# %
Govt. Managed	2.22	1.12	1.34	1.07*	0.02	2.2
Community Managed	2.38	0.88	1.58	(1.3)* 0.58**	0. 1	17
Industrial Plantation	0.02	0.02	0.013	0.01	0.01	
Sub-Total	4.602	2.02	2.923	1.66	0.13	
Private Forest	0.74	0.444	1.26	(1.26) 1.01***	0.6	48
Grand Total	5.342	2.346	4.183	(4.2) 2.7	0.73	

Note: * adjusted for 20 per cent illegal harvest and further adjusted assuming 40 per cent traded in C.F. **; *** adjusted for 20 per cent informal trade or consumed by the owner; # computed dividing adjusted yield by actual yield in per centage point;

The National Timber Production Plan drafted by DoF for FY 2015/16 had estimated annual timber supply potential from the national forests, combining GMF and CBFM, as 0.1 million $m^{3,}$ which is pretty close to the average annual production (0.13 m. m^3) of the last three fiscal years presented in Table 1 above.

Data in Table 1 above indicates that private forests contribute a considerable share of the timber market, which is expected to elevate further along with the expansion of public infrastructure and reduced timber export duty. This will continue until 80 per cent of its harvest reaches the formal market, and the remaining 20 per cent will be directly consumed or traded informally in the local market. Thus, Expanded wood industries and reduced export duty will have a big push on the value function of forests and increase raw timber supply, which will elevate the value function of forests and increase competition for raw timber supply in the market.

The data from Table 2 below also supplements the above argument by showing the expansionary impacts of public infrastructure and modern wood processing facilities on timber industries. Provinces with better public infrastructure facilities- such as electrification, rural road networks, and wood-based industries- supply more timber than weak ones. Similarly, Provinces with better electrification facilities in urban centers have more raw timber demand for wood processing and furniture-making industries.

[5] Filter used for slope>19 degree + Area<100 ha for CBFM; restricted access by law, policy and plans ; and ecological sensitivity defined by operational plans;

[6] Estimated using formula (1) and (2) for Fiscal year 2022/23 with respect to base year 2014

[7] Estimated using formula 3 and assumed adjusted values

[8] Average annual production estimated from data available from seven provinces for last three fiscal years

Table 2: Expected spillover effect of infrastructure facility in timber supply (in m^3)

Description	Prov. 1	Prov. 2	Prov. 3	Prov.4	Prov.5	Prov. 6	Prov. 7	Total
Saw-mill [a]	246	366	275	42	258	12	28	1227
Furniture [a]	1226	673	2396	987	1035	164	215	6696
(a) urban)	1056	542	1997	747	768	132	171	5413
(b) Rural	170	131	399	240	267	32	44	1283
Road (Km)[b]	1893	915	1890	1300	2385	1441	1335	11178
Electrification [c]	82.43 %	99.05%	94.44%	92.78%	91%	34.7%	64.69%	
Forest (ha)[d]	1157905	237636	1154685	787865	996941	837016	989268	6161316
For Cover (%)	44.44	24.78	56.93	35.88	51.64	27.31	49.24	
CF(ha)[e]	432688	78855	377330	253408	395517	353096	401272	2292166
CF (in %)	37.37	33.18	32.68	32.16	39.67	42.19	40.56	
Timber [f] m^3	520594	5573	60043	25387	73095	17235	25641	7275685
GMF %	17.8	4.1	38.3	3.3	5.7	24.7	6.0	100
CBFM %	35.4	3.3	10.7	7.6	18.7	8.1	16.2	100
P F per cent	79.9	0.2	6.7	2.8	8.7	0.5	1.2	100

Source: a= NSO (2022); b= DoR, (2022); c= FRTC (2022); d = CFSD (-); e= Bishwokarma *et al.* (2020) f = compiled from seven provincial forest directorates.

Data from Table 2 above also indicates that further expansion of public infrastructure, such as rural roads and electrification in Karnali Province (6) and Farwest Province (7), will lead to the establishment of more timber industries. The north-south road network is expected to serve as an economic corridor connecting northern hinterland forests to the south-based modern wood processing industry. However, the small-scale furniture business will grow, using informally traded small-size timber in remote rural mountains.

The timber import data for FY 2022/23 reveals a volume of 0.3 million m^3 (Doc, 2023), imported timber contribution of one-fourth (World Bank 2019), and projected demand for 2020 as 3.7 million m^3 (Kanel *et al.* 2012), we argue that predicted timber can satisfy the demand for raw timber in the market and replace imports.

CONCLUSION AND RECOMMENDATIONS

Mountain ecosystems, by nature, are considered very fragile, where spatial dynamics and ecological sensitivity matter a lot in determining the forest harvesting scale and intensity. We argue that safety standards must be adopted while executing timber harvesting decisions on steep mountain slopes such as mid-hills and Churia Hill forests. Such measures are crucial to reduce environmental and social costs to nearby living communities and downstream.

The timber producers from the national forests must balance economic and environmental goals. They must consider such constraints because society expects their harvesting activity to be regulated for broader societal benefits. As a result, it leads to the production

of limited quantities and determines the price. In that way, they have the power to influence the market to some extent. There are different projections regarding annual timber production potentials in national forests (including all regimes). Unfortunately, their estimates range widely due to different predictors used by different authors.

Unlike national forests, private forest owners aim to earn maximum return from timber without considering society's environmental goals. Numerous individuals supply timber in such small quantities that individual producers cannot influence the market but accept prices offered by the timber buyers.

Considering the ecological fragility in mountain forests, we disagree with timber production predictions that use gross forest areas as suitable for commercial timber harvesting. Such projections must consider the location of the forest from the settlement, the forest land's slope, and the forest landscape's ecological sensitivity to determine timber production potential forests for Nepal.

About 2.02 million ha of national areas (including all forest regimes) would be suitable for timber production under the SFM practices. The rest of the forests will not be financially viable for producing timber at a commercial scale. However, these forests will keep supporting local consumption. Based on this estimate, we predict that 1.7 million m^3 of raw timber will be sold annually in the market from the national forests and 1.01 million m^3 from private forests.

It is worth noting that timber supply from government-managed- and community-based-managed forests has stayed the same in the last fifteen years. Meanwhile, the contribution of private forests has significantly increased. Unless the government supports SFM practices, the contribution of national forests will not significantly increase as that of private forests.

Following the recent forest resource assessment result, mature forests need immediate management intervention to increase harvesting intensity. However, the current annual allowable harvesting quota determination methods need to provide more flexibility in elevating harvesting intensity in such forests. We suggest revisiting the current methodology to determine the harvesting quota in the over-mature forests.

The mid-hill forests have the lowest sawn-timber volume but a relatively balanced diameter class distribution. Since there is a high density of community forests as well as a high rate of migration, mid-hill community forests will continue to augment growth and improve forest quality due to underutilisation. These forests will contribute little to the timber market and continue to supply for local consumption. It is the Terai and inner Terai Valley forests where SFM practices need to be aggressively extended.

The recent decision to reduce timber export duty will likely impact the domestic timber industry. However, studies show that nations that can influence the global timber market through voluminous exports have benefitted from such decisions. Nepal is a land-locked nation where imported timber contributes almost one-fourth of the total timber market, and domestic timber is more expensive than similar imported timber. We argue that reduced export duties will make less of a difference to timber producers from the national forests.

The reduced export tax may increase demand for raw softwoods produced in private forests and elevate competition in domestic

industries for input products. This will create new job opportunities for unskilled labor, and skilled labor may lose their jobs. There is a risk of re-importing exported domestic raw timber after value additions, negatively impacting the industry and economy. We suggest adjusting fees to compete with similar imported products to minimize risk.

Annex-1: Compilation of MAI values from literature review

Region	Forest Type	SFM Area (m. ha)	MAI (m3/ha/yr)	Est. Prod. m. m^3	Reference
Terai	Sal Forest		14.3		(DoF, 2017) pp 70
	All Forest	0.24	2.1	1.3[9]	(DoF,2017) Pp 81
	Sal forest		3-6		(Amatya *et al.* 2022)
	Sal Forest		8.0		(Amatya *et al.* 2022)
	All forest	1.39	6.0	8.34	(Magrath *et al.* 2013)
	All forest		5.0		(GoN 2017)
	Eucalyptus		5.5		(Amatya *et al.* 2020)
	Teak		2.9		(Amatya *et al.* 2020)
Chure	All forest	0.8	2.3	7.9	(DoF 2017) Pp 81
	All Forest	1.24	5.0		(GoN 2017)
			2.0	9.0[10]	(NNRFC 2022)
			2.0	1.5[11]	(Kanel *et al.* 2012) PP 34
Mid-hill	Broad leaved		7.5		(MSFP 2016)
	All forests		2.0		
	All forests	4.43	3.0	13.31	(Magarath *et al.* 2013)
	Pine Forest	}	3.0		(Kanel *et al.* 2012) PP 10
	Katus-Chi-laune		2.3	2.3[12]	" " PP34
			0.4		" " "
	Sal forest		2.1		(Amatya et al. 2020)
	Khote salla				
Mountain	All forests	0.19	3.0	0.57	(DoF 2017) Pp117
				0.3[13]	(Kanel *et al.* 2012) PP 34

[9] Kafle includes dead and fallen timbers

[10] Rai estimates for all region

[11] include Terai and inner Terai for year 2020

[12] Projected for Year 2020

[13] Projected for year 2020

Annex-2: Timber production potentiality of different forest regimes in nepal

SN	Source	Total Area (ha)	SFM Prodn. Area (ha)	MAI m^{3}-ha	Potential Yield	Adjusted Yield/yr	Actual Prodn.[14]	Producer
1	National Forest	2.2 M	1.1 M ha	2.0	1.3 M m^3	1.072		84 DFOs
	1.1. State Managed Forests							
	1.4 Block Forest	0.02 M	0.02 M	3.0	0.034 M m^3			7 DFO
	Total SMF	**2.22**	**1.12 M**		**1.334 M m^3**		**0.023 M m^3**	**<2 % Prod.**
2	2.1 Community Forests	2.3 M	0.8 M ha	3.0	1.44 M m^3	(1.14) 0.46* Mm^3	0.09 M m^3	22,415
	2.2. Collaborative Forests	0.08 M	0.08 M	3.0	0.14 M m^3	0.12Mm^3	0.006 M m^3	30 CoF MC
	Total CBFM	**2.38**	**0.88**		**1.58 M m^3**	**0.58Mm^3**	**0.10 Mm^3**	**CBFM 17 %**
3	Planted Forest	0.02 M	(Eucalyptus) 9600 ha	14.0	0.01 M m^3	0.01Mm^3	0.01Mm^3	Data not Available
			(Sisoo) 4800	4	0.002 M m^3			
			(Teak) 1600	4	0.001 M m^3			
4	3.1 Protected Forests	0.33 M ha	NA	NA	0	NA	NA	DFO and Protected FUG
5	1.6. Pro-poor leasehold For	0.04 M	NA	NA	0			7,487 forest user groups
Total (National Forests)		**4.93 M**	**2.02 M**		**2.9 M m^3**	**1.7M m^3**	**0.12 Mm^3**	
6	Private Forest	0.7 M ha	0.44	4.0	1.26 M m^3	1.01Mm^3	0.6 Mm^3	Owner (<48 %
	Current status (Potentiality Vs actual Production)				4.18 Mm^3	2.7Mm^3	0.73 Mm^3	

Note: * assuming 40 per cent harvested timber is sold in formal market; assumed 20 per cent informally traded or consumed by owner in private forests

[14] Source: Author calculated average production from timber production data accessed from seven provincial forest directorate office for fiscal year 2020/21 – 2022/23

EXPLANATORY NOTE FOR ALTERNATIVE SCENARIO

The SFM guideline adopts a minimum area threshold of 100 ha to practice SFM in CF, which qualifies 0.88 m ha CF as SFM potential. However, 0.15 million CF area is within 50 to 100 ha size categories, a non - ScFM timber producer that can contribute an additional 0.21 million m^3. The timber supply from CBFM, as shown in Table 1, indicates that its contribution is around 20 per cent of the potential. Adjusting 60 per cent in internal consumption and 40 per cent in market supply potential, we estimate 0.4 million m^3 timber production from CBFM. Combining both SFM and non-SFM scenarios, the annual timber supply in the market would reach 1.09 million m^3 (less than 1.66 mm3 estimated above) from national forests.

The forest sector strategy aims to expand CF areas, reducing GMF areas by 2025. This shift may decrease GMF timber yield to 0.1 million m^3. CFs suitable for SFM cover 0.88 million ha, with non-SFM scenarios an additional 0.21 million m^3. The annual timber supply from national forests could reach 1.09 million m^3 in the formal market.

REFERENCES

Acharya, K. P. and Dangi, R. B. 2009. Case Studies on Measuring and Assessing Forest Degradation. Forest Degradation in Nepal: Review of Data and Methods. *Forest Resources Assessment Working Paper, Forestry Department*; FAO-UN, Rome, Italy.

Acharya, K.P., Dangi, R.B., Tripathi, D.M., Bushley, B.R., Bhandary, R.R., and Bhattarai, B. (Eds.) 2009. Understanding Forest Degradation in Nepal. In *Ready for REDD? Taking Stock of Experience, Opportunities, and Challenges in Nepal,* Chapter 6, pp. 49-73. Nepal Foresters' Association, Kathmandu, Nepal.

Amatya, S.M. and Lamsal, P. 2017. Private Forests in Nepal: Status and Policy Analysis. *Journal of Forest and Livelihood,* **15**(1): 9-18. Available at: https://forestaction.org/app/webroot/vendor/tinymce/editor/plugins/filemanager/files/JFL15(1)/9.%20Amatya%20and%20Lamsalm.pdf

Amatya, S. M., Thapa, H. B., and Bhatta, B. 2022. Theory and Practice of Forestry Management in Nepal. Hetauda: Faculty of Forestry, Agriculture and Forestry University (AFU).

Bhatta, L., Kotru, R., Munankami, R., and Shah, S. 2010. Unlocking Eucalyptus for Poor Communities: Applying Pro-Poor Value Chain Approach for Increased Income. Kathmandu, Nepal: SNV Netherlands Development Organisation.

Bishwokarma, R., Paudyal, B., Chapagain, P., Bajgain, S., and Shakya, H. 2020. Deep Neural Network-based Automatic System for Electricity Meter Reading in Nepal.

CBS. 2013. Supply Use Tables of Nepal 2004/2005. CBS Occasional paper. Central Bureau of Statistics. Kathmandu, Nepal. https://api.giwms.gov.np/storage/36/posts/1693046196_27.pdf;

CBS. 2018. Supply Use Table of Nepal 2010/2011. Central Bureau of Statistics, National Accounts Section. Thapathali, Kathmandu, Nepal. https://nsonepal.gov.np/list/resource/865?parent=1574;

CFD. 2017. Official Records of the Community Forestry Division. Community Forestry Division, Department of Forests, Kathmandu, Nepal.

CFSD. n.d. Using the Gini Coefficient for Analyzing Distribution of Community Forests by Provinces in Nepal. *Community Forestry Study Center.*

Dangi, R., Sharma, AR., Khanal, KP., Shrestha, RB., Acharya, KP., Rasaily, NK., Chowdhary, KP and Pariyar, S. 2007. Potential Policy Options for Economic and Financial Aspects of Forestry Sector, Democratization Governance and Sustainable Development of the Forestry Sector of Nepal. In *Proceedings of the National Workshop on 5-7 July 2007,* pp. 298-316. Available at: https://www.academia.edu/112236436/Potential_policy_options_for_economic_and_financial_aspects_of_forestry_sector_in_Nepal_1

DFRS. 2015. State of Nepal's Forests. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey, Kathmandu, Nepal.

DoC. 2023. Nepal Foreign Trade Statistics. Fiscal Year 2022/23. Department of Customs, Tripureshwor, Kathmandu. Available at: https://www.customs.gov.np/page/fts-fy-207980

DoF. 2015. National Production Plan of Timber and Fuel-Wood for Fiscal Year 2072/73. Department of Forest, Kathmandu, Nepal.

DoF. 2017. Silviculture for Forest Management: Proceedings of the First National Silviculture Workshop, Kathmandu, Nepal, 19-21 February, pp. 80-93; pp. 103-120.

DoR. 2022. Road Length with Category. Department of Road, Highway Management Information System (HMIS) Unit, Kathmandu, Nepal.

FCGO. 2021a. Consolidated Financial Statement. Fiscal Year 2019/20. Financial Comptroller General Office, Anamnagar, Kathmandu, Nepal. Available at: https://www.fcgo.gov.np/storage/uploads/publications/20210523121905_CFS_2019_20%20final.pdf

FCGO. 2021b. Consolidated Financial Statement. Fiscal Year 2021/22. Financial Comptroller General Office, Anamnagar, Kathmandu, Nepal. Available at: https://www.fcgo.gov.np/storage/uploads/publications/20230619133028_CFS%20Report%20For%20Website.pdf

FRTC. 2022. National Land Cover Monitoring System of Nepal. Forest Research and Training Centre, Kathmandu, Nepal

GoN. 2017. President Chure –Terai Madhesh Conservation and Management Master Plan. President Chure-Terai Madhesh Conservation Development Board, Kathmandu, Nepal.

HMGN. 2000. Forestry Sector Policy 2000. Ministry of Forests and Soil Conservation. Kathmandu. https://faolex.fao.org/docs/pdf/nep150857.pdf

Kanel, K.R., Shrestha, K., Tuladhar, AR. and Regmi, MR. 2012. A Study on the Demand and Supply of Wood Products in Different Regions of Nepal. *REDD-Forestry Climate Change Cell, Babarmahal, Kathmandu.* Available at: https://www.forestcarbonpartnership.org/system/files/documents/Annex%201-%20Demand%20and%20Supply%20of%20Wood%20Products.pdf

Khanal, K.P. 2002. Under Utilization in Community Forest Management: A Case Study From Lalitpur District. *Banko Janakari,* **12**(2): 26-32.

Magrath, William B., Shrestha, A., Subedi, Bhishma., Dulal, HD. and Baumback, Rex. 2013. Nepal Forest Sector Survey: Policy priorities and recommendations. Washington, DC: Program on Forests (PROFOR). https://www.profor.info/knowledge/nepal-forest-sector-survey

MoF. 2022. Economic Survey 2021/22. Annex 7.17: Status of Forest Product Collection, pp.108. Available at: https://www.mof.gov.np/uploads/document/file/1674635120_Economic_Survey_2022.pdf

MoFE. 2022. Annual Progress Report for Year B.S. 2078/79. Ministry of Forest and Environment, Singhdarbar, Nepal. Available at: https://mofe.gov.np/uploads/documents/annual-report-078-79pdf-7076-384-1684837725.pdf

MSFP. 2016. Sustainable Forest Management in Nepal. An MSFP working paper, MSFP, pp.14.

NNRFC. 2022. A Souvenir Published on the Auspicious Occasion of the Annual Function. National Natural Resource and Fiscal Commission, Kathmandu, Nepal, pp. 222-229.

NSO. 2022. National Industrial Survey 2019/20. Provincial Report: Province No. 1. CBS, Kathmandu, Nepal. Available at: https://api.giwms.gov.np/storage/36/posts/1694917586_46.pdf

Poudyal, B.H., Khatri, D.B., Paudel, D., Marquardt, K. and Khatri, S. 2023. Examining Forest Transition and Collective Action in Nepal's Community Forestry. *Land Use Policy,* **134**: 106872. ISSN 0264-8377. Available at: https://doi.org/10.1016/j.landusepol.2023.106872.

TKP. 2024. Nepal's informal economy. Published in The Kathmandu Post, January 27th, 2024. https://kathmandupost.com/money/2024/01/26/nepal-s-informal-economy-is-38-6-per cent-of-gdp

World Bank. 2019. Nepal Environment Sector Diagnostic: Path to Sustainable Growth Under Federalism (A Country Environmental Analysis). Washington, D.C. Available at: https://documents1.worldbank.org/curated/es/141591574193407696/pdf/Nepal-Environment-Sector-Diagnostic-Path-to-Sustainable-Growth-under-Federalism.pdf