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PRINT: ISSN 0970-9274 ONLINE: ISSN 2456-6322
J Hum Ecol, 84(1-4): 1-12 (2023)
DOI: 10.31901/24566608.2023/84.1-3.3358

Identifying Forest Potential Areas in the Western Himalayan Region of the Chamba District (India)

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KEYWORDS Analytical Hierarchy Process. Biophysical Attributes. Forest Landscape. Remote Sensing and GIS. Geo-Spatial Analysis

ABSTRACT This study aims to identify potential areas for forest development and explore the biophysical characteristics of the existing forest landscape in the Chamba district of the Western Himalayas. It adopts a descriptive-cum-model-making research approach, integrating geospatial analysis and modelling techniques to evaluate forest potential based on ecological factors like soil type, topography, and vegetation cover. The results reveal three major high-potential areas for forest development and two low-potential zones. Certain forest ranges, such as Masrund and Bhalei, exhibit high potential, while Sandi and Ajog have low potential. The study identifies very high potential areas suitable for various plant communities and finds that *Pinus roxburghii*, *Cedrus deodara* and *Quercus leucotrichophora* thrive in high and moderate potential areas. These findings underscore the significance of strategic forest management practices for sustainable forest development and can guide policymakers and stakeholders in devising targeted conservation and afforestation strategies.

INTRODUCTION

Forests of the Western Himalayas, including Chamba district in Himachal Pradesh, harbour exceptional biodiversity with over 3,300 plant species (Rana and Rawat 2017; Bharti et al. 2021; Lata et al. 2021; Forest Survey of India (FSI) 2021; Yadav et al. 2023). These mountain forests provide vital ecosystem services to local communities, such as water provisioning, soil conservation, ecotourism revenue, and non-timber forest products (Rawat and Jishtu 2006 Joshi and Negi 2011; Akash et al. 2022; KC et al. 2022; Das and Mishra 2023; Kumar et al. 2024). However, deforestation and biodiversity decline threaten the sustainability of these fragile ecosystems (Intergovernmental Panel on Climate Change (IPCC) 2007, 2014). Compared to the Eastern Himalayas, the Western Himalayas naturally have lower productivity, humidity, tree lines, and alpine vegetation ranges, leading to biodiversity differences between the regions (Akash et al. 2022; Tyagi and Kumar 2022). Alarmingly, the extent of intact natural forests is declining sharply nationwide (FSI 2021). In Chamba, unsustainable practices like agricultural expansion on steep slopes and overexploitation of community forests degrade the environment (Ahmad 1993; Chand et al. 2022). Furthermore, looming climate change brings additional stresses (Barnett et al. 2005; Tewari et al. 2017; Dimri et al. 2018; Singh et al. 2022), putting endemic biodiversity and ecological stability at high risk while reducing critical ecosystem services (IPCC 2007, 2014). Additional climate change pressures threaten the survival of endemic species (Barnett et al. 2005; Tewari et al. 2017). In mountainous regions, anthropogenic infrastructure developments severely fragment habitats (Munsi et al. 2010; Akash et al. 2022), while haphazard tourism and settlements disrupt the sensitive ecology (Kumar A et al. 2022). These complex pressures necessitate integrated conservation planning, yet the spatial-temporal dynamics shaping Himalayan forest landscapes are inadequately characterised (IPCC 2007, 2014). Although studies evaluate specific issues like climate change impacts on plant communities (Pareta and Pareta 2011; Tyagi N et al. 2022) or climate vulnerability assessments (Pandey et al. 2022), no thorough examination or synthesis delineates areas of productivity or suitability for forest development.

This landscape-scale knowledge gap regarding biophysical drivers and ecosystem interactions limits effective conservation policy making tailored to the unique Western Himalayan ecology and socio-economics (Singh and Kumar 2022). As Chamba district harbours rich biodiversity (FSI 2021), research here can provide an urgently needed model for the fragile region (Tewari et al. 2017). By conceptualising forests as dynamic landscapes linked to interacting factors (Mucher et al. 2003; Antrop and Van Eetvelde 2018) and identifying potential areas using geospatial data and field sampling of biotic and abiotic variables (Wang et al. 2010; Freeman et al. 2015), this study seeks to address a critical gap constraining conservation. The findings aim to facilitate balanced policies protecting endemic biodiversity while sustaining local community livelihood.

Objective

The primary aim of the study is to identify potential areas suitable for sustainable forest development in the Chamba district of the Western Himalayas by examining the biophysical drivers and ecosystem interactions shaping the forest landscapes in the region. Some suitable research questions associated with this objective are:

1. What are the key biophysical factors influencing the productivity and sustainability of forest ecosystems in the Chamba district?
2. What are the highly suitable areas for productive, biodiverse, and sustainable mountain forests in the Chamba district, based on the analysis of biophysical parameters?
3. How can the identified potential areas for sustainable forest development inform conservation policies tailored to the unique ecology of the Western Himalayan ecosystem?

The research design appears to be a mixed-method approach, combining geospatial techniques (for example, remote sensing, GIS) and field-based observations. The study employs an integrated landscape approach and utilises the Analytical Hierarchy Process (AHP) to synthesise biophysical data and identify highly suitable areas for sustainable forest development. It is an exploratory research that aims to understand the forest landscapes as dynamic units shaped by biotic and abiotic factors, and to delineate potential areas based on their capacity to sustain ecological communities over time.

Study Area

The district's coordinates are 32p 11'30" to 33p 13'06" north latitude and 75p 49'00" to 77p 8'30" east longitude (Figure. 1). Physically, the region has three broad valleys constituted by the three major river systems of Chenab-Pangi Valley, Beas Valley (situated on the southwest side of the district and more fertile), and Ravi-Chamba Valley. The Chamba district, with an altitudinal range from 515 metres to 6,421 metres, encompasses an official area of 6,522 square kilometres according to the Census of India (2011). However, the study area demarcated through geospatial technology exhibits a distortion of 19.75 square kilometres, resulting in a total calculated area of 6,502.25 square kilometres. This district supports a population of approximately 519,080 individuals. As the region is more fertile on the southwest side, the population distribution is mainly confined to these valleys. The climate varies from semi-tropical to semi-arctic.

MATERIAL AND METHODS

The datasets used in this study were from secondary sources and some ancillary data were gathered through field observations, interviews, and satellite or remote sensing data to better clarify a few factors. This research follows an Integrated Landscape approach (Freeman et al. 2015), utilising geospatial data analysis and mapping to assess landscape parameters in an unbiased way. Nine biophysical criteria were conceptualised from a literature review, that is, rainfall, temperature, elevation, slope, drainage density, aspect, geomorphology, land use, and forest cover. The Analytical Hierarchy Process (AHP) method was employed to identify potential areas for forest development based on various attributes. This method was chosen as the most appropriate approach, as it utilises both factual data and existing knowledge-based weightage to evaluate the significance of the attributes concerning their importance to forests (Golden et al. 1989; Saaty and Kearns 1985). The AHP method involves three main components, that is, the Pairwise Comparison Matrix, the Normalised Comparison Matrix (Eigen Vector or Priority Vector), and the Weighted Score or Weight of Importance. Through this process, the significance of the attributes is calculated based on their relevance to forests. The attributes considered in this

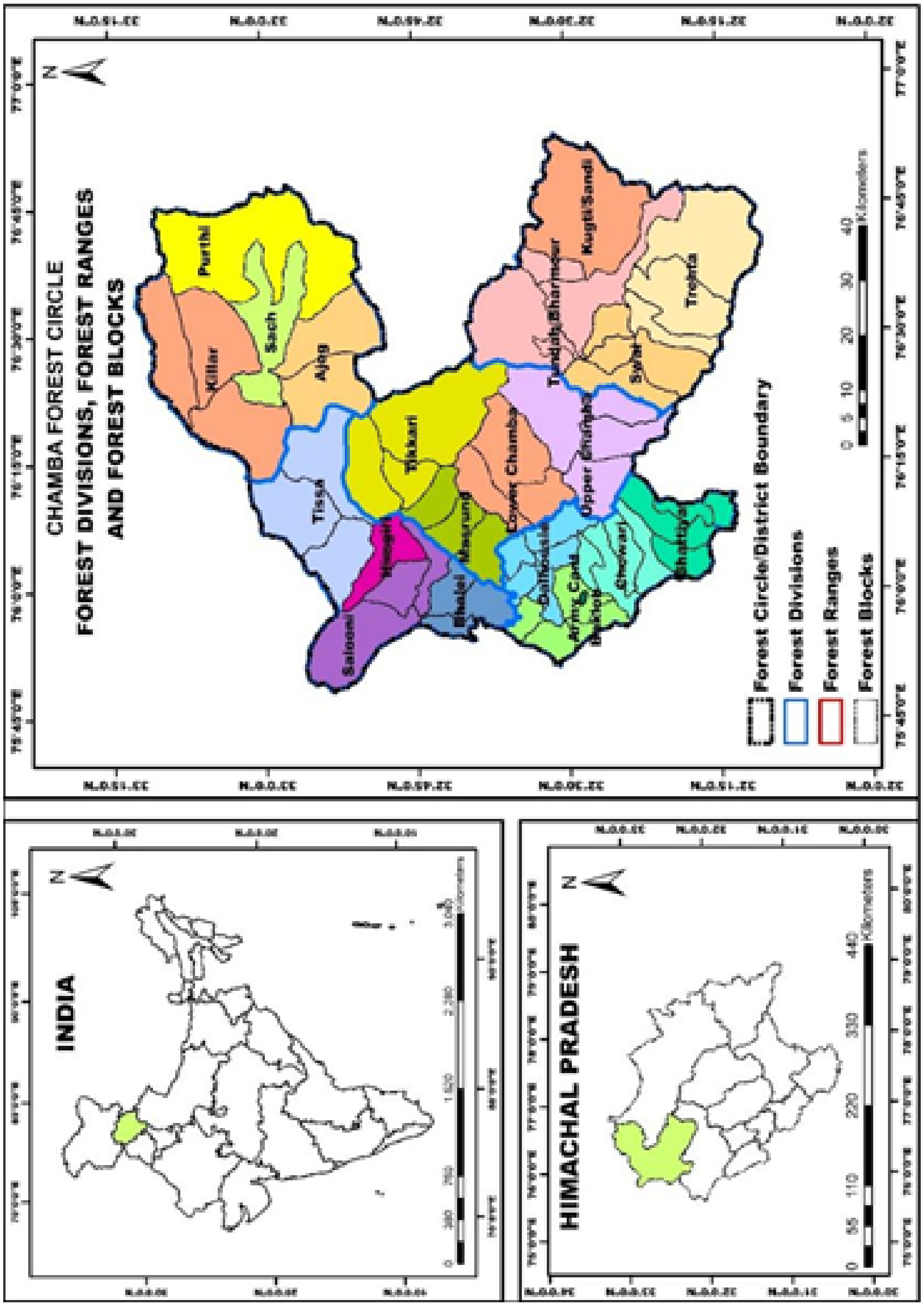

Fig. 1. Locational map of the study area along its administrative and forest boundaries

study were arranged in the following order of importance, that is, rainfall, temperature, elevation (relief), slope, drainage density, aspect, geomorphology, land-use and land-cover, and types of forests. This systematic arrangement of attributes was determined through a literature review of the forestry sector, location perceptions of the area, and field observations. The Pairwise Comparison Matrix allowed for the evaluation of each attribute's importance relative to the others, resulting in the Normalised Comparison Matrix and the Weighted Score or Weight of Importance. These components facilitated the identification of potential areas suitable for forest development based on the collective significance of the attributes.

The final output information has been analysed and mapped through a Geographical Information System (GIS), and numerous other computer simulations, as potential areas for forest development. This multi-evidence approach allows sustainable management of ecological processes across different landscape scales.

DISCUSSION

Biophysical Attributes

The biophysical characterisation of forest landscapes is crucial for understanding their diversity, ecological services, and dynamics, influenced by natural disturbances and human activities (Indirabai et al. 2021). Assessing site suitability for forest restoration and afforestation programs requires a multifaceted approach, considering species characteristics (Dolos et al. 2015), site conditions such as soil quality, structure, and nutrient supply (Prescott et al. 2021; Bello and Ruiz 2013), climate change impacts and potential shifts in species distributions, landscape attributes like forest cover and slope (Tymchuk 2021), and the integration of geospatial tools and decision-making frameworks (Bello and Ruiz 2013). Märkel (2017) developed a measure of site suitability for tree species, combining occurrence probability and growth, to identify priority regions for climate change adaptation. Aguirre-Salado (2015) used a weighted linear combination method to classify land suitability for tree plantation establishment in Mexico, considering agro-ecological requirements and constraints. Salehnasaheb et al. (2016) applied the analytic hierarchy process and geographic information system to determine suitable areas for a local forest park in Iran.

Recent studies have emphasised the importance of integrating multiple biophysical parameters to accurately assess site suitability for forestry initiatives. Kadam et al. (2021) in the Western Ghats of India highlighted the significance of incorporating terrain characteristics, climatic variables, and soil properties in identifying suitable sites for afforestation and reforestation efforts, employing a multi-criteria decision analysis (MCDA) approach. Tyagi et al. (2023) in the Western Himalayan region of Uttrakhand underscored the role of aspect and slope in shaping the distribution and composition of forest ecosystems. Research has also recommended prioritising afforestation efforts in areas with favourable soil conditions, drainage, and proximity to existing forests, as demonstrated by Joshi et al. (2024), who found assisted natural regeneration (ANR) techniques effective in restoring degraded forests in the Central Himalayan region of Nepal. Furthermore, studies have highlighted the potential impacts of climate change on forest growth and distribution in the Himalayan region, emphasising the importance of considering climate change projections when planning long-term afforestation strategies (Mahajan et al. 2022).

Climate

Rainfall and temperature data shows that around 40 percent of the area receives adequate rainfall, between 100-200 cm annually, to support forest growth. However, over 26 percent is dry sub-humid with only 50-100 cm annually, potentially limiting forests. Additionally, 14 percent is arid with very low, that is, less than 50 cm rainfall unsuitable for most forests (Table 1). The variability indicates

Table 1: Rainfall distribution in the study area.

Rainfall zones (In cm)	*Area (Km²)*
Arid (Below 50)	934.21
Dry Sub-Humid (50 – 100)	1703.72
Moist Sub-Humid (100 – 150)	1290.37
Humid 150 - 200	1687.62
Wet Humid (Above 200)	886.33
Total	6502.25

Source: WorldClim- Global Climate Data. (Period 1970-2000), Feed Future, The US Governments Global Hunger and Food Security Initiatives regions with sufficient moisture could sustain forests but drier areas would require drought tolerant species. Targeting wetter humid zones for afforestation could be most productive while strategic efforts in drier areas may involve selecting low water-need trees or supplemental irrigation to enable forests. Integrating rainfall data with soil, drainage and terrain can help pinpoint the most promising locations for forest development and expansion in the area. Table 2 shows the area has a diverse range of annual temperature zones. Over 20 percent is frigid below 0°C where limited vegetation can grow. Another 18 percent is very cold at 0-5°C, which is also challenging for forests. However, around 40 percent is mild, cool and warm climates of 10-15°C or more suitable for many forests. The variability supports diverse ecosystems but very cold areas will restrict forest development. Targeting cool/warm zones for afforestation could be most productive while efforts in colder regions may involve conifer species tolerant of cold and frost. Integrating temperature with other factors can delineate promising forest growth sites. Additionally, climate change warming may enable expanding forests into some cooler zones currently less hospitable.

Table 2: Temperature variation in the study area

Temperature zones (In !)	*Area (Km²)*
Frigid (Below 0)	1353
Very Cold (0 – 5)	1156
Cold (5 – 10)	1266.11
Cool (10 – 15)	1391.12
Warm (Above 15)	1336.02
Total	6502.25

Source: WorldClim- Global Climate Data. (Period 1970-2000), Feed Future, The US Governments Global Hunger and Food Security Initiatives

Relief

The data (Table 3) shows that over 60 percent of the area has intermediate to very high absolute relief of more than 2500 metres. This rugged terrain can support varied forest ecosystems at different elevations. However, over 30 percent have low relief below 2500 metres, which may limit forests. Nearly 95 percent of the area has moderate or higher relative relief between 200-800 or more metres per unit area (Table 4), indicating continued elevation changes suitable for diverse forests. But 6.97 percent shows minimal relative relief less ideal for forests. While terrain analysis indicates much land could support forest growth, strategic efforts should prioritise higher relief and slope areas, which provide environmental variability that favours more robust, resilient forests.

Table 3: Elevation zone classification in the study area

Absolute relief (in meters)	*Area (Km²)*
Very low relief (397-1500)	773.07
Very low relief (397-1500)	1570.02
Low relief (1500-2500)	1726.06
Intermediate relief (2500-3500)	1557.85
High relief (3500-4500)	875.21
Total	6502.25

*Minimum elevation = 503 meters; maximum elevation = 6421 meters; Mean = 3.40.67; Standard deviation = 1198.17.
Source: DEM SRTM, 1Arc-Second Global (30m spatial resolution)

Table 4: Types of slope in the Chamba district

Slope types	*Area (Km²)*
Level (0-10 degrees)	282.16
Gentle (10-25 degrees)	1523.06
Moderate (25-35 degrees)	1964.05
Steep (35-50 degrees)	2337.45
Very steep (Greater than 50 degrees)	395.53

Source: DEM SRTM, 1Arc-Second Global (30m spatial resolution)

Slope

The analysis shows that over 70 percent of the area has moderate to very steep slopes between 25-50 (or more) degrees. Steeper-sloped terrain is often more suitable for robust and biodiverse forests. However, about 28 percent of the land is relatively flat or gently sloping, which can limit forests (Table 4). In terms of aspect, exposure is fairly balanced across north, south, east, and west facing slopes. This variability in insulation and moisture helps support diverse forests adapted to different microclimates based on slope orientation. Aspect refers to the compass direction that a slope faces, which plays a crucial role in determining the amount of solar radiation received and the subsequent environmental conditions. From the data, one can observe that the largest area is covered by the southwest aspect (883.60 km²), followed by the

Table 5: Drainage density zones in the study area

Drainage density	*Area (Km²)*
Very low (Below 0.5)	3345.23
Low (0.5 – 1.5	1709.24
Moderate (1.5 – 2.0)	1051.29
High (2.0 – 2.5	328.71
Very high (Above 2.5)	67.78
Total	6502.25

Source: DEM SRTM, 1Arc-Second Global (30m spatial resolution)

northwest (853.20 km²), northeast (852.63 km²), and north (804.79 km²) aspects. These north-facing and west-facing slopes generally receive less direct sunlight, leading to cooler and moist conditions, which are favourable for the growth of certain tree species adapted to such environments. On the other hand, the south-facing (804.79 km²) and southeast-facing (717.91 km²) aspects receive more direct sunlight, resulting in warmer and drier conditions (Table 6). These areas may support different types of vegetation, including species that are more drought-tolerant or adapted to warmer conditions. Overall, the prevalence of steeper slopes indicates much of the land could support forest growth. Targeted afforestation efforts on shallower gradients could aim to plant drought and heat-tolerant species to expand forests across all slope conditions. In summary, slope aspect significantly influences vegetation patterns and attributes in the Western Himalayas, with north-facing slopes generally having more favourable conditions for forest growth and productivity. However, the specific impact of slope aspect on the growth of different forest species in this region requires further investigation.

Drainage Density/Hydrology

The area shows that over half the area has very low drainage density below 0.5, indicating relatively poor drainage. Excess moisture can limit forest growth. However, about 22 percent has moderate to very high drainage density between 1.5-2.5 (or above), indicating towards better drainage more suitable for forests (Table 5). The mean density is 1.78 with low standard deviation, reflecting generally inadequate moisture drainage across the area. Strategic afforestation efforts should prioritise the minority regions with higher drainage density as moisture regulation is critical. Additionally, drainage improvement projects in low density areas via channels or ditches could help expand forest coverage. Integrating this drainage data with other factors can help identify and target the most promising locations for thriving, sustainable forests.

Geomorphology

The investigation shows over 72 percent of the area comprises highly dissected structural hills and valleys (Table 7). This rugged topography with significant elevation changes can support varied microclimates suitable for diverse forests. However, nearly 12 percent is covered in snow, which limits forests. About 2 percent consists of glacial

Table 7: Physical setting of the study area

Geomorphological features	*Area (Km²)*
Rivers, dam and reservoir	72.18
Glacial valley	128.45
Highly dissected structural hills and valleys	4706.19
Glacial Moraine	1.86
Mass wasting products	108.66
Moderately dissected structural hills and valleys	699.36
Road cutting	0.08
Snow cover	748.33
Alluvial plain	37.12
Total	6502.25

Source: Geological Survey of India

Table 6: Direction of the slope in the Chamba district

Aspect	*Area (Km²)*	*Aspect*		*Area (Km²)*
Flat (-1)	37.23	South	(157.5-202.5)	804.79
North (337.5- 22.5)	852.63	Southwest	(202.5-247.5)	883.60
Northeast (22.5-67.5)	784.95	West	(247.5-292.5)	875.25
East (67.5-112.5)	692.67	Northwest	(292.5-337.5)	853.20
Southeast (112.5-157.5)	717.91	South	(157.5-202.5)	804.79

Source: DEM SRTM, 1Arc-Second Global (30m spatial resolution) landforms that allow limited forest growth. Nearly 11 percent is moderately dissected terrain also potentially conducive to forests. Though geomorphic features indicate much of the land could support forests, the prevalence of snow cover and glaciation pose challenges. Strategic afforestation efforts could focus on lower-elevation hills and valleys as well as the alluvial plains to take advantage of the complex terrain while avoiding snow-bound and glaciated areas.

Land Use and Land Cover

The data (Table 8) shows that 36 percent of land is covered by evergreen forests providing abundant area for robust forest growth and expansion. However, barren land represents over 27 percent of area with opportunity for afforestation efforts. An additional 18 percent is grasslands and open/deciduous forests where restoration initiatives like in-filling and underplanting could enhance forests. The remaining less than 20 percent is developed land limiting additional forest growth. Prioritising barren areas bordering intact forests, combined with targeted grassland and open forest restoration, provides significant opportunity to increase both forest land cover and connectivity in the region. Strategic planting aligned to soils, drainage and other factors could help enable successful, sustainable new forest growth in the area.

Table 8: Land use land cover in the Chamba district

LULC categories	*Area (Km²)*
Built-up Area	13.36
Agricultural land	280.25
Open forest	229.36
Evergreen forest	2345.06
Deciduous forest	252.41
Grasslands	946.78
Barren land	1804.14
Water bodies	82.38
Snow cover	548.51
Total	6502.25

Source: Resourcesat-2, LISS 111, Cartosat, IIRS, Bhuvan, India

Forest Cover Types

Table 9 shows that over 64 percent of the area has no forest cover. Expanding forest coverage into these non-forest zones through strategic afforestation could significantly increase regional forest areas and connectivity. The remaining 36 percent of land supports very dense to open forests, providing a strong foundation. Prioritising afforestation bordering existing forests could help consolidate and bolster these intact forest ecosystems. Additionally, targeting fragmented scrub and open forest patches for restoration via in-filling and underplanting could further enhance forest conditions and biodiversity. Integrating forest cover data with soils, drainage and other factors will delineate promising sites for successful and sustainable new forest growth in the region.

Table 9: Types of the forest cover in the study area

Forest cover types	*Area (Km²)*
Very dense forest	762.11
Moderate dense forest	898.28
Open forest	634.91
Non-forest/others	4170.89
Scrub forest	20.34
Water bodies	15.72
Total	6502.25

Source: Resourcesat-2, LISS 111, Cartosat, IIRS, Bhuvan, India

Additionally, the region's old metamorphic geology and Cambisol soils provide ideal substrate conditions for forest growth across over 60 percent of the area. Moderate to steep slopes and relief also support diverse, resilient forest ecosystems. Though nearly 30 percent face drainage limitations and over 25 percent receive low rainfall, strategic tree selections can expand forests. Over 35 percent already supports very dense to open forests, while barren and grassland areas allow forest expansion. Low temperatures and snow cover pose local constraints but over 40 percent has milder climates conducive to forests. Targeting favourable soils and slopes adjoining existing forests, alongside restoration of grasslands and barrens, provides significant opportunity for enhanced forest land cover, health and connectivity across the region.

Analytical Hierarchy Process (AHP) Method

The Analytical Hierarchy Process (AHP) provides a structured (Saaty and Kearns 1985) framework to assess complex biophysical criteria that influence forest growth, such as rainfall, temperature, slopes, and soils. By enabling the systematic comparison of these factors through pairwise comparison matrices, AHP allows for the quantification of their relative importance and impact on forest growth based on findings from literature reviews and field investigations (Morales et al. 2021; Cao 2022). Once criteria layers have been mapped using geospatial tools, AHP derives priority vectors that reflect the cumulative influence and weights of each variable (Cao 2022). These weighted layers can then be integrated in a GIS environment to produce an overlay mapping that delineates zones ranging from high to low suitability for forests in a given region based on biome conditions. As AHP includes consistency validation to ensure a robust analysis, the resulting suitability map provides a holistic evaluation of the landscape that accounts for the terrain, climatic and substrate factors that impact forest growth (Cao 2022). The AHP-GIS forest suitability mapping outputs can direct targeted afforestation efforts towards ecologically viable sites that are most likely to support healthy, sustainable forests with minimal intervention. As an adaptable method for regional planning, AHP can also incorporate other ecological and stakeholder considerations. Iterative application further aids the progressive siting of forest growth in optimal areas. Overall, by identifying priority regions for strategic afforestation, AHP provides a versatile, evidence-based approach to evaluate landscapes holistically and determine locations that can best enable forest establishment and connectivity.

RESULTS

Potential Areas for Forest Development

Based on the analysis, five forest potential zones were identified, that is, *very high, high, moderate, low, and very low suitability* (Fig. 2). About 50 percent of the area was classified as having very high potential, mostly in the forested regions of Trehta, Upper Chamba, Chowari, and Bharmour (Table 10). These areas are characterised by rich biodiversity, including dominant plant communities like deodar, chil, kail, ban oak, fir, moru oak, and kharsu oak. Approximately 50 percent of the area was classified as a high potential zone, spanning across ranges like Tikkari, Tissa, Upper Chamba, Trehta, Salooni, Lower Chamba, and Masrund. These regions benefit from favourable conditions such as ample rainfall, suitable temperatures, gentle slopes, and existing deciduous/dense forests. The moderate potential zone (10.16% of the area) serves as a transitional zone between high and low potential areas, while the low potential zone (6.92% of the area) and very low potential zone (8.63% of the area) are less favourable for forest development due to factors like high elevations, steep slopes, or unfavourable conditions. The study suggests that the very high, high, and moderate potential zones, covering over 75 percent of the area, present significant opportunities for forest landscape development in Chamba. Tailoring afforestation plans to site-specific species selection and involving the community will enhance the effectiveness of these initiatives.

CONCLUSION

This study presents a comprehensive spatial analysis and prioritisation of forest landscapes in Chamba district, Western Himalayas, based on an integration of critical biophysical factors. The findings reveal significant potential for sustainable forest development and expansion across the region. Approximately 75 percent of the area, spanning the very high, high, and moderate potential zones, offers abundant opportunities for enriching existing forests and establishing new ones through targeted management practices. Notably, nearly <65> percent of the current forest cover, concentrated in 18 forest ranges and 3 wildlife sanctuaries within the very high and high potential areas, demonstrates exceptional scope for sustainable intensification and productivity enhancement. While the moderate potential zone requires more considered interventions, it can still contribute to forest landscape development. However, the low and very low potential zones, comprising about 15 percent of the existing forests, exhibit limited viability due to constraining site conditions. This stratification enables the adoption of context-specific prescriptions tailored to the inherent potentials and limitations of different zones, optimising returns from the region's diverse forest resources. By providing a robust ecological foundation, this research can guide strategic planning and governance for the holistic development of Chamba's forest landscapes, fostering biodiversity conservation and

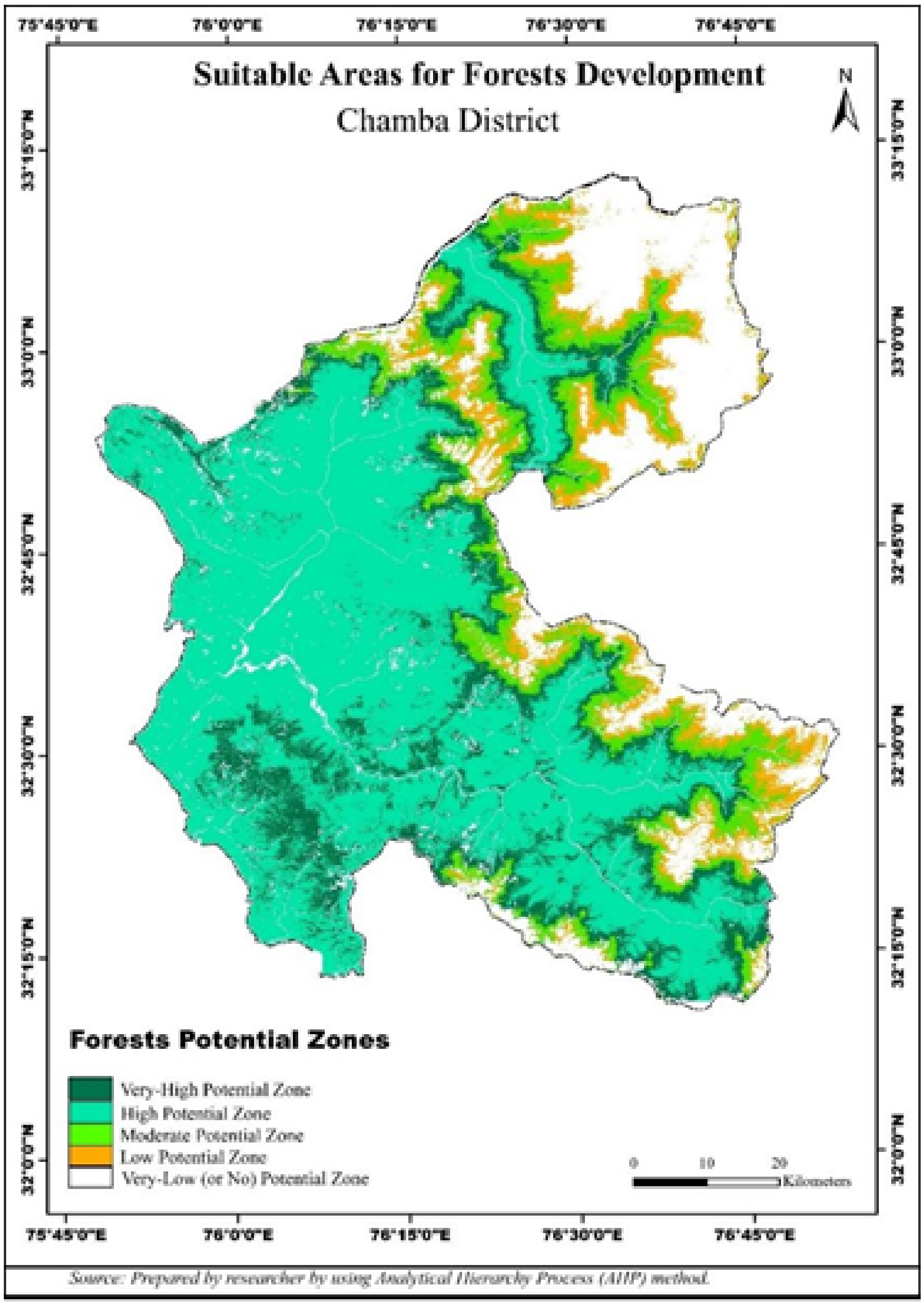

Fig. 2. Potential areas or zones in the Chamba District for Forest Development.

Table 10: Potential areas for forest development and the dominant forest range with the covered area

Potential zone	*Percentage of forest area (in Km²)*	*Ranges (maximum covered area in Km²)*	*Forest cover (in %)*	*Characteristics*	*Suggested strategies*
Very high potential zone	943.29 (14.5 %)	Trehta Upper Chamba (116), Chowari Bharmour (78),	Above 90%	- Dominant species: deodar, fir, oaks. - High biodiversity and carbon stoc. - Withstands anthropogenic pressures	- Focus on sustainable harvesting. - Enrichment planting. - Adaptive climate proofing
High potential zone	3245.12 (49.9 %)	Tikkari (307), Tissa (302), Upper Chamba (297), Trehta (281), Salooni (276), Lower Chamba (272), Masrund (205).	60-90%	- Structurally and compositionally diverse - Tropical, subtropical, temperate, mixed forests natural regeneration .	- Intensify plantations with suitable native species - Agroforestry, Assisted
Moderate potential zone	660.91 (10.16 %)	Killar (135), Saandi (105), Bharmour (97), Ajog (83), Tikkari (68), Trehta (67), Sach (59).	20-60%	- Transitional between high and low zones. - Constraints but targeted interventions viable - Intercropping models	- Site-specific species selection. - Community participation.
Low potential zone	6.92 %	Saandi (140), Killar (108), Bharmour (100), Ajog (87), Purthi (87).	-Alpine meadows, grasslands	- Unfavourable for economic forestry	- Promote meadows conservation. - Afforestation unviable ecologically
Very low potential zone	8.63 %	Purthi (343), Killar (160), Ajog (47), Saandi (45), Sach (26), Bharmour (21).	Significant abiotic and biotic limitations	- Better suited for conservation goals rather than forestry	- Explore ecological restoration practices

Source: Computed values, drawn through the AHP Method and Spatial analysis.

sustaining vital ecosystem services for local communities.

RECOMMENDATIONS

The study provides valuable insights into the site suitability assessment for forest development in the Western Himalayan region. However, to further enhance the effectiveness of the recommendations, future research should focus on identifying and integrating key parameters from diverse perspectives, beyond biophysical attributes. This holistic approach can be achieved by conducting a comprehensive evaluation of factors across various themes, such as socio-economic, cultural, and political dimensions, that significantly influence forest development. By assessing the combined impact of these parameters on the forest landscape, researchers can develop a more comprehensive understanding of the complex interplay between different factors. Additionally, it is recommended to involve stakeholders from various backgrounds to align their perspectives and assign weights to the identified parameters based on their relative importance. This participatory approach will ensure that the management strategies are tailored to the specific needs and priorities of the region. Furthermore, future studies should explore the integration of these diverse parameters using advanced analytical techniques, such as multi-criteria decision analysis or machine learning algorithms, to develop robust and data-driven decision support systems for sustainable forest management. These systems can facilitate the implementation of context-specific, adaptive management practices that are responsive to the dynamic nature of the forest landscape.

LIMITATIONS

While the study provides an integrated biophysical analysis to identify potential areas for forest development in the Chamba district, it has certain limitations. The lack of fine-resolution data constraints localised precision. Exclusion of socioeconomic and cultural variables like community dependence, land ownership, and local values overlooks important stakeholder considerations. The snapshot analysis fails to capture dynamic forest landscape changes over longer time periods. The weighting and ranking of criteria in the Analytical Hierarchy Process involves researcher subjectivity. Furthermore, the absence of sensitivity analyses undermines the objectivity of input assumptions. Refinements in methodology, inclusion of additional variables, consideration of temporal effects, and sensitivity testing could strengthen the landscape suitability analysis and enhance its applicability to management planning.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the University Grants Commission (UGC), under the Ministry of Human Resource Development, Government of India, for the financial support provided in the form of a Junior Research Fellowship (UGC-NET/JRF). This funding assistance has been instrumental in facilitating the successful completion of the present research work.

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Paper received for publication in February, 2024
Paper accepted for publication in June, 2024