Assessment of the Potential Impacts of Biobased Construction on Forests of Bhutan

October 2023

Climate Smart Forest Economy Program
Unlocking Forests' Potential

Published by:

The Climate Smart Forest Economy Program,

https://www.csfep.org

Commissioned by:

The Climate Smart Forest Economy Program, represented by Dalberg Catalyst

https://www.csfep.org

Focal Contact:

Robyn van den Heuvel, Dalberg Catalyst
robyn.vandenheuvel@dalberg.com

Cover Photo: *Paro Taktsang Monastery, © Norbu Wangdi*

Suggested Citation:

Wangdi, N.; & Norbu, N.,2023. Assessment of potential impacts of biobased construction on Forests of Bhutan. Climate Smart Forest Economy Program.

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1.Introduction

1.1 Background

The Kingdom of Bhutan, under the leadership of His Majesty King Jigme Khesar Namgyel Wangchuck, is undertaking a transformation of Bhutan's urban construction sector. The Thimphu-Paro urban landscape has witnessed rapid expansion in the last few decades and increasing demands for housing and infrastructure continues to place significant pressure on natural ecosystems and sites of cultural import.

However, despite rapid growth, the construction sector has witnessed little innovation in terms of energy efficiency, building design and adoption of sustainable practices. Current reliance on extractive and mineral-based materials entails significant financial and ecological costs. Globally, buildings generate close to 40% of global carbon emissions annually, of which materials and construction account for 13%[1]. On the current trajectory, Bhutanese urban buildings will continue to entail significant construction costs, and risk becoming ecological and economic liabilities in the longer run.

There is global recognition for the need to transition to a sustainable built environment, both from an operation and a construction end. The use of wood and biobased construction materials, mass timber in particular, is gaining increasing favor as a material of choice, and is being viewed as an option to reduce construction related GHG emissions.[2]

Bhutan continues to nurture about 70% of its land area under forest cover and Bhutan's constitution mandates the maintenance of a minimum of 60% of its land mass under forest cover for all times. Sustained forest cover allows Bhutan to be one of the carbon negative countries in the world today and serves as a linchpin for the administration of principles related to Bhutan's famed development philosophy of Gross National Happiness (GNH). In keeping with GNH tenets, Bhutan's forest management practices are guided by principles of sustainability and spelt out in the Forest Management Code of Bhutan. There was a growing

[1] United Nations Environment Programme (2022). Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

[2] Himes, A., & Busby, G. (2020). Wood buildings as a climate solution. *Developments in the Built Environment*, *4*, 100030.

recognition that sustainable and judicious use of forests – regenerative forestry – will be key to building a robust economy and helping Bhutan remain carbon neutral.

In May 2022, Bhutan's erstwhile Ministry of Works and Human Settlement (MoWHS)[3]convened a working group composed of representatives from the government and visiting experts from forestry, industry, city planning, engineering, and architecture. The working group was mandated to assess the building sector and develop an implementation strategy to remap building supply chains and reshape construction practices. In particular, the assessment was to consider the use and deployment of mass timber material systems and techniques, and gauge potential environmental benefits that might accrue from their adoption. In addition to mass timber, the potential development of other bio-based construction materials and products and, more broadly, a domestic circular construction economy, were also to be considered.

The result of the two-and-a-half week series of presentations, workshops, and study trips, was an interdisciplinary, system-wide analysis with topics ranging from the makeup and condition of forest sources; through silvicultural methods and practices; material processing and product manufacturing; construction delivery and building regulation; and ultimately to the healthy inhabitation and sustainable operation of high performance urban building in Thimphu and urbanized settlements throughout Bhutan.

Given the positive potential for adoption and deployment of mass timber coupled with opportunities to develop bio-based economies, it is important to further understand the implication of such a move on Bhutan's forests.

1.2 Purpose and Objectives of the Study

The study will address the following key questions:

1. What is the current state of Bhutan's forests, and what are their existing risks and challenges?

2. How might an increased demand for biobased construction in Bhutan impact the state of its forests?

[3] Renamed as the Ministry of Infrastructure and Transport

3. What potential scenarios can be envisaged for the impact, and what underlying assumptions or principles guide these scenarios?

4. How might the increased demand for biobased construction holistically impact Bhutan's forests, considering environmental, ecological, and societal factors, following a safeguarding approach?

5. What key principles and recommendations should policymakers consider when formulating new regulations pertaining to biobased construction?

2 Methodology

A mixed-methods approach, combining qualitative and quantitative techniques,was employed to provide a comprehensive understanding of the potential impacts of biobased construction on Bhutan's forests.

The following approaches were administered:

- **Literature Review**: An extensive review of existing literature on Bhutan's forest status, forest conditions, management practices, biobased construction, and sustainable development was carried out and summarized.
- **Expert Consultations**: A consultative meeting for biobased construction was organized with experts from Forestry, construction, sustainability, on 22nd September 2023 in Thimphu to gather insights and recommendations. A total of 7 experts attended the meeting (List attached in Annexure I).
- **SWOT Analysis & Scenario Analysis:** During the consultative meeting a detailed SWOT analysis for Biobased construction in Bhutan was conducted. Potential scenarios for the impact of increased bio-based construction demand on Bhutan's forests, considering factors such as resource availability, technological advancements, and market trends was also carried out.
- **Safeguarding Approach**: During the consultative meeting on 22nd September 2023, comprehensive evaluation of the holistic impact of biobased construction on Bhutan's forests, considering ecological, environmental, and societal dimensions, employing a safeguarding approach to identify potential risks and benefits was also carried out. Plausible recommendations for mitigation risks and safeguards were also identified and discussed.

3. Findings

3.1 Bhutan's Forests: Current State, Risks, and Challenges

Current State of Forests

Bhutan is known for its rich forest cover, which plays a crucial role in maintaining biodiversity, regulating climate, and providing ecosystem services to its population. Bhutan has also committed to maintaining a minimum of 60% forest cover as part of its conservation effort for all times to come[4]. As of 2022, a forest cover of 69.71(2.68 million ha) is estimated of the total land area while 30.29 % (1.16 million ha) of the total land area is estimated to be non-Forest area. The forest cover decreased to 69.71 % in 2022 from 71% in 2016[5].

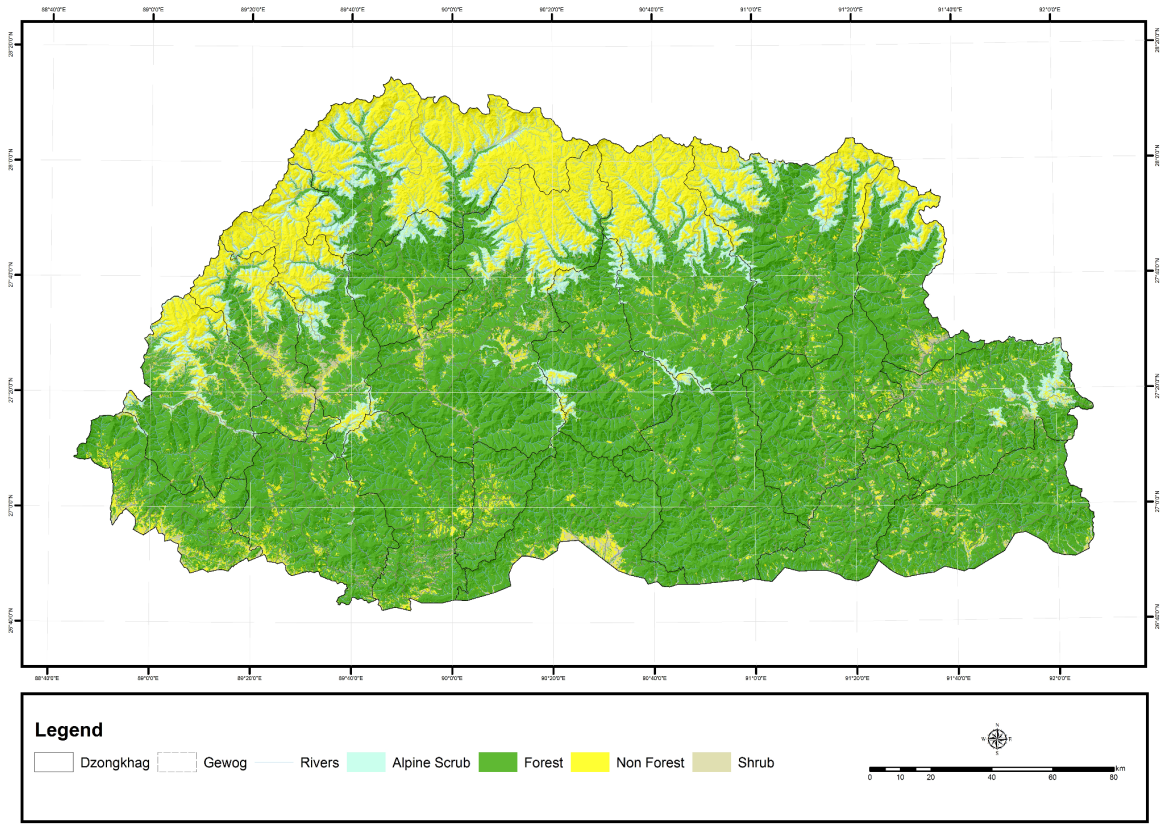

Figure 1:National Forest Cover Map of Bhutan (Source: DoFPS, State of Forest Report,2023)

[4] The Constitution of the Kingdom of Bhutan,2008.

[5] National Forest Inventory Volume I: State of Forest Report. Department of Forests and Park Services. Ministry of Energy and Natural Resources. Thimphu, Bhutan, 2023.

Bhutan has diverse climatic conditions which are classified into three climatic zones — 1) the southern Subtropical foothills with high humidity and heavy rainfall; 2) the central temperate valleys characterized by cool winters and hot summers with moderate rainfall; and 3) the high Alpine mountains with cold winters and cool summers.

Within these zones, there are ten forest types,namely subtropical forests, warm broadleaved forests, Chirpine forests, cool broadleaved forests, evergreen Oak forests, Blue Pine forests, spruce forests, hemlock forests, fir forests, and Juniper-Rhododendron scrubs.

Broadleaved Forest constitutes 67.99 % (1,819,649.63 ha) of the total forests while Coniferous Forest constitutes 32.01 % (856,895.79 ha) of the forest area (DoFPS, 2023). Cool Broadleaved Forest dominates the Forests in Bhutan accounting for 28.18 % of the total forest.

Cool Broad-leaved Forest and Warm Broad-leaved Forest together account for 53.16 % of the total Forest area in Bhutan. Evergreen Oak Forest and Spruce Forest have the smallest area coverage constituting 1.52 % and 1.58 % of the total Forest respectively.

Table 1: Forest Type and Cover of Bhutan (DoFPS, 2023)

Forest Type	**Area (ha)**	**Cover %**
Subtropical Forest	356,115.97	13.31
Chir Pine Forest	78,403.59	2.93
Warm Broadleaved Forest	668,674.38	24.98
Evergreen Oak Forest	40,653.71	1.52
Cool Broadleaved Forest	754,205.57	28.18
Blue Pine Forest	10,348,218	3.87
Spruce Forest	42,237.62	1.58
Hemlock Forest	130,408.66	4.87
Fir Forest	432,671.66	16.17
Juniper Rhododendron Forest	69,692.08	2.6

Total Growing Stock

The standing volume of trees has reached 759 million m3, marking a decline of 20% since the previous National Forest Inventory in 2015(DoFPs, 2023). Among this figure, Coniferous Forests contribute to only 32%, while the remaining portion constitutes Broadleaved Forests. Interestingly, the populace tends to favor conifer species over broadleaved ones for timber,

underscoring the need to reevaluate and explore the management and utilization of specific tree species.

The proportion of smaller trees has also increased, with over 72% of estimated trees having a Diameter at Breast Height (DBH) below 30 cm. A total of 1,008 million trees alongside 523 million saplings are estimated. The tree count has increased by 26% since 2015. Each hectare of forest holds a volume estimation of 283.65 m3, accompanied by an average carbon density of 195 tonnes per hectare.

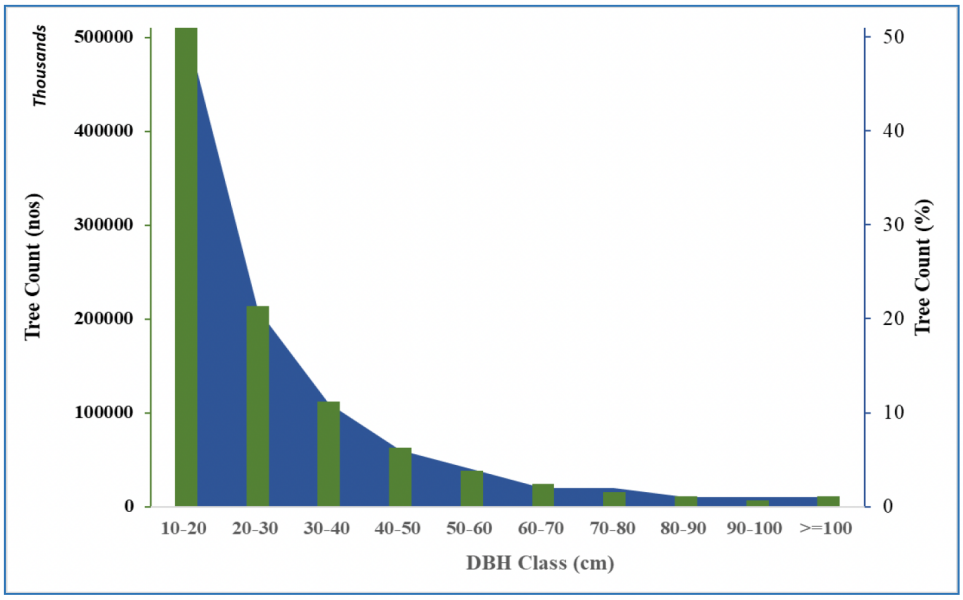

Figure 2:Comparison of tree count and proportion of total trees in different DBH class (DoFPS, 2023)

Carbon Sequestration Capacity

The carbon sequestration capacity of Bhutan's forest has increased from 9.6 million tonnes of CO_2 in 2015 to 11 million tonnes, according to the State of Forest Carbon (SoFC) Report[6]. The forest ecosystem in Bhutan stores approximately 523 million tonnes of carbon out of the total carbon stock of 609 million tonnes. This increase in carbon sequestration capacity has occurred despite the reduction in forest cover and carbon content, due to accelerated rate of Basal Area Increment.

The total Basal Area Increment for the entire forest over the last five years is 1.22 million m^2, equivalent to a periodic annual basal area increment of 0.46 m^2 per hectare per year, leading to a biomass increment of 2.43 tonnes per hectare per year (DoFPS,2023).

[6] National Forest Inventory Volume II: State of Forest Carbon Report.Forest Monitoring and Information Division,Department of Forests and Park Services, Thimphu, Bhutan,2023.

Existing Risks and Challenges:

Deforestation and Degradation:
Almost all forest areas in Bhutan are held under public administration, with more than 50 % of the area designated as protected areas and the remainder as "state reserve forest" which includes other forest management regimes such as " forest management units", "community forests", and local forests"[7]. With the rapid pace of socio-economic development, there is pressure on State Reserve Forest land to be converted for infrastructure development in the form of "right of cleared way" for power transmission lines and road construction.
Forest degradation is also a serious concern – as the forest is thinned through, livestock grazing beyond the pasture lands, and illegal logging or over-extraction of timber and firewood, habitats are destroyed, exposed slopes become vulnerable to landslides and erosion, and the degraded forest becomes more vulnerable to fire (NEC, 2020). Bhutan's per capita fuel wood consumption is one of the highest in the world since it remains the dominant source of energy for cooking and heating in rural areas. The demand for timber for construction is also growing to supply construction activities for urban centers, industrial areas, hydropower plants, and public infrastructure. Much of these needs are illegally supplied from forests outside of the designated Forest Management Units (FMUs). Many FMUs lack well formulated resource management plans, and some do not fulfill their harvesting potential (NEC,2020).
Agricultural expansion, infrastructure development, and urbanization can put pressure on forested areas. In 2022 ,793 forestry clearances were issued for various purposes, covering a total of 3,608.527 hectares. In addition, 2,276 forestry clearances were issued for Removal of forest produce from private land covering 2,066.06 hectare (DoFPS, 2022).

[7] Sears, et. al (2017). Forest ecosystem services and the pillars of Bhutan's Gross National Happiness.CIFOR Occasional Paper.

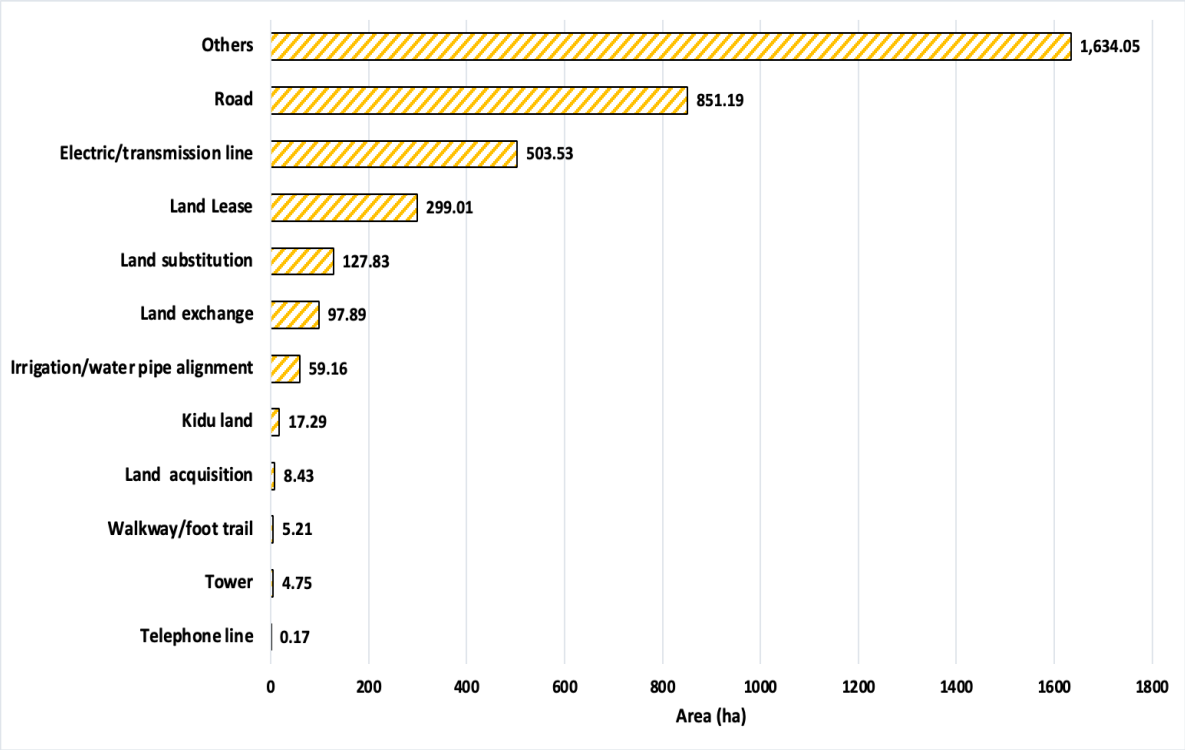

Figure 3:Forest Clearance issued for various purposes in 2022(Source: DoFPS, 2022)

Figure 3:

Illegal Logging:

Illegal logging posed a significant risk to Bhutan's forests. It threatens not only the health of the forests but also the livelihoods of local communities dependent on forest resources. A total of 1284 offences related to forest resources were recorded in 2022 and offences related to illegal logging were the highest in 2022 (Table 2). Forest offence cases peaked in 2020 with 1917 cases apprehended while it was lowest in the year 2017 with 1150 cases (Fig.4).

Table 2: Forest Offences recorded in 2022(DoFPS, 2022)

Sl. No	Offence Type	Number
1	Aquatic	215
2	Forest fires	11
3	Illegal timber	705
4	Land related	43
5	NWFP Collection	244

6	Timber misuse	43
7	Wildlife Poaching	25
	Total	**1284**

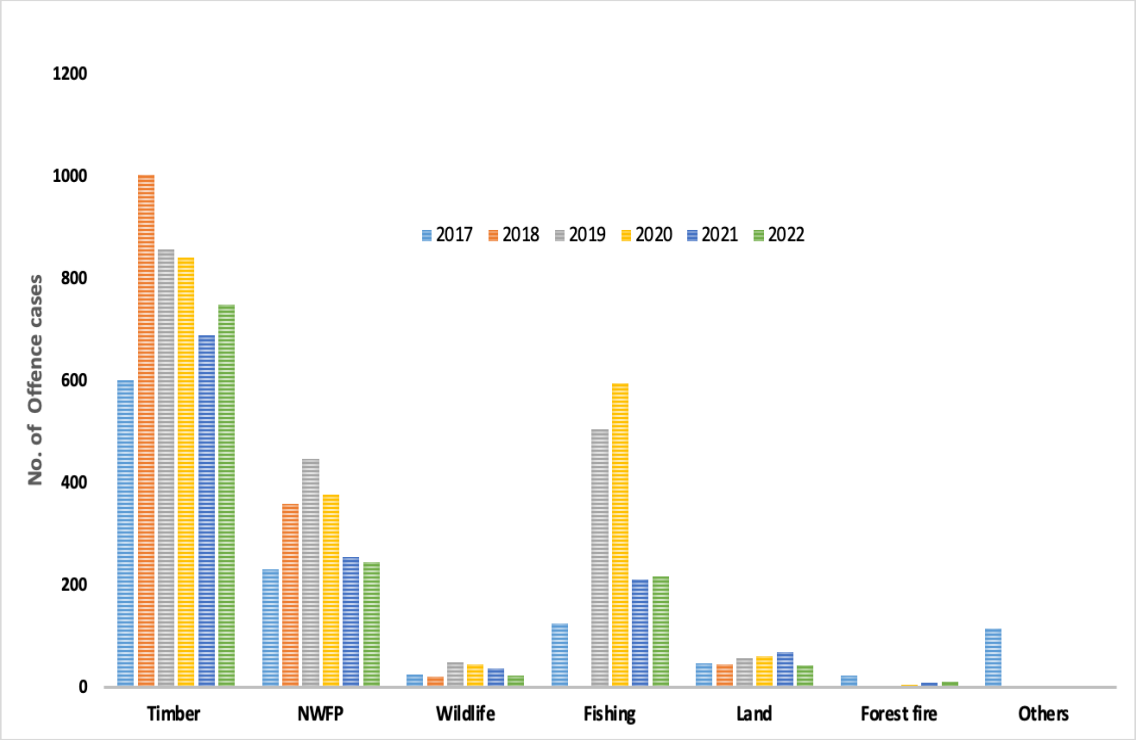

Figure 4:Trend of Forest Offences from 2017-2022 (Data Source: DoFPS)

Climate Change:

Mountain environments, in particular the Hindukush Himalayas, are highly vulnerable to the impacts of global warming due to the combined factors of high sensitivity to climate change and limited possibilities for species migration to favourable locations which renders mountains as "islands" in a "sea" of surrounding lower-lying ecosystems (Shrestha et al. 2012). Climate change has synergistic effects with many of the other primary threats or constraints to biodiversity. With increased temperature and reduced precipitation, alpine meadows and shrubs may migrate to places higher up the mountains (Wester et al.,2019). Grabherr et al. (1994) estimated that a 0.5 °C rise in temperature per 100 m elevation could lead to a theoretical shift in altitudinal vegetation belts of 8–10 m per decade (Grabherr et al. 1994). In the eastern Himalaya, this altitudinal shift is expected to be around 20–80 m per decade (based on current estimates of temperature increases of around 0.01–0.04 °C per

year) with greater shifts at higher altitudes, as the rate of warming is expected to increase with altitude (ICIMOD 2009).
Climate change impacts, including changing precipitation patterns and the increased risk of forest fires, species range shifts, could affect Bhutan's forests. Climate change poses great risk to forests and biodiversity, through potential changes in habitats and ecosystem functions. The increasing risks of forest fires due to drier and warmer winters not only threatens biodiversity but could also jeopardize Bhutan's carbon sinks (DECC,2023).

Forest Fires

Forest fires in Bhutan persistently cause significant damage to wildlife and biodiversity. On an annual basis, there is an average of approximately 57 fire incidents (UNDP,2021) (as depicted in Fig.5), causing an annual scarring of around 200 hectares. It is important to note that these forest fires do not occur uniformly throughout the country, with specific Dzongkhags, namely Thimphu, Wangdue Phodrang, Punakha, Mongar, Lhuentse, and Trashigang, experiencing a higher frequency of fires (as shown in Figure 6).

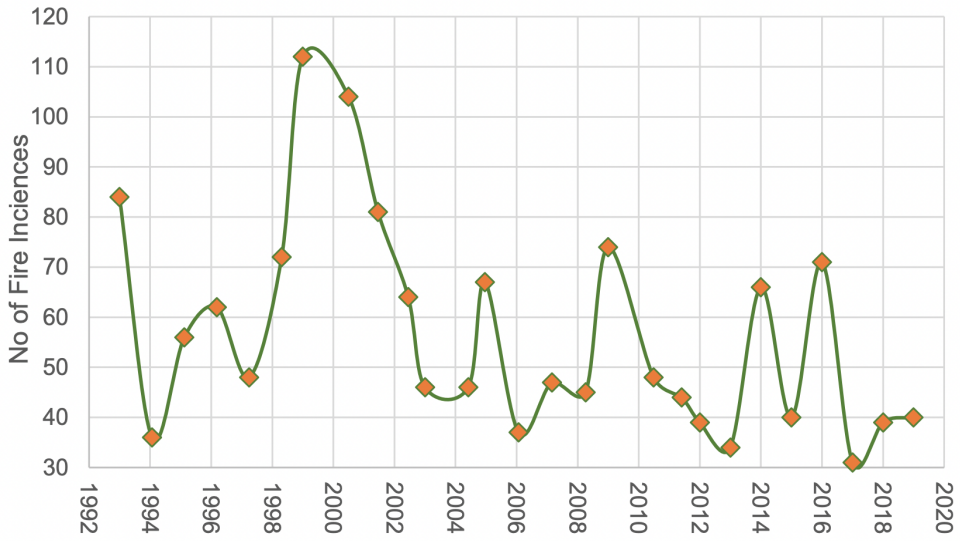

Figure 5:Number of fire incidences from 1992 till 2019(Data Source:DoFPS)

A total of 52 forest fires occurred in 2022, damaging an area of 5,171.87 hectares (DoFPS, 2022). Records maintained by the Department of Forests and Park Services (DoFPS) indicate the following to be the main cause of forest fires in Bhutan:

- Agriculture debris burning
- Children playing with ignition source (such as matchsticks)
- Lemon grass harvesters
- Smokers
- Cattle herders for new grass

- Roadside workers
- Picnickers
- Campfires
- Electric short circuits

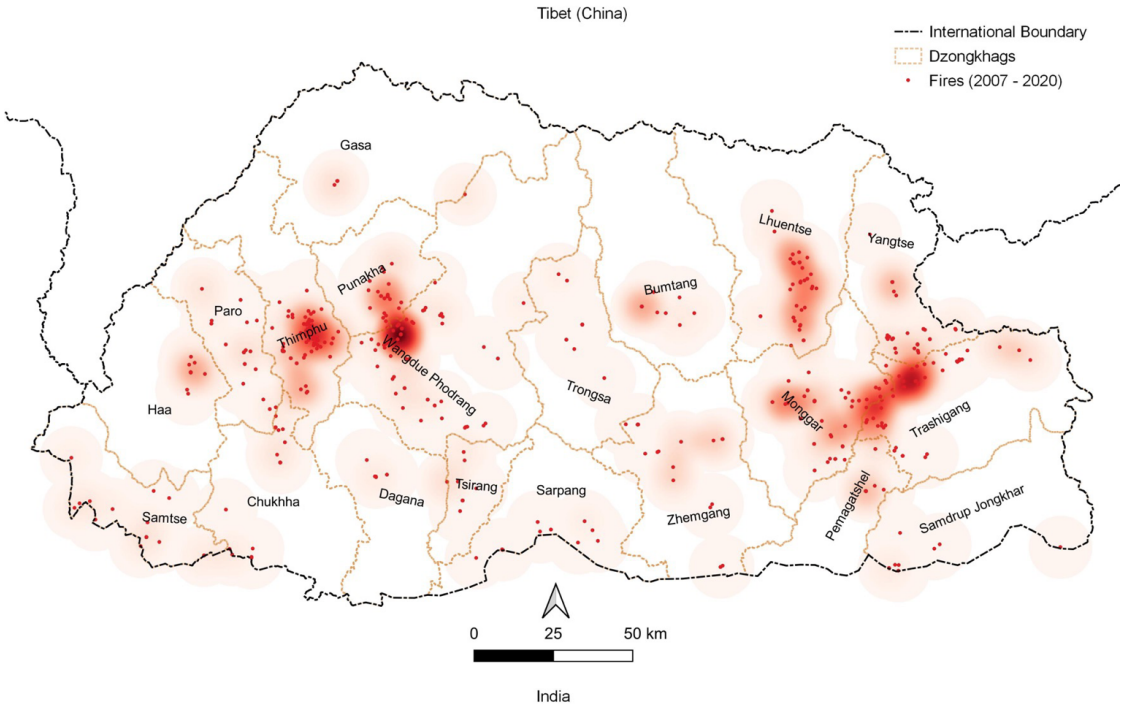

Figure 6:Spatial Distribution of Forests Fires (2007- 2020) (Source:UNDP, 2021)

As per report on assessing climate risks on forests and biodiversity for National Adaptation Plan (NAP) formulation process in Bhutan published by UNDP (2021), in the short-term, the risk of forest fire is most at the mid-altitudes in the temperate montane forests. The risk extends to the subtropical vegetation zone in the mid to long-term. Under RCP[8] 4.5[9], in the next 30 years, in the temperate zone, an estimated 626 km^2 of blue pine, 921 km^2 of chir pine and 879 km^2 of mixed conifer forests will be at high risk(Fig.7).

[8] *A Representative Concentration Pathway (RCP) is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC.*

[9] *RCP 4.5 is described by the IPCC as an intermediate scenario. Emissions in RCP 4.5 peak around 2040, then decline.*

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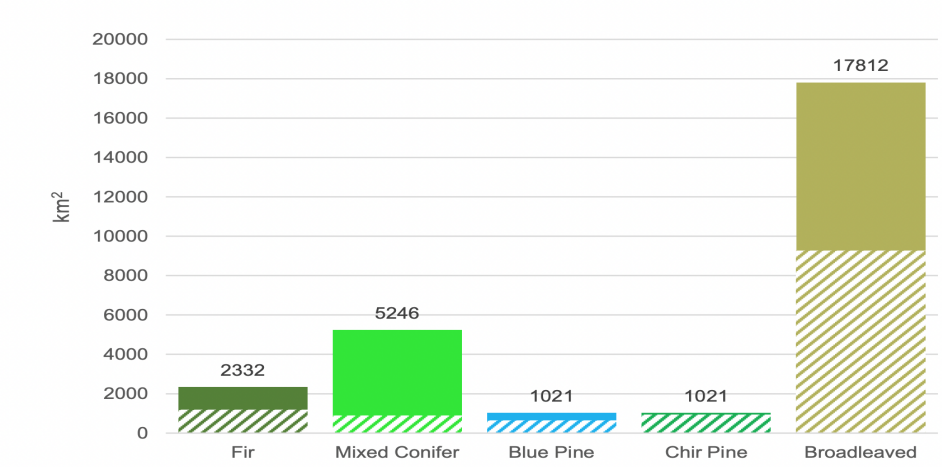

Figure 7:Forest types, area coverage and portion under risk (shaded) in each forest type from now till 2050 (UNDP, 2021)

Risks to broadleaved forests at lower elevations (<2000) are projected to increase from now to 2050 with over 9000 km2 of broadleaved forests at high fire risk under both RCP 4.5 and RCP 8.5.[10] These temperate and broadleaved forests mostly occur along mid and interior valleys and remain vital as sources for timber and other forestry resources. These forests are also home to a significant portion of the eastern Himalayas' rich biodiversity.

Concurrently, since settlements within these valleys are located close to forest areas, forest fires pose increased threat to people and property. Both flame length and the rate of fire spread are expected to increase in all forest types (except for fir) under both RCP 4.5 and RCP 8.5, and for all time slices. This means that forest fires will be more intense with

[10] In RCP 8.5 emissions continue to rise throughout the 21st century.RCP8.5, generally taken as the basis for worst-case climate change scenarios, was based on what proved to be overestimation of projected coal outputs. It is still used for predicting mid-century (and earlier) emissions based on current and stated policies

increasing possibility of more crown fires. Coupled with a faster rate of spread, the possibility of larger fires burning over longer periods is an imminent possibility (UNDP, 2021).
Assuming the continuation of the previous trend of forest fires, by 2030, about 93,800 Ha of forest area are predicted to be damaged by fires across the country (DoFPS, 2017).

Invasive Species:

Invasive Alien species (IAS) can threaten the native flora and fauna of Bhutan's forests. Managing and controlling invasive species is an ongoing challenge. Invasive species (plants, animals, and insects) pose a threat. Global Invasive Species database records 46 Invasive Species from Bhutan out of which 11 are alien[11]. However, there has been no systematic and comprehensive inventory of Invasive Alien Species (IAS) in Bhutan, apart from a few scattered studies. A pilot inventory carried out by the National Biodiversity Centre recorded more than 40 invasive plant species, out of which eight were categorized as major invasive plant species(NBC,2014).The invasive plant species *Parthenuim sp*., *Lantana camara* and *Eupatorium sp*. and climbers like *Michenia sp*. cause real problems in Bhutanese forests. In plantations these species cause heavy damage to the favoured plant species by suppressing their growth. Frequent weeding and removal of these species is required which entails heavy expenditure for the Government.
In Bhutan, although information on the impacts of these species is lacking, most have been reported to reduce crop productivity, and some of them have been described as encroaching the forest understory, particularly, *Ageratina adenophora, Chromolaena odorata, and Michenia micrantha (Pallewatta et al,2003).*

Pests & Diseases

Bark beetles (Coleoptera: Scolytidae) are some of the most destructive pests impacting conifer forests globally. In Bhutan, the Eastern Himalayan spruce bark beetle, known as *Ips schmutzenhoferi*, poses a significant threat to conifer forests situated at elevations ranging from 2500 to 3800 masl(Holzschuh 1988, Schmutzenhofer 1988) . This scolytid primarily targets healthy trees or infests freshly felled logs of Eastern Himalayan spruce, Himalayan blue pine, and occasionally Himalayan larch (*Larix griffithiana*). During the 1980s, *I. schmutzenhoferi* triggered a devastating outbreak in Western and Central Bhutan, leading to the infestation of over 2060 hectares of forest (Chhetri, 1991) and causing a staggering loss of approximately 2 million cubic meters of timber (Schmutzenhofer, 1988).
Bhutan's Forests are still being devastated by the bark beetle despite management efforts by the Department of Forests and Park Services.

[11] *Source: Global Invasive Species database, http://www.issg.org/database/species*

Further, the threats of climate change in the Himalayas are more pronounced as the rate of warming in the Himalayan region is much greater than the global average (IPCC, 2023, Wester et. al,2019).These changes are expected to alter the frequency, intensity and timing of drought events, forest diseases and bark beetle outbreaks which may make forest ecosystems more vulnerable against aggressive forest pests like the spruce bark beetle species *I. schmutzenhoferi*. Under such circumstances, it is more likely that bark beetle outbreak incidence could increase in the future *(Tshering & Tshering,2018)*.

Bark beetles are indeed well-known vectors of various blue-stain fungi, which belong to the ascomycete genera Ceratocystis and Ophiostoma *(Wingfield et al. 1993, Kirisits 2004)*. These fungi are responsible for causing blue, grey, or black discoloration in the sapwood of living trees, logs, and lumber, primarily in coniferous trees.

Another concern in conifer species is the mistletoe infestation. Mistletoes are parasitic plants that attach themselves to tree branches and draw nutrients from the host tree. This can weaken the tree and make it more susceptible to various stresses, including bark beetle infestations. Combining mistletoe infestations with bark beetle attacks and blue-stain fungi colonization can lead to a significant decline in tree health and vitality, ultimately affecting the overall health of the forest ecosystem and the quality of timber resources *(Tshering & Tshering,2018).* In the southern regions, the most common type of pest is the sal borer which affects Sal trees. Other diseases such as chirpine dieback and bluepine dieback are also common.

Records maintained with the Department of Forests and Park Services for the past 6 years (2017-2022) show that 1,33,771.99 m^3 of standing timber volume was affected by various pests and diseases such as barkbettle infestation, sal borer, chipine dieback and bluepine dieback. A total of 98,218.29 m^3 of standing timber volume, mostly of spruce species, was damaged by bark beetle infestation in the past six years (Fig. 8).

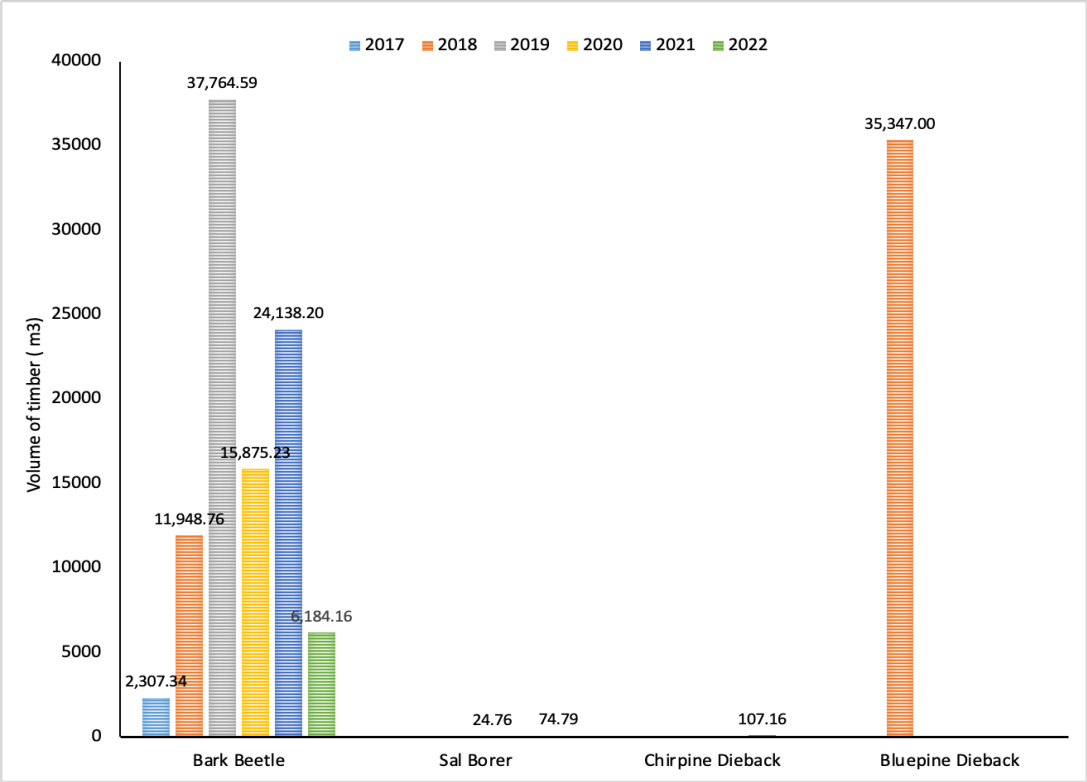

Figure 8:Volume of standing timber (m3) affected by pests and diseases (2017-2022) (Data Source: DoFPS)

Figure 9:A spruce forest infested by Bark beetles in Lonchhu Forest Management Unit, Haa (Changa Tshering, 2019)

Human-Wildlife Conflict:

Bhutan's forests are home to various wildlife species, and conflicts between humans and wildlife, such as crop damage by animals like elephants, are a concern.The issue of Human-Wildlife Conflict (HWC) is becoming increasingly worrisome ,where over half of its total land area is designated as protected area, and roughly two-thirds of the population relies on agriculture and livestock farming for their livelihoods. This conflict leads to significant challenges, particularly in the form of wildlife causing harm to both livestock and crops, posing substantial threats to people's means of living and the local biodiversity (NBSAP, 2014).

Given that human-wildlife conflict imposes significant economic and social burdens on rural populations, it results in retaliatory killings, frustration with existing policies, and a lack of support for conservation efforts. For example, a few decades ago, retaliatory killings involving the poisoning of dholes nearly wiped out this species in the wild (WCD, 2013).

In 2022, a total of 155 incidents related to Human Wildlife conflicts were reported (DoFPS,2022).

Data and Monitoring:
Ensuring precise data collection and robust monitoring systems is vital for an accurate assessment of Bhutan's forest conditions and for addressing emerging challenges. However, enhancing these systems poses a significant challenge.

Human Resources & Technical Capacity
One of the foremost challenges Bhutan encounters in its management of forestry is the deficiency in human resources and professional expertise. As of the year 2022, the Department of Forests and Park Services (DoFPS) has a workforce of 1568 officials, comprising 1280 technical staff and 288 non-technical staff (DoFP, 2022). This leads to under-staffing in some areas, resulting in decreased oversight and management. Given that nearly 70% of Bhutan's land area is covered by forests, the efficient oversight and monitoring of all forestry and conservation activities have consistently posed a formidable challenge. Moreover, the constraints of limited financial resources and insufficient provision of field equipment compound the impediments to effective management.

3.2 Strengths, Weakness, Opportunities and Threats Analysis of Bio-Based Construction in Bhutan (SWOT Analysis)

SWOT analysis is one of the most popular strategic analysis models. It involves looking at the strengths and weaknesses of your business capabilities, and any opportunities and threats to your business[12].
Once you identify these, you can assess how to:

- capitalise on your strengths
- minimise the effects of your weaknesses
- make the most of any opportunities
- reduce the impact of any threats

[12] https://www.nibusinessinfo.co.uk/content/swot-pestle-and-other-models-strategic-analysis

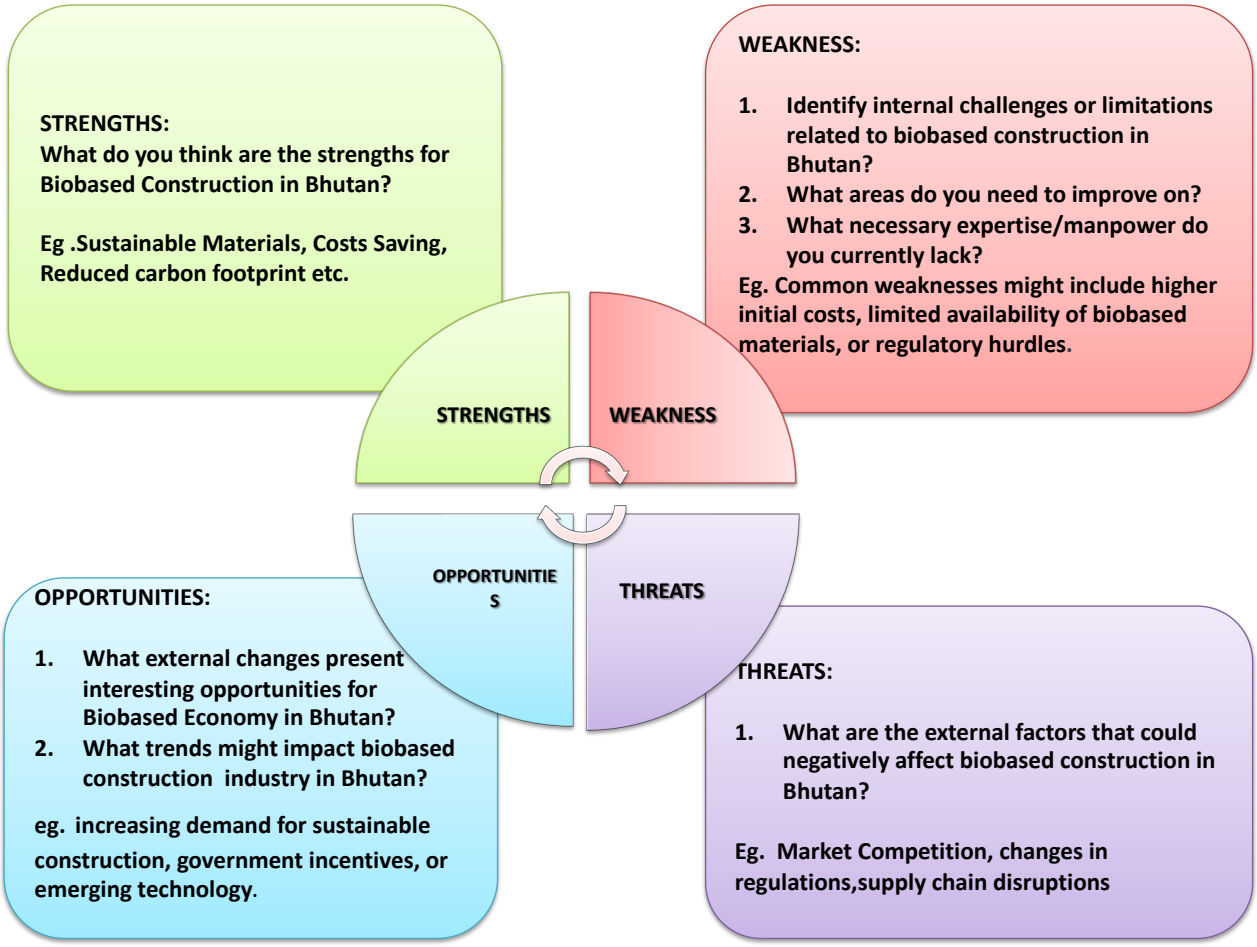

Figure 10: Framework for SWOT Analysis

Based on the stakeholder consultative meeting with the national experts the following strengths, weaknesses, opportunities, and threats for Biobased construction were identified using the framework (Fig.11).

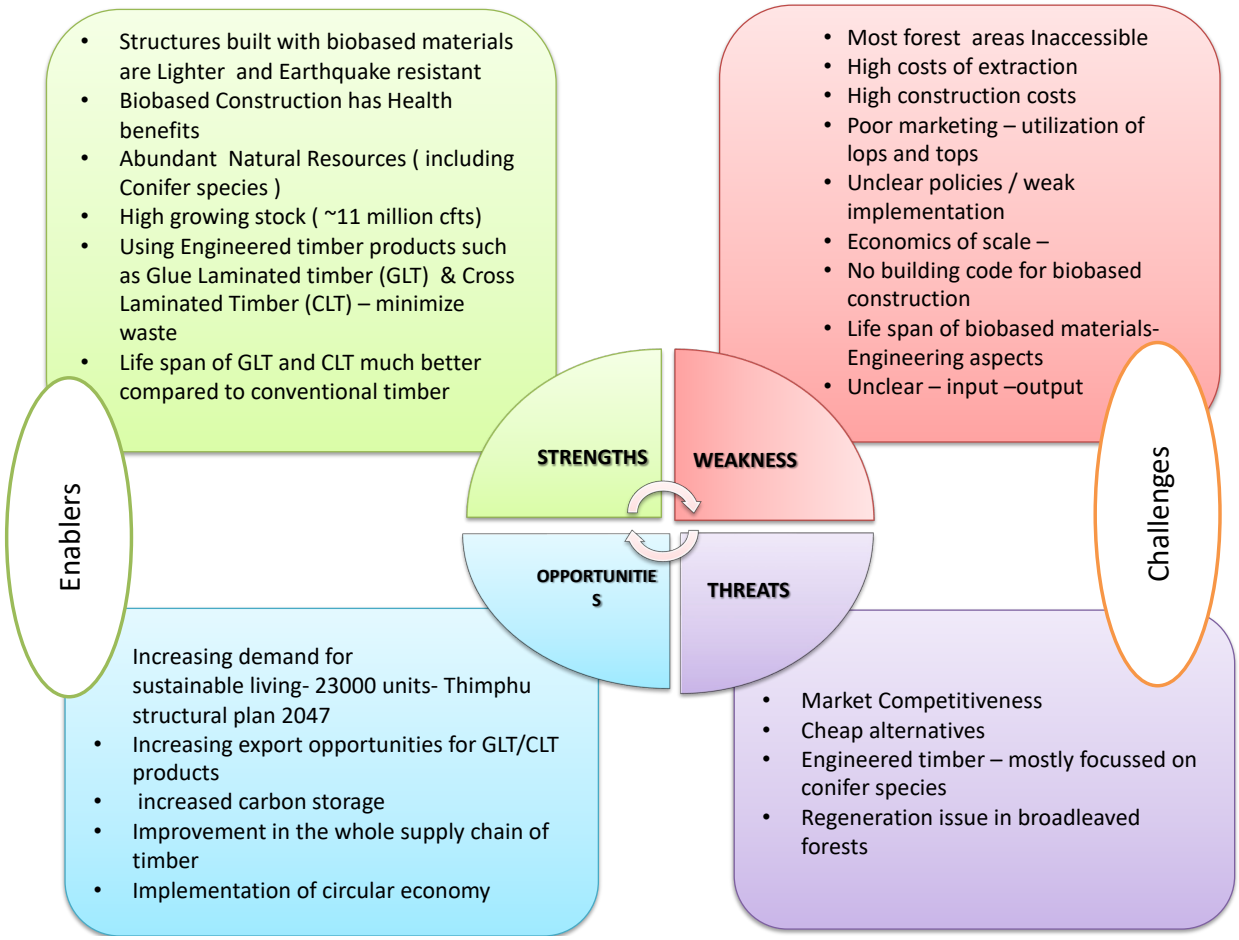

Figure 11: SWOT Analysis for Biobased construction economy in Bhutan

3.3 Scenarios Analysis: Impacts of biobased economy

Scenario Analysis is a comprehensive, systematic, and strategic planning tool that assists decision-makers in understanding the potential consequences of various future events or situations[13]. This involves the creation of multiple plausible scenarios based on key variables, uncertainties, and trends. By analyzing these different scenarios, stakeholders can gain insights into potential risks, opportunities, and implications, thereby enabling them to make more informed decisions.

For the scenario analysis for biobased economy and its impacts to Bhutan's forests, the following guiding questions and considerations were taken:

[13] https://www.financestrategists.com/wealth-management/fundamental-vs-technical-analysis/scenario-analysis/

- What will happen to our forests?
- What will be the consequences?
- What are the pathways, risks, and safeguards?

Considerations:

- policies, capacities, institutions
- Global, regional, local trajectories
- Physical limits
- Emerging risks | disease, pathogens, fire,

We then used the scenario analysis framework (Fig.12 & Fig.13) to analyze the plausible impacts of the biobased economy on forests in Bhutan; the possible states are described based on the Forest and Ecological conditions and economy and jobs.

A positive state (+ve) ; when the forest ecosystems are great and the economy is robust and there are abundant jobs. A neutral state when nothing changes and a Negative State (-ve), when the health of forest ecosystems deteriorates, there are no economic opportunities and no jobs (Fig.12).

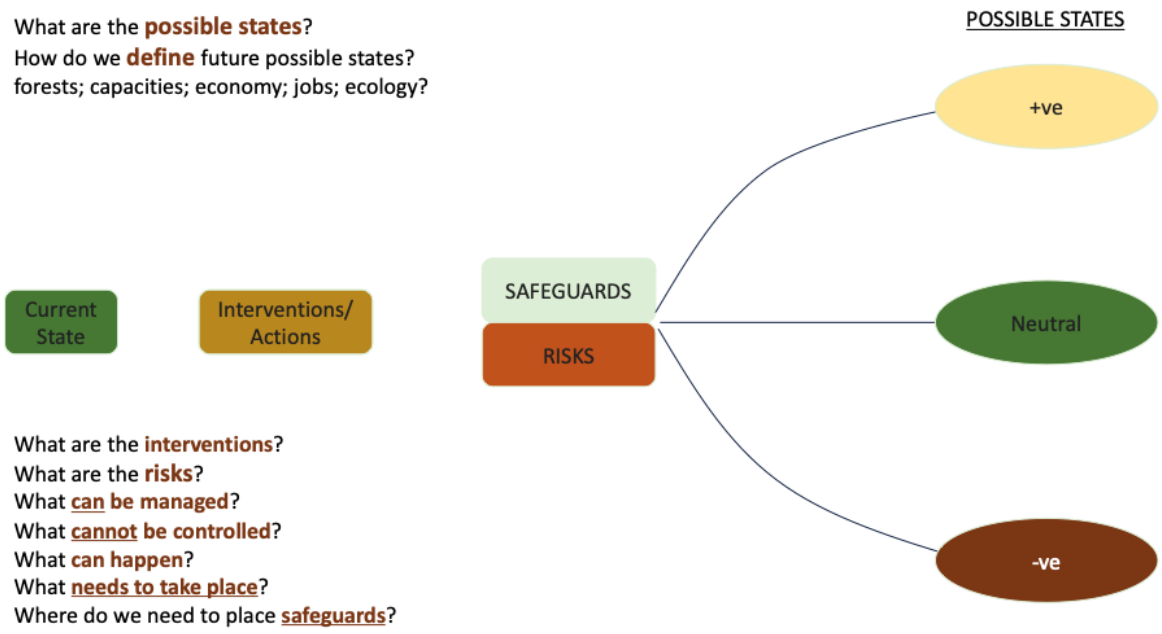

Figure 12:Framework for Scenario Analysis

A safeguarding approach was also employed to analyze the holistic impact of increased bio based construction on forests, which examines environmental, ecological, and societal dimensions in assessing impacts.

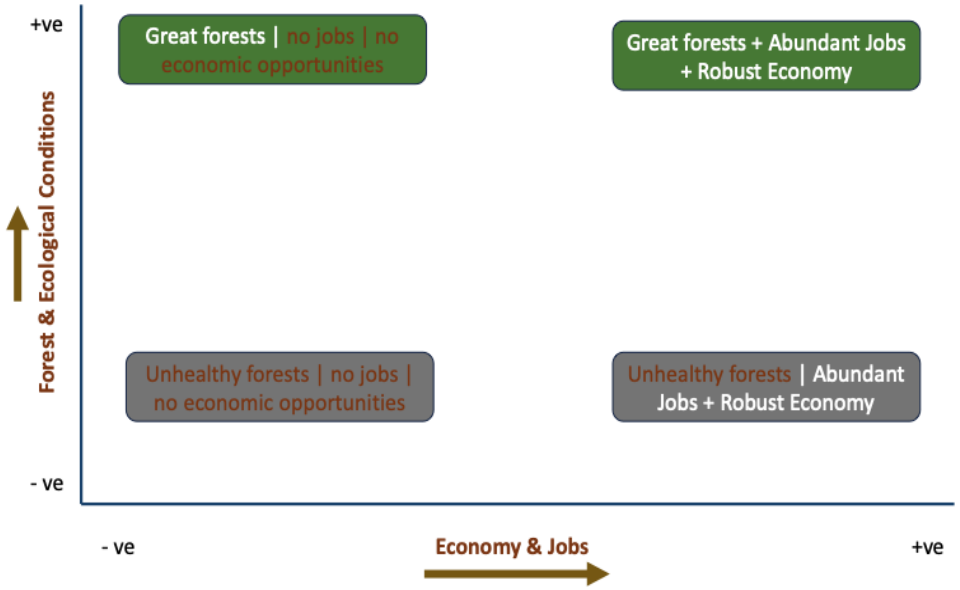

Figure 13:Scenario Analysis: Possible states and impacts on Forests and Economy

From the analysis during the stakeholder meeting, the following scenarios and possible impacts, risks and safeguards were identified:

Positive Scenario:

- Good forests
- Increased carbon sequestration- net removal
- Increased economic opportunities.
- Vibrant forest-based industries-jobs with dignity
- Regenerative buildings and cities
- Enhanced wood-based technologies
- Increased import substitution
- Opportunities for export
- Fast and clean construction
- Increased access to biobased materials
- Enhanced institutional capacities.
- Impacts on biodiversity

Negative Scenario

- Degraded forests
- Reduced carbon pool
- Fire prone
- Reduced Forest cover
- Loss of donor confidence-Brand Bhutan
- Increased natural calamities.
- Change in microclimate.
- Impacts on water recharge functions
- Loss Soil fertility/Land degradation, increased soil erosion
- Increased climate risks
- Disturbed ecological integrity
- Loss of jobs
- Loss of export opportunities
- Loss of trade balance

Key Risks:

- Increased risks from Climate-Related Hazards such as Forest Fires and Diseases
- Long gestation period for Conifer Species
- Absence of Adequate Regeneration
- Heightened Vulnerability to Invasive Species
- Alterations in Forest Composition and Diminished Biodiversity
- Unclear Market for biobased materials for construction thereby increasing financial risks.
- Consumer Preference for traditional timber for construction than other biobased materials
- Structural Integrity of Bio-Based Structures
- Limited Availability of Conifer and Preferred Wood Species
- Absence of Building Regulations- Codes for Biobased constructions

Safeguards

- Certification for Forest and Timber
- Framework for Incentives (e.g., Subsidies or Green Loans)
- Enhanced Capabilities (e.g., Wood Engineering, Architects, Structural Engineers, Construction Workers, etc.)
- Engagement of key Stakeholders such as the Department of Human Settlements, Department of Culture, Construction Development Corporation Ltd.,Natural

Resources Development Corporation Ltd, National Housing Development Corporation Ltd, Association of Wood Based Industries etc.
- Heightened Public Awareness
- Tailored Building Codes for Bio-Based Construction
- Enhanced and Streamlined Construction Technology to Revitalize the Industry
- Elimination of Construction Contractors Operating as "Thekadars"[14]

4. Policy Recommendations

The following are some key recommendations for implementing bio-based construction in Bhutan:

- Establish an incentive framework to provide subsidies/green loans for bio-based construction projects in Bhutan.
- Establish incentive framework to improve supply of biobased materials for construction.
- Create a Timber and Forest Certification Framework and mechanisms to ensure the sustainability of bio-based construction materials.
- Formulate specific building codes tailored for bio-based construction in Bhutan.
- Allocate resources for the development of local expertise and capacity in bio-based construction, including training wood engineers, architects, structural engineers, and construction laborers.
- Develop strategies to transition away from the traditional "Thekedar" system in the construction industry and maximize the potential opportunities from traditional bio-based construction practices.
- Promote greater public awareness regarding the advantages of bio-based engineering structures.
- Increase research and development efforts focused on the utilization of broadleaved timber species in bio-based construction.
- Integrate sustainable climate smart forestry practices, concepts of the circular economy, and environmental preservation into bio-based construction initiatives in Bhutan.

[14] Local term for Indian Construction contractors.

5.Acknowledgements

We extend our sincere gratitude to the Department of Forests and Park Services, the Department of Human Settlements, and the Natural Resources Development Corporation Ltd. for their invaluable and unwavering support throughout this study, including their prompt provision of necessary data and information.

Furthermore, we express our heartfelt appreciation to all the dedicated officials who actively engaged in the consultative meeting concerning the biobased construction potential in Bhutan, generously sharing their expertise and insights.

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Annexure

Annexure 1 List of Stakeholder /Experts Consulted

1.Mr. Pasang W. Norbu , Specialist- Advisor, Department of Forests and Park Services (Retired)

2. Ms. Tshering Denka, Sr. Architect, Department of Human Settlements,Ministry of Infrastructure and Transport

3. Mr. Dorji Wangdi, Principal Forestry Officer, Department of Forests and Park Services, Ministry of Energy and Natural Resources

4. Mr. Tashi Norbu Waiba, Deputy Chief Forestry Officer, Department of Forests and Park Services, Ministry of Energy and Natural Resources

5. Mr. Nima Dawa, Production Manager, Natural Resources Development Corporation Ltd.

6. Dr. Nawang Norbu, Executive Director, Bhutan Ecological Society

Figure 14:Stakeholder Consultative meeting in Thimphu