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Forest figures of the past (and present): Consequences on the future of settling with/in forests of the Garhwal Himalayas, India

Abstract

This research unfolds the notion of 'settling with/in forests,' shaped by the dynamic environmental and socio-political interactions in India's Garhwal Himalayas. Garhwal's forests perform diverse ecosystem functions that characterise the regional landscape. Settling with/in forests is fundamental to Himalayan communities as, directly and/or indirectly, forests structure the ecology, livelihoods, settlements, and seasonal mobilities across the mountainous landscape. Today, Garhwal's forests are endangered by the cascading impacts of global warming, increasing urbanisation, natural disasters, and extensive infrastructure construction. Using a "thick description" approach, the research seeks to examine the intertwined layers of forests, local habitats, practices, and institutions, provide insight into the region's unique environmental history, and identify the challenges associated with settling with/in forests. The research combines fieldwork, archival materials, and interpretive mapping to examine a case study in the Garhwal Himalayas. The findings highlight the conflicts and coexistence of State policies and non-state adaptations, as well as the vulnerability of the region's forests to climatic stress and future anthropogenic change. The forests of Garhwal are critical to the larger Himalayan ecology, and the research findings point the way forward for developing potential adaptations that strengthen the concept of settling with/in forests.

Ashim Kumar Manna[1*], Kelly Shannon[1], Bruno De Meulder[1]

1) KU Leuven, OSA Research Group, Department of Architecture, Faculty of Engineering Science, Leuven; Belgium.

* Corresponding author: KU Leuven, Department of Architecture, Faculty of Engineering Science, Kasteelpark Arenberg 1–bus 2431, B-3001 Leuven, Belgium. Email: ashimkumar.manna@kuleuven.be

Ashim Kumar Manna
https://orcid.org/0000-0002-2813-2879

Kelly Shannon
https://orcid.org/0000-0002-4817-8540

Bruno De Meulder
https://orcid.org/0000-0001-6975-4140

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1 Introduction

The Garhwal Himalayas are home to several climax forests that sustain the headwaters of the Bhagirathi River, an important tributary to the Ganges River. These forests perform critical ecosystem functions—preserving biodiversity and hydrological balance, regenerating soil, and reducing soil erosion—that sustain local communities and those living downstream (Government of Uttarakhand, 2016; Pandit, 2017). Settling with/in forests is an approach towards urbanism where "forests act as a fundamental organizing element across different scales (in relation to mobilities, livelihoods, settlements and ecology)" (De Meulder et al., 2019). It is premised on the notion that 'as found' conditions of forests were only modified (for settling and production) to the extent that they remained a healthy ecological system. Forests are essential for people living in the Garhwal Himalayas, as forests form the foundation of their lives, culture, and identities due to their adaptations to the dynamic environment (Shiva, 1988; Pathak, 1997; Guha, 2000). Several studies (Shiva, 1988; Pathak, 1997; Guha, 2000) contend that 'State' and 'non-state' ownership, contestations, and practices shaped Garhwal's extractive landscape or its "second nature"—a term borrowed from William Cronon (Cronon, 1991). Cronon explained "first nature" and "second nature" in his interpretation territorial transformation of 19th century Chicago. For Cronon, "first nature" is not pristine wilderness, but the Indigenous American communities' adaptation to the natural world. "Second nature" is imposed on the landscape through a series of extractive, market-driven practices.

Today global warming, haphazard urbanisation and infrastructure construction significantly exacerbate the region's ongoing environmental degradation and prompt a critical re-examination of the region's ecological crisis, often magnified during natural disasters (Pandit, 2017; Whitmore, 2018; Sati et al., 2020). Contemporary research on Uttarakhand and the Himalayan landscape delves extensively into forest policy and monitoring, resistance movements, the effects of large-scale infrastructure, and geological risks (Pandit, 2017; Sati et al., 2020; Dasgupta et al., 2022). However, the local impact on settling with/in forest morphologies requires in-depth discussions. Like the rest of the Himalayan region, Garhwal in western Himalayas is warming faster than the global average, exposing its forests to new environmental threats and declining ecosystem functions (Rao et al., 2016; Wester et al., 2019). By 2050, Uttarkashi district within Garhwal is predicted to experience a 4°C increase in its annual average temperatures and a 16% increase in yearly rainfall over a shorter rainy season compared to 2016 (Rao et al., 2016). With Increasing global warming, Garhwal's forests will emerge as crucial global warming hotspots, making them vulnerable to future environmental stress (Forest Survey of India, 2021). These vulnerabilities impact local communities that primarily rely on forests, subsistence agriculture and livestock. Declining agricultural productivity has resulted in decades of urban migration (Guha, 2000; Rautela and Karki, 2015; Meena, 2016). Garhwal's forests, as part of the larger Himalayan ecology, can play a critical role in mitigating ongoing environmental crises, including global warming, receding biodiversity, and ecological resilience (Thadani et al., 2015; Pandit, 2017). This study highlights the importance of balancing forest preservation in the face of global warming and increasing urbanisation in the Himalayas. It aims to analyse the interplay of State Forest policies and non-state practises, identify contemporary challenges and strike a balance of settling with/in forests. The research framework employs "thick descriptions" as defined by Clifford Geertz in his book "The Interpretation of Cultures" (Geertz, 1973). Geertz defined a "thick description" as the intertwined relationship between local environments and human behaviour, practices, and institutions. The research addresses two questions: [1] how do State development and non-state practises coexist, transform, adapt to global warming, and [2] can there be a more effective complementarity of these notions in relation to settling with/in forests? The research consists of three sections. The first section introduces the case study and the methods to examine forest-settlement relationships. The second section interprets the case study's morphological change through several themes. The third section includes the discussion and conclusion, concisely summarizing results, and highlighting the study's relevance within the larger Himalayan landscape.

2 Methods and research context

2.1 The study area

The case study lies in Uttarkashi, an administrative district in the northern Indian state of Uttarakhand (fig.1 A). Uttarkashi is situated along an international border (of India and China) and covers a geographical area of 8016 km^2 (Meena, 2016). The average temperature in the winter is around 0°C and up to 25°C in the summer; precipitation (average yearly rainfall of 1902 mm) is limited to a short monsoon season (July-September) and winter snowfall. Around 38% of the geographical area is covered by a gradient of dense and open forests. The State Forest Department controls over 88% of the geographical area, encompassing forests, high altitude grasslands, barren lands, and glaciers (Meena, 2016). Uttarkashi is sparsely populated with 330,000 inhabitants (yearly growth rate of 1.18%) (Meena, 2016). 92.7% of Uttarkashi's population resides in villages clustered around forests, where agriculture coupled with forestry and livestock rearing is the primary means of livelihood (Meena, 2016).

Uttarkashi's forests are increasingly vulnerable to the effects of global warming, as forest fires, altitudinal movement of treeline, and growth of invasive species become frequent (Mungi et al., 2018; Kotnala, 2022; Sharma and Sati, 2022). At the same time, there is a greater reliance on the forest for household needs, coupled with a lack of widespread adaptation among Uttarkashi's rural communities. Clearly the region's rural livelihoods will be further negatively impacted in the future (Rautela and Karki, 2015; Rao et al., 2016). Uttarkashi's high-altitude villages rely heavily on local forests for their fuelwood, fodder, leaf litter, and other non-timber forest products (NTFP), which increases during winter (Awasthi et al., 2003; Meena, 2016). According to the 2011 Uttarkashi district census, approximately 66% of rural households rely on local forests. Increasing water scarcity, land degradation, and poor agricultural outputs have resulted in the outmigration between 6 to 9% of Uttarkashi's population (Institute for Human Development, 2019). In addition to the ongoing environmental degeneration, the region continues to face increasing threats from global warming and natural disasters. Several natural disasters, i.e., the 1991 Uttarkashi earthquake, the 2003 Varun-

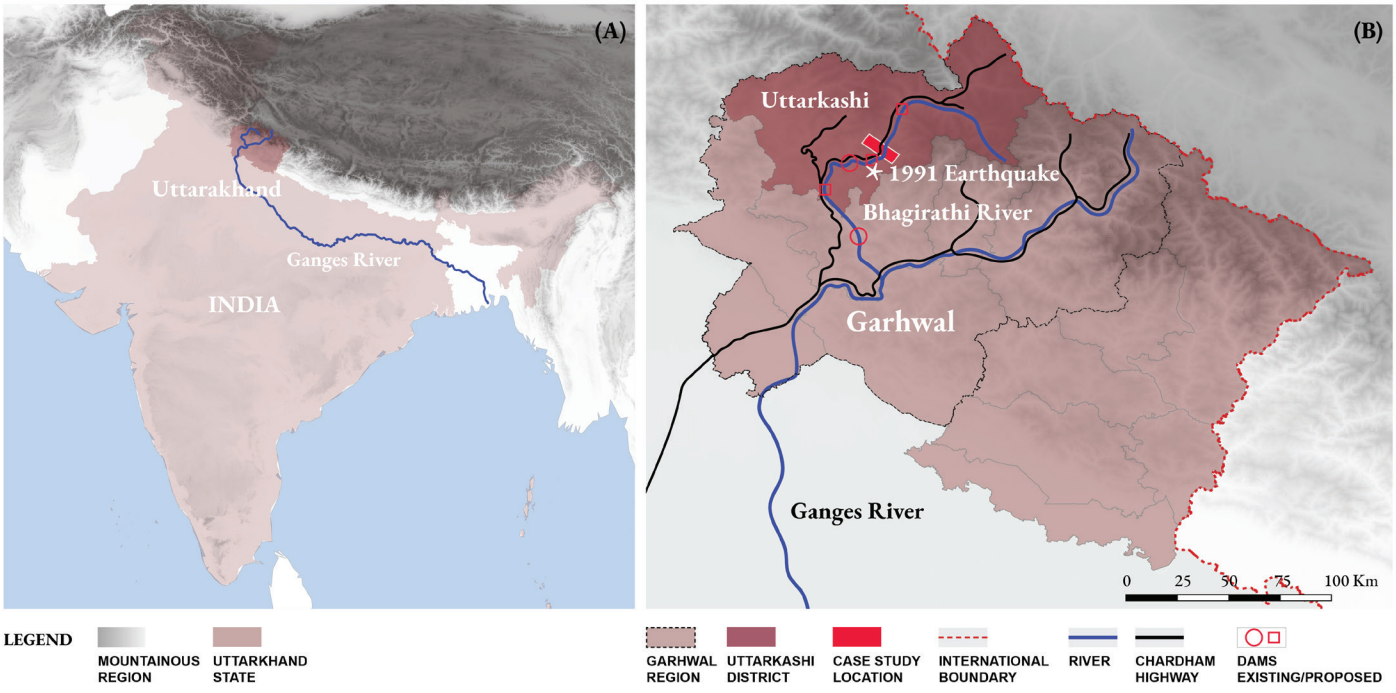

Figure 1. Location of the case study within Uttarakhand, a state in northern India (A). The case study is situated along the Bhagirathi River, a key tributary of the Ganges River, the in-construction Chardham Highway, and existing and proposed dams (B). Drawing: Manna, adapted from data obtained from Bhuvan, Bhukosh, PMGSY geoportal, and OpenStreetMap (June,2023).

avrat landslide, 2012 and 2013 flash floods have claimed several lives and destroyed livelihoods (Parkash, 2015; Joshi, 2016). The upper catchment of the Bhagirathi River was designated as the 'Bhagirathi Eco-Sensitive Zone' (BESZ) in 2012 to protect the region's fragile ecosystem. The BESZ sought to conserve natural resources and promote sustainable livelihoods through the designation of 88 forest-dependent villages and regulation of large-scale construction, including three hydropower projects (construction of which is presently stalled), Loharinag Pala (600 MW), Pala Maneri (480 MW), and Bhairon Ghati (Roy, 2008; Meena, 2016).

Altitudinal variations, soil conditions, slope, and solar orientation (amongst other variables) create differences in atmospheric pressure, temperature, moisture, and wind. Such variations were observed by Alexander von Humboldt in the Andes in the 18th century. His observations focused on distinct socio-ecological relationships at different altitudes, often referred as "ecological floors" (Bromme, 1851; Murra et al., 2017). Similarly, the case study's ecological floors are defined by its vegetation: sub-tropical pines (from 1400 msl to 2000 msl), temperate deodar (from 2000 msl to 3000 msl), subalpine firs and spruce (above 3000 msl), kharsu-oak, birch, juniper, and alpine meadows (above 3800 msl) (Raturi, 1938; Rizvi, 1979) (fig.2). The study examines a transect located between the altitudes of 1400-3800 meters above the sea level (msl), in the Uttarkashi district of Garhwal, India (fig.1). The transect reveals landscape evolution since the 6th century, colonial forest policies, State development, disasters, mass tourism, infrastructure, and risks through morphological changes. The transect is a *pars pro toto*—it embodies larger issues of the region and lessons drawn from it can benefit other sites in Garhwal.

2.2 Methods

The research uses a mixed method by combining a variety of sources and a case study analysis through on-site observation and interpretative mapping (where secondary data complements fieldwork). The notion of a "transect" (Bromme, 1851) and "thick descrip-

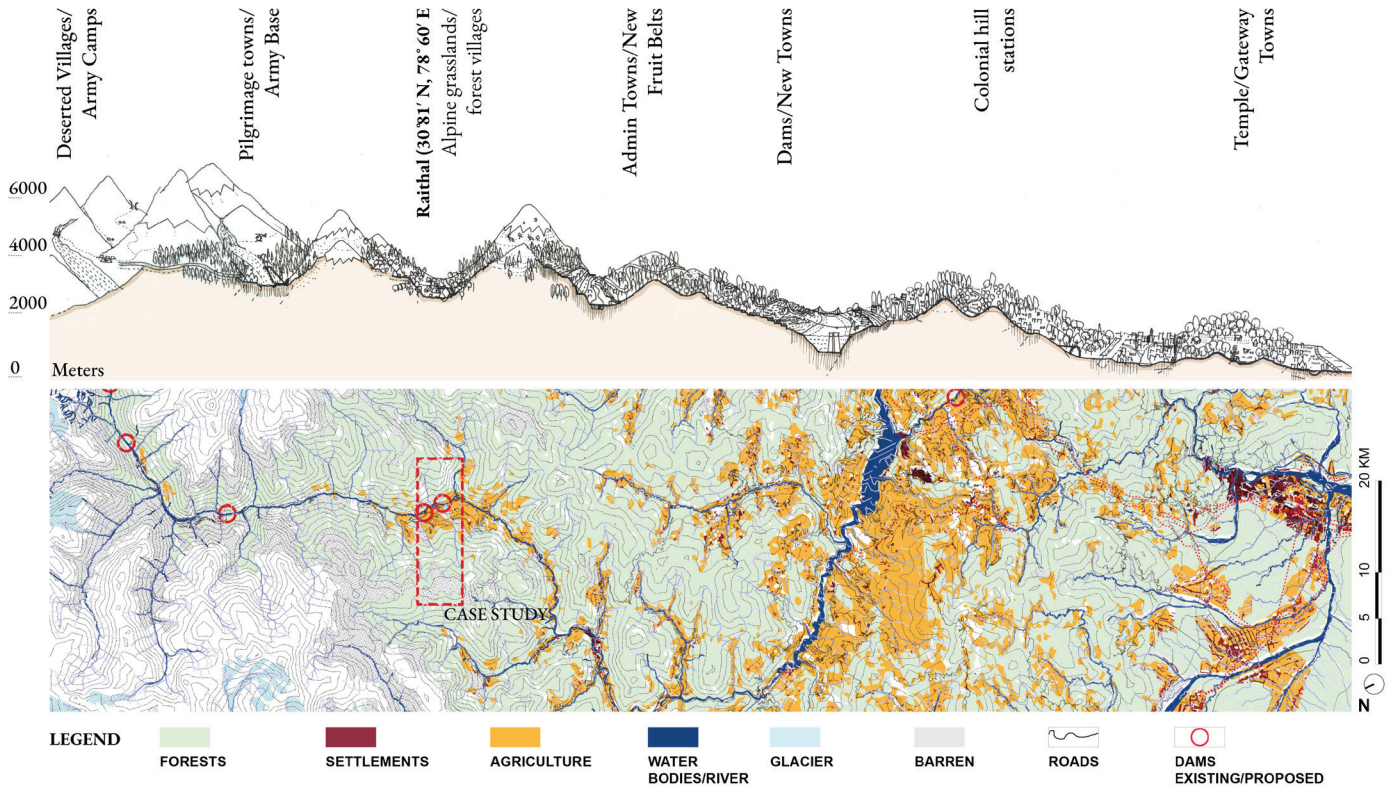

Figure 2. The situation of the case study within the larger environmental setting of the Garhwal Himalayas reveals a transect from the foothills to the high Himalayas, framing by its altitudinal diversity. Drawing: Manna, adapted from data obtained from Bhuvan, Bhukosh, PMGSY geoportals, and OpenStreetMap (May,2022).

tions" was employed to examine early settlements (6th to 18th century), the influence of State policies (1823 to 1980s), and the impact of infrastructure and mass tourism (since 1960s). Fieldwork was conducted in February 2020, October 2021, and November 2022. It was supplemented with archival research in India, online resources, and external literature. Archival materials, including gazetteers, historical topographical sheets from the Survey of India, Forest Working Plans from the Forest Research Institute in Dehradun, India, and online resources, were referred to interpret the spatial consequences of State policies on the landscape. A contemporary translated version of *teerth mahatmyas* (pilgrimage guides), ancient Sanskrit texts dating back to the 15th century, served as a valuable source with regards to myths and cultural practices interwoven with pilgrimage routes and the landscape of Garhwal. For analysis of the contemporary landscape, including ongoing developments and geological risks, base maps were prepared using geospatial data from India's National Remote Sensing Centre's Bhuvan geoportal, Geological Survey of India's Bhukosh, Pradhan Mantri Gram Sadak Yojana (PMGSY), and open street maps.

3 Results

3.1 Early settlements and adaptation of settling with/in forests (6th – 18th Century)

Early pastoralists and migrants from the Indian plains moved into the Himalayas for fodder and refuge. They cleared dense forests and consecrated nature by building temples dedicated to the sun, fire, and snakes (*naag*) near water sources. Early livelihoods included rearing livestock, exchanging borax, salt, and gold from Tibet, and extracting fodder, fruits, medicines, and timber from forests. Human settlements consisted of two to three-floor structures made of wood and stone (Singh, 1997). Early communities practised *khil* (shifting agriculture) on marginal lands, growing millets using animal manure. Gradually, the search for fodder and pastures for their livestock resulted in seasonal and annual migrations across various ecological floors (Raturi, 1938; Saklani, 1998). Human mobilities across the region formalized the Hindu tradition of conducting yatra (pilgrimage) in the Garhwal Himalayas. T*eerth mahatmyas* (literature composed between the 8th-15th century) elaborated the practice of *sthawar tirtha* (pilgrimage to immovable places) across ancient Garhwal. The literature elaborately described the routes and customary practices to be followed during pilgrimages. Pilgrims and traders obtained food, fuel, and shelter near the forests or villages along the route (Todariya; Ohri, 2016; Whitmore, 2018). As a result of centuries of ebb and flow of human mobilities—pastoralists, cultivators, pilgrims, traders, and others fleeing persecution or famines—Garhwal's "first nature" (fig. 3) evolved around the notion of settling with/in forests (Raturi, 1938; Saklani, 1998).

Raithal, a sedentary village within the case study, flourished in the 15th century along an ancient trade and pilgrimage route. An abandoned sixth-century sun temple and several snake (*naag*) temples near forests suggest earlier settlements. Folklore celebrates *Rana Gambheru*, a feudal landlord who took refuge near the forests in the 15th century. Over the centuries, Raithal grew around the *panch-pura*, a five-story deodar wood mansion built by *Rana Gambheru* (S. Rana, personal communication, February 2020). Local forest species influenced local cultivation and livestock rearing, resulting in settling practices unique to the region. Today, an entire repertoire of settling practices developed in response to the ecological floors remains. Permanent settlements (*gaon*) are found on spurs (*dhar*), with slopes (*dhuras*) around the settlements preserved for cultivation. Cultivation was practised on terraces (*khet*), and rocky edges of the forest (*katil*) were cleared to build homesteads (*channi*) and were occasionally cultivated in relation to the permanent settlements. Seasonal migration or transhumance was practised within summer camping sites (*tappad*) and the alpine meadows (*bugyals*) (Awasthi et al., 2003; Negi and Maikhuri, 2017). Raithal's morphology (fig. 4) evolved through agroforestry practices in response to seasons, and the need to obtain food, fuel, fodder, fertiliser, fibre, timber, and medicine from the forests and alpine pastures.

Figure 3. Agroforestry, trade and pilgrimage sustained Garhwal's "first nature." Early settling practices existed along an altitudinal gradient. Collage: Manna, adapted from 'Views in India, chiefly among the Himalaya Mountains' by George Francis White (1836), 'The Map of 'Territory Restored to the Rajah of Garhwal' (1841) (Mountains of Central Asia Digital Dataset) and The Gazetteer of Garhwal Himalaya (1910).

Figure 4. A 'thick description' of Raithal's "first nature" includes (A) a superimposition of ecological floors, forest, and human occupation in the century (B) a 6th-century sun temple at Raithal village (November 2022); (C) a 300-year-old *naag* (snake) temple which protects the sacred *thuner* (*Taxus wallichiana*) groove at Sukki (31.00° N, 78.69 ° E) along the ancient pilgrim route (November 2022) and (D) the 15th-century *Panch-Pura* in the village's historic core (February 2020). Drawing and photos: Manna.

3.2 Contested figures: forest transformation through 'State' policies and non-state resistances (1823-1980s)

In pre-colonial Garhwal, the king controlled all lands and decided their use. The forest was central to the village, as communities collectively managed forests and thrived from husbandry and agriculture. In 1816, The East India Company (EIC) annexed Garhwal and established Tehri State as a subordinate (Guha, 2000). Beginning in 1823, a series of colonial 'Settlement Surveys' were prepared to classify the landscape based on potential revenue. Village configurations, farmlands, forests, uncultivated commons (*gaon-sanjait*), and cultivable blocks (*thok*) were measured, including human and livestock censuses. Farmlands were classified based on their productivity into (1) irrigated terraces (*talaon*) with clayey soil, (2) unirrigated terraces (*upraon*) with loamy gravel, (3) inferior terraces (*ijran*), and (4) deforested edges (*katil*); the latter two had impoverished soils (Walton, 1910; Rizvi, 1979). Weak forest management, based on the 1823 "Settlement Surveys," (fig. 5) depicted hastened deforestation, forced unpaid labour (*coolie-begar*) of locals, and an increased practice of cultivation on recently deforested slopes (*naya-bad*) (Negi and Todaria, 1993; Pathak, 1997). In the 1850s, Tehri State leased forest 'blocks' along the Bhagirathi River to Frederick Wilson, an enterprising British timber contractor and later to the Provincial

Figure 5. Landscape classification, ownership, and revenue surveys led to the loss of Raithal's early commons. The 1939 Survey of India Map of Tehri State distinguishes "State" and "non-state" ownership through forest boundaries, agriculture, and settlements. Drawing: Adapted by Manna from the 1939 Survey of India toposheet Nr. 53 J NE Tehri-Garhwal, 126k Maps of South Asia. https://zenodo.org/record/6513238 [Accessed 4 May 2022]

British Government in 1864. Following the construction of the Upper Ganges Canal (1842-54) and railways (1850s) that required large amounts of wood, large-scale deforestation occurred along the upper catchment of the Bhagirathi River, including the forests around Raithal (Raturi, 1938; Pathak, 1997).

Rapid deforestation in Garhwal and elsewhere on the Indian subcontinent became an 'economic concern' for the colonial State. The Indian Forest Act of 1865 (later amended in 1878 and 1927) granted the State sole ownership of all Indian forests. Under the act, the forests were categorised into (1) Reserved Forests for resource extraction, (2) Protected Forests for conservation, maintenance of watersheds, and prevention of soil erosion and desertification, (3) Village Forests for local needs, (4) Private Forests, and (5) Wastelands (Guha, 2000; Rangan, 1995). Village commons were often demarcated on sparse forests or *benaap* (unmeasured) land. Access to seasonal grazing was essential for keeping livestock healthy, an important 'non-state' possession amongst villagers and transhumance communities. Locals often burnt forest undergrowth to facilitate the growth of fodder grass, a customary non-state practice to date. As a measure of 'conservation,' the State prohibited all 'non-state' practices such as grazing, the lopping

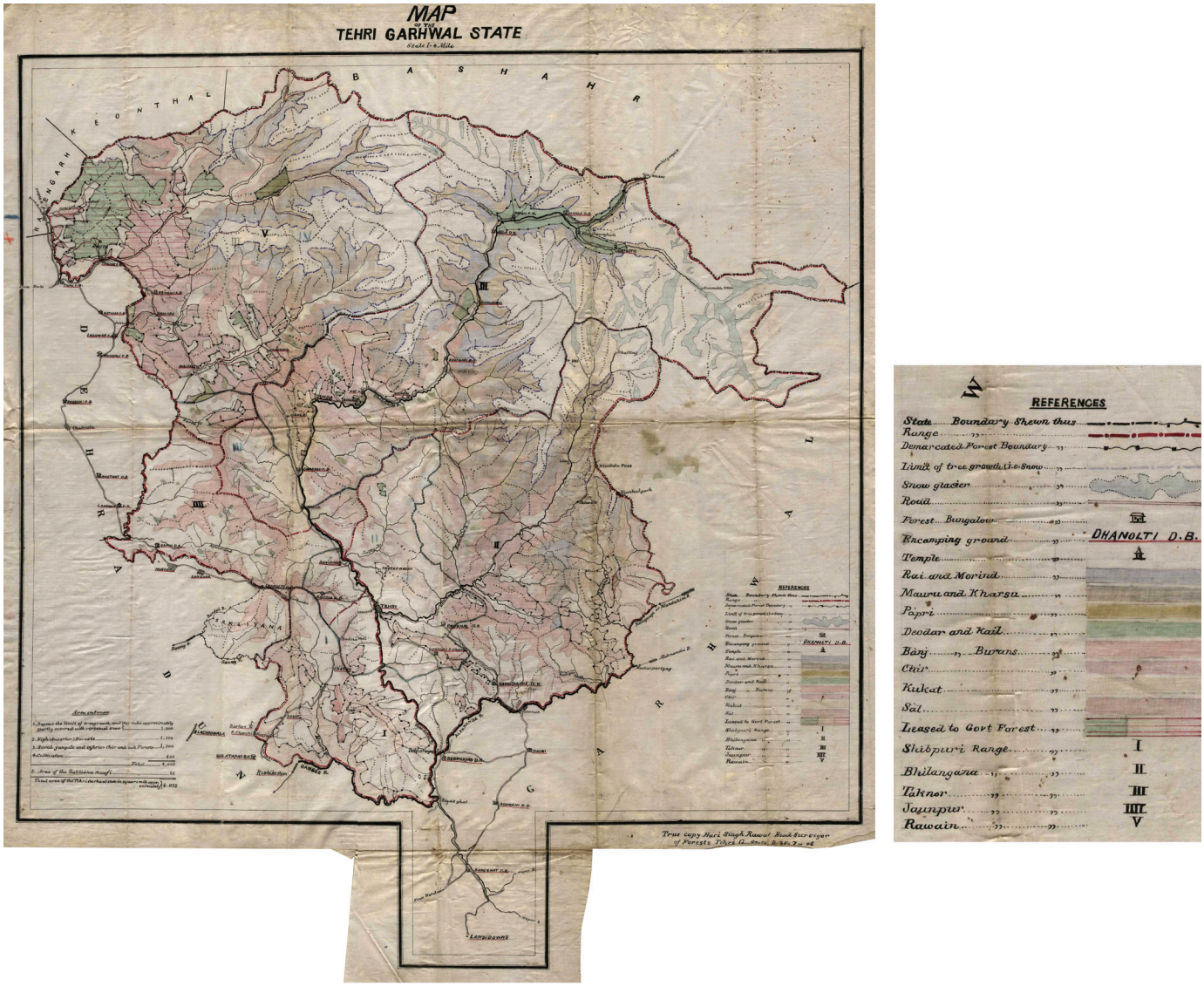

Figure 6. The Tehri State Forest Working Plan of 1906 relied on colonial scientific forestry, with a focus on economic benefits, as shown by the legend's inclusion of exclusively profitable forest species. Map: The Tehri Garhwal State by H.S. Rawat, 1906, Mountains of Central Asia Digital Dataset.<https://pahar.in/pahar/1906-tehri-garhwal-state-by-hs-rawat-jpg/> [Accessed 18 November 2019]

of branches, and forest floor burning. Without forest access, villagers often depleted the village commons of existing trees. Banj-oak (*Quercus leucotrichophora*), a locally beneficial species—that regulate hydrological cycles and provides leaves as animal food and wood for farming tools—was largely exhausted to meet fodder and fuelwood needs (Pathak, 1997; Guha, 2000).

In the process of creating "legible State forests" that could be easily managed and harvested, "scientific forestry" and "Forest Working Plans" were prepared to exploit Indian forests (Pathak, 1997; Guha, 2000). "Scientific forestry" and "Forest Working Plans" were limited to commercially valuable species, resulting in extensive landscape manipulation to meet the State's economic needs. In 1897, the Forest Working Plan (fig. 6) of the Tehri created "Chir," "Deodar," and "Protection" forest working circles for systematic silviculture, and prevention of "exploitation" by locals (Raturi, 1938). At the end of the nineteenth century, the State converted all unmeasured lands into Protected Forests, limiting villagers' access to forest resources. Several peasant uprisings broke out across Garhwal due to the destruction of livelihoods, restrictions on traditional and customary rights, massive clear-felling, monoculture plantations, and the regeneration of only commercially valuable species. *Dhandhak*, a traditional and nonviolent protest, emerged as a critical 'non-state' response which demanded the restoration of local forest rights. In response to state-wide *Dhandhaks*, some forestry-use rights were restored in 1921. Economically less valuable *soyam* (uncultivated 'wasteland') was made available to the village councils (*panchayat*).

In 1949, Tehri State was incorporated into independent India, with Uttarkashi becoming a frontier district along the Indo-China border. Cash crops such as potatoes, oil seeds, and apples were introduced in the 1950s to incentivise 'development.' The farmers in villages located above 1800 msl, like Raithal, welcomed cash crops such as apples and potatoes over climate-resilient millets such as *jhangora* (E*chinochloa frumentacea*) and *manduwa* (*Eleusine coracana*). As subsidised cash crops became a farming mainstay, ecological and morphological changes became evident throughout the landscape. By the 1960s, fertiliser use rose from 11.2 to 189 tonnes in the Uttarkashi district. By 1964, 34,950.7 hectares of land within the district was under cultivation (up from 22,193.3 hectares in 1924), with cash crops and orchard terraces carved out along poor, unirrigated *katil* (forest edges) or *benaap* (unmeasured) lands (Rizvi, 1979). Incentivised cash crop cultivation had devastating, long-term impacts on mountain farming. Crop rotation and the usage of forest leaf manure diminished, reducing the soil's organic composition, and increasing erosion. Reductionist commercial agriculture, like scientific forestry, failed to adapt to the indigenous systems of terraces and traditional agroforestry (fig. 7) (Shiva, 1988; Pathak, 1997; Guha, 2000).

A parallel can be made with Cronon's "second nature" about the extensive alteration of Chicago's hinterlands which increasingly became bound to State-controlled market forces (Cronon, 1991). The regime of land ownership and forestry under the colonial State (and its postcolonial continuation) created a highly extractive "second nature" across Garhwal. Increasing demands for railway sleepers, building materials, resin, and paper favoured the afforestation of fast-growing conifers from 1000-2135 msl in 1960s-1970s. Previously, large deforested tracts and village commons were afforested with fast-growing conifers (Maikhuri et al., 1997). Reductionist postcolonial commercial forestry compromised the ecological floors by altering forest species, disrupting water cycles, and topsoil degeneration. Forests of deodar and banj-oak, which were critical to regulating local hydrology were systematically replaced by same-age chir-pine to extract lumber, charcoal, and resin. These disconnected human-forest links resulted in poor agricultural conditions throughout Garhwal (Shiva, 1988; Pathak, 1997). By the late 1980s, Raithal and its neighbouring villages lost all their apple orchards and experienced a decline in cash crops due to the poor soil quality (S. Rana and S.Raturi, personal communication, February 2020 and November 2022). In the late 1970s and early 80s, a series of natural disasters impacted commercial forestry on Uttarkashi's landscape. Widespread floods and heavy rains as well washed away agricultural terraces and destroyed local livelihoods (Parkash, 2015). In the absence of their pre-scientific forest communities, the same-age, mono-species forests could not nat-

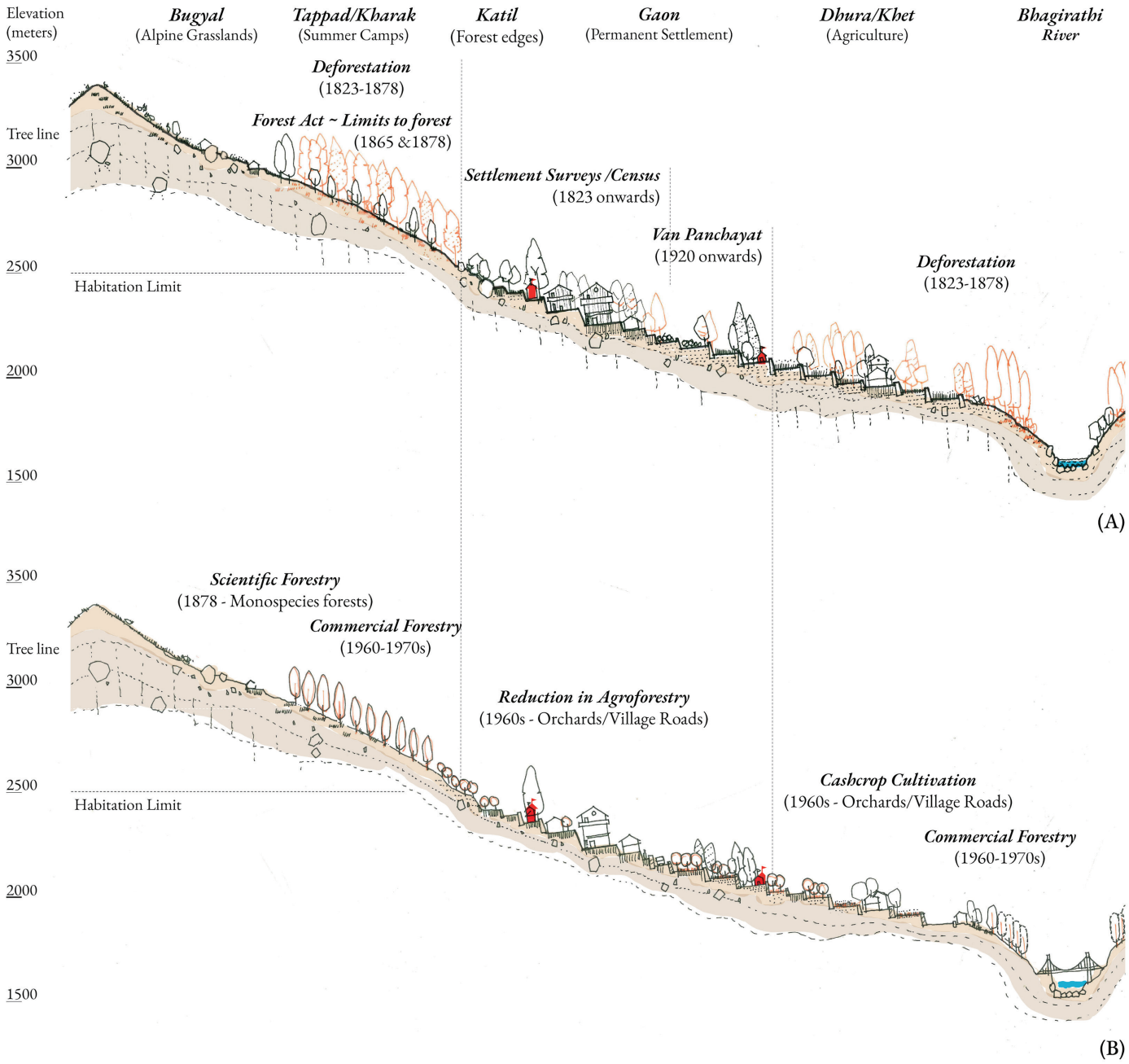

Figure 7. The sections reveal the imposition of "second nature" and reductionist forestry. (A) Consequences of the Forest Act classified "State" and "non-state" ownership and replaced Raithal's customary forests; (B) Ecological diversity was further reduced during the post-Independence cash crop revolution and commercial forestry, which continued to follow the colonial figures and favoured economically valuable species. Drawing: Manna.

urally regenerate, limiting their ecological function. In the early 1970s, increasing commercial forestry, dwindling agriculture, and the end of customary forest access rekindled non-state resistance across Garhwal in the shape of the *Chipko* (hug the tree) movement. *Chipko* opposed the State's reductionist forest policies. It resulted in the enforcement of the 'Uttar Pradesh Tree Protection Act of 1976', banning the felling of certain species, and a 15-year ban on commercial forestry above 1000 msl. *Chipko*'s success, on the other hand, had a significant negative impact on forest villages situated above 1000 msl. As forest felling was banned, forest cooperatives were disbanded, ceasing the local livelihoods that relied on daily wages or commodity extraction of forest resources (Rangan, 1996; Guha, 2000).

3.3 Impact of border roads, natural disasters, and mass tourism on forests (1962 – ongoing)

Military infrastructure and highway modernisation in the Himalayas increased after India's loss of the 1962 Indo-China War. Since the formation of Uttarakhand as a new state in 2000, large-scale infrastructure development has increased the flow of people, commodities, and energy across Garhwal, ignoring its fragile landscape (Sati, 2005; Pandit, 2017). At the same time, over 50,000 hectares of forests were lost due to the construction of roads, highways, power lines, and hydropower dams since 2000 (Azad, 2020). Since the early 1990s, Garhwal has also been devastated by earthquakes, glacial and cloud outbursts and landslides (Parkash, 2015). Despite these hazards, several large projects, including the planned 889 kilometres long '*Chardham Mahamarg*' a double lane, 'all-weather highway' and railways connecting four Hindu *dhams* (pilgrimage sites), facilitate a massive influx of tourists, pilgrims, and troops across Garhwal. The 120-billion-rupee ($ 1.5 billion) highway includes the construction of 12 bypasses, 15 flyovers, 101 bridges, 3,596 culverts, and several tunnels, primarily through forested and landslide-prone areas of Garhwal (SANDRP, 2018). The final 94 kilometres long route of the Chardham Highway to Gangotri temple cuts through the 4179.59 sq. km Bhagirathi Eco Sensitive Zone (BESZ) (fig. 8). It is estimated that 12,000 trees, including 6000 deodar trees, would be felled to widen the highway passing through the BESZ (S.Raturi, personal communication, November 2022). Large-scale loss of climax forest species, including the deodar, will have a cascading impact on local ecosystems, similar to the adverse impacts of colonial deforestation and postcolonial commercial forestry.

Forest degeneration in Garhwal is not limited to large infrastructure, but has also been linked to rural road construction since the 1960s. Uttarkashi district lies within the 'Seismic Zone IV,' a severe intensity zone with potentially high damage during an earthquake. Since 1803, several earthquakes, landslides, flash floods, and land subsidence have claimed lives and destroyed livelihoods (Parkash, 2015; Yadav et al., 2020). In 1991, a 6.8 magnitude earthquake struck Uttarkashi, with its epicentre 11 kilometres south of Raithal, killing 768 persons and 3,086 livestock, injuring 5,060 persons, and destroying over 20,000 houses and agricultural terraces (Revi, 1992; Ravindra and Das, 1993; Parkash, 2015). Following the series of large-scale disasters, forest lands were diverted for the construction and rehabilitation of rural roads. Uttarkashi's road length doubled from 856 km in 1991 to 1472.81 km in 2021 (Arora, 2021). Under the "Pradhan Mantri Gram Sadak Yojna (PMGSY)", a state funded rural infrastructure and poverty alleviation project, 97 kilometres of new rural roads are planned to connect the high-altitude forest villages within the BESZ. As many of these villages are located near forests, new road cross-sections result in forest fragmentation and changes in local geology (Batar et al., 2017; Santoshi, 2023). The homogeneous 'engineered' cross-sections are rife with keywords such as 'widening,' 'rehabilitation,' 'upgradation,' 'design length,' 'chainage,' 'lanes,' 'paved shoulder,' 'landslide treatment,' and 'slope stabilisation,', synonymous to reductionist scientific forestry. These engineered road designs ignore the notion of "thick description" (Geertz, 1973) and qualities associated with Himalayan forests, species, watersheds, soils, terraces, and settlements. A new 12-kilometre-long road opposite Raithal is being constructed by blasting and cutting the mountain's edge for seventy-eight million Indian rupees ($ 980,000) to connect the remote villages of Pilang and Jadao to the highway (fig. 9 A-B). A total of 323 trees of twelve local species will be felled, with 'compensatory' afforestation done on a 13.5-hectare patch of degraded land situated thirty kilometres away (S.Raturi, personal communication, November 2022).

With the modernisation of highways and the construction of rural roads, village settlements expanded into agricultural terraces and forest edges. Bhatwari, a colonial timber depot south of Raithal and pilgrim stop to Gangotri, became a market town, and has schools, health care, administrative, and transport facilities. Bridle paths to Raithal were replaced by motorable roads after the 1991 earthquake (S. Rana, personal communication, February 2020). Raithal's traditional built-up area grew significantly after the 1991 earthquake. Affected families could not rebuild centuries-old vernacular houses due to State restrictions on obtaining timber and stone

Figure 8. The imposition of infrastructure on the landscape. Highlighted are landscape hazards, forest densities, forest fires, hydropower infrastructure, Chardham Highway growth, and rural road impacts on local forests. Drawing: Manna, adapted from data obtained from Bhuvan, Bhukosh, PMGSY geoportals, and OpenStreetMap (May,2022).

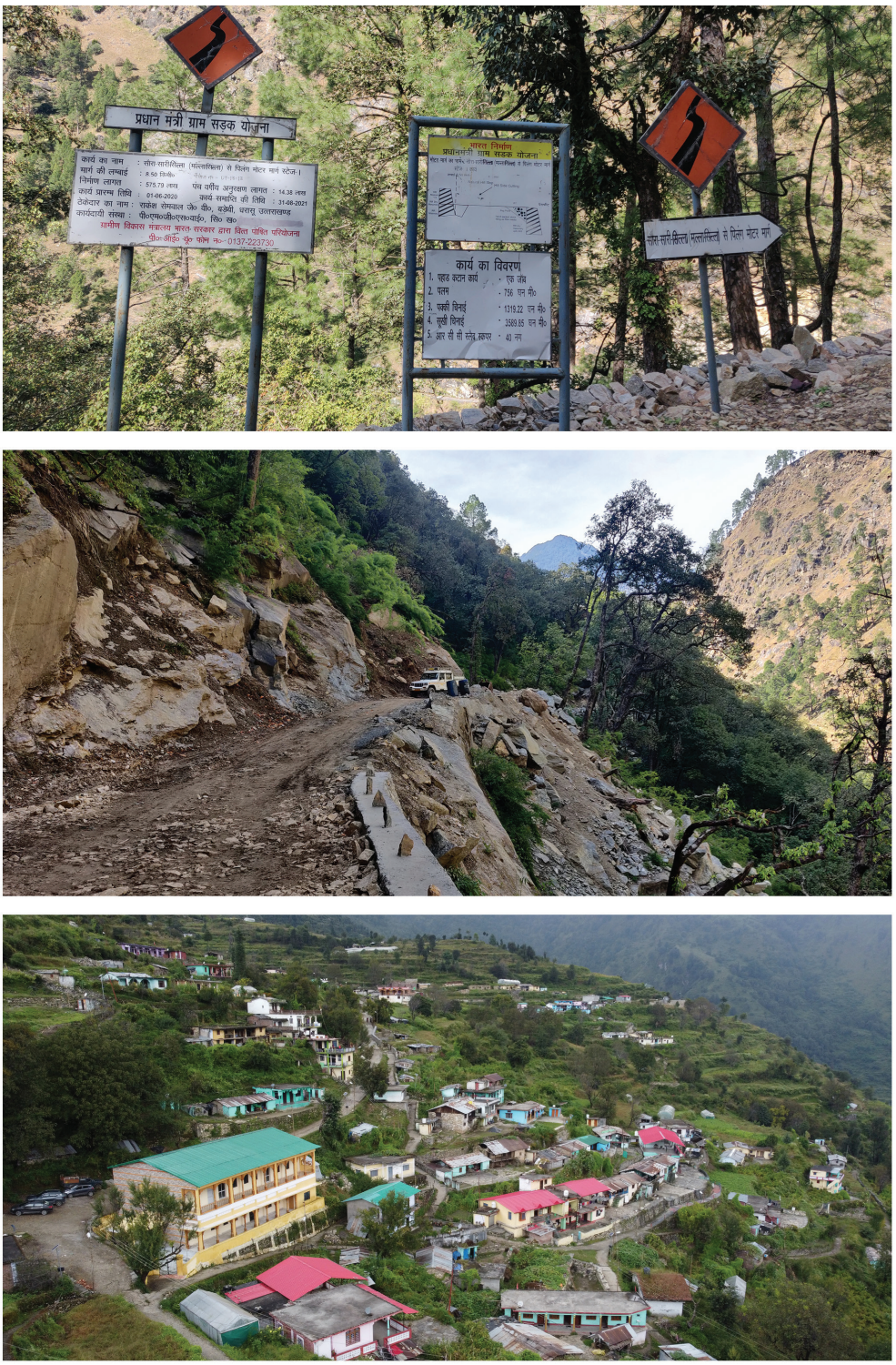

Figure 9. Imposition of infrastructure on the contemporary landscape. (A) Road project signage describes engineered details such as road length, details of slope cutting, excavation (November 2022); (B) The blasting and cutting of the mountains for the new road results in a fragmented forest (November 2022); (C) Raithal continues to expand into its agroforestry lands since the 1991 earthquake and influx of tourism (October 2021). Photographs: Manna.

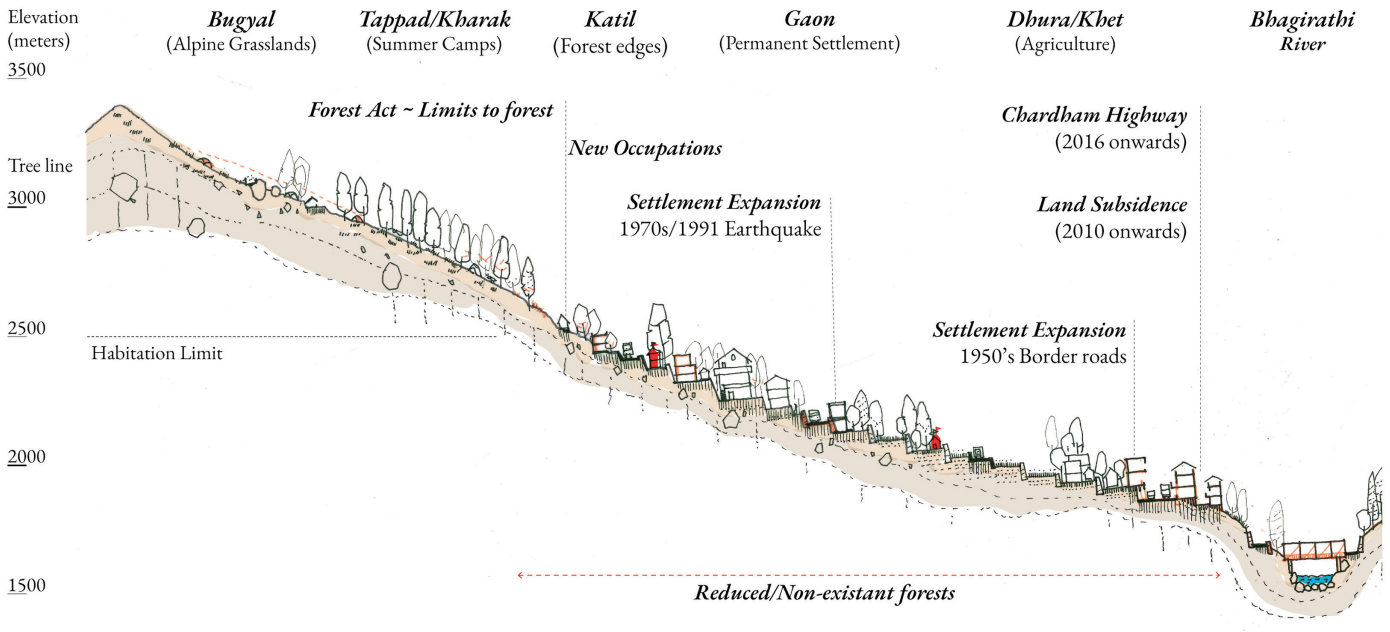

Figure 10. The imposition of contemporary infrastructure and increased anthropogenic activities on the landscape. Grazing and tourism in the alpine pastures as well as the construction of highways is resulting in increased topsoil erosion and land subsidence. Drawing: Manna.

from the forests. Therefore, repurposed debris and State-supplied disaster relief materials, such as corrugated tin roofs, bricks, and cement, were used to build modern houses in village outskirts (Revi, 1992; Ravindra and Das, 1993). The construction of '*Chardham Mahamarg*' has resulted in a ten-fold increase in tourists to the Gangotri Temple and a growth in speculative built-up along its route (Whitmore, 2018). The alpine meadows of Dayara (3800 msl), above Raithal, became a major year-round trekking destination. Raithal's speculative built-up area can be experienced through house extensions, added floors, new earthworks, and the carving terraces for hotels, homestays, and guesthouses that replace former cattle sheds and orchards (fig. 9 C).

The speculation of built-up areas in Raithal and Bhatwari was further triggered by the diversion of agricultural and forest land for hydropower infrastructure and disaster relief projects. The 600 MW Loharinag-Pala hydropower project was one of several projects planned along the Bhagirathi River. Without accounting for the loss of fuelwood, pastures, and other local shared resources, the project resulted in the loss of 144 hectares of community forests along its route and 26 hectares of agricultural land below Raithal. The Loharinag-Pala hydropower project was halted in 2010 due to local resistance, but its 16-kilometre-long mountain tunnels which diverted the river's flow to the powerhouse were already completed. Several studies in local communities have identified an increase in land subsidence (12-22 mm/year) along village roads, market areas, and agricultural terraces since the 2010s due to geological failure, historical deforestation, and increased anthropogenic activities (Yadav et al., 2020; Sundriyal et al., 2023). Today, the case study's landscape (fig. 10) is dominated by both geological risks and speculative real estate projects.

4 Discussion

The research interprets an interplay between forest dynamics and human settlement patterns through a "thick description" of territorial transformation. It focuses on aspect that are often neglected in contemporary state development narratives. The early settlements had intimate forest-settlement relationships, with seasonal mobilities. There were also pilgrimage routes used by non-inhabitants, and which have long been part of the cultural identification of the region. However, landscape interventions imposed by forest policies of the colonial state and the post-independence system of commercial forestry

and cash crops deteriorated forest-settlement relationships, giving rise to several non-state resistance movements and daily-life practices. Aggressive contemporary infrastructure building has resulted in speculative development, which in turn accelerated material and human mobilities. The increased frequency and intensity of with natural disasters, has resulted in Garhwal's forests being at the forefront of large-scale ecological degradation. Conflicts between State Forest policies and non-state practices also resulted in the spread and dominance of certain tree species across the landscape. Raithal's forests reveal a sequentially structured "second nature", dominated by the State-promoted, water-intensive chir-pine and the locally beneficial, water-conserving banj-oak (fig. 11). Dry needles of chir-pine limit forest regeneration by preventing undergrowth and increasing the risk of forest fires (S. Raturi, personal communication, November 2022). Between April and May 2022 alone, 37 forest fires occurred in the area of Uttarkashi and Raithal, most within the chir-pine forests (Kotnala, 2022). Increased forest fires are followed by amplified soil erosion and landslides as well as the growth of invasive species such as lantana (*Lantana Camara*). In turn, lantana displaces fodder grass and further increases the risk of forest fires, preventing forest regeneration and accelerate land degradation during dry season across Garhwal (Mungi et al., 2018). These adverse impacts persistently disrupt ecosystems and have a severe impact on agriculture, which is the mainstay of the Garhwal's livelihood (Rao et al., 2016; Mungi et al., 2018).

By further revising its forest policies, the State intends to divert more forest land for mining, commercial exploitation, infrastructure development, and compensatory reforestation linked to such developments. The recent amendment to the Forest Conservation Act (1980), aims to 'develop and manage' Indian forests. The proposed amendment exempts forest clearance for infrastructure within 100 kilometres of the international border and "fast tracks strategic and security-related projects of national importance" (Government of India, 2023). Diversion of village forests for development purposes will no longer require the agreement of local communities and *panchayats* (village councils). Further, Uttarakhand State amendments include the classification

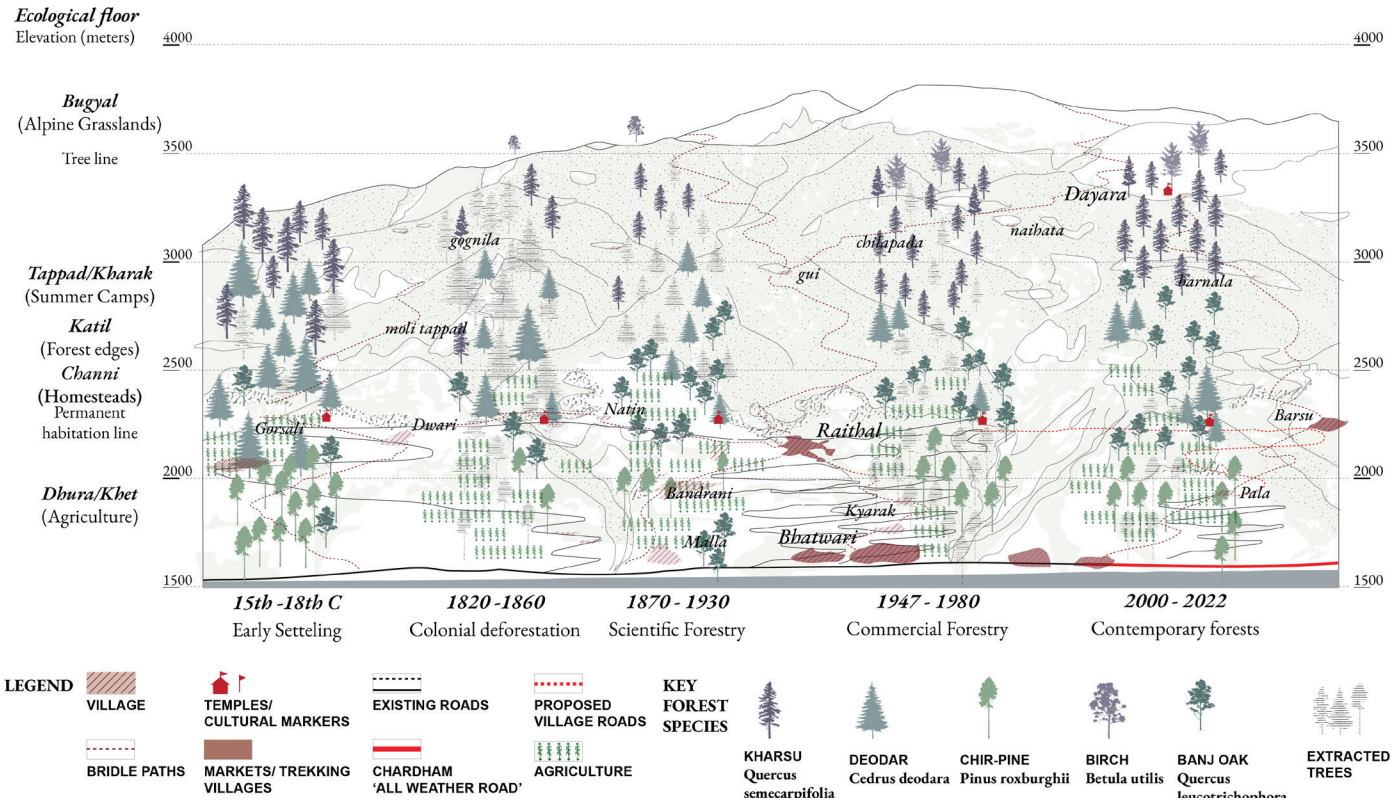

Figure 11. A comparative analysis of the case study's ecological floors highlights dominance of chir-pine and banj-oak, ecological gaps within the forest figures. Drawing: Manna.

of "forest" as a land of at least ten hectares, with a forest canopy density of 60 percent and 75 percent native tree species. The amendments further allows the 'diversion of forest land' from hilly or mountainous areas and conducts compensatory afforestation without consulting the local communities (Sehgal, 2021). As forests are critical for rural communities, increased global warming and proposed State policies will significantly impact the village groves and accessible forests outside State Forest boundaries—locally known as *jungle*, *ban*/*bani*, *jhadi*, *benaap*, and *soyam*—compromising local agroforestry practices. These challenges further burden rural communities, particularly women, who walk between five and eight kilometres daily to collect fuel wood, fodder, and leaf litter for their households (Negi and Todaria, 1993; Dasgupta et al., 2022). The changes in the law erode the constitutionally recognized rights of forest-dependent communities, as enshrined in the Forest Rights Act (2006). They diminish the participation of local van panchayats in forest governance, further exacerbating the slow implementation of forest rights (Sushmita, 2022). Clearly, both State and non-state practises will continue to shape future forest figures and local morphological changes. It is also evident that existing localised activities must be evaluated for their potential significance in balancing forest use and conservation.

4.1 Towards future forest figures, countering ecological ruptures

As the State continues to revise its forest policies, non-state claims and adaptations continue to appear in the case study. Since 2016, earnings from increased tourism, microloans, and State-sponsored schemes have diversified livelihood adaptations across Raithal and its neighbouring villages. Several families now run homestays as part of the '*Veer Chandra Singh Garhwali Paryatan Swarojgar Yojana*', a tourism-led livelihood improvement scheme. Homestay numbers rose from two in 2011 to 23 in 2022. The increase of tourism within forests indirectly provides new livelihoods, as local youths operate trekking, taxi and tourist information services as well as work as porters, trek-leaders, cooks or guides (S. Rana and S. Raturi, personal communication November 2022). Adaptations such as vegetable greenhouses, drip irrigation tanks, organic composting, high-value crop orchards, afforestation of fruit trees, and cultivation of climate-tolerant millets are visible along the periphery of the village (fig. 12 A). Families have constructed water tanks that store rain and snow to grow vegetables in greenhouses all year. These adaptations have allowed households to diversify farm produce and increase their incomes. Suman Rana, a local farmer, built Raithal's first homestay in 2011. His homestay earnings have enabled him to improve his homestead (*channi*) (fig. 12B) with a new stone shed and rear two milch buffaloes. He planted flowering plants, high-density apples, pear, peach, walnut, green oak (*Quercus floribunda*), *chullu* (wild apricot), and banj-Oak, which his family occasionally uses as an alternative to forests for fuel wood and fodder.

Environmentalists Sundar Lal Bahuguna and Vandana Shiva have emphasised that Garhwal's forest and its diversity of trees, shrubs, legumes and grasses are integral to Garhwal's cultural practices (Shiva, 1988; Awasthi et al., 2003; James, 2013). Similarly, landscape adaptations are not only limited to individual households; they also exist as vernacular practices and customs that strengthen local forests, linking them to the cultural beliefs of the local community (fig. 13). Customary traditions, such as conserving deodar trees near temples and sacred groves and protecting village deities within the forests, continue to exist (Singh et al., 2017). Festivals such as *dhundi utsav* (butter festival) at *Dayara bugyal* (alpine meadows) celebrate the return of cattle and shepherds from alpine meadows, *Naag Panchami* (snake worship) at the forest grove, *Selku mela* (flower festival) at Raithal encourages cooperation amongst villagers. Local women groups prefer planting banj-oak on their land, which provides more fodder for the cattle, even during the harsh winters. The revival of organic farming using leaf litter as livestock insulation and farm manure, mixed cropping, millet cultivation, migration to alpine pastures, rotational grazing that limits soil erosion, and afforestation of water-conserving species highlight the continuation of traditional farming practices (Awasthi et al., 2003). Planting dense fruit orchards and medicinal plants conserves water while providing an opportunity to recreate forest canopies, regenerating local ecology, increasing landscape productivity, and supporting

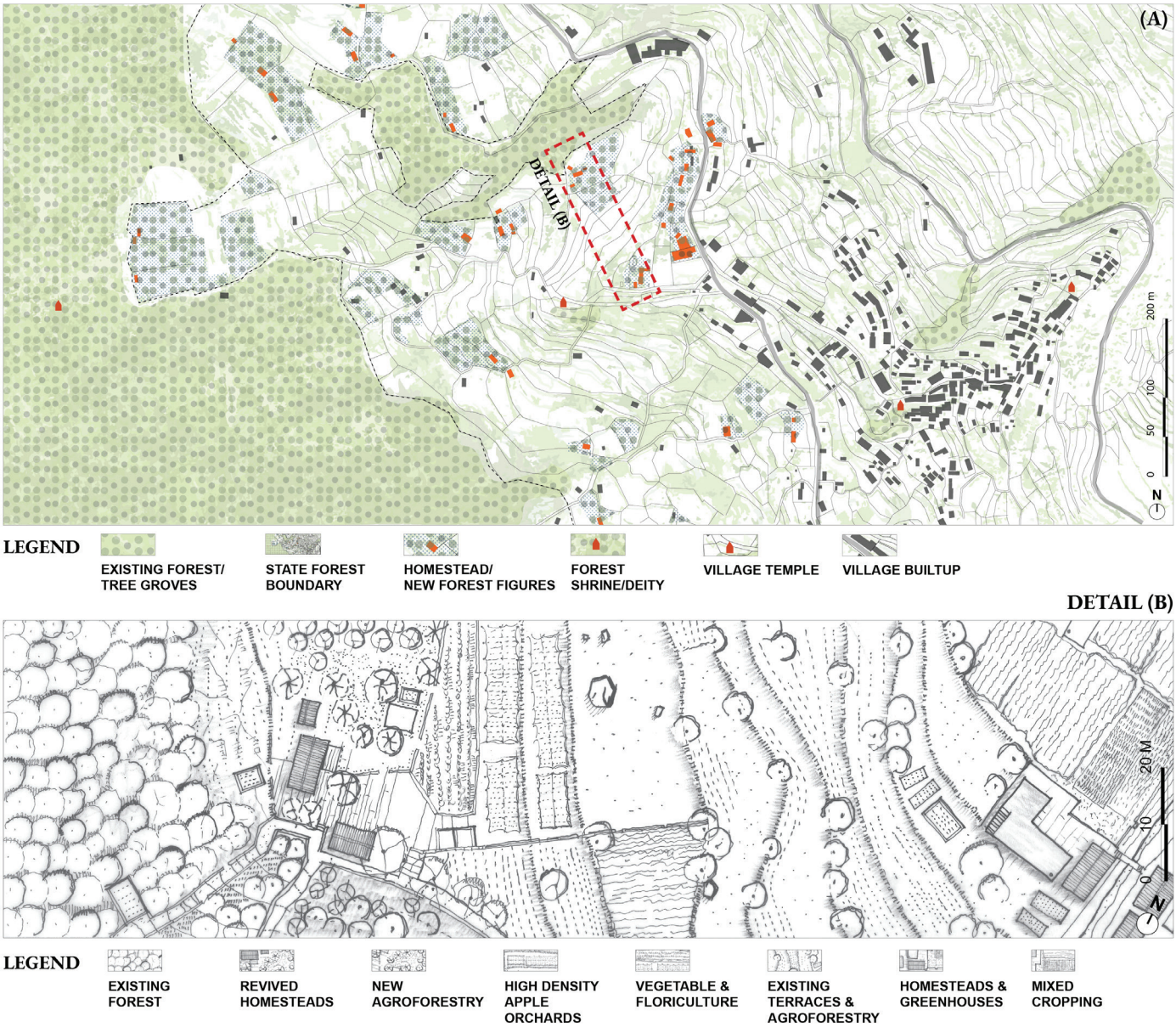

Figure 12. Forest figures outside the State forests boundaries. (A) A series of village homesteads help local communities revitalise agroforestry, revive traditional practices that collaborate with the existing forests, and strengthen the local forest figures; (B) A detail of the village *channi* (homestead). Drawing: Manna.

local livelihoods (Rautela and Karki, 2015; Papnai et al., 2020). Small-scale yet critical 'non-state' practices such as the '*beej-bachao*' (save the seeds) and the cultivation of '*barah-anaaj*' (twelve grains) continued to resist the predominance of cash crops by cultivating nutritious and climate-resilient local crops in Garhwal (Shiva, 1988). Local Van Panchayats (village forest councils) and *Mahila Mangal Dal* (women's self-help groups), have successfully restored degraded forests in Kangad village (1977), Henwal River watershed (2005 & 2018), and Ranichauri (2011), combining agroforestry, afforestation, and watershed development (Shiva, 1988; Dewan and Rautela, 2001; Sahay et al., 2019). These community-led changes have contributed to a revived sense of ownership and shared responsibility for forest commons, ensuring a wide range of ecosystem functions, such as carbon sequestration, water storage, biodiversity conservation, food security, and strengthened livelihoods (Thadani et al., 2015; Papnai et al., 2020). Though speculative in nature and suited to changing scenarios, adaptations continue to appear and reclaim the region's ecological floors

Figure 13. The sustained involvement of non-state actors plays a pivotal role in fostering the continuity and revitalization of traditional practices and innovative adaptations; (A) Locally protected forest grove near the village temple and water source (September 2021); (B) Revived *channi* (homestead) incorporates agroforestry, livestock, and high-density apple orchards and strengthens local forest figures. (February 2020); (C) Local youths have reclaimed their family's high-altitude ancestral homesteads for grazing livestock, harvesting alpine medicines, and hosting alpine tourists (October 2021). Photographs: Manna.

5 Conclusions

While the larger mobilisation of people, properties, material entanglements and infrastructure are being studied in the western Himalayas (Negi et al., 2016; Negi, 2023), this study highlights the importance of morphological modification and local adaptation linked to 'settling with/in forests'. By developing a "thick description", this research concludes that Garhwal's contemporary forests will continue to transform due to the dynamic interactions between the State's forest policies and non-state practices. As the State policies continues to facilitate a "second nature" through infrastructural projects, the region's forests will continue to bear the lion's share of the environmental consequences. Despite their differences, there is an urgent need for State policies and non-state practices to complement each other to create resilient forest figures that can respond and adapt to climate change and global warming. "Thick descriptions" reveal a nuanced approach to identifying forest figures, their ecological ruptures, and their latent potential for responding to contemporary crises. The study highlights the importance of local adaptations because of a constant interaction between state policies and locals that stimulate conservation, livelihood opportunities, and morphological changes, with the potential for broader implementation and expansion. As global warming continues to negatively influence agroforestry and livestock practices, it threatens large populations across Garhwal Himalayas. Lessons from the case study invites researchers, experts, and policymakers to reimagine forests as complex societies rather than just as species, forest classification, forest boundaries, biomass, or canopies. The study highlights the importance of integrating existing and future settlement patterns—integrating traditional knowledge, water, forests, and new settlement typologies for settling with/in Garhwal's forests—for the local communities to thrive. The study emphasizes the importance of local adaptations and their potential to be scaled up and impact future State policies. It should be noted, however, that this research does not capture the whole ecological diversity and seasonality of the case study, nor does it quantify the social, environmental, and economic implications of these adaptations within its restricted time frame. These limitations suggest that long-term research and monitoring are required to fully understand the benefits and impacts of local adaptations.

Conflicts of Interest

The authors report no potential conflict of interest.

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