Climate Change and Migration in Bhutan: An Integrative Review

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Abstract: Bhutan is the world's first carbon-negative country, yet it is disproportionately affected by climate change, including rising temperatures, shifting precipitation patterns, and glacial retreat. Today, the country is faced with two profound existential threats – climate change and emigration-driven demographic change. This integrative literature review examines the emerging relationship between changes in the environment and a country's demographic shift, including both internal and international migration. On the one hand, climate hazards are intensifying both in frequency and degree of damage, and on the other hand, migration in Bhutan is driven primarily by economic, professional development, and aspirational reasons. An increasing number of academic and grey literature reveal that climate change acts as a background stressor, gradually driving migration through amplified compounded precarity and influencing the decision to migrate as a potential adaptive strategy for risk diversification in the face of declining agricultural

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productivity. However, there persists a gap in longitudinal research – both quantitative and more so qualitative – to establish two-way influence. There remains a prospect of integrating traditional ecological, socio-cultural, and spiritual knowledge in scientific assessment to understand local adaptation strategies. This article advocates for interdisciplinary policy approaches that bridge climate adaptation and migration governance to better understand the complexities of human mobility and the changing climate.

Keywords: Bhutan, Climate Change, Migration, Integrative Literature Review, Compounded Precarity, Livelihood Strategies, Adaptive Capacity, Sustainable Development, Interdisciplinary research.

Introduction

Bhutan is disproportionally vulnerable to climate change. Its impacts are 'already-there', caused by global factors and trends. The country itself has pledged to remain carbon-neutral as a part of its nationally determined contributions during the Paris Agreement, rectified on 19 September 2017. Bhutan today is carbon-negative.

Despite strong traditions of environmental stewardship, as mandated by its Constitution, scientific assessments increasingly document rising temperatures, disrupted precipitation regimes, glacier retreat, and recurrent and intensified natural hazards. As a landlocked developing country with a fragile mountain ecosystem, studies show climate-related impacts on the country's economy, reliant sectors like agriculture, hydropower, natural ecosystems and biodiversity, and rural livelihoods. In view of Bhutan's development goal to become climate-resilient, which is integrated into every sectoral development pathway and strategy, it positions climate change as one of the most significant development challenges.

In parallel to emergent environmental transformation – primarily demonstrated through observations related to changing climate – Bhutan has experienced (and continues to experience) profound demographic change in the recent past. Starting from rural depopulation resulting in empty households (Gungtong) and empty land (Satong), to mass outmigration of youth to international destinations, migration continues to emerge as a significant socio-economic phenomenon. Migration scholarship in Bhutan largely views this through operational economic lenses, encapsulating education/skill and aspiration, employment and market opportunities, and the reconfiguration of rural socio-cultural aspects.

Given the simultaneous emergence of these trajectories – environmental and demographic transformations – their relationship and impending course in Bhutanese scholarship remains uncharted. While most of the climate research hinges on themes like climate variability, trend, and projection, assessment of vulnerability and impact assessment, and mitigation and adaptation, migration scholarship focuses on dynamics of changing demography, aspiration and economics behind migration, and socio-cultural changes in the place of origin.

This integrative literature review aims to critically examine – based on fragmented studies spread across various distinct domains – whether migration can be situated within the climate change context in Bhutan. It frames climate change in the background highlighting its interaction (primarily stress) with environmental, economic, and socio-cultural changes while avoiding the premise of a direct causal relationship. It is guided by the need to understand, in the Bhutanese context, whether migration is i) an outcome of compounded precarity, ii) an adaptive strategy to ensure livelihood, or iii) completely independent of environmental changes. This is very contextual to Bhutan.

Although climate–migration linkage is substantially studied globally, examining relationship between impacts of climate change impacts and the factors of mobility, which influence degree and pattern of movement, these studies essentially underscore involuntary migration primarily coerced by environmental crises. There are records of increased frequency and extent of climate extremes and natural hazards in Bhutan but, as I will show, this global narrative framing is inadequate to capture the subtle interactive pathway of climate change and migration in a small mountainous country.

Anchored on the three major concepts of climate risk assessment framework (IPCC 2012; Van Praag and Timmerman 2019), environmental migration framework (IOM 2007; 2024), and sustainable livelihoods framework (Carney 2003; De Haan 2012), this integrative literature review explores three themes i) current status of climate change research in Bhutan, ii) prevailing patterns and characteristics of migration in Bhutan, and iii) evidence – direct or indirect – of linkage between climate variability and environmental stress, to migration decisions. It aims to bridge fragmented scholarship to identify opportunities for conceptual integration.

Methodology

An integrative approach allows for the inclusion and synthesis of various forms of evidence, including empirical, qualitative, theoretical, and policy-oriented literature. Studies related to climate change and migration cross-cut disciplines such as climate and natural sciences, geography, social and political studies, anthropology, economics, and developmental studies. In this context, integrative review permits a holistic understanding in the way that an otherwise narrowly defined systematic literature review would not. For this article, the integrative review is conducted in the style of narrative

synthesis, drawing on elements of both systematic and scoping review methodologies. Building on the systematic principle to ensure rigour of search and screening, scoping was first conducted to map the breadth of existing literature, to understand established concepts, trends, dynamics, and policy-related conversations, and ultimately point towards the research gaps.

A comprehensive search for published literature in three major academic databases – Web of Science, Scopus, and Science Direct – was conducted for their rich repository of peer-reviewed journals. Keyword combinations were employed centered around climate change, climate hazard, environmental change, climate vulnerability, climate resilience, climate adaptation, climate migration, climate mobility, climate displacement, (in Bhutan) using Boolean operators 'and' and 'or'. The initial search yielded 139 articles. These keywords were carefully selected with the aim of finding articles by searching through (and aligning with) research titles, abstracts, and research keywords, to ensure maximum relevance and manageability.

In addition, this review also includes so-called 'grey literature,' mostly institutional reports and policy papers, from relevant organizations and their websites: Bhutan Statistical Bureau, Centre for Bhutan and GNH Studies, Department of Environment and Climate Change, National Centre for Hydrology and Meteorology, Office of the Attorney General, Department of Human Settlement, Department of Agriculture, Department of Forest and Park Services, Office of the Prime Minister, United Nations – Bhutan, the United Nations Framework Convention on Climate Change, the World Bank, Asian Development Bank, Japan International Cooperation Agency, International Centre for Integrated Mountain Development. This was done in recognition of the fact that extensive knowledge on climate change and migration is produced beyond strictly academic journals. Exclusion of such knowledge would limit inclusivity and potentially undermine real-ground

representation as it captures contextual and ongoing trends and policy responses. The 'grey literature' review was conducted through manual (bibliographic) targeted search with prior knowledge of institutional outputs and from the reference lists presented in journal articles. Books, special publications, and compiled works – both qualitative and quantitative outputs – are also included in the synthesis of this narrative literature review.

For this article, literature was selected using a multi-staged screening process. After systematic search and identification of the literature, a scoping assessment was conducted for suitability and eligibility. A thematic annotation was done for each article. Given the design of this review, relevant and necessary information from deselected articles were also retained. For quality, Critical Appraisal Skills Programme (CASP) was used to assess clarity, methodological appropriateness, data applicability, and ethical consideration. However, selection of grey literature was primarily based on institutional credibility. Data extraction was carried out using the structured matrix, carefully considering themes of climate change, migration, and policy responses, and therein presenting trends and research gaps. Despite the integrative approach, this literature review may not have included every published article and has potentially overlooked variability in methodology.

Status of Climate Change Research in Bhutan

Nodal Agencies of Climate Research

The Royal Government of Bhutan (RGoB), together with its citizens, is constitutionally bestowed with the responsibility to protect the country's environment. The Department of Environment and Climate Change (DECC), under the Ministry of Energy and Natural Resources, serves as the secretariat to the National Environment Commission (NEC), functioning as a national

coordinating body for environmental governance. Within DECC, the Climate Change Division is responsible for coordinating and overseeing national climate change actions. They formulate policies, plans, and interventions, implement these, and submit reports to the government.

From the wider national development aspect, the impacts of climate change intricately link with Bhutan's development philosophy of Gross National Happiness, which prioritizes sustainable development for citizen wellbeing in ways that climate change threatens to obstruct. It integrates the need to maintain ecological diversity and resilience within development strategies. Yangka *et al*. (2023) point out that Bhutan's carbon negative status is a testament to the country's commitment to it. However, with time, challenges increase as the pressure of economic development, complemented by global anthropogenic climate change, threaten GNH-based development outcomes.

Underpinning climate change research is a recognition of the importance of knowledge creation and the development of informed climate action (RGoB 2020). The Climate Change Policy of the Kingdom of Bhutan 2020 delineates institutional responsibilities to generate climate knowledge and application. The National Center for Hydrology and Meteorology (NCHM) is mandated to generate, manage, and provide hydro-meteorological and climate data, while the Royal University of Bhutan (RUB) and other research institutions are mandated to conduct needs-based research to support evidence-based decision-making, planning, and implementation of climate change actions. For instance, NCHM (2018) has a total of 167 meteorological stations and 75 hydrological stations generating data.

For this review it is noted that, based on the selected articles, climate change research has increased in both volume and thematic coverage in Bhutan since 2010. A bibliometric assessment by Wangdi (2023) engaging 4145 Bhutan-related publications retrieved from the Scopus database published between

1894 and 2022, suggests a steady growth in research on climate change since 2000. Climate change was found to be one of three most occurring keywords in the study.

Climate Science and Trends

Climate research observed consistent increase in temperature across Bhutan since 1960, with sharper warming observed after 1991 (NEC 2021; NCHM 2024a; Dorji. S., 2025). Spatially, temperature increases are higher in northern parts of Bhutan compared to southern regions. Temperature projection under various Shared Socio-economic Pathways (SSPs) suggest a likely increase of annual temperature in the ranges of 2–5°C by 2100. In contrast, long-term historical records of annual precipitation show a decreasing trend. Yet, interestingly, climate projection till the end of century indicate an increase in annual precipitation in the ranges of 56mm to 300mm under various SSPs. Central, northern, and western regions of Bhutan are projected to receive relatively higher precipitation compared to other parts of the country (NCHM 2024a).

Cryosphere studies constantly report negative annual mass balance of glaciers in Bhutan, indicating loss of glacial mass exceeding glacial accumulation. Projections suggest that glacier terminus retreat rate will accelerate with increasing temperature (NCHM 2019; 2021; 2024b; 2024c; 2025). These changes will have significant implications for Bhutan's water availability, hydropower generation, agriculture production, and exacerbate downstream risk, including Glacial Lake Outburst Floods (GLOF).

Despite these literature findings, there is a high degree of uncertainty in climate projections in Bhutan, and the broader Hindu Kush Himalayan region. It is largely attributed to the global climate models' inability to adequately account complex topography and associated microclimatic conditions

(Shrestha *et al*. 2015). Dorji, U. *et al*. (2016) demonstrate strong spatial variation across Bhutan, with temperature and precipitation primarily affected by elevation and latitude, respectively. For instance, their model estimated mean temperature ranging between -20 to 20°C in winter, 0 to 30°C in summer, and 0 to 20°C annually, across Bhutan. It is largely affected by temperature decreasing by 0.42–0.58°C with every 100m elevation gain and bimodal pattern in temperature lapse rate. These findings underscore the need of place-based and context-specific pathways to integrate climate policies with sustainable development strategies within a within contextual socioeconomic framework (Kamei *et al*. 2021). While significant increase in the research directly addresses climate change, a wide range of research on water resources (and management), agriculture, energy, forests, health, land use, migration, wellbeing, and development intersects with climate change concerns, reflecting the cross-cutting nature of climate risk and response.

Climate vulnerability

Bhutan is recognized as one of the world's most vulnerable countries to the impacts of climate change (Katel *et al*. 2024). This fact is routinely transmitted in articles on climate change in Bhutan. Bhutan's exposure to various climate-related hazards and climate-intensified vulnerability stem from three main aspects: its geographical terrain, fragile Himalayan ecosystems, and a heavily climate-dependent economy (DECC and UNDP 2025). In addition to the heightened exposure to hazards such as landslide, there is flooding triggered both by flashflood and Glacial Lake Outburst Flood, windstorms, and forest fire. Moreover, Bhutan's fragile ecosystems are highly vulnerable to glacial retreat, changing precipitation patterns, and overall ecosystem degradation. On top of this, Bhutan's climate-dependent economy, which heavily relies on agriculture, hydropower, and forest resources, poses challenges to sustainability livelihoods under the duress of climate change.

The recent DECC and UNDP (2025) report highlighted that Bhutan is already facing significant climate-induced economic losses. The World Bank Group (2025) estimated the current average annual losses from climate-related events at USD 169.3 million (6.9% of GDP). Projections for 2050 estimate that climate risks could reduce Bhutan's GDP by up to 3%, primarily from sectors such as agriculture, livestock, water, infrastructure, and forestry. These sectors are within what Meenawat and Sovacool (2011) identified as climate vulnerable, which includes landslides and flooding, deteriorating agricultural production, impoverished forests, worsening health security, and impaired hydroelectricity generation. Based on historical records, Bhutan is highly vulnerable to various natural hazard like landslides, floods, fires, windstorms, hailstorms, and earthquakes. Tempa's (2022) multi-hazard zoning for population at risk, grounded in weighted scores for 1224 recorded occurrences between 1968 and 2021, highlighted 70% of total districts with moderate to severe multi-hazard vulnerability.

Flooding in Bhutan, both pluvial and riverine, is primarily caused by glacial lake outbursts and by torrential rainfall (orographic cloudburst and prolonged heavy rainfall). The compounding factors such as Bhutan's topography, changing precipitation, increased glacier retreat, and increasing infrastructure development increases this vulnerability.

Glacial Lake Outburst Floods

Glacial Lake Outburst Flood (GLOF) is a flood caused by sudden burst of glacial lake releasing large amounts of water typically caused by the failure of naturally formed ice or moraine dam. It is characterized by sudden onset, long-runout distance, high-magnitude discharge, with a high velocity, and a tendency to flow over the existing flood plains (Rinzin *et al*. 2021). It makes

GLOFs by far the most dangerous form of flooding (Worni *et al*. 2012).

Rising temperature in the Himalayan region has led to rapid glacier retreat and mass loss (Immerzeel *et al*. 2010). With over 5000 glacial lakes, of which 200 are classified potentially dangerous, it intensifies the risk of Glacial Lake Outburst Floods (GLOF) (Mir *et al*. 2025). In Bhutan specifically, there are 567 glacial lakes, of which 17 lakes are listed as potentially dangerous (NCHM 2021a; NCHM 2019). As the northern Bhutan rises high into the Himalaya, these glacial lakes are predominantly situated there, where rising temperature causes rapid glacial retreat and permafrost degradation (Rinzin *et al*. 2021). Cryosphere studies report negative annual mass balance of glaciers in Bhutan, indicating loss of glacial mass exceeding glacial accumulation. For instance, Ganju La glacier recorded cumulative net balance of -28,500 mm, resulting in a 30% area reduction between 2004 and 2020 and Thana glacier recorded cumulative net balance of -6530 mm leading to 7% shrinkage in area between 2016 and 2020 (NCHM 2021a; 2021b). A similar study by Bajracharya *et al.* (2014) showed that Bhutan's glaciers have suffered an area loss of 23.3 ± 0.9% from 1980 to 2010. This leads to the formation of new lakes and expansion of the existing lakes.

In high mountain Asia, Wang *et al*. (2011) noted that 114 new lakes covering an area of 9.8km^2 were formed between 1990 and 2018. In Bhutan, a study by Chen *et al*. (2021) noted annual lake area expansion of 0.95km^2. As such, trends in Bhutan follow wider trends across Asian mountains. Projections by NCHM suggest that glacier terminus retreat rate will accelerate with increasing temperature (NCHM 2019a; 2021a; 2021b; 2024b; NCHMc; 2025). Mir *et al*. (2025) observed that has been 40% increase in meltwater discharge over the last decade in Asian mountains. Similarly, Sato *et al*. (2022) note that lake expansion and surface lowering rate have been constant since 2000 for Luge Glacier while Thorthormi Glacier experienced 2-fold increase in the thinning

rate, as direct consequences of climate change. Formation of new lakes and expansion of existing lakes, which will only be exacerbated by climate change, pose a severe threat of GLOF to the community living downstream. Since 1990, Bhutan has recorded three major flood occurrences triggered by Glacial Lake Outburst, in 1994, 2015, and 2016 (NCHM 2021c). The October 1994 Glacial Lake Outburst Flood was caused by partial burst of the Luggye Tsho and claimed 20 lives, while it also extensively damaged property along the Punatshangchhu river basin (NCHM 2019b). As tributaries of Punatshang Chhu, Mangde Chhu, Chamkhar Chu, and Kuri Chhu host potentially dangerous lakes, these specific river basins are highly vulnerable to GLOF hazards (NCHM 2019b). Furthermore, the overall geo-hydrological changes will have significant implications for Bhutan's water availability, hydropower generation, and agricultural production.

Floods and Landslides

While the Himalayan region is prone to various natural calamities, floods and landslides represent two of the most recurring hazards extensively damaging land, infrastructure, and human lives (Dikshit *et al*. 2020a). Bhutan is no exception to this given it is highly landslide-prone and the country has experienced recurrent flooding mostly during the monsoon season (Dikshit *et al*. 2020b). In 2004, flash floods in six eastern Dzongkhags claimed 9 lives, washed away 29 houses, damaged 107 houses, and destroyed 664 acres of farmland (NCHM 2021).

With reference to the recorded history, intense precipitation pattern occurring across the country during the monsoon is identified as a primary driver of flood and landslide (Chhogyel and Kumar 2018; Tempa, 2022). NCHM's two compendiums of Climate and Hydrological Extremes in Bhutan reported 61 incidences of flood between 1968 and 2016 (NCHM 2018) and 30 incidences

between 2017 and 2021 (NCHM 2021c). A graphical representation of these incidences are shown in the figure 1.

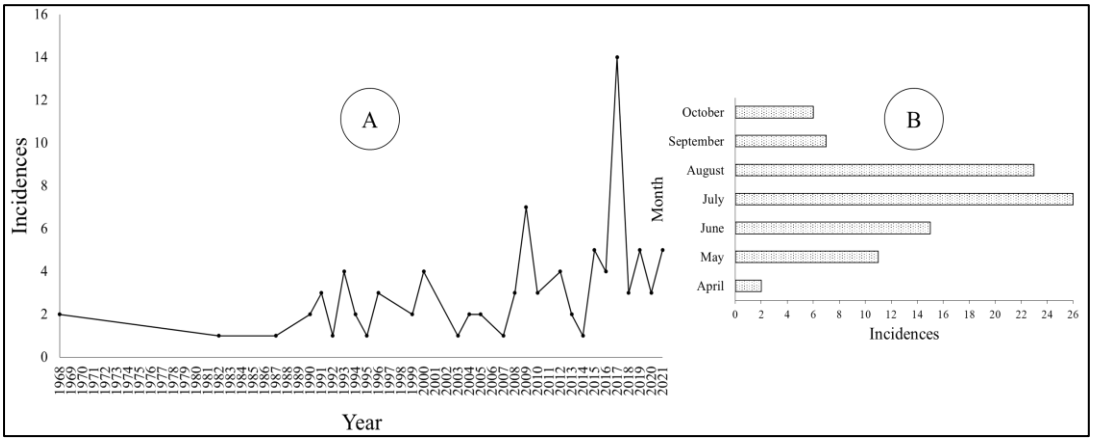

Figure 1: Incidences of flood since 1968. Data source: NCHM 2020, 2022. Graph generated by author.

However, studies increasingly link the escalated frequency and intensity of flood and landslide to climate change impacts as it brings in heavier rainfall and causes disruption in its pattern in tandem to changing hydrological systems and an overall deterioration of ecosystem (Sajid *et al*. 2025; Ali and Parvin 2025). A study by Tempa (2022), analyzing 116 historical flood events across Bhutan between 1968 and 2020, indicates increased frequency in the flood occurrence by three times, in the recent past. DECC and UNDP (2025) reported that Bhutan's annual average crop loss due to flood and rainfall-related hazard have grown up to USD 568,035 in terms of economic loss between the years 2016 and 2024.

While frequency and intensity have increased, vulnerability to these hazards are not uniform across the country. Although, as shown above, a district-wise multi-hazard zoning base on the historical hazard occurrence of hazard showed 70% of Bhutan's 20 dzongkhags (districts) are exposed to moderate to

severe multi-hazards, the dzongkhags of Chhukha, Mongar, Sarpang, and Zhemgang were identified as the most severely affected areas (Tempa and Yuden 2023). This is an outcome of vulnerability to flood and any other natural hazards being a function of impacts from the event, key socioeconomic factors, and environmental services (Ali *et al*. 2016). A study employing analytic hierarchy processes in Samtse, took factorial compounding for environmental, social, and physical factors of 58%, 16%, and 25%, respectively (Tempa 2022). As a case here, a vulnerability assessment using 40 indicators by Waiba and Dorji (2024) conducted for eight selected places, indicates Dagana (-0.72) and Sarpang (-0.71) as the most vulnerable because of these two places' high exposure to natural hazard and sensitivity, while Tsirang (-0.35), Thimphu (-0.36), and Haa (-0.38) are least vulnerable attributed to their higher adaptive capacity to potential climate induced natural hazards (negative index value indicates the net effect of exposure, sensitivity, and adaptive capacity (Il Choi 2019)).

In response to these risks and vulnerability, Bhutan has implemented structural and institutional reforms. The enactment of the Disaster Management Act 2013 established national disaster management committees in all 20 districts to coordinate mitigation and response efforts. However, literature show significant challenges in practical implementation of risk reduction strategies (Tempa and Yuden 2023). Assessment of risk and implementation of response strategy to GLOFs, flooding, and landslides requires integration of social, physical, economic, and environmental dimensions (Cajano and Olpenda 2025). The analysis of literature shows that the vulnerability assessments in Bhutan is moving from once predominantly indicator-based employing geospatial technologies (Chan *et al*. 2022; Tika *et al*. 2025) to using holistic frameworks that incorporate physical, environmental, and socio-economic factors (Panigrahi and Sharma 2024). Although there are multivariate approaches used, which integrate social surveys aimed at

understanding socio-cultural-ecological complexities that affect adaptive capacity (Choden *et al*. 2021), no long-term community-based qualitative approach to data collection are incorporated, hitherto. A research done by Yin *et al*. (2025) establishes how focusing only on the natural hazards often overlook our fundamental understanding of systemic relation between socioeconomic, cultural, environmental, and political factors that influences resilience and vulnerability shaping human safety.

Forest Fires

The incidences and intensity of forest fire have increased in the past few decades (Gurung *et al*. 2023). In Bhutan, an average of 3158 forest fire incidences destroying an average area of 658,778.4 hectares and significantly threatening ecological integrity, human wellbeing, and global effort to fight climate change was observed each year (Wang *et al*. 2021). This is also with the backdrop that dendroecological studies reveal fire regimes having shifted significantly around 1970 due to changes in forest policy and land-use practices (Tenzin *et al*. 2024). The current trend and occurrence show significant increase in fire frequency during the winter and spring months. This is directly related to low seasonal precipitation and high human activity in the forest areas. Climatically, it corresponds to the monsoon-based weather pattern of the Indian subcontinent, which brings in wet and humid summer followed by cold dry winter (Tenzin *et al*. 2024), and wider El Niño-Southern Oscillation system, which often amplify drought conditions and extension of dry season (Chatterjee and Adhikari 2024; Mamgain *et al*. 2023).

Bhutan's rich forest resources, being largely undisturbed by commercial extraction, has rich vegetation biomass, with the potential of fueling fire and rapid spread. This is further compounded by the mountainous terrain and prevalence of localized wind system. Literature on forest fire vulnerability

assessment in Bhutan shows high occurrence of fire in places with coniferous species, low elevation, steeper slopes, and closeness to human settlements, roads, and the southern international border (Tshering *et al*. 2020; Gurung *et al*. 2023; Tenzin *et al*. 2024). In the year 2017–2018 alone, Bhutan witnessed 37 fires across 12 districts destroying approximately 16000 acres of forest (Shacha *et al*. 2021). Interestingly, Bhutan, on the comparative Asian regional level records fewer fire incidences, attributed to vigilance of forestry personals, and strong education and public campaign against forest fire. A study by Bhattarai *et al*. (2022) recorded 30462 active fires in March-April 2021 through MODIS sensor, showing the highest incidence in Myanmar and least in Bhutan.
Existing research on forest fire dynamic is limited to fire frequency, post-fire regeneration, and vulnerability mapping. Although frequency study posits that the fire incidences have increased in the recent past, there exists only scant scholarship on the relationship between climate variables and fire regimes in Bhutan (Bhattarai *et al*. 2022).

This limitation, along with scarce historical data on forest fire (before early 2000s), challenges comprehensive prediction into future (Tenzin *et al*. 2024; Waiba and Dorji 2024). Looking at the fire vulnerability in the face of climate change, Kim *et al*. (2023) predicted, applying the SSP5-8.5 scenario, the possibility of forest fire risk in Bhutan will increase over the next 50 years, with the risk being highest during the months of October to January. SPP5-8.5 is a fossil-fuelled high-emissions development scenario with a projected significant global warming of >4°C by 2100. The literature also points to how changes in forest legal frameworks – primarily prohibition of traditional burning, disruption in indigenous land management systems, and criminalization of fire – led to increased fuel loads (Namgay *et al*. 2021; Smith *et al*. 2024). Increased fire loads with climate change intensified risks through prolonged dry season and amplified weather extremes, are expected to increase fire occurrence in future.

As one of the most significant environmental concerns in Bhutan, the predicted increase in forest fire can have multi-faced impacts on the overall wellbeing of Bhutan communities (and the planet at large). Firstly, fire threatens biodiversity and the undermining of ecosystem services. It can lead to accelerated habitat loss, soil degradation, and increasing emissions of greenhouse gases. Secondly, for a country with its economy based on natural resources and where third of its population depending on ecosystem-based livelihood, it will have adverse socio-economic consequences (Kumar *et al*. 2025; Soontha and Bhat 2025). Thirdly, it can adversely affect human health through smoke pollution and weaken environmental services (Bhattarai *et al*. 2022).

Climate Mitigation

Bhutan is carbon negative. A national greenhouse gas assessment conducted by Department of Environment and Climate Change in 2022 estimated Bhutan's net emission at -9707.94 Gg CO_2-equavalent (DECC 2024). While gross emission (at the source) primarily originates from the sectors of Industrial Processes and Product Use, Energy, Agriculture, and Waste (in order of total contribution), Bhutan's forest, cropland, and grasslands sequester more carbon than is emitted.

As part of national commitment under the Nationally Determined Contributions (NDCs), Bhutan has pledged in all three NDCs to remain carbon neutral (RGoB 2015; 2021; 2025a). This is anchored in the constitutional mandate to maintain a minimum of 60% (RGoB 2008) of the country's total land area under forest cover for all time. This threshold is currently exceeded, with the forest cover estimated at 69.71% (DoFPS 2023a). In addition, Bhutan has adopted a range of mitigation strategies aimed at achieving long-term low

greenhouse gas emission from key development sectors (DECC 2023).

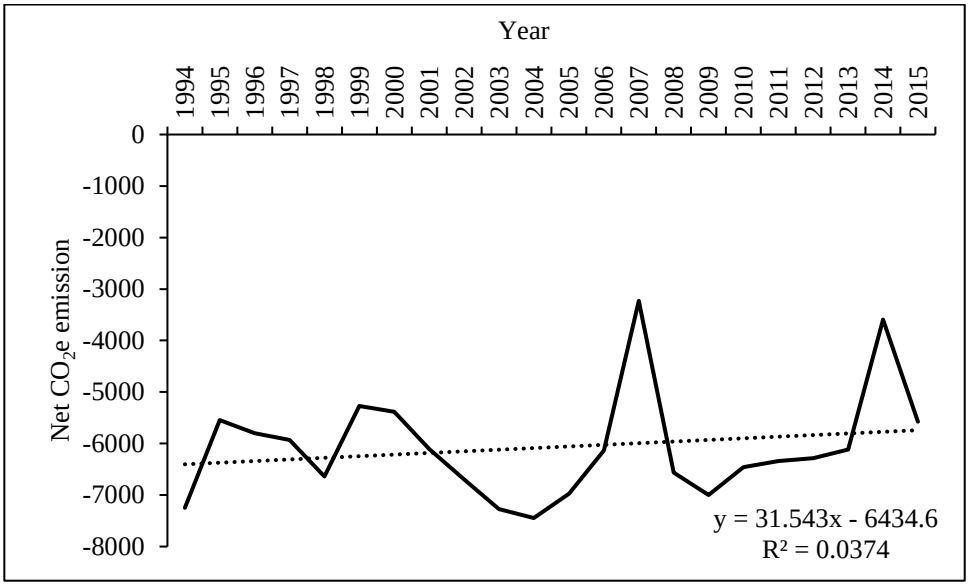

Figure 2: GHG emission trend from 1994 to 2015 in Gg CO_2e. (Data Source: NEC 2020. Graph generated by author).

However, rapid economic growth and country's development pressure threatens Bhutan's ambition of sustained carbon neutrality (NEC 2021; RGoB 2025a). A trend analysis of greenhouse gas emission (in Gg CO_2e) from 1994 to 2015 shows gradual increase in net emissions over time. While the long-term linear trend is weak and statistically insignificant (R^2 = 0.0374) - interannual variability dominates the emission dynamics. Such variability is likely driven by fluctuations in forest carbon sequestration, land-use changes, hydropower generation, economic activity, and methodological refinements in greenhouse gas accounting rather than by a steady structural shift.

To support a holistic development, (in Bhutan, a Gross National Happiness-guided development), the adoption of appropriate technologies would be needed to align economic growth with a carbon neutrality goal. Besides

conservation of natural environment, design and implementation of comprehensive sustainable development plans, strategies to decarbonize sectors that emit greenhouse gases, and advocating technological adoption are some of the other climate mitigation measures in Bhutan.

However, rapid economic growth and development pressures pose increasing challenges to sustaining carbon neutrality (NEC 2021; RGoB 2025b). Aligning economic development with Bhutan's Gross National Happiness-guided development philosophy will require the adoption of appropriate low-carbon and climate-resilient technologies. Beyond forest conservation, key mitigation priorities include the development and implementation of integrated sustainable development plans, sector-specific decarbonization strategies, and the promotion of technological innovation to reduce greenhouse gas emissions while supporting inclusive economic growth.

Impact of Climate Change

Ecosystem

Bhutan is a global biodiversity hotspot. A mosaic of Himalayan ecosystems, ranging across varied altitudinal gradients (from 200 masl to 7000+ masl) and climatic zones, have about 11,248 species. Within these taxa are about 5,114 species of animal, 5,369 species of plant, 690 species of Fungi, 55 of Chromista, 18 species of Eubacteria, and two species to Protista (NBC 2019). This diversity is primarily hosted within the 69.71% of Bhutan's landscape under forest cover, protected through a network of five national parks, four wildlife sanctuaries, and a strict nature reserve, all well-connected with biological corridors (DoFPS 2023b). The forest also serve as a critical carbon sink (Yangka *et al*. 2023). National Forest Inventory II reports the 127.61 tonnes/ha of

biomass carbon and 68.12 tonnes/ha of Soil Organic Carbon (DoFPS 2023b). The country's ecological integrity, at the background is deeply rooted in the Bhutan's cultural and spiritual values, which highlights the importance of harmonious connection with nature (Ura 2001; Allison 2017, 2019; Vajpayee 2024). It is further underscored by the constitutional mandate to maintain minimum of 60% forest cover in all times to come (RGoB 2008) and other developmental policies, including Gross National Happiness (Yangka and Newman 2018; Kaewkhunok 2019).

However, this rich biodiversity is increasingly faced with anthropogenic pressure and threatened by climate change (Kattel 2022). It can disrupt livelihoods that rely on ecosystem services, affecting their productivity and the relational functioning of ecosystem integrity, such as soil stability, water regulation, and nutrient cycling (Dorji et al. 2023). These impacts are further escalated by physical hazards like flood (and so on) threatening various ecosystems by destroying habitats, distressing population, displacing species, and fragmenting gene pool, which often lead to extinction (Kattel 2022; Favretto and Stringer 2024; Dulari 2025).

A research on useful, to humans, highland plant species including incense and Codyceps in the highlands of central and western Bhutan showed people's perception of decreased availability, quality, and potency. They attributed it to the changing climate and exploitation of these resources (Choden *et al.* 2021; Choki 2021; Gyeltshen *et al*. 2025). Although not studied in Bhutan, studies from around Himalayan region show that one of the most common changes in ecosystem is upward migration of species – treeline, animal species, and also phenological impacts like early greening and flowering of the plants – leading to alteration in the species composition (Dasila *et al*. 2021; Lepcha 2024). The disruption in ecosystems would increase human-wildlife conflict undermining rural-livelihood (Yangka *et al*. 2018; Wangchuk *et al*. 2023a;

Peldon *et al*. 2025). The study by Wangchuk and colleagues (2023a) reveals that farmers from Tashiyangtse and Tsirang report an average loss of half a month to more than a month's worth of household food requirements to wildlife.

Modelling studies indicate that continued warming trends will likely lead to further habitat loss, altered species interactions, and reduced ecosystem resilience across Bhutan's diverse ecological zones. Although only 0.1 percent of the population cites natural calamities as a reason for migration (NSB 2018), the expected increase in climate change impacts, combined with literature pointing out that these stresses are becoming ever more embedded into broader livelihood vulnerability (Johnson 2023) and eroded resilience, means that rural households will become more susceptible to economic shocks pushing them to migrate. There is an urgent need for proactive conservation measures and adaptive management strategies to mitigate the escalating risks to Bhutan's natural capital and ensure the sustained provision of critical ecosystem services (Nepal 2022; Kattel 2022). Indeed, Katel *et al*. (2024) suggest that the future migration pattern will be influenced by the intersection of environmental degradation and economic aspiration.

Hydropower

Hydropower is a cornerstone to Bhutan's economy contributing 11.78% to the Gross Domestic Product in 2024 (NSB 2025). This significant contribution is driven by the country's rich water resources. Bhutan generates about 70,576 cubic hectometers (hm^3) of annual freshwater. The country only consumes about 1% (NEC 2016). The underutilization of water resources is attributed to unique hydrological dynamics made of rugged topography, summer monsoon, and young Himalayan geology (Rinzin *et al*. 2021). It leads to

substantial runoff often resulting in erosion, flooding, and landslides (Dorji 2016). On the other hand, a major part of this water resource predominantly depends on glaciers. This Bhutanese hydrological regime is particularly sensitive to climate change (Williams *et al*. 2016; Hill *et al*. 2020). Some places in Bhutan, indeed, already face significant challenges in water management (Tariq *et al*. 2021), including localized scarcity and seasonal shortages (Gamble *et al*. 2024).

Water resources known as 'white gold' generate about 99% of the electricity used in Bhutan. It is estimated that Bhutan's water resources have the potential to generate approximately 30,000 MW of power (Uddin *et al*. 2007; Chhopel 2014). Currently, Bhutan harvests about 2,326 MW of electricity and Bhutan's economic roadmap aims to generate 10,000MW of electricity by 2035 and 25,000 MW by 2050. It is going to underpin Bhutan's energy security from clean energy driving green sustainable economy.

Despite this strategic importance, the sector's long-term sustainability is increasingly threatened by climate-induced hydrological variability (Katel *et al*. 2024). The increasing rate of glacier retreat and changing precipitation patterns pose substantial threat to stability of hydrological regimes (World Bank Group 2025). This is compounded by risk of GLOFs, which threaten infrastructure as well as the sustainability of energy production. The change in hydrological cycles characterized by fluctuating river discharge can potentially lead to water scarcity as well as flooding challenging reliability, operational safety, and sustainability of the hydropower plants (Amjath-Babu *et al*. 2018; International Energy Agency 2022). These physical threats would be further compounded by landscape instability processes such as permafrost thaw, rock-ice avalanches, and debris flows, which mobilise large amounts of sediment that can fill reservoirs, degrade power turbines, and potentially cause dam failure (Bhandari *et al*. 2025; Li *et al*. 2022).

Agriculture

With climate change impacts, Bhutan's approximately 57% of agrarian population is faced with rapidly changing environmental variabilities. Farmers lose significant amounts of crops to pest and disease outbreaks, erratic rainfall, windstorms, hailstorms, droughts, flash floods, and landslides (Chhogyel and Kumar 2018). Cases such as the 1996 blast disease that caused 80–90% rice crop loss in high-altitude areas and Turcicum leaf blight of maize that damaged over 50% in 2007 underscore the severity of climate change-induced or exacerbated, risks to agriculture. Such cases depict shift in agriculture-ecology as a result of environmental stresses like changing climate.

Bhutan's mountainous topography presents major challenge to agriculture (Parker *et al*. 2017). Firstly, while more than half of Bhutan's population depends on agriculture for their immediate livelihoods, Bhutan has only about 2.96% arable land under cultivated agriculture equivalent to approximately 281,186.290 acres, which leads to small land holdings (approximately 1.4 ha per farmer) (DoSAM 2023). Secondly, the current farming practices are totally dependent on monsoon rain. Besides, water scarcity is emerging as a critical challenge due to drying up of local water sources (Chhogyel and Kumar 2018; Katel *et al*. 2024).

Given these realities, climate change impacts would render food production very susceptible to its variability and extremes. The sensitivity of the country's primary cash crops – such as rice, maize, potato, chilies, potatoes and apples – to changes in temperature and water availability, means that food security is jeopardized (Meenawat and Sovacool 2010; Rai *et al*. 2022). Thirdly, extreme weather events are becoming more rampant as shown above. It causes huge physical damage and also threaten major shift in the agriculture ecology

(Alvar-Beltrán and Franceschini 2024). Climatic trends show historical evidence of decreased rainfall with increasing temperatures, particularly above 1000 meters. These, along with a projected increase in precipitation (both amount and variability) and with further warming as presented under various Shared Socio-economic Pathways, suggest a significant amplification in both the frequency and intensity of natural hazards (Dorji, K. *et al*. 2016; Dorji, S. 2025), making the future of farming precarious and uncertain (Wangchen and Dorji 2022).

Some literature suggests a likely net gain in the suitable areas for cultivation due to climate change, as shown in case of paddy cultivation by 5,432.78 acres in 2050 under Representative Concentration Pathway (RCP) 4.5 and RCP 8.5, presenting 10% increase on the current suitable area, (Chhogyel *et al*. 2018). RCP represents greenhouse gas concentration trajectories used by the IPCC, to model future climate change where RCP 4.5 assumes an intermediate stabilization scenario resulting in ~2°C–3°C warming by 2100 while RCP 8.5 represents a business-as-usual (high-emission) scenario with 4°C or potentially higher. However, the gain in the agriculture-suitable-land area and scope for increased food production will be limited by geographical restrictions and amplified agricultural challenges due to climate change impacts. For instance, climate change and changing rainfall patterns will remain a major background amplifier of landslide hazards (Chettri *et al*. 2022).

Equally, implications of climate change on Bhutan's livestock sector are multifaceted. However, compared to the implications of climate change on crop production, climate impacts on livestock sector remain under-researched. The existing literature depicts that it affects both the highlanders and broader agriculture economy leading to reduction in productivity. The highland regions, for example, experience rising temperature altering the rangeland and shifting botanical compositions (Phanchung *et al*. 2022; Dorji *et*

al. 2023). In addition, climate-modified growing season, changing snow cover and invasive plant species encroaching the highlands disrupt the native plant's phenology (Katel *et al*. 2024). The highlanders suspect nutritional decline in the natural feed (Wouters 2021). It is further worsened by changing hydrological regime and proliferation of climate-sensitive vector-borne diseases (Waiba 2023).

Although not necessarily or solely attributed to the climate change impacts, yak herding has substantially reduced. Gyeltshen and colleagues (2025) attribute the decline of yak population from 52,911 in 2006 to 29,699 in 2023 to diminishing grassland productivity and animal health. A study by Namgay *et al*. (2014) in six highland communities of Bhutan shows the total number of households practicing transhumant agro-pastoralism having declined by about 31% between 1990 and 2010. The reasons identified range from shortage of farm labour and alternative livelihood choices, to government policy changes and climate change altering weather and pastures. Dorji *et al*. (2023) also observed that when the temperature increased (exceeding 13°C), the physiological resilience of livestock is undermined, decreasing productivity. This is further compounded by environmental degradation such as less snowfall, drying water sources, and erratic rainfall that threaten the long-term sustainability of rangeland resources (Tenzing *et al*. 2021). Literature also show the gain in grassland area due to reduced snow cover and glacier, which however is offset by migration of invasive species and overall decline in carrying capacity (Gyeltshen *et al*. 2025; Hoy *et al*. 2015). This, nevertheless, calls for more research.

The decrease in agriculture productivity has profound implications for rural livelihoods. It basically undermines the ability of materially poor subsistence farmers to achieve food security as they have limited access to financial, human, and natural capital (Gyeltshen *et al*. 2025). The weakened adaptive

capacity to cope with climate shocks reduce overall social-ecological resilience of the household (Choden *et al*. 2021) forcing the community to adopt alternative livelihood strategies (Dendup *et al*. 2022; Dorji *et al*. 2023). In many cases, inefficient agriculture investment or operation renders farmers to look for other livelihood option, often pushing them to urban areas. (Katel *et al*. 2024).

Although climate change has not yet emerged as the primary driver of mobility, a growing number of rural farmers view moving to cities as a necessary adaptation as it compounds the decline in agricultural production acting as a push factor (Wangchuk and Wangdi 2018; Johnson 2023). FThese persistent environmental stresses create a vicious cycle by economically marginalized – and migrated – population causing to loss of labour pool in the communities further affecting adaptive capacity (Suberi *et al*. 2018; Khan *et al*. 2023; Katel *et al*. 2024; Paldon *et al*. 2025). Prevalence of 'Gungtong' – abandoned house and 'Satong' – abandoned agriculture land indicate this demographic shift in Bhutan (Wangchuk *et al*. 2023b).

Migration

Migration has always been central to the making of Bhutan, as it is for countries around the world, having constitutively shaped its tradition, culture, language, religion, and political identity. George van Driem (1999; 2008) highlights that our understanding of ethnolinguistic landscape of Bhutan, with nineteen local languages distributed across the country, can only be understood through better historical context of migration, settlement, and adaptation. Historical accounts on introduction and propagation of Vajrayana Buddhism, Bhutan's dominant religious tradition, as shown in Bhutan history, happened through waves of trans-Himalayan religious mobility linking India, Nepal, Tibet, and Bhutan (Aris 1979; Phuntsho 2013). The trade routes

connecting Bhutan to Tibet, Assam, Bengal, Sikkim, and Arunachal Pradesh facilitated movements of not only goods but also people, ideas, and identity embedding Bhutan into wider Himalaya emerging historically in the dynamic crossroad shaped by migration (Ray and Sarkar 2005; Ardussi 2015).

Although the drivers of migration may have changed over the time, and fast forward to today, it remains the procedural and foundational conditions for defining nation (Childs 2012), not simply as an event or disruption in the history. Today's migration is increasingly characterized by rural-urban internal, and internation migration (Ansari 2017). Perhaps this is a reflection of important transition from state-driven demographic change to forth bringing individual or a household agency in deciding movement.

Internal migration

Bhutan's migration landscape exhibits complex patterns, encompassing both internal population shifts and significant international outflows, particularly evident in recent decades (Alaref *et al*. 2025). The internal migration is predominantly characterized by a shift in rural-urban population and internal mobility. The urban population could reach 77% by 2040 at this rate (Yangka *et al*. 2018). It was first evidenced in 2017 Population Housing Census (NSB 2018), which recorded Thimphu Dzongkhag as the most populous with 138,736 residents, representing almost 20% of the national total, marking a significant increase from the 2005 census figures (Rajan 2023). Besides rural-urban migration, the census also underscored various internal mobility dynamics within the country (Gosai and Sulewski 2023). The movement and population redistribution within the country is influenced by varying scales of economic development and demographic shifts across different regions (Das and Basu 2023). A research conducted in Khaling Gewog, Trashigang, in

Eastern-Bhutan, on rampant rural out-migration and mobility within the country suggest that internal migration patterns are often influenced by a complex interplay of familial ties, employment opportunities, and educational pursuits (Choda 2012; Rajan 2023)

An east-west dichotomy is observed in Bhutanese migration. There are larger number of people moving out of eastern regions while the western regions experience a net increase in migrant populations (Ura *et al,* 2023). Specifically, districts like Thimphu and Phuentsholing experience a net increase in migrant population while districts like Zhemgang, Lhuentse, and Trashigang have seen a net loss (Tenzin *et al*. 2022). This dichotomy is underscored by data indicating that 138 out of 205 gewogs in the country experience net negative migration, with a majority (42%) located in the eastern part of the country, compared to 38% in the central and 20% in the western regions (Rajan 2023). This has led to a demographic shifts. The rural east has seen increased elderly population (Tenzin *et al*. 2022). It has structurally resulted into erosion of inter-generational care and communal cohesion at the source communities (Choki *et al*. 2025). Furthermore, number of 'Gungtong' and 'Satong' are becoming concentrated in the eastern region. Research by Wangchuk *et al*. (2023b) highlights the linkage between proliferation of 'Gungtong' and broader socio-economic and ecological issues, which include 'Satong', ageing rural population, labour shortage, and increasing human–wildlife conflicts. Similarly, Rajan (2023) argues that the distinct regional migration patterns are indicative of underlying socio-economic disparities and varied accessibility to essential services and opportunities across the country. However, further investigation into these regional disparities must be conducted to elucidate the specific push and pull factors that contribute to differing rates (Siddiqui *et al*. 2019). The uneven distribution of migrants is basically influenced by varied development and economic opportunities across the country.

The primary drivers of internal migration are economic necessities - better livelihoods and employment opportunities (Gosai and Sulewski, 2023) as people living in economically inactive districts are pushed towards urban centers in Bhutan. With 34.66% of immigrant households in Thimphu citing business opportunities as their primary reason of migration, it is another important driver (Chand 2017). Perceived reliability of essential services is also an important underlying factor. For instance the districts with poor infrastructure and limited access to basic services have witnessed increased population loss. The recent report from the Alaref *et al*. (2025) shows how uneven distribution of infrastructure and economic development contributes significantly to regional disparities, compelling individuals from less developed areas to seek opportunities in more prosperous regions (Ansari, 2017). Rajan (2023) argues that the availability of roads, acting as a proxy for market access, significantly impacts migration dynamics, so that approximately 78% of gewogs having less than 20 kilometers of roads experience net negative migration rates.

Often, internal migration is linked to international migration. Migrants uses urban centers as a transition space to migrate to international destinations. This allows migrants to accumulate capital, learn skills, and undertake procedural task and also maneuver logistically complex journey. It is also linked through flow of remittances, when international migrants invest in real estate and businesses in the domestic urban area (Alaref *et al.* 2025).

International migration

International migration has seen a notable surge in the recent years evolving into significant demographic phenomenon, largely driven by the pursuit of higher incomes and enhanced prospects abroad among young adults (Ura,

2024; Tobgay, 2022; Choki *et al.* 2025). The scale of international migration has become a concern for government as it has potential implications for brain drain (Dorji and Hosoe 2025). For instance, Australia has become an increasingly attractive destination for educated Bhutanese over the past two decades, with the proportion of tertiary-educated migrants increasing significantly from 8.56% in 2000 to 13.53% in 2020 (Alaref *et al*. 2025). Dendup (2025) highlighted that from the concentrated Bhutanese migrants in Perth, Australia, 53% were college-educated indicating a severe drain of talented labour from the domestic economy. This upward trend reflects a broader global pattern of skilled migration, where individuals from developing nations seek better professional opportunities and higher standards of living in more economically advanced countries. Figure 2 depicts the growth of total international migrants from Bhutan since 1990. For Bhutan, the economic implications are growing as emigration of skilled professionals create severe gaps in service sectors like healthcare, education, and civil administration (Tshering, 2023). While migration of skilled professionals to a country of destination addresses shortage of labour, they often experience occupational downgrading – mostly by being employed in low-skilled roles despite being well-qualified and skilled (Alaref *et al*. 2025). It is still accepted given their decision to migrate and seek employment in migrant destinations is an outcome of intersection of low-wage, dissatisfactory working condition, rigid hierarchical and centralized governance structure, lack of professional advancement, and weak economy at home (Poudel and Shrestha 2024).

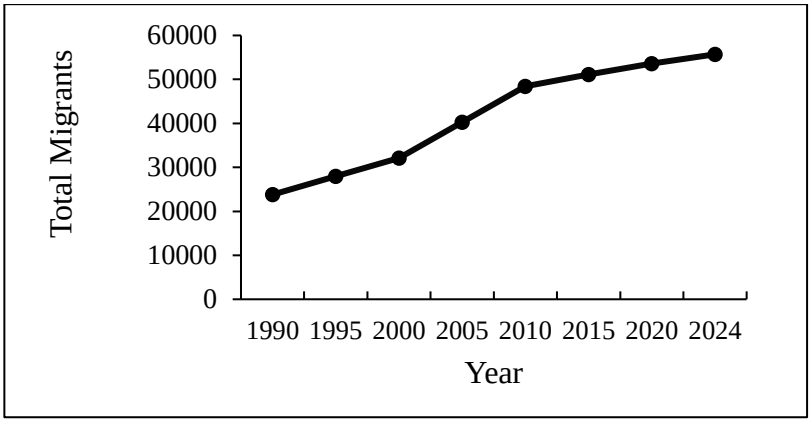

Figure 3: Total number of international migrants from Bhutan. Data source: Migration Data Portal (2024).

The motivations behind this international migration are multifaceted. It encompasses socio-economic factors such as upgrading education and livelihood improvement (Tobden *et al*. 2025). World Bank reported that from the aspiring migrants in Bhutan, 64% cited education as their primary reason fostered by 40% of the population viewing education quality better abroad (Alaref *et al*. 2025). This shows how individual aspirations and their choices, which is important determinant in migration decision-making, is intentional and deliberate. This aspiration is shown to be more pronounced amongst women (Choki *et al*. 2025). It suggests migration is also a mechanism of empowerment. On the other hand, Schmidt (2017) warns that migration decisions are not always voluntary. It often stem from underlying socioeconomic challenges, even when we perceive them to be intention. The challenges like limited landholding, less job opportunities, and resource scarcity often push individual while improved opportunities and individual aspirations draw them to destinations abroad. These push factors are very visible for migrants originating from underdeveloped places like Mongar, Samtse, Dagana, Sarpang, and Chukha (Ura *et al.* 2023). It perfectly aligns with a neoclassical microeconomic framework. Migrants, indeed, do cost-benefit

analysis before making rational decisions based on available information (Kaluarachchi and Jayathilaka 2024). This explains the surge in migration in the aftermath of the COVID-19 pandemic, when Bhutan's labour market further weakened (Alaref *et al*. 2025; Tobden *et al*. 2025). It also indicated how complex defining goals of economic betterment as a response to domestic challenges is, in many cases, influenced by external driving forces (Ura *et al*. 2023; Dorji and Hosoe 2025).

On the other hand, an increase in remittances is emerging as important financial support for rural households. It also provides a stable flow of foreign currency. The remittance also facilitates increased capital accumulation through investments – in business, land, and housing – and also community development (Tobden *et al*. 2025). Furthermore, circulation of human capital through return migration introduces valuable skills and knowledge (Tobgay, 2024; Dorji and Hosoe 2025).

Bhutan is expected to see evolved migration dynamics. With Bhutan's trajectory of economic development, strong education system, access to information and transportation, and limited domestic labour market, there will be sustained outward mobility. It would be furthered with diversification of destination preferences seeking stability and safety in less vulnerable regions (Rajan 2023; Alaref *et al*. 2025). While the existing body of research under-explores the intersection between migration and climate change, the catalytic role of climate change in decision-making processes will become more pronounced (Paldon *et al*. 2025).

Migration and Climate change

Due to their multi-causal and context-specific nature, identification of definite

linkage between climate change and migration remains challenging (Bruin *et al*. 2024). Despite this challenge, research shows that while climate change may be a weak sole-driver, regions with population whose livelihood depends on climate vulnerable agriculture and ecosystem services show patterns of negative human mobility (Katel *et al.* 2024). Although there is very limited existing literature for Bhutan, it shows that climate change and other environmental stressors act as a push factor within the agricultural sector influencing people's decision to move (Katel *et al*. 2024; Yu *et al*. 2025).

This passive and indirect but pervasive influence shapes individual decisions to move to a place where services and opportunities for a better livelihood are present. The access to infrastructure and services like communication and information, transportation and banking might further encourage such movements (Katel *et al*. 2024; Paldon *et al*. 2025). A case in point, as presented by Katel and colleagues, when 284 water sources dried up in Dagana disrupting livelihood, people saw relocation as a viable adaptation strategy. However, further research is needed to understand how far the environmental changes need to go for people to adopt migration decisions, especially given climate change as an indirect factor (Maharjan *et al*. 2020). In Bhutan, due to climate change temperature will rise, monsoons will become unpredictable, and extreme weather will become frequent, directly impacting livelihoods dependent on natural resources, compelling some communities to seek alternative residences and income sources (Gosai and Sulewski 2023). Researches show how agricultural yields would be changed due to climatic shifts, undermining food security (Katel *et al*. 2024). These climatic and environmental factors after interacting with socioeconomic determinants will create a network of incentives and disincentives, a decision dynamics for migration, which will influence the individual, particularly youths, who aspire to economic stability and educational advancement. There is an urgent need to understand and integrate policy approaches that address both climate

change adaptation and sustainable development to mitigate involuntary displacement. Specifically, in rural areas where traditional livelihoods like farming predominate, the impacts of climate change are likely to trigger increased out-migration as communities face mounting adaptation challenges (Katel *et al*. 2024).

Reflection on methodological strengths and epistemological gaps

Climate change has emerged as one of the most researched and studied fields in Bhutan. As mentioned, bibliometric analysis of research publications in Bhutan between 1894–2022 shows climate change as one of the most used key words (Wangdi 2023). Based on the understanding derived from this literature review, the popularity of climate change as a field of study can be attributed to two factors. First, the robustness and continuous development of methodology. The majority of research published in Bhutan adopts quantitative methodology, including predictive models, scenario-building, satellite observations, and large-scale statistical analyses. This enables regressive scenario-building and allows researchers to map, with increasing precision, various dimensions of environmental, social-cultural and economic development. Second, in addition to methodological strength, the field allows interdisciplinary collabouration. From the total literature referred to for this review, about 96% of the climate change research was collabourative; however in many cases, climate change made only a brief appearance.

Simultaneously, climate change and migration research, even when interdisciplinary, is often exclusionary in Bhutan. It fails to engage with the social sciences and humanities, and because of this it overlooks the place-based, deep, lived knowledge tradition of the local communities. In Bhutan,

long-term ethnographic and qualitatively engaging research has yet to catch up with the general quantitative research trend, both for climate change and migration. For instance, a few extended ethnographic studies provide a deep understanding of communities' everyday negotiation with climate variability, culturally rich interpretations of environmental changes, and traditional knowledge used to respond to such changes. The hegemony of quantitative research approach over qualitative, or simply ignoring the local interpretations, risks limiting our understanding of traditional negotiation strategies, community mobilization, and the process of embedding climate variability in the moral and cosmological framework by simply viewing it as a biophysical phenomenon (Yangzom and Wouters 2024; Wouters and Dema 2024; Dorji 2025).

Migration studies show a similar strength and weakness. In Bhutan migration study remains very recent. While most research concerns push-pull factors, rural-urban migration, international migration, migration motivation, and remittance, the research remains short-term and very event-driven. A sustained longitudinal study would enable us to understand changing aspiration of migrants, socio-economic transection, dynamics and geographies of emotion, and long-term community restructuring. For instance an ethnographic study by Chophel (2024) on the Bhutanese diaspora in Australia found that Buddhism – seen as uneconomic in Weberian view – is deeply embedded in material productivity and community resilience. To enhance the strength and address the gap, future scholarship needs to adopt mixed methodology to ensure scientific robustness and social insights for multiple epistemologies.

Conclusion

This integrative literature review attempting to situate migration within the

broader context of climate change sets out that while a singular direct link of causality between climate change and migration is not firmly established in Bhutanese literature, there is an increasingly evolving interplay between climate change (or for that matter environmental stresses), socio-economic changes, and migration decisions. Migration in Bhutan is not purely an outcome of economic aspiration or environmentally determined. Instead, the literature points to it as an outcome of compounded vulnerability and precarity influenced by factors like structural inequalities, climate variability, developmental scenarios, and changing aspirations.

Climate research clearly documents changes in temperature, precipitation, hydrological regime and the increasing frequency as well as intensity of natural hazards transforming biophysical elements, threatening climate-sensitive sectors like biodiversity, hydropower, and agriculture. There are established evidences that climate-related shocks intensify insecurities of food, environment, and livelihood primarily for the community depending on natural resources. This further leads to collective weakening of adaptive capacity, more so for geographically isolated and economically disadvantaged communities.

Running in tandem, migration studies in Bhutan primarily frame mobility through the economic, developmental, and aspirational aspects. Limited economic prospects, fewer employment opportunities, access to services and infrastructural provisions, and aspiring social mobility explains internal as well as increasing international migration in Bhutan. Imbalance in development, which has left eastern region less developed than the western region, has resulted in sustained depopulation, aging demographics and rampant land and house abandonment. This situation, combined with aspirations for better income and livelihood, professional and educational advancement, is often constrained by domestic challenges like an uncertain

agriculture future and labour market saturation, which drive international migration.

Putting these two bodies of literature together, an entry point of convergence emerges. Climate change is not an immediate factor for displacement. It is rather a background stressor that interacts with socio-economic vulnerabilities. Declining environmental integrity, declining agricultural productivity, and changing climatic conditions may not necessarily produce migration but they weigh on the calculus of sustainable livelihood. Migration could be factored in as an anticipated move towards stability through using it as an adaptive risk diversification strategy.

However, for Bhutan, significant research gaps remain. First, there are is very limited longitudinal, community-based qualitative research, which is crucial in understanding the lived experience of people through changing climate that could translated into a migration decision. Second, both climate change and migration research use indicator-based approaches adapting geospatial (for climate research) and predominantly economic (for migration studies) methods undermining and often overlooking socio-cultural, spiritual and cosmological, intergenerational and gender dynamics that influence the lived experiences. Finally, policy discourses address climate adaptation and migration governance separately, given the evident intersection. This will lead to migration becoming increasingly embedded and adopted by people as an adaptive livelihood strategy, but often overlooked, as climate risk amplifies. As migration is deeply intertwined within the nexus of environmental stress, economic restructuring, structural inequalities, and individual and collective aspiration, there should be research in the future that considers and prioritizes contextual, interdisciplinary, and community-grounded approaches to understand the complexity underpinning human mobility and livelihood security in the face of climatic uncertainty.

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