

Tourism & Change: A Longitudinal Analysis on Lodge Development
and Energy Consumption in Sagarmatha National Park

by

Kaitlyn Manninger

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Environmental Studies

in

Geography

Waterloo, Ontario, Canada, 2025

© Kaitlyn Manninger 2025

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Tourism in remote, high-altitude mountain areas presents complex challenges for sustainable development, particularly where there is limited energy infrastructure and environmental sensitivity. The tourism industry has an interdependent relationship with the economy, culture, and lifestyle of mountain communities. Within the industry, lodge accommodations and hotels are the most energy intensive components and are reflective of tourist activity because of their large economic value. Resource consumption within lodges can indicate changes within the socio-economic structure and development of destinations as they evolve to accommodate for tourism demand. This study examines longitudinal patterns of tourist lodge development and energy consumption in Sagarmatha National Park and Buffer Zone (SNPBZ), Nepal. It aims to characterize how tourism interacts with infrastructure and resource use over time to establish a historical database of change over time. Using spatial data, lodge surveys, and semi-structured interviews with lodge owners, this thesis analyzes temporal and spatial trends in lodge development and energy consumption. Data from 1997, 2011, and 2024 were compared to identify long-term shifts and patterns. The results show significant growth in both lodge development and capacities, particularly along the Everest and Farak routes. Energy use has shifted towards alternative sources such as LPG and electricity, though traditional fuels remain common in higher altitude areas. Findings also suggest a growing dependence on tourism revenue for access to sustainable energy sources. This study situates SNPBZ between the development and consolidation stages of Butler's Tourism Area Lifecycle model, with early signs of stagnation emerging. Inconsistencies in tourist flows and climate variability challenge the resilience of the park's energy infrastructure and raise questions about carrying capacity and adaptive capacity. This research contributes a longitudinal, place-based perspective to the

understanding of sustainable tourism development and energy transitions in high-altitude protected areas. The Government of Nepal should develop formal policy and regulation that supports community-based energy disaster and resilience planning while also considering tourism flows to properly align energy and tourist infrastructure development with revenues. Further research should investigate the supply side dynamics of resource management and the extent to which tourism may place additional pressure on surrounding areas outside of park boundaries.

Keywords: Tourism; Lodge development; Energy consumption; Sustainable Development; Mountain areas

Acknowledgements

This thesis is the result of many kilometers trekked, lots of elevation gained, new friendships made and some of the most precious memories and experiences a person could ask for. I have immense gratitude to everyone in both, Canada and Nepal, who supported me throughout this journey.

Firstly, I would like to thank my thesis committee here at the University of Waterloo. Thank you to my supervisor Dr. Sanjay Nepal for your unwavering encouragement and belief in me to carry out this study. I am so thankful that I had the opportunity to collaborate with you on a project you've been involved with since your PhD studies. Thank you to Dr. Michelle Rutty for your valuable insight and feedback throughout this process. I'd also like to thank Dr. Erin O'Connell for acting as the Reader for my thesis.

A special thanks to Dr. Thomas Kohler, at the University of Bern, for aiding with the funding of this project. I would like to acknowledge the role that Nepal Mountaineering Academy had in the organization of my fieldwork. Thank you for your kind hospitality and warm welcome to Nepal, and for helping with the bureaucratic aspect of this research.

I have so much appreciation and a very special place in my heart for my research assistant, Wooser Dolma Budha. Thank you for joining me on an adventure of a lifetime and for being such a pillar of this fieldwork. I have many sisters at home in Canada and I feel so lucky that I was able to feel like I had sister in Nepal. I hope there is more tea, momo, and games of 99 in our future.

I am also so grateful for all the people I met along the way, whether fellow trekkers or locals to SNPBZ, you were all instrumental to this project. A special thanks to Tenzin at Namche Terrace

and Sherpa Pemba Tseri at Panorama Lodge in Pheriche. Every person we met along the way was so extremely kind and inviting, SNPBZ really became a home away from home.

This thesis has been one of the most enriching and challenging adventures of my life – both academically and personally. It is characterized by long days, cold nights, deep reflection, magnificent mountains, spontaneous adventures, and good friends. Nepal is truly a magical place.

On a more personal note, I would like to thank my mom, my sister, Allie, and my very best friend, Emily. Thank you for teaching me to be courageous, brave, and authentic. Your support throughout this degree has encouraged me to stay the course, even when the going gets tough – on or off the mountain.

I will be forever grateful for the insight, memories, experiences and people I encountered while in Nepal. It truly takes a village, and in the case of my thesis, every village in Sagarmatha National Park.

Table of Contents

Author's Declaration	ii
Abstract.....	iii
Acknowledgements	v
List of Figures.....	ix
List of Tables.....	xi
Chapter 1: Introduction & Research Context.....	1
1.1 Mountain Environments and Tourism	1
1.2 Tourism Development and Energy Implications	3
1.3 Tourist Lodges and Energy Consumption in Sagarmatha National Park	4
1.4 Study Purpose and Objectives	6
1.5 Structure of Thesis	7
Chapter 2: Literature Review	8
2.1 Mountain Environments	8
2.1.1 Importance of Mountain Environments.....	8
2.1.2 Mountain Characteristics.....	9
2.1.3 Agenda 21 and Agenda 2030: A Call to Action.....	11
2.2 Sustainable Mountain Tourism	13
2.2.1 Tourism Development and Associated Implications	13
2.2.2 Mountain Environment Carrying Capacities and Tourism Lifecycle.....	17
2.2.3 Sustainability and Mountain Tourism Development	18
2.2.4 Approaches to Sustainable Mountain Tourism Development	20
2.3 Mountain Tourism and Energy	22
2.3.1 Tourism and Energy Geographies	23
2.3.2 Energy Consumption Implications and Mountain Destinations.....	25
2.4 Summary of Literature	26
Chapter 3: Methodology.....	27
3.1 Study Area and Background	27
3.1.1 Tourism Development in Sagarmatha National Park	27
3.1.2 Tourism Development Management in Sagarmatha National Park	30
3.1.3 Energy Consumption in Tourist Lodges in Sagarmatha National Park	32
3.2 Research Design.....	35
3.3 Research Objectives and Questions	36
3.4 Data Analysis.....	37
3.5 Electricity Data Analysis.....	38
3.6 Limitations of Methodology	40

Chapter 4: Results	41
4.1 Results of Lodge Development	41
4.1.1 Research Area and the Trekking Village Types	41
4.1.2 Lodge Growth and Development	46
4.1.3 Lodge Capacity Development and Growth	51
4.2 Results of Lodge Ownership, Management, and Labour Structures	62
4.2.1 Lodge Ownership and Labour Demographics	62
4.2.2 Labour Provenance	71
4.3 Results of Energy Consumption Patterns	73
4.3.1 Electricity Consumption	73
4.3.2 Fuel-based Energy Consumption	81
4.3.2.1 Firewood Consumption	82
4.3.2.2 Animal Dung Consumption	84
4.3.2.4 Kerosene Consumption	86
4.3.2.4 Liquid Petroleum Gas Consumption	88
4.3.2.5 Relationship Between Fuel-based Energy Sources	90
4.3.3 Water Consumption	96
Chapter 5: Discussion	100
5.1 Lodge Growth and Development Patterns	100
5.2 Shifts in Energy Consumption	104
5.2.1 Transformation of the Energy Mix	104
5.2.2 Electricity Adoption through Hydro and Solar Power	107
5.2.3 Park-Wide pressure on Fuel-based Resources	109
5.3 The Intersection of Tourism, Lodge Growth, and Energy Consumption	110
5.3.1 Energy Demand and Lodge Development	110
5.3.2 Tourism Recovery, Development Risk, and Energy Trade-offs	111
5.3.3 The Feedback Loop Between Tourism, Lodge Infrastructure, and Energy Transitions	112
5.3.4 Externalized Resource Pressure and the Park Boundary Illusion	113
5.4 Labour Structures and Sociocultural Change	114
5.4 Framing the Findings: Tourism Lifecycle, Carrying Capacity, and Sustainable Development	115
5.4.1 Tourism, Lodge Development, and Energy Consumption as Indicators of Destination Lifecycle Stages	116
5.4.2 Sustainable Development and Carrying Capacity	118
5.5 Natural Disaster and Climate Change	119
5.5.1 Natural Disaster, Climate Change, and Energy	119
5.5.2 Natural Disaster, Climate Change, and Tourism	121
Chapter 6: Conclusion	123
6.1 Recommendation for Policy and Practice	125
6.2 Further Research	126
References	128
Appendix A: 2024 Survey	137
Appendix B: 2011 Survey	140
Appendix C: Lodge Distribution Maps	142

List of Figures

Figure 1: Main trekking locations (Gehrig, 2014)	42
Figure 2: Distribution of lodges throughout SNPBZ in 2024	47
Figure 3: Fall 2024 GLOF aftermath	48
Figure 4: Total number of lodges per area in 1997, 2011, and 2024.	49
Figure 5: Percent of lodges per area of total lodge amount in 1997, 2011, and 2024.	51
Figure 6: Percent of room types across SNPBZ in 1997, 2011, and 2024.....	53
Figure 7: Total bed capacities in all lodges in 1997, 2011, and 2024.	54
Figure 8: Bed capacities in single rooms in 1997, 2011, and 2024.	55
Figure 9: Bed capacities in double rooms in 1997, 2011, and 2024	56
Figure 10: Bed capacities in triple rooms in 1997, 2011, and 2024.	57
Figure 11: Bed capacities in dormitories in 1997, 2011, and 2024.....	58
Figure 12: Average number of beds per area in 1997, 2011, and 2024.....	59
Figure 13: Total beds occupied in 2024 tourist seasons.....	60
Figure 14: Total beds occupied in Fall season, 2011 and 2024.....	61
Figure 15: Percentage of lodge ownership in 1997, 2011, and 2024.....	63
Figure 16: Owner-operated lodges managed by hired staff in 2024.....	64
Figure 17: Rented/managed lodges that are locally owned in 2024.	65
Figure 18: Family involved in lodge labour force in 1997, 2011, and 2024.	66
Figure 19: Hired staff in lodge labour force in 1997, 2011, and 2024.....	67
Figure 20: Relative distribution of labour force in 1997, 2011, and 2024.....	68
Figure 21: Gender of familial labour force in 1997, 2011, and 2024.	69
Figure 22: Gender of hired labour force in 1997, 2011, and 2024.....	70
Figure 23: Labour provenance in SNPBZ in 1997, 2011, and 2024.....	71
Figure 24: Labour provenance in SNPBZ by gender in 2011 and 2024.....	72
Figure 25: Number of lodges using hydropower in 2011 and 2024.	73
Figure 26: Number of lodges using solar in 2011 and 2024.....	75
Figure 27: Percent of lodges using hydro and solar power in 2011 and 2024.....	76
Figure 28: Daily units of electrical energy consumed per area in 2024	77
Figure 29: Daily hydroelectricity consumption and reporting rates in 2024.	78
Figure 30: Electricity consumption along the Thame route in 2024.....	80
Figure 31: Hydroelectricity consumption in Pangboche in 2024.	81
Figure 32: Total firewood consumption per area in 1997, 2011, and 2024.	82
Figure 33: Daily firewood consumption per area and deviation from park average in 1997, 2011, and 2024.....	83
Figure 34: Total dung consumption per area in 1997, 2011, and 2024.....	85
Figure 35: Daily dung consumption per area and deviation from park average in 1997, 2011, and 2024.....	86
Figure 36: Total kerosene consumption per area in 1997, 2011, and 2024.	87
Figure 37: Daily kerosene consumption per area and deviation from park average in 1997, 2011, and 2024.....	88
Figure 38: Total LPG consumption per area in 2024.....	89
Figure 39: Daily LPG consumption per area and deviation from park average in 2024.	90
Figure 40: Percent use of each fuel-based energy source per area in 1997, 2011, and 2024.....	92

Figure 41: Total fuel-based energy demand in joules per trekking area in 1997, 2011, and 2024.	95
Figure 42: Percent of total fuel-based energy consumption per area in 1997, 2011, and 2024. ...	96
Figure 43: Total daily water consumption per area in 1997, 2011, and 2024.	98
Figure 44: Daily water consumption per area and deviation from park average in 1997, 2011, and 2024.....	99

List of Tables

Table 1: SNPBZ Trekking village types and the change from 2011 to 2024.	44
Table 2: Total energy consumption of each trekking area in Joules in 1997, 2011, and 2024.	91

Chapter 1: Introduction & Research Context

1.1 Mountain Environments and Tourism

Mountain areas are biodiverse environments that supply various benefits to natural and human systems. These regions contain 30% of all major biodiversity areas on the planet and provide various ecosystem services which regulate the natural environment and yield resources such as food, medicine, and water (Colasante et al, 2024). Although mountains cover only 20% of the entire land surface on Earth, over half of the world's population benefits from mountain ecosystem services, their associated resources and runoff (Godde et al, 2000; Gret-Regamey & Weibel, 2020). Since mountains are such biodiverse areas and supply many resources to vast populations, they are extremely vulnerable to environmental change. Mountains also encompass rare cultural and environmental features that designate them as enticing tourist destinations (Godde et al, 2000).

Mountain areas have become the second most popular tourist destination, after coastal and island regions (Godde et al, 2000). Tourism has various implications on mountain regions that incorporate both, opportunities and challenges for mountain communities and environments. On the positive side, mountain tourism has influenced rapid economic development within remote and rural communities. This has resulted in the creation of jobs, government revenue, and infrastructure development (Isryad et al, 2019). This development has further increased the attractiveness of mountain areas as tourist destinations because they have become better equipped to provide and satisfy for tourist needs. However, tourism has also imposed negative implications on mountain regions through the overexploitation of resources, additional pressure on land use, and changes within the demographic structures of these areas (Colasante et al, 2024; Garrard et al, 2016). Tourism has the power to shape lifestyle and culture in mountain regions. Most people who reside in these areas rely on tourism, whether directly or indirectly, for economic purposes (Bhatta et al, 2022). This portrays the significance of tourism, thus why it is the focus of this study. In combination with rapid globalization and climate change, mountain

areas have become even more vulnerable, impacting their ability to produce ecosystem services and the supply of such resources (Gret-Regamey & Weibel, 2020).

There is a major difference between tourism growth of mountains areas in developed countries compared to developing areas. Mountain regions that experience tourism development in developed countries are characterized by organized management and regulation regarding environmental protection, waste disposal, and energy consumption. This management enables these areas to sustainably develop such that issues associated with resource exploitation and economic leakage are less pronounced in developed mountain areas. Meanwhile, developing nations experience high economic leakage, resource exploitation, and a loss of culture due to political instability and their characteristics of marginality, inaccessibility, and remote locations (Nepal, 2002). These implications on developing mountain regions limits, rather than liberates, economic opportunity within these communities (Bishwokarama et al 2023; Israyd, 2019). Thus, it is important to examine tourism development and the influence it has on resource consumption in developing mountain communities as the implications of development are far more severe due to the characteristics of these areas.

Tourism also heavily relies on the resources which mountains produce, sometimes beyond the point of the carrying capacity of these areas (He et al, 2023). Tourism is a major energy consuming sector (Sun et al, 2024) which has influenced development within mountain areas. Subsequent to this, there has been a growing demand and use of energy within mountain communities. Energy production and consumption is dependent on the resources available within mountain areas. In relation to development, energy is “one of the most important strategic inputs for socio-economic development in any economy” (Hussain et al, 2019). After transportation, accommodations and hotels are one of the most energy intensive sectors in the tourist industry (Lenzen et al, 2018; Scott & Gossling, 2021). From the perspective of mountain tourism and resource management, energy use patterns in lodges can indicate changes in socio-economic and tourism development and resource consumption. This is evident as the energy demands of lodges and accommodations are not only influenced by the number of tourists consuming energy, but also the amenities available within the lodge infrastructure (Gehrig, 2014). In combination with the amount and type of energy use, tourist accommodations are reflective of both, resource

management and use, as well as the operational efficiency of lodges which has influence on consumption patterns. This is through their portrayal of labour systems and consumption. Lodges are an indicator of these changes because they are the main type of infrastructure used by tourists. Infrastructure is the foundation of an organization and are commonly used to measure development within societies (Gehrig, 2014). The characterization of growth within tourist lodges will enable a comparative analysis of change relating to labour structures, lodge operations, and infrastructure and facility development.

1.2 Tourism Development and Energy Implications

In the broader context, tourism and energy consumption is often associated with greenhouse gas emissions and its contributions to climate change (Nepal, 2008; Katircioglu et al, 2014; Katircioglu, 2014). Although this is an important aspect of energy consumption, and climate change does indeed impose impacts on mountain regions, there needs to be a focus on localized issues relating to energy consumption (Calvert, 2016; Nepal, 2008). Specifically, energy resource use and management are important to examine in the context of mountain regions due to the issue of scarcity. There is a gap between the demand for resources and their availability within mountain areas (Gret-Regamey & Weibel, 2020). Since tourism influences the development of mountain communities, additional pressure is placed on land use and resource consumption as there is an increase in human activity within vulnerable regions. On top of resource scarcity, mountain communities also face issues associated with inefficient energy use, limited energy sources, and little access to renewable energy sources (Nepal, 2008). It is important to examine energy consumption patterns in tourist accommodations to understand the implications tourism has on natural resources due to its association with scarcity. Previous studies have called for comprehensive longitudinal research that aims to develop an understanding of the impacts of tourism and sustainability at the destination level (Butler, 1999). This thesis fills this gap through a longitudinal analysis that compares tourism development and energy consumption patterns from the perspective of resource management and scarcity to contribute to knowledge relating to the sustainability of mountain destinations.

1.3 Tourist Lodges and Energy Consumption in Sagarmatha National Park

Sagarmatha National Park and Buffer Zone (SNPBZ) is an established UNESCO World Heritage site and home to some of the tallest mountains in the world, including Mt. Everest. Due to the region's unique natural landscape, it has experienced rapid tourism development which has resulted in the growth and expansion of small mountain communities and settlements (Garrard et al, 2016). SNPBZ is the focus of this research because it is located in a developing country that has taken advantage of rapid tourism development. The tourism industry is one of the leading sectors for economic development in Nepal, contributing to 7% of Nepal's gross domestic product and employs more than 400,000 people (Nepal, 2022b). The park is also isolated and home to some of the tallest mountains on Earth, meaning that its unique environment provides an authentic outlook on the implications of development and resource use in high altitude environments. Finally, the rapid development that the area has experienced due to an increase in tourism and accessibility to alternative energy sources has changed the way in which energy is consumed in SNPBZ (Sun et al, 2024; Aubriot et al, 2019). This allows for an analysis of change over time as it is known that development has resulted in change, it is just a matter of understanding what has changed and the implications of change in energy use patterns.

There are two main type of energy sources used within SNPBZ: traditional and alternative energy. Traditional energy consists of sources such as animal dung and firewood while alternative energy comprises of any other resource, including renewable and non-renewable sources, such as solar power and kerosene (Aubriot et al, 2019). Tourist activity has influenced the way in which energy is consumed in SNPBZ as it has changed the scale of activity (Sun et al, 2024). Over time, the number of tourists arriving in SNPBZ has continuously increased (Bodach et al, 2016). As lodge accommodations have developed to meet the needs of tourists, more amenities have become available including hot showers, heating, and air conditioning (Bodach et al, 2016). It is evident that these changes are influenced by tourism because studies have identified that local people have not expressed a need or want for heating and cooling systems within their homes and lodging (Bodach et al, 2016). The changes in the scale of activity, combined with the influx of tourists, has resulted in changes to the sources of energy consumed in the park. These changes to energy use have occurred due to the implications that energy consumption has on local resources. For example, the increase in tourist activity in SNPBZ

resulted in an increased pressure on firewood where the supply of the resource could not meet its own demand forcing consumption to other sources of energy (Sun et al, 2024). Previous studies (Bhochhibhoya et al, 2017; Bhochhibhoya et al, 2020) have examined the impacts of hotel lodge accommodations in SNPBZ through a lifecycle analysis which identified that most impacts occur during the use stage of accommodations as energy consumption and its impacts are at their greatest during this stage. The “use” stage is the lifecycle stage in which lodges are operating and accommodating for tourists. Studies such as this provide evidence that it is important to investigate energy use consumption patterns within accommodations to understand the ways in which tourism has influenced resource use within SNPBZ.

This research aims to understand how tourism development has influenced energy consumption patterns within lodge accommodations and the associated implications on resource use and management in SNPBZ. Various studies have identified that tourism development has changed energy consumption patterns and have imposed additional pressure on resource management in the area (Sun et al, 2024; Bhochhibhoya et al, 2017; Bhochhibhoya et al, 2020; Gehrig, 2014; Mattle 1999). Previous studies have also found that there is a lack of standardized historical data relating to energy consumption (Bhuyian et al, 2024; Baptista, 2018). Dhananjayan et al (2023) recognized that there is limited data relating to mountain-specific energy data in the Hindu Kush Himalayan region. This thesis aims to fill these gaps by building off two previous research papers, creating a historical knowledge base of lodge development, energy consumption patterns, and resource implications over a period of 27-years in SNPBZ. The research that this study is based upon included Robert Gehrig’s research titled “Lodge Development in Sagarmatha National Park, Nepal” (2014) and Beatrice Mattle’s paper titled “Dynamic Development of Lodges, Their Energy Use, and Employment in Lodges in the Everest National Park, Khumbu, Nepal” (1999). Both studies include a complete survey of all lodges, lodge ownership, energy use of lodges, and lodge employment structures. This thesis intends to complete an updated inventory of survey data similar to that of Gehrig (2014) and Mattle (1999). It builds upon the statistical analysis conducted by Gehrig (2014) to understand the implications that tourism development and energy consumption in lodge accommodations has on resource use in SNPBZ. This research will also document the social organization of lodge accommodations by recording

labour and employment structures. Both Gehrig (2014) and Mattle (1999) documented this in their data collection.

More recently, a similar study conducted by Sun & Watanabe (2021) analyzed how tourism development in lodge accommodations transformed the social dimension of local communities in SNPBZ. The study by Sun & Watanabe (2021) had a sample size consisting of 76.1% of total lodges in SNPBZ. This research fills that gap through a complete census, covering 100% of lodges in the park. This thesis from this and will fulfill any missing data as it will include a complete census of all lodges in the park and will provide a study of change over time through a longitudinal analysis. There is limited literature on the nexus between tourism and energy consumption, particularly within a local context (Nepal et al, 2019) and this research contributes to the knowledge base within this subject of geography.

1.4 Study Purpose and Objectives

The main purpose of this research is to understand how tourism development has influenced and changed energy use patterns and energy types within lodge accommodations in SNPBZ over time through a longitudinal analysis. To achieve this goal, two research objectives were pursued:

- Objective 1: To characterize the growth of tourist lodges
- Objective 2: To examine energy consumption patterns and energy types consumed in tourist lodges

It is important to understand mountain tourism development, specifically through the perspective of tourist lodge growth, because tourism embodies major sources of economic revenue (Bodach et al, 2016), lodges are reflective of tourist activity as they develop and evolve to accommodate for tourist demand (Mattle, 1999; Gehrig, 2014), and, because of their major economic leverage, they have the power to influence the lifestyles of local mountain communities (Nepal, 2005; Spoon, 2012). A longitudinal analysis that examines the characteristics of growth amongst tourist lodges and the associated energy consumption types and patterns allows for an establishment of a knowledge database that will convey a thorough depiction of change within SNPBZ and will portray the ways in which tourism development and energy consumption within lodges has

evolved overtime. This may enable an enhanced understanding of the implications of tourism development and growth on remote mountain communities.

1.5 Structure of Thesis

This thesis is divided into six chapters: Introduction and Research Context; Literature Review; Methodology; Results; Discussion; and Conclusion. The first chapter introduces the research by outlining its context, purpose, and objectives. The second chapter explores the nexus between sustainable development, tourism, and energy consumption in high altitude areas. The third chapter examines the study area and positions the SNPBZ within the current literature. Chapter three proceeds to explain the research methods used to conduct fieldwork and data analysis. The fourth chapter establishes lodge development and growth, as well as energy consumption trends. Chapter five then explores what these patterns mean in the broader context of sustainable development within the park and in high-altitude areas. The final chapter concludes by reflecting on the findings of this thesis, the limitations of the data, and identifies recommendations for policy and further research.

Chapter 2: Literature Review

This chapter explores the nexus between mountain environments, tourism development, and energy consumption. This thesis encompasses a longitudinal analysis that examines the characteristics of tourist lodge development and the energy consumption patterns of those tourist lodges within the mountain area, SNPBZ. This review aims to outline the relationship between mountain environments, tourism development, and the implication of tourism development on energy resources in mountain regions. The literature review will characterize mountain environments, establish the current context of sustainable mountain tourism frameworks and research, and identify gaps in current research related to mountain environments, sustainable mountain tourism, and energy consumption.

2.1 Mountain Environments

This section explores the importance of mountain areas on both, a local and global scale. It then identifies the characteristics of mountain regions and how their characteristics are fundamental to the sustainable development of these areas. The section concludes by positioning mountain areas in the context of the United Nation's Sustainable Development Goals.

2.1.1 Importance of Mountain Environments

One-tenth of the global population resides in mountain regions, comprising the highest number of ethnic groups in the world and encompassing a diversity of cultures and traditional knowledges (Godde et al., 2000). Mountain aesthetics embody natural and cultural diversity which have established mountains as major tourist destinations (Nepal & Chipeniuk, 2005). In turn, tourism offers many opportunities for mountain communities to expand their economies through job creation and infrastructure development, which places themselves on the global map, taking advantage of globalization. However, when mountain regions become enmeshed in the tourist economy, local communities are often burdened with the negative implications of tourism, including economic leakage and resource scarcity (Nepal et al, 2019). Meanwhile, external stakeholders reap the benefits of development and foreign investment (Nepal et al, 2019; Nepal, 2022a; Schorner, 2010; Bishwokarma et al, 2023). This exacerbates the vulnerability of mountain communities and further instills poverty within these areas.

Mountain areas make up 20% of the planet's land surface and provide provisioning services for over 50% of the global population (Godde et al, 2000; Wehrli, 2014). The vast biodiversity of mountain regions provides various services which include drinking water, irrigation, hydropower, timber, food, and medicine (Wehrli, 2014; United Nations, 1993). Mountain environments are vulnerable, fragile, extremely biodiverse, and provide the Earth with crucial natural resources that support life all around the world. The United Nations (1993) has deemed these environments as "essential to the survival of the global ecosystem." In principle, mountain areas are especially important because of their diverse and abundant resource base that benefits all people around the world. Thus, it has been established that mountains are imperative for sustainable development in both, local and global contexts (Wehrli, 2014; United Nations 1993; United Nations 2012). In 1992, Agenda 21 was developed by the United Nations as a plan of action to address issues relating to human impacts on the environment at the local, regional, and global scale. This Agenda also emphasizes importance of mountain areas and the need to protect, conserve, and sustainably develop these areas (Godde et al, 2000). However, due to the characteristics of mountains, such as their marginality and limited accessibility they have yet to be prioritized in the context of global sustainable development.

2.1.2 Mountain Characteristics

Mountain areas are extremely diverse and are comprised of various bio-physical and socio-economic characteristics that define their unique and attractive environment. Physically, mountains are distinguished by their steep slopes, high altitude, and dramatic peaks. The natural environmental features of mountains make them extremely vulnerable and susceptible to the effects of climate change which includes soil erosion, landslides, and a loss of biodiversity (Wehrli, 2014; United Nations, 1993). Socially, mountains may be perceived as spiritual epicentres and hold religious value as places of worship (Godde et al, 2000). Due to the remoteness and rigor of their environments, mountain economies are typically reliant upon agriculture and tourism as a means of financial growth (Garrard et al, 2016). Not only are mountain environments fragile and remote, but so are the communities that exist within these areas. Mountain communities often experience government neglect and corruption as well as a lack of investment (Wehrli, 2014). Combined with the tough biophysical environment, mountain

societies are often characterized by vulnerability and poverty (Wehrli, 2014; United Nations, 1993). Between their natural landscape and divinity, mountains are dominated by rare attributes that make them popular tourist destinations around the world. Tourism can often be seen as a means to alleviate vulnerability and poverty in mountain regions, but often, it can exacerbate the implications of these characteristics (Mukwada & Mutana, 2018).

Nepal & Chipeniuk (2005) describe mountain areas through six major characteristics which are applicable to the natural, socio-cultural, and economic elements of mountain regions. These characteristics include diverse, marginal, limited access, fragile, niche, and aesthetic. The biophysical characteristics of mountain regions – high altitude, slopes, and topographic variability – have allowed multiple ecosystems to exist within one region, facilitating a wide-range of biodiversity (Godde et al, 2000). Mountain cultures have also embodied diversity as they have adapted to the complexity of their surroundings. This diversity has been maintained through their remote location as they continue to practice traditional lifestyles separate from the normalities of globalization (Godde et al, 2000). Economically, mountain regions possess diversity as they have been capitalized for their touristic appeal and peripheral attractions as well as their allure to mountain recreationalists who pursue specific activities including climbing, trekking, and mountaineering (Nepal & Chipeniuk, 2005).

Mountains can also be described as marginal based on their remote geographic locations and; as peripheral regions they lack prioritization regarding global development planning (Wehrli, 2014). Although mountain communities have lifestyles that sustainably coexist with the environment, they are recognized as marginalized by the United Nations (2012) as they are not typically considered in development planning. In combination with a lack of prioritization and limited government involvement, mountain economies and societies are further marginalized as they often lose autonomy over resource management and experience an increased dependency on foreign investment and activity (Nepal & Chipeniuk, 2005).

Mountain areas are considered as remote and peripheral areas, meaning that they are difficult to physically access. This lack of accessibility has limitations on the infrastructure available within these areas and subsequently, their connectivity to other areas of the world. However, Nepal &

Chipeniuk (2005) note that the limited accessibility of mountain areas can also be perceived as an economic advantage through the development of unique tourism products that can generate large revenues. Fragility is a fundamental attribute of mountain regions due to their natural landscapes, rurality, and remoteness (Nepal & Chipeniuk, 2005; Wehrli, 2014). The ecosystems in these regions are extremely susceptible to the impacts of climate and land use change (Garrard et al, 2016; Nepal et al, 2019; Gouvis et al, 2004). Considering this vulnerability to environmental change, mountain economies and societies are also fragile as they rely upon the ecosystem services and resources provided by these environments. Fragility of these areas means that activity must occur within the scale of the carrying capacity of mountain regions (Nepal & Chipeniuk, 2005; Butler, 1980).

The term ‘niche’ can also be used to describe mountain regions. Niche depicts features of mountain areas because it identifies the rarity of the landscape, culture, and exclusive activities that occur within these environments. This characterization is associated with the diversity and fragility of the natural environment and the affiliated carrying capacity (Nepal & Chipeniuk, 2005). This is because the niche features of mountains are often exploited for economic benefit thus placing pressure on fragile ecosystems that do not possess the capacity to sustain excessive activity. Because of their theatrical landscape and associated notions of spirituality, mountain areas have acquired an attractive aesthetic that has placed a high intrinsic value on these regions. Because of their profound beauty and unique recreational activity, mountain regions are often deemed as ‘superior’ to other landscapes by various cultures (Nepal & Chipeniuk, 2005). Aesthetic is an important characteristic of these areas because it portrays the value that the world places on mountains in the context of recreation, spirituality, and beauty. The characteristics of mountain areas, as well as their importance, has put them in the global spotlight for sustainable development as the United Nations includes them in strategies for sustainable development.

2.1.3 Agenda 21 and Agenda 2030: A Call to Action

Chapter 13 of Agenda 21 focuses on the importance of mountain areas and establishes a foundation to manage sustainable development in these regions. Programme 1 specifically relates to this research as it calls for specific information on natural resource potential and socio-economic activities in mountain areas (United Nations, 1993). This is applicable to this thesis as

it documents a longitudinal analysis on socio-economic activity such as the characteristics of tourist lodge infrastructure and lodge ownership and labour structures, as well as natural resource data relating to energy usage patterns. Chapter 13 proceeds to describe the necessity of the creation and maintenance of a global mountain database as it will provide crucial information that will allow for further establishment of sustainable mountain development strategies (United Nations, 1993). Mountains are important for their tourism and recreational opportunities and, more importantly, their natural resource base that provides ecosystem services to the entire world. Tourism in mountain areas has various associated advantages and disadvantages on local communities. However, when approached properly, it has the potential to promote sustainable development within mountain regions (Bhuiyan et al, 2024). It is imperative that mountain areas are protected and developed sustainably because of the role that mountain resources play in both, local and global contexts. Therefore, this research is relevant and important as it contributes to the objectives of Chapter 13 in Agenda 21 by producing a knowledge base that documents the historical influence of tourism development on energy resource use in an extremely vulnerable mountain environment, SNPBZ.

Although Agenda 21 has a greater focus on sustainable mountain development, this research also aligns with Agenda 2030 which prioritizes both sustainable tourism development and mountain conservation through its recognition of the sustainable management of natural resources through the conservation of mountain areas and the promotion of sustainable tourism (United Nations, 2015). Since this research has a focus on sustainable tourism development in mountain regions, it addresses the Sustainable Development Goals (SDG) numbered 8, 12, and 15 (in addition to several associated sub-targets).

SDG 8 intends to “promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.” Sub-target 8.9, aims to formulate and implement policies to encourage sustainable tourism which will create jobs and promote local culture and products (United Nations, 2015). By providing a database of knowledge relating to tourism development in SNPBZ, this research contributes to Goal 8 because the findings can be used to create sustainable tourism development policy.

SDG 12 is to “ensure sustainable consumption and production patterns,” with its sub-target 12.b directly links to this research as it aims to “develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promote local culture and products” (United Nations, 2015). This research will help meet sub target 12.b through a longitudinal analysis that examines change and impacts associated with sustainable tourism development in SNPBZ. The research examines sustainable tourism development over a 27-year period, providing a unique perspective of change that can be used by government and policy makers to foster sustainable development through tourism.

SDG 15 intends to “protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.” It’s sub target 15.4 is to “ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development” by 2030 (United Nations, 2015). Since this research creates a historical database of knowledge on tourist lodge development and energy consumption patterns, it holds the potential to address SDG 15 and sub-target 15.4 because the data provides energy resource management information that can be used to support policy and strategy that can foster the sustainable consumption of resources within the mountain area, SNPBZ.

2.2 Sustainable Mountain Tourism

The following section examines the relationship between tourism development and mountain environments. It analyzes the current literature to develop a thorough understanding of the impacts and management strategies of mountain tourism development.

2.2.1 Tourism Development and Associated Implications

Tourism is a vast and complex industry that has the power to influence development and promote modernization in remote destinations. Tourism has been a part of human culture for centuries and can date back to Roman society (Butler, 2015). However during the industrial revolution, the accessibility and convenience of tourism was transformed by railroad development. The convenience of tourism was further stimulated through air travel. Over time, tourism has become

tangible for tourists of many different class levels by providing cheap travel fees to large masses of people (Butler, 2015). In 2022, tourism accounted for 7.6% of the global gross domestic product (WTTC, 2024). Although the technological resources and means to tourism have changed over time, the activities and reasoning for tourism have remained consistent. The purpose of tourism encapsulates leisure, escapism, spirituality, history, and nature. There has been an increasing interest in mountain and wilderness tourism. This is due to a paradigm shift from perceiving these areas as treacherous and unsafe to the romanticization of mountains and nature inspired by poets, philosophers, and naturalists such as John Muir (Butler, 2015). Despite the paradigms towards mountain tourism, accessibility of mountain regions has greater influence on the popularity of mountain tourism as it has become easier for all types of tourists to visit these remote, high-altitude areas (Apollo, 2017). The characteristics of mountain regions make them crucial for both, global and local, economic development. Tourism in mountain regions must be examined because these peripheral areas have been marginalized and tourism presents various economic opportunities for these communities to participate in development (Nepal et al, 2002).

Tourism is a holistic field of study that is comprised of economic, environmental, and socio-cultural aspects that influence and effect the way in which and to the extent that tourism develops and vice versa (He et al, 2023). As tourism has been present throughout human history and the number of tourists is only expected to increase, it has proven to hold an unlimited potential for growth and development at both, the destination, and global level (Butler, 1980). This is evident as global tourist arrivals were at 1.2 billion in 1997 and by 2020, this number reached 2.4 billion tourists (World Bank Group, 2025). At first glance, tourism is recognized as a means for economic growth and development amongst remote destination communities, particularly those located in rural mountains areas. Often, tourism is perceived as a solution to poverty within marginalized communities due to its associated benefits (Mukwada & Mutana, 2018). This is because an increase in tourism activity influences an influx of economic revenue which prompts infrastructure development and job creation (Nepal et al, 2019). Areas that become tourism hotspots experience globalization as development attracts external stakeholders including travel agencies, hotel chains, and other private entities (Nepal, 2015).

Foreign involvement in the tourism economies of developing nations has formed a dependent relationship in which destinations rely on external enterprise and markets to dictate the marketability and economic development of these areas (Britton, 1982). This is true for two reasons. First being that developed countries provide the ‘demand’ of tourism as their residents are those who travel to destinations that provide the ‘supply’ of tourism. Second, foreign investment in developing nations often results in the development of infrastructure that is catered to the tourist (e.g., restaurants and peripheral activities) and consumes specific resources that either exploit the local environment (e.g., deforestation) or relies upon the importation of goods from developed countries (e.g., novelties such as Guinness beer served in Namche Bazaar) (Britton, 1982; Sgroi, 2020; Gouvis et al, 2004; Nepal, 2015). The arrival of tourists imposes pressure on the environment and economy because they often seek similar amenities available in their home countries that are not typically present in remote, mountain environments. This alters the way in which local communities consume and interact with resources and amenities at the destination level (Nepal, 2015). The involvement of developed nations in the tourism economies of developing countries can therefore counter the benefits of tourism on local development and, sometimes, generates more harm than good on these areas by imposing economic, environmental, and social inequality (Britton, 1982). This highlights that the pressures of tourism development have resulted in changes to the consumption of resources as tourist specific infrastructure has expanded to accommodate for the various needs of the traveler. Additionally, tourism development has been highly influenced by the motivations of external stakeholders on a global scale, and not the communities who are directly involved in and impacted by development. Relative to this research, the development of tourism infrastructure and the pressure that it places on energy resources in a mountain region is examined.

As tourism development involves the expansion of mountain communities through globalization and foreign investment, it imposes change to on sociocultural state of these areas. This change is felt through a shift in communal power dynamics and the beneficiaries of development. Often, only the wealthier members of the community experience the economic benefits of tourism development as they have the resources to initially invest in the sector. These individuals hold greater control in the way that development occurs as they have monopolized the industry and have obtained greater economic and social power (Jamal & Dredge, 2014).

Tourism development results in shifts in land cover and land use change through greater exploitation of natural resources to meet the demand for tourist demands and infrastructure such as lodge accommodations and energy consumption. Many of these changes result in environmental degradation through the loss of vegetation and forest areas due to clear cutting and building expansion (Mukwada & Mutana, 2018; Gouvis et al, 2004). This is evident in mountain areas such as the Dongling Mountains in China where tourism has imposed a loss of species richness and heterogeneity in subalpine areas (Schmeller et al, 2022). The excessive consumption of natural resources and the associated implication of environmental degradation diminishes the ability of mountain areas to produce crucial ecosystem services. In this context, especially in mountain areas of the Global South, such as the Himalayas, there has been evidence of a decline in ecosystems services since the early 21st century (Gret-Regamey & Weibel, 2020).

Mountain tourism can often be considered a negative externality to these areas because of the way in which it exacerbates negative socio-cultural and environmental impacts of the area in which it unfolds (Bhuiyan et al, 2024). The concept of a ‘carbon footprint’ can be applied in the context of mountain tourism development because tourism can amplify the inequity of resource consumption trends (Nepal et al, 2015). This is because mountain areas are typically located in peripheral regions that are considered emerging nations where they do not experience consumption levels comparable to those of developed countries. Tourism considerably increases resource consumption in vulnerable areas, such as mountains, which induces additional pressure on the natural environment, imposing excessive demand from ecosystem services that have limited supply. A study by Gret-Regamey & Weibel (2020) found an increasing gap between supply and demand of ecosystem services in mountain areas, though the study was representative of one period in time. As such it did not include greater insights on the socio-ecological history of resource supply and demand in mountain areas. This thesis offers a longitudinal analysis to better understand whether tourism, a socio-economic industry, has influenced a change in the consumption or demand of energy resources in a vulnerable mountain region. The understanding of scarcity and the fact that there is a gap between the supply and demand of mountain resources relates to the key mountain issues relating to carrying capacity and stagnation development.

2.2.2 Mountain Environment Carrying Capacities and Tourism Lifecycle

Butler (1980) established a conceptual framework, known as the Tourism Area Lifecycle (TALC) model that acknowledges that tourist areas have a carrying capacity and a lifespan which can be depleted. As a destination grows and becomes popular, the carrying capacity diminishes. Essentially, an increase in tourist activity results in a decrease in the availability of resources to support future tourism. These resources are not limited to natural resources. They also include physical infrastructure such as transportation and accommodations, as well as social elements of overcrowding (Butler, 1980). As tourist activity increases and the availability of resources decrease, tourist activity will also eventually decrease. This is due to various reasons including diminishing aesthetic because the influx in development impairs both the resource base and the allure of the destination, general overuse of the area, and the associated environmental, economic, and socio-cultural impacts. This ideology perceives rapid tourism growth as a positive feedback loop that will eventually result in the demise of destinations that experience tourism development without proper planning and management. Throughout the destination lifecycle, there are various stages in which an area may evolve. These stages include involvement, development, consolidation, stagnation, decline, and rejuvenation (Butler, 1980). The carrying capacity of a destination often influences the stage of the destination within the tourist lifecycle and vice versa (Martin & Usyal, 1990). Martin & Usyal (1990) identifies that there is a dynamic relationship between the two concepts of carrying capacity and tourism lifecycle in which the carrying capacity of a destination is determined based on the lifecycle position of the destination (i.e. the carrying capacity of a destination is different at each lifecycle stage).

The idea of a tourism lifespan and carrying capacity is especially relevant in mountain areas because tourism is often thought of as a solution to poverty. Although, it does indeed provide economic opportunity in remote communities, it can also collapse mountain destinations by exceeding the carrying capacity and driving these regions to the decline lifecycle stage. The characteristics of mountains areas are also important to consider when examining carrying capacity because of the vulnerability of these areas and the importance of their resource base in the global context. It is evident that there is a gap between the supply and demand of the resources available in mountain regions (Gret-Regamey & Weibel, 2014). The concept of carrying capacity and lifespan in tourist destinations demonstrates that resources within these

areas are finite and that without proper planning and management, tourism activity is not sustainable. This conceptual framework is applied to this thesis as it aims to identify changes in energy resource consumption over time. This study reveals the current demand of these resources, analyzes the changes in demand over time and discusses how tourism has influenced changes in demand. A knowledge base that exhibits the demand tourism imposes on energy resources will provide information that could contribute to studies relating to the tourist lifecycle stage of SNPBZ.

2.2.3 Sustainability and Mountain Tourism Development

The counterproductive implications of tourism call for the integration of sustainability and tourism to promote the healthy development of tourist communities. Tourism in remote, mountain areas is characterized by haphazard development that often results in environmental degradation, economic leakage, resource exploitation, and a loss of cultural heritage (Nepal, 2002; Bishwokarama et al, 2023; Israyd, 2019). The sustainable development of mountain areas is especially important because of their role in resource provisioning services in the global context (Godde et al, 2000; Wehrli, 2014; United Nations 1993; United Nations 2012). Although the tourism industry advocates for sustainability, it practices excessive growth expansion (Nepal, 2022b). Consequently, there is a divide between the positive intentions of tourism and the way in which it operates (and the subsequent negative implications). Approaching tourism from the perspective of sustainability can guide development within mountain regions to conserve the natural environment and promote healthy socio-economic growth at the local scale. Considering that tourism can have negative socio-economic and environmental impacts, sustainable tourism should be applied in mountain regions as one of many methods to achieve sustainable development. This will help facilitate the equal prioritization of the economy, society, and environment such that employment opportunities increase, social infrastructure becomes available, and natural areas and resources are protected and conserved (Gouvis et al, 2004).

The concept of sustainable tourism encompasses many definitions and has been interpreted differently by various scholars and organizations within the field of sustainable tourism and geography. In 1993, the World Tourism Organization defined sustainable tourism as “tourism which meets the needs of present tourists and host regions while protecting and enhancing

opportunity for the future” (Butler, 1999, page 10). Meanwhile, the Countryside Commission defined it as “tourism which can sustain local economies without damaging the environment on which it depends” (Butler, 1999, page 10). Eber (1992) identifies sustainable tourism as a holistic concept in which “tourism and associated infrastructure that: both now and in the future operates within natural capacities for the regeneration and future productivity of natural resources; recognizes the contribution that people and communities, customs and lifestyles, make to the tourism experience; accepts that these people must have an equitable share in the economic benefits of local people and communities in the host areas.”

Although all three of these definitions vary, they all present a fundamental theme wherein sustainable tourism promotes the long-term socio-economic development of tourism while maintaining the current natural state of the destination. For tourism itself to be inherently sustainable, it requires that it be a “a form of tourism which can maintain its viability in an area for an indefinite period of time” (Butler, 1993). In the context of sustainable tourism development, Butler (1993) presents a definition that combines all three definitions to identify a standard meaning behind ‘sustainable tourism’: “tourism which is developed and maintained in areas (community, environment) in such a manner and at such a scale that it remains viable over an infinite period and does not degrade or alter the environment (human and physical) in which it exists to such a degree that it prohibits the successful development and well-being of other activities and processes.”

This definition is applicable to the understanding of the relationship between sustainable tourism and sustainable development because it recognizes that tourism presents socio-economic opportunities for destination communities. Simultaneously, it acknowledges that tourism should not be the central focus of development because it holds the potential to impose constraints on other economic activity and areas of development. This is especially important because tourism can often act as a competitor for resources resulting in negative environmental and socio-economic impacts in mountain regions. Bhatta et al (2022) recognizes that tourism is on a sustainable path and contributes to sustainable development when it is possible in the long term, culturally compatible, socially balanced by equally spreading its advantages and disadvantages, ecologically viable by placing low pressure on the environment, and economically productive.

When considering sustainable mountain development, sustainable tourism is often recognized as a growth management strategy. The relationship between mountain communities and tourism has demonstrated that tourism provides economic opportunity and development for these communities and that it depends on the natural environment of mountain areas for aesthetics, which attract tourists, and resources, which accommodates them (Schorner, 2010). When implemented strategically, sustainable mountain tourism can stimulate sustainable development outside of the realm of tourism within the communities it exists. This is observed through the implementation of policy and law that conserve the natural environment, the reinvestment of tourism revenues into social services, the empowerment of women, and the improvement of land use management and infrastructure investment (Schorner, 2010). Tourism growth can be integrated into sustainable mountain development and vice versa using tourism concepts that promote longevity and sustainability of destinations. Frameworks such as carrying capacity and destination lifecycle present a managerial foundation for sustainable mountain tourism development as they observe that resources within destination areas are finite and understand the implications of excessive consumption. To promote sustainable mountain development, sustainable tourism must focus on small-scale, local development (Butler, 1999; Nepal et al, 2015).

2.2.4 Approaches to Sustainable Mountain Tourism Development

Bhuiyan et al (2024) examined sustainable tourism in developing countries, such as Vietnam, and identified that development management policies and strategies are crucial to prevent and reduce the negative implications imposed by tourism. When management strategies are applied at the local scale, they are typically most successful. Nepal (2015) proposes that destinations should scale down their approaches to sustainable tourism to emphasize the locality of tourist activity and establish sustainability from the ground up rather than using it as an intervention method that reacts to the impacts of mass, conventional tourism. This may be challenging for emerging mountain destinations because of the tourism ‘hierarchy’, presented by Britton (1982), in which developed countries dominate the way tourism activity occurs in these areas. Mountain communities in developed countries have access to greater financial and political resources that enable them to adopt management strategies to promote sustainable development. However,

these management strategies may also be suitable for developing mountain communities. Aspen, (Colorado, US) and Whistler (British Columbia, Canada), are two popular North American mountain destinations that have experienced rapid tourism growth and have implemented local growth management strategies to regulate the implications of development. Two major strategies adopted that are applicable to emerging mountain communities include the involvement of community stakeholders and the recognition and understanding of the region's stage of development or lifecycle stage (Gill & Williams, 1994).

Community involvement in sustainable mountain tourism development is important because the community is often considered the foundation of a destination as they provide the product that tourists seek (Gouvis et al, 2004). This strategy coincides with Nepal's (2015) doctrine that management should be implemented through a bottom-up approach because it involves those who are most involved and impacted by the implications of tourism. The second strategy involves understanding of the destination's lifecycle stage aligning with the concept of tourism lifespan and carrying capacity presented by Butler (1980). Colasante et al (2024) also emphasized that research with a focus on carrying capacity and the relationship between demand and supply, such as Gret-Regamey & Weibel's (2020) study is applicable and important to the management of sustainable tourism development in developing nations.

Carrying capacity and tourism lifecycle stages can depict the current state of development and the implications that tourism has on an area while community involvement can be used a method to adapt to and improve the carrying capacity and the destination life stage. Community based natural resource management (CBNRM) is a development strategy often used in protected mountain areas to implement sustainable tourism and alleviate poverty. This management framework engages the community to involve them with local institutions and toward the management of natural resources within the area (Dahal et al, 2014). This form of development management has been applied in various areas around the world, including both developed and developing countries, such as Nepal, the United States, and India (Milupi et al, 2017). In affiliation with carrying capacity, CBNRM provides communities with the ability to regulate the use of natural resources within their environment to avoid issues associated with common pool resource theories and the tragedy of the commons (Ngwira, 2013). These issues entail the

overexploitation of resources as they are considered the ‘commons’ amongst communities in which their use is not regulated and they are available for anyone to use. Issues relating to the tragedy of commons have been present in SNPBZ as overconsumption has resulted in deforestation, overgrazing, and resource scarcity (Byers, 2005). Lea (1998) identifies that if the tourism industry is to contribute any means of development to a country, community involvement is imperative. This will promote revenue retention within the community and prevent economic leakage. Since tourism provides such vast economic opportunities for developing destinations, CBNRM acts as a nexus between tourist activity and government management (Ngwira, 2013).

CBNRM as a management strategy for sustainable tourism development has many associated benefits and challenges. For example, in African countries such as Botswana, Namibia, and Zambia, CBNRM has influenced improved attitudes toward natural resources, community development, and the conservation of natural resources. However, CBNRM has affiliated challenges because there is often a lack of management skills within community-based organizations, minimal government support, and limited policies that integrate CBNRM into national development plans (Ngwira, 2013). This thesis informs community-based natural resource management because it identifies community perspectives through surveys and portrays the management of energy resources through examining consumption patterns. The establishment of a historical knowledge base on tourism development and energy consumption patterns may inform the tourism life stage of SNPBZ which could provide information for policy development that can be applied to CBNRM frameworks and promote sustainable tourism development.

2.3 Mountain Tourism and Energy

Tourism and energy have an interconnected relationship that is mutually dependent. This section examines this relationship and positions tourism and energy consumption in the context of mountain areas.

2.3.1 Tourism and Energy Geographies

Like tourism, energy is a factor that can influence and determine development within a destination (Amin et al, 2020). Energy use and development is often reflective of the socio-economic status of an area as energy systems are spatially embedded into the cultures of consumption and infrastructure (Baptista, 2018). This is apparent in the type of energy and its use patterns based on the available infrastructure that can support energy consumption. The use of energy can also depict the organization and governance of energy and the social systems that influence its use (Baptista, 2018; Calvert, 2016). This relates to this thesis as it aims to understand changes in both, the labour structures and operations of lodge accommodations and energy consumption patterns. An analysis on energy systems within lodge accommodation will provide an outlook on how labour structures may have changed based on resource availability and consumption. Although this research examines labour structures to understand the operation behind energy patterns and consumption efficiency, there is potential to make connections between changes in infrastructure development and labour structures, and how energy consumption indicates change.

Energy consumption requires specific infrastructure to facilitate the use of different types of energy resources. The available energy infrastructure can influence the way in which an area develops based on the types of energy resources that the infrastructure can support (Baptista, 2018; Bridge et al, 2013; Calvert, 2016; Sun et al, 2024). Historically, changes in energy infrastructure often align with mass social change such as industrialization, urbanization, and modernization (Bridge et al, 2013). This means that energy consumption is associated with more than just resource implications, but also can influence significant change to the broader natural, social, and economic environment. The presented research holds the potential to portray energy transitions over time within SNPBZ that can reflect socio-economic development influenced by the evolution of both tourism and energy development. In the context of natural resource implications, the environmental consequences of energy consumption are often overlooked due to the strong correlation between economic development and energy consumption (Bridge et al, 2013). This portrays that the implications of energy consumption are not often understood holistically, providing an argument for the further understanding of energy consumption implications on both, the environmental and sociocultural aspects of a community.

Both, energy consumption and tourism can influence development within an area as they endorse foreign direct investment, job creation, and globalize areas such that they adopt modern lifestyles (Khan & Hou, 2021). The way in which tourism interacts with the environment impacts energy and vice versa. Studies have found that, typically, tourism activity results in increased energy consumption which has established the sector as an energy-intensive industry that imposes issues of resource scarcity (Selvanathan et al, 2021; Nepal, 2008). Although some research has shown that tourism can increase energy consumption, it has also been found that energy consumption can reduce tourism activity (Nepal et al, 2019). This is due to increasing energy consumption that places too much pressure on natural resources, depleting the resource base and limiting further economic opportunity in a destination. This relationship portrays that the rate of tourism activity and its associated energy consumption can impact the carrying capacity of a destination, thus influencing the tourism lifecycle stage.

Scott & Gossling (2021) identified tourist accommodations as an important area for decarbonization and energy efficiency. The hospitality industry within the tourism sector is also acknowledged as one of the most important areas for economic development as more accommodations are built by investors to support the growth of tourism activity (Bodach et al, 2016). Along with this development comes an increased demand for energy as newly built accommodations are equipped with amenities that provide comfortable lodging. The change in the availability of amenities has the power to modify the social organization of the labour structures of these lodges (Calvert, 2016). An example of this could be that the accessibility of stoves for cooking have improved the efficiency of meal preparation, meaning that women may spend less time cooking, changing their role within the accommodation. This is an important perspective within energy transitions as it portrays that energy can simultaneously influence economic, socio-cultural, and environmental change.

Nepal et al (2019) recognized that there is a need for further research on the causal interactions between tourism and energy consumption, noting that there is limited literature on this relationship due to a lack of quality in time-series data. The study used time-series data, obtained from Nepal Tourism Statistics and World Development Indicators, to provide an in-depth

analysis on tourist arrivals, energy consumption, and associated pollution over time. The study concluded that energy consumption can limit the carrying capacity of a destination, thus impacting the economic opportunities presented by the tourism industry. Although there are similarities between this study and this thesis, there are important differences. Both studies incorporate a longitudinal analysis, however, this thesis is based upon primary data and the research of Gehrig (2014) and Mattle (1999) who established the foundation for this study. Additionally, the research by Nepal et al (2019) focused on the entire country of Nepal and general tourism arrivals, whereas the scope of this thesis is centered around SNPBZ and tourism activity within the lodge accommodations. The relationship between tourism and energy consumption patterns are important to examine because they both encompass the power to influence, inhibit, and indicate sustainable development within a destination.

2.3.2 Energy Consumption Implications and Mountain Destinations

The implications of energy consumption in mountain areas are typically associated with the impacts that it has in the global context which relates to pollution and greenhouse gas emissions. However, the scope of this research is relative to energy consumption in lodge accommodation which has local implications associated with environmental degradation and resource scarcity. The accommodation sector relies on primary resources such as fuelwood which may cause deforestation, further triggering natural hazards and environmental risks (Nepal, 2008). It is important to note that energy consumption often influences more energy consumption as the demand of the function for energy becomes greater (Amin et al, 2020). This is evident as energy consumption influences the development of greater infrastructure which promotes even further consumption. For example, in a lodge accommodation, energy consumption may initially supply light and cooking, however, it may evolve into hot showers and heating. As tourism grows within mountain destinations, so does the demand for energy, which then places pressure on local resources and contributes to carbon dioxide emissions (Selvanathan et al, 2021). As Nepal et al (2019) established, the carrying capacity of mountain destination is often impacted by energy consumption which in turn decreases tourism activity.

The characteristics of mountains must also be considered when examining energy consumption patterns within these regions as they influence both, the type and amount, of energy consumed.

Mountains are characterized by high altitudes where temperatures are often cooler meaning that there is a greater demand for energy to heat lodge accommodations. It also takes longer to boil water at high altitudes, meaning that more energy is consumed for basic activities such as cooking (Nepal, 2008; Katsoulakos & Kaliampakos, 2016). The types of energy available at different altitudes varies due to the remoteness of mountains. Not all energy resources are available at all altitudes, meaning that the limited diversity of resources places additional pressure on local resource availability (Katsoulakos & Kaliampakos, 2016). The relationship between tourism and energy consumption is holistic as it influences and indicates development through economic, socio-cultural, and environmental change. This is evident through the connectivity of the opportunities and implications of tourism and its associated energy consumption patterns.

2.4 Summary of Literature

This literature review explores the three key topics of this thesis: mountain environments, tourism development, and energy consumption. Mountains are important in both, the global and local context, such that they provide crucial resources to more than half of the world's entire population. Mountains are tourism hotspots and are extremely susceptible to the implications of tourism due to their many characteristics including fragility, marginality, and remoteness.

Tourism within mountain areas can often result in excessive consumption of limited natural resources which impacts the carrying capacity and viability of these destinations. There is often a discrepancy between tourist demand and the availability of resources. The consumption of energy within mountain tourism areas is a positive feedback loop in which energy consumption often results in even greater energy consumption. Within the topic of sustainable mountain tourism and energy consumption, current research lacks an accurate representation of tourism-energy related data as previous studies have limited sample sizes. Additionally, the need for a longitudinal study on tourism and sustainability at the destination level has been emphasized throughout the literature. Lastly, there is limited research relating to mountain-specific energy data within the Himalaya region. This literature review sequentially analyzes mountain environments and the implications of tourism on these areas, as well as the associated implications on energy resource management.

Chapter 3: Methodology

This chapter outlines the methodological approach used to develop the longitudinal analysis aimed to characterize lodge development and identify patterns in energy consumption throughout SNPBZ. This section begins by positioning the park within the current literature by identifying tourism development management strategies and energy patterns. It then explains the research design of this thesis, based upon two previous studies (Mattle, 1999; Gehrig, 2014) to produce a longitudinal analysis of change. The objectives and questions of this research are then highlighted, and the data analysis is explained, followed by a summary of the research limitations.

3.1 Study Area and Background

SNPBZ was established in 1976 and became a designated UNESCO World Heritage Site in 1979. It is located in north-eastern Nepal and is home to the tallest mountain on Earth, Mt Everest (8,848 m). The park is divided into a core zone and a buffer zone. The core zone is approximately 1,148 km² and the buffer zone is 275 km². The lowest point of SNPBZ is in Monjo which is 2,845 m above sea level while the highest point is the summit of Mt Everest. It has an elevation range of 6,000 meters. The topography of the park is characterized by bare rock, shrubland, forests, snow, and glaciers. The area is highly biodiverse and home to approximately 2,500 people. These include hemlocks forests, rhododendron plants, red pandas, snow leopards, and musk deer. The ecological and cultural diversity of SNPBZ has made it an extremely popular tourist area in which tourism activity has influenced much of the development within the region.

3.1.1 Tourism Development in Sagarmatha National Park

Mt. Everest became a popular adventure and mountaineering tourism destination after its first confirmed ascent by Edmund Hilary and Tenzing Norgay on May 29th, 1953 (Nepal, 2022b). Prior to this, tourism activity was limited in Nepal due to the autocratic Rana regime which restricted foreign visitors from entering the country (Nepal, 2022b). When democracy returned to the country in the early 1950s, tourism became an ever-growing industry with the first organized travel tour introduced by Thomas Cook in 1955 (Nepal, 2022b). Within a 20-year period, from 1960-1980, the Khumbu region experienced a growth in visitor activity from 20 tourists to over

5000 tourists (Jeffries, 1982). This increase in tourist activity boosted the country's total tourism revenue by US \$50 million. Despite the economic benefits, SNPBZ experienced disruptions to their land management practices and major deforestation as the pressures of tourism resulted in an increased demand for fuelwood and timber product (Byers, 2005).

Between the economic and environmental implications of tourism development in the later half of the 20th century, the tourism industry in Nepal was characterized by haphazard management and budget tourists from Western countries (Nepal, 2022b). In the 1970s and 1980s, the level of environmental degradation in the Himalayas was reaching the point of no return as there was a continuous increase in deforestation and overgrazing which culminated in fuelwood shortages, soil erosion, landslides, and flooding (Byers, 2005; Jeffries, 1982). Prior to this boom in tourist activity, forest resources were mainly used for building, cooking, and limited heating in SNPBZ. By the beginning of the 1980s, resources are used to support tourist activity and provide larger lodges and hotels which depend on increased resource consumption, accelerating the rate of exploitation of natural resources in the area (Jeffries, 1982).

By 1985, Nepal entered its phase of accelerated growth in which the government stressed the need to attract high value tourists rather than budget travellers (Nepal, 2022b). During this phase, infrastructure development increased further, establishing roads, airports, major hotels, information centres, and banks in the area. Over time, tourism has become a major source of economic revenue for Nepal. In 1996, the industry generated over \$117 million USD which accounted for approximately 3.8% of the country's gross domestic product (Nepal, 2000). The environmental implications associated with tourism such as forest degradation and soil erosion did not subside over time in the park, but escalated with tourism development (Nepal, 2000). At the beginning of the 21st century, tourism hit a standstill due to a Maoist uprising in the country. However, when the civil war ended in 2006, the tourism industry received greater government investment to rehabilitate tourism within Nepal (Nepal, 2022b). Many traditional economic activities have been abandoned in the pursuit of tourism. Agricultural activity decreased over time as local people were enticed by the economic benefits of the tourism industry, eventually establishing a monoculture tourist economy in SNPBZ (Garrard et al, 2016).

Between the early to mid 2000s, SNPBZ received approximately 35,000 visitors annually (Nepal, 2015). The Park has over 400 lodges to accommodate for tourists, has established telecommunication amenities and is home to the world's highest altitude Irish pub. Tourism within the park has influenced major transformations in the socio-cultural and economic environment of the communities within the park such that most residents are dependent upon it (Nepal, 2016). As of 2022, tourism accounted for 7% of Nepal's gross domestic product and provides employment to more than 400,000 people (Nepal, 2022b). Despite the benefits of tourism development in SNPBZ, it can generate risk within tourism-dependent communities. As Britton (1982) established, developing nations often experience high economic leakage due to foreign investment. SNPBZ has experienced the consequences of this as a significant portion of tourism revenue is retained in developed countries that participate in foreign investment in the region (Nepal, 2000; Nepal, 2022b). There is little economic retention in the periphery of the park, nor is there opportunity for visitors to spend their money in regions outside of core tourist areas. This level of development has also further marginalized local communities through commercialization as areas become much more vulnerable to environmental change as resource consumption increases (Nepal, 2000).

This synopsis of tourism development in SNPBZ presents many conceptual themes that have been established by Britton (1982), Gret-Regamey & Weibel (2014), Butler (1980), and Martin & Usyal (1990). The historical tourism development of SNPBZ has had many issues associated with limited supply to meet increasing demand, exceeding carrying capacity, varying tourist lifecycle stages, and economic leakage. The challenge of tourism development in SNPBZ is to find a balance between development and environmental conservation such that the negative implications of tourism are reduced while the benefits are simultaneously maximized. To achieve this, Nepal (2000) identifies that there is need for an understanding of the environmental process within SNPBZ and knowledge on the tourism dynamics at the local, national, and regional scales. This thesis contributes to the solution as it provides specific information relating to how tourism development has grown and influenced energy resource consumption dating from the 1997 to the present day. This data may be used to understand changes in carrying capacity, tourism lifecycles, and the demand of energy resources. It can also be applied to the understanding of economic leakage as it identifies lodge ownership within the park. It is also

important to understand the current context of how SNPBZ is approaching and managing sustainable tourism development within the park.

3.1.2 Tourism Development Management in Sagarmatha National Park

SNPBZ is a World Heritage Site that receives global recognition as a tourist destination. If combined with successful site management, the distinction of SNPBZ could make it a prime example of sustainable mountain development. Examining tourism growth and its management in SNPBZ is important because all citizens of the area are impacted by tourism through socio-economic and environmental change (Bhatta et al, 2022). Residents have responded positively to tourism growth within the park as they have expressed satisfaction in tourism activity and its associated development. However, the issues associated with tourism growth have been handled subtly and its rapid development has raised questions regarding the viability of tourism based on the region's carrying capacity (Bhatta et al, 2022).

In response to tourism growth in SNPBZ, sustainable development management strategies have been reactive rather than proactive (Nepal, 2000; Jeffries, 1982). In the late 1970s, the New Zealand Project was established to facilitate sustainable development within the park. The project ended in 1981 and established a foundation towards sustainable development. It had seven main objectives including, but not limited to, tourism, nature conservation, energy, and religious and historic values (Jeffries, 1982). The foundation left by this project has not necessarily been applied to the sustainable management of SNPBZ. More recently, to preserve forests, the government has implemented a ban on woodcutting (Aubriot et al, 2019). Although this discourages residents from deforestation, it shifts resource pressure as residents seek alternative sources of energy (e.g., dung, kerosene, etc.) that are not regulated which further contributes to the tragedy of the commons and resource scarcity within the area.

To manage deforestation, the government has implemented community management programs related to firewood use, which vary between the regions of SNPBZ (i.e. different rules based on each individual community), with some areas having not collected firewood in over three years (Sun et al, 2024). The management of forest resources have been successful within SNPBZ as

one-third of tourism facilities do not use fuelwood as a source of energy (Sun et al, 2024). However, the buffer zone still relies greatly on wood as its primary energy resource.

In 2016, the government of Nepal released the SNPBZ Management Plan. The overarching objective of this management plan was “to enhance the biodiversity of the park, promote tourism and regulate it where necessary to maintain delicate balance between conservation and tourism, and also support the livelihoods of the local communities through effective management of the natural and cultural heritages” (SNP, 2016). The plan has various objectives that all pertain to environmental, economic, and socio-cultural development. One of these objectives is specific to tourism which aims to “promote sustainable tourism and regulate it for maintaining ecological integrity and cultural heritage” (SNP, 2016). Historically, SNPBZ has had a focus on tourism management through waste management mitigation strategies. The 2016-2020 management plan identifies previous efforts towards tourism management as the establishment of the non-governmental organization called Sagarmatha Pollution Control Committee (SPCC) which was committed to managing the waste implications of tourism within the park (SNP, 2016). However, this narrowly focused approach means that there is little to no attention paid to unregulated and increasingly concentrated tourism activities resulting from increasing tourism demand, a lack of infrastructure demand, a lack of a department dedicated to tourism management, and a lack of strategies and policies to manage tourism activity and growth (SNP, 2016).

The response of the community to tourism management strategies determines the success of such policies (Bhatta et al, 2022). For example, the interests of residents often conflict with the interests of park management such that rules are only adhered to if they do not contradict personal interests of business and locals (Bhatta et al, 2022). This is a key example of the tragedy of the commons in SNPBZ as residents consume resources in their own self-interest rather than in the interest of the community. It is imperative that park management imposes strict regulations and management strategies to enforce local compliance. However, this is difficult to do because there is a lack of resources such as staff, budget, and willingness to deal with conflicts between the government and community (Bhatta et al, 2022).

Since SNPBZ is a designated UNESCO World Heritage Site, the UNESCO World Heritage Convention analyzes the sustainable management of the park on an annual basis. In their 2023 assessment, the convention addressed that the 2016-2020 management plan must be revised to include key sections regarding tourism and resource management (UNESCO, 2024). The tourism chapter in the next management plan will include data relating to visitor numbers and waste management. However, a limitation of the next management plan is that it will not include a study on the visitor carrying capacity of the park or a specific tourism management plan (UNESCO, 2024). Currently, there is no management plan created since the previous 2020 plan. Additionally, the Convention identified that tourist accommodations and energy resource consumption throughout the area are two major factors that impact SNPBZ. To combat this, the next management plan will discuss methods that can reduce fuelwood consumption and promote alternative energy sources (UNESCO, 2024). Aligning with this, the 2016-2020 SNPBZ management plan recognized various research priorities to help develop proper management strategies for the park. These research priorities included the trends of tourism and the status of energy usage in SNPBZ (SNP, 2016). This thesis directly correlates to the research priorities of the SNPBZ management plan as it aims to understand tourism development over time and the associated energy consumption patterns. Furthermore, the research may contribute data to any future studies on the carrying capacity of SNPBZ, as requested by the UNESCO World Convention.

3.1.3 Energy Consumption in Tourist Lodges in Sagarmatha National Park

Liquefied petroleum gas and electricity are the primary sources of energy in lodge accommodations in SNPBZ. This energy trend is similar in the buffer zone; however, the area also relies on firewood as one of the most common sources of energy (Sun et al, 2024). The difference in firewood consumption is due to the proximity of lodges in the buffer zone to forest resources and varying firewood collection rules throughout the park (Sun et al, 2024). Most of the area still relies on non-renewable sources of energy. There is a lot of potential for renewable resource energy consumption based on resource availability yet they only account for 10% of energy production (Proietti et al., 2017). Although there is a current understanding of energy consumption patterns within SNPBZ, it is important that the historical evolution of these patterns is understood and the way in which tourism has influenced this change. This thesis is based upon

previous research that examined tourist lodge development through the documentation of labour structures, energy consumption patterns, and lodge capacities (Gehrig, 2014; Mattle, 1999). In the most recent study, it was identified that between 1997 and 2011, there was a great shift in energy use and supply. Through a comparison of data, it was discovered that lodges within SNPBZ consume significant amounts of energy and more resources than in 1997 (Gehrig, 2014). It was also realized that traditional energy is limited due to the resource availability of firewood and dung. This was reflected in the data as the main energy supply in SNPBZ was from fossil fuel sources, such as kerosene, which are not accessed locally.

In 2016, a study was conducted which examined energy consumption in lodge accommodations in Nepal to provide recommendations for energy efficiency in these buildings (Bodach, 2016). The study used building simulations to explore the energy consumption patterns of different types of accommodations in the country. It identified that energy consumption in lodges may vary based on the available facilities and services, location, and size.

A similar study was conducted that assessed the environmental and economic impacts of three types of commercial lodges throughout their entire lifecycle in SNPBZ (Bhochihbhoya et al., 2017). It was established that lodge accommodations have the most impacts during their use stage, when they are actively welcoming visitors and consuming energy. The study entailed questionnaires that collected primary data relating to building size, building materials, and energy consumption. The results of this research included an analysis on energy consumption in each lodge type including information relating to energy sources and the amount of energy consumed based on one additional guest per night. This analysis is important to this thesis as it provides a basis in which the data could be organized and analyzed. It also portrays that the greatest impact occurs during the use stage, meaning that energy consumption patterns are most influential while lodges are operating and accommodating guests.

The research conducted by Bhochihbhoya et al. (2017) was extended through a study that examined the sustainability of hotels in SNPBZ at each lifecycle stage (Bhochihbhoya et al, 2020). A major factor that contributes to greater energy consumption during the use stage of lodge accommodations is that the building materials allow for heat loss which results in greater

energy consumption (Bhochihbhoya et al., 2020). Although both studies were conducted from the perspective of lifecycle assessment and lodge accommodation building construction, they contribute to this thesis as they provide important information relating to energy consumption patterns within lodges in SNPBZ. However, there are limitations to Bhochihbhoya et al.'s (2020) study because the sample size contained only 45 lodges, and it did not focus on renewable energy sources. The study also called for further research relating to the socio-cultural impacts of energy consumption within lodge accommodations.

Sun & Watanabe (2021) analyzed the status of the labour organizations of tourism-facilities in SNPBZ. The data collected in this research is similar to the data collected for this thesis as it includes information relating to employee gender and ownership. The purpose of Sun & Watanabe's (2021) study was to understand any imbalances in development and the unequal distribution of benefits. This research is outside the scope of this study, but it does contain a perspective relating to the socio-cultural dimension of development which the research may also contribute to through survey responses.

More recently, and even more similar to this research, Sun et al. (2024) investigated energy use patterns in tourism facilities in SNPBZ and the relationship between energy use and tourism facility development. The objective of this research closely aligns with that of this thesis as it also aims to examine patterns of energy consumption in lodge accommodations in SNPBZ. It was discovered that tourism-induced energy demand amplifies issues related to energy resource pressure, especially at the local level (Sun et al, 2024). The study established that tourism has placed pressure on and altered energy consumption and management within the park. Although there are immense similarities between Sun et al.'s (2024) research and this thesis, there are still notable differences that make this research unique and necessary. This thesis entails a longitudinal analysis that will compare change relating to tourism lodge development, labour structures, and energy consumption patterns over a 27-year period through a full census. This analysis will provide an accurate and reliable representation of the way in which tourism has influenced development and energy consumption patterns within SNPBZ.

3.2 Research Design

This research is based upon two previous studies conducted by Gehrig (2014) and Mattle (1999). To conduct this research, a standardized survey was distributed to every lodge accommodation throughout SNPBZ (see Appendix A), which mirrors Gehrig (2014) (see Appendix B). The survey was administered throughout the park from October 18th to November 15th, 2024, to examine lodge development, labour organization, and energy consumption patterns within lodges. These four weeks of fieldwork occurred during the peak tourism season in SNPBZ. The Fall tourist season is typically between October and November while the Spring tourist season is between March and April. The Fall season is typically busier with trekking tourists while the Spring season is busier with expeditionist. It was crucial that the fieldwork occurred during one of these two seasons to best reflect tourist activity and consumption in the park.

The survey was administered by the primary researcher and a research assistant hired from the Nepal Mountaineering Academy. To fulfill the census, villages were approached systematically, visiting each lodge consecutively. Locals were consulted with to ensure that no lodges were excluded from the study and any missed lodges identified by residents were surveyed. The survey questions were asked verbally by either the primary researcher or the research assistant. Surveys were conducted in both English and Nepali, depending on the language proficiency of the lodge owner. All results were recorded in an Excel document on the primary researcher's personal device.

Informal, semi-structured interviews were incorporated into the fieldwork to provide anecdotal insight on lodge owner's perspectives on climate change and natural disaster impacts on tourism and energy accessibility. Open ended questions were asked to 14 different lodge owners, typically over dinner or breakfast, inquiring about personal opinions on how climate change and natural disaster has influenced the flow of tourism and the accessibility of energy resources. All observations were recorded in the same Excel document as the survey responses. Participants for these interviews were recruited by asking if lodge owners were available for a short conversation about climate change, tourism, and energy.

3.3 Research Objectives and Questions

The purpose of the presented research is to document the establishment, growth, and history of tourist lodges within SNPBZ. To achieve this goal, two research objectives are sought:

This research consists of two main objectives:

- To characterize the growth of tourist lodges
- To examine energy consumption patterns and energy types consumed in tourist lodges

Associated with these objectives are specific research questions. The first objective relates to the characterization of tourist lodge development will portray information relating to how lodges have changed over time. This information may allow for further discussion that could answer the follow questions relating to tourism development in SNPBZ:

- Is the ownership of tourist lodges local or external?
- When were tourist lodges established?
- What is the tourist lodge distribution throughout the park?

The second objective of this research will compile data to examine energy consumption patterns within the park. This information provides the opportunity to answer the following research questions:

- What energy resources are used within tourist lodges?
- Which energy resources are lodges most dependent on?
- Has there been a change in the energy sources consumed within lodges?

Overall, the data collected from this research will provide an analysis of tourist lodge development and growth, as well as energy consumption patterns, over a 27-year period. This study will allow for a comparative analysis of change over time. Any identified patterns or trends in the data may also open further discussion relating to the following questions:

- Have any changes to the operational/labour structures of lodges influenced change on energy consumption patterns?
- Is there a trend in energy type used at varying altitudes?
- Has tourism development influenced the consumption/demand of energy?
- Are any changes in labour structures apparent, and if so, have these changes improved the efficiency of energy consumption?

3.4 Data Analysis

The data was examined through a comparative analysis that identified change over time between all three studies conducted in 1997 (Mattle, 1999), 2011 (Gehrig, 2014), and 2024 (primary data collected during fieldwork for this thesis). The entire data record from surveys in 2011 was available for analysis while only a summary of 1997 was available (Gehrig, 2014). All data records including 1997, 2011, and 2024 data sets used for analysis in this thesis are available for anyone interested in viewing the raw data.

To compare the data from all three studies, the values of energy consumption were converted into joules as the energy sources are measured in both kilograms and litres, with varying energy values. The data compared in the analysis were obtained from various sources including the data sets from Gehrig (2014) and Mattle (1999), the literature review, field observations, semi-structured interviews, and the primary data collected during fieldwork. To comprehensively analyze the patterns identified in the results, the sources were triangulated to understand the interdependent relationship between tourism, lodge development, and energy consumption. Data triangulation is specifically important in this analysis because of the complex, interdependent relationship between development, tourism, and energy. Triangulation between literature, data, and fieldwork allowed for a comprehensive analysis and understanding of study results. Given the focus on temporal and spatial trends, descriptive statistics and data visualization are used in this analysis rather than causal inference through statistical analysis. The results of the data are portrayed through graphs that visually depict change in the data between 1997, 2011, and 2024.

For this study, only those lodges within SNPBZ that were operating at the time of the fieldwork (October/November 2024) were included in the data. These lodges are all typically open in the Spring season, meaning that the seasonality of the survey (Fall vs. Spring) does not significantly influence data results. Additionally, there are various lodges in SNPBZ that do not accommodate tourists. They exist only to accommodate porters, guides, and Nepali people. Those accommodations were excluded from this study because this research project focuses only on tourist lodges. There is a total of 519 lodges in the park and 431 surveys were conducted for this study. 88 lodges were not surveyed because they were either closed or unavailable to tourists and only accommodated Nepali. Out of those 431 surveys, 18 lodges were excluded from this study

because they were either newly built lodges with extremely limited data or the respondents could not confidently respond to survey questions due to a lack of knowledge. Therefore, for the purpose of comparison, only 413 lodges were included in the 2024 data and are considered the only “active” lodges in the park.

3.5 Electricity Data Analysis

The datasets from 1997 and 2011 do not contain information relating to how much electricity is consumed by lodges in SNPBZ. However, the 2024 questionnaire did include this by asking lodge owners how much hydroelectricity they consume per day. The original survey question inquired how many daily watts of electricity are consumed in each lodge, however, this question was too specific, and most lodge owners did not know this detail of electricity consumption. Some areas of SNPBZ either pay for hydropower based on units of energy consumed (unit system) or based on a level system. Since lodge owners did not know the number of daily watts of electricity consumed, the data was recorded as either unit of energy or the level system that they use for electricity consumption.

Most areas in SNPBZ use a unit system for electricity consumption in which they pay Nepalese Rupee (NPR) per unit of energy. The only areas in SNPBZ that use a level system for hydroelectricity is the Thame route and the village Pangboche which is located along the Everest route. A level system means that lodges pay a flat rate to receive a specific amount of energy each month. For analysis and comparison, the Thame route and Pangboche area analyzed separate from the rest of SNPBZ.

In Namche and along the Gokyo and Everest routes, lodge owners informed the author that one unit of energy is worth 16 NPR. Lodge owners in these areas reported their electricity consumed based on the amount spent on their monthly bill. To calculate the daily number of energy units consumed, the author took the number of NPR paid per month and divided that number by 16 to find the total number of energy units consumed per month. This number was then divided by 30 (average number of days per month) to find a daily average of energy units consumed.

Throughout Namche, and the Gokyo and Everest routes, some lodge owners would inform the author with the number of kilowatts consumed per day – however this data was not included in the data set due to two main limitations. (1) Only three lodge owners responded with the number of kilowatts consumed per day and (2) these data points were not accurate. The accuracy of these data points was questioned because the number of kilowatts reported were extremely low and not comparable to the consumption of surrounding lodges of similar sizes/capacities.

Some lodge owners expressed that one unit of energy is equivalent to one kilowatt of electricity, however, this information is unreliable because various lodges would report more than 50 units of energy consumed per day which is extremely high. In addition, the author had a conversation with the local energy company in the Thame area, in which the employees expressed that most lodges *would* operate on a Level 3 basis of electricity consumption which means that they can consume a maximum of six kilowatts of electricity per month. The employees at the energy company also expressed that depending on the level of energy that the business has subscribed to consume, they would typically pay a flat rate and then an additional 16NPR per unit of energy consumed. However, lodge owners never expressed that they pay a flat rate, they only stated that they pay 16NPR per unit of energy consumed. Additionally, hydroelectricity consumption along the Thame route is not applicable to other areas because they operate differently and use different levels of electricity and payment systems. So, the observation made by the electricity company employees cannot be depended on for data analysis of all trekking areas.

It is important to note that due to the above reasoning, there is no way to accurately depict how much electricity is in a single unit of energy consumed by lodges in villages that pay on a per energy unit basis. In Lukla and along the Farak route, most lodge owners expressed that one unit of energy costs 10NPR. So, to calculate the daily units of energy consumed, the total number of NPR paid per month was divided by 10, and then divided again by 30 (average number of days per month).

For analysis purposes, it is assumed that lodges do not pay a flat rate for electricity in Namche, Lukla, and along the Everest (Tengboche and Deboche), Goyko (Khunde and Khumjung), and Farak routes.

3.6 Limitations of Methodology

The methodology of this thesis is limited due to its reliance on self-reported data from lodge owners, many of whom lacked records on tourists' activity and energy consumption. This means that recall bias may skew the results of this study because there may be inaccuracies in survey responses. To avoid recall bias, particularly regarding energy consumption, proxy measures were used by asking lodge owners quantifying questions such as "how many cannisters of LPG do you use on a monthly basis during the tourist season?" The data is also limited due to the inconsistencies in energy quantification across the park where different villages use different methods to measure energy use, as previously described.

Chapter 4: Results

This chapter explores the results of the data collected during fieldwork in the Fall of 2024. It first examines the lodge development within the park, then changes in lodge ownership and labour structures, and lastly, identifies patterns in energy consumption.

4.1 Results of Lodge Development

To characterize the growth of tourist lodges this thesis compares and analyzes data sets from 1997, 2011, and 2024 to examine how selected indicators of tourism have changed, thus demonstrating how tourism has developed between 1997 and 2024.

Followed by the analysis of lodge growth and infrastructure development, then the lodge ownership and labour structures, and finally, the energy consumption patterns within lodges. Although lodge ownership and labour structures do not contribute to the objective of this thesis, they are important to analyze as they have been in the previous 1997 and 2011 studies because they add to the overall longitudinal analysis.

4.1.1 Research Area and the Trekking Village Types

Throughout time, the number of villages in SNPBZ offering lodge accommodations to tourists has increased from 38 villages in 1997, to 49 villages in 2011, and 54 villages in 2024. All villages are distributed within the park and buffer zone, and all offer different facilities and services to local communities and tourists. Since there are many villages within SNPBZ, the villages have been classified by area. Previously in 1997, these areas were divided into four geographic corridors: Lukla, Thame, Gokyo, and Everest. However, in the 2011 study, the park was divided into six areas based on both, geographic location, and touristic importance. These areas are defined as: Lukla, Farak route (all villages between Lukla and Namche), Namche, Thame route (the Bothe Koshi side), Gokyo route (along the Dudh Koshi River), and the Everest route (included all villages in the Dudh Koshi Valley up to Everest Base Camp). This division of SNPBZ is applied to this thesis because there has been little growth in the number of villages within the park and these same areas remain as the major trekking areas (Figure 1).

Map of SNPBZ Trekking Routes

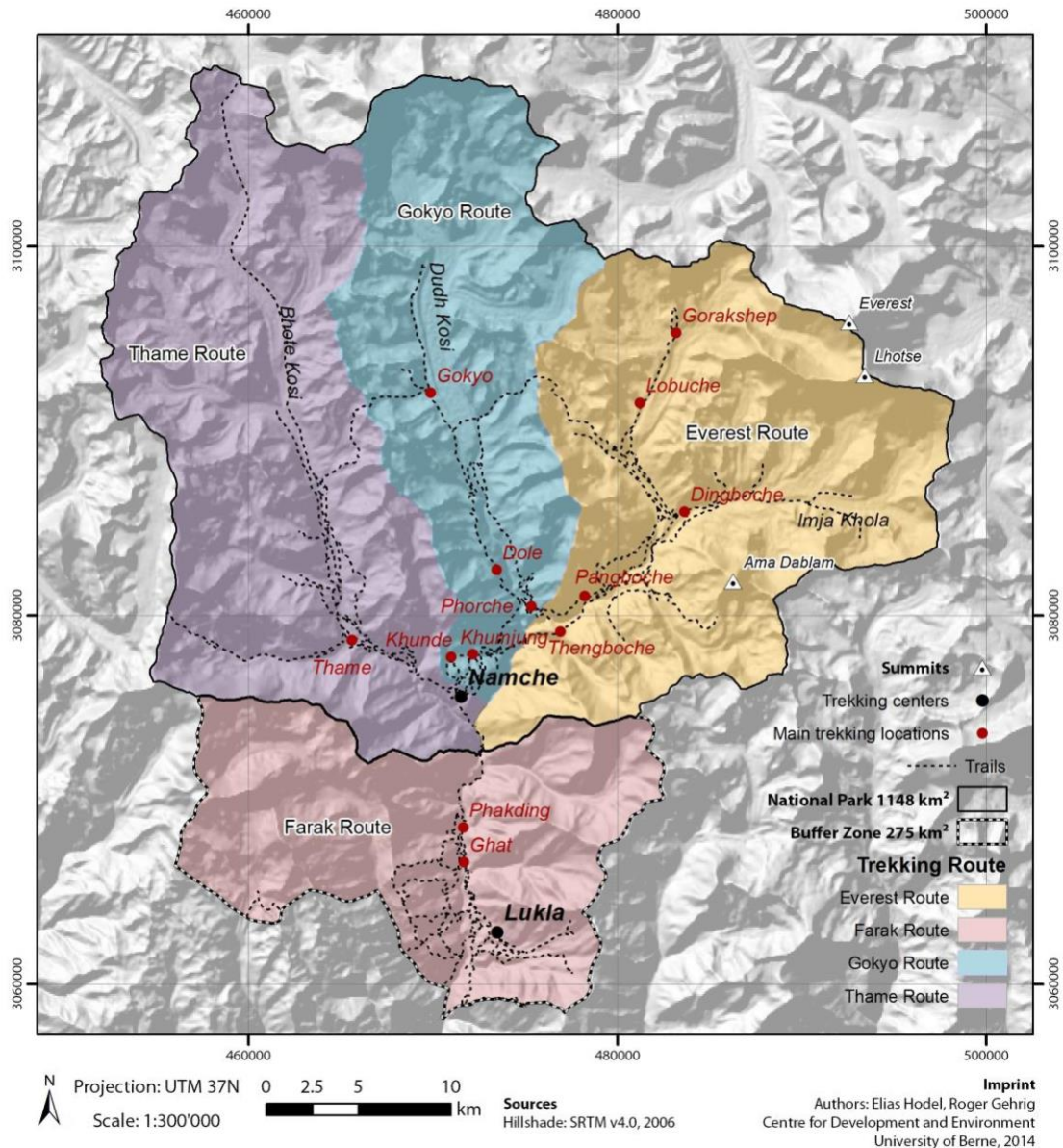


Figure 1: Main trekking locations (Gehrig, 2014)

While the entire park was distinguished into six major trekking areas, every village is also defined by its own trekking type. These trekking types are differentiated by four different types: trekking centre, trekking main location, trekking location, and special location. Mattle (1999) categorized the village trekking types which were then modified by Gehrig (2014) to adapt for changes in lodge structure. The same categorization of trekking types adjusted by Gehrig (2014) are used in this thesis and are distinguished as follows:

Type 1: Trekking Centre

- More than 20 lodges
- Has shops, police station, ATM, medical services, etc.
- Tourists usually spend more than one night

Type 2: Trekking Main Location

- Less infrastructure than type 1 (less shops) but still has several tea houses, which also include shops
- More than 8 lodges per location

Type 3: Trekking Location

- Several lodges (4-7) with lower quality standards than type 1 and 2
- Only a few shops

Type 4: Special Location

- Single lodges outside of settlements, less than 3 lodges
- Mainly for provisions, lunch stops etc., overnight stays are exceptional

Lukla and Namche are identified as their own trekking area due to their importance as tourism hubs in the park. These two villages are considered trekking centres. Lukla is the centre where most tourists arrive and leave from because it has the Tenzing-Hillary Airport, with Namche serving as the main tourist centre of SNPBZ. Tourist typically stay longer than two nights in both villages.

The region between Lukla and Namche, the Farak route, includes 12 villages: Jorsalle, Monjo, Chumoa, Benkar, Toktok, Zamphuti, Phakding, Chhathawa, Thadokoshi, Ghat, Cheuplung, and Chaurikharka. These villages are located outside of the entrance to SNPBZ and consist of many lodges and lunch spots.

The Thame route is northwest of Namche and is most popularly trekked by tourists who are crossing Renjo La Pass. This route includes nine villages: Thamo, Samde, Tarnga, Maralung, Lungdhen, Arya, Thamethanga, Thame, and Kongde. Out of all trekking areas, this route is least visited compared to all other trekking routes.

The Gokyo route is the main alternative route to the Everest Base Camp trek as Gokyo Lake has become a major attraction to tourists. This route includes 13 villages: Syangboche, Khumjung, Khunde, Dragnag, Gokyo, Fanga, Machhermo, Luza, Larfarma, Dhole, Phortse Thenga, Phortse, and Mongla.

Finally, the most popular trekking route is the Everest route as it leads to popular destinations such as Ama Dablam Base Camp, Everest Base Camp, and Kala Patar. Ama Dablam Base Camp is considered a village in this analysis as it has two tourist lodges. There are 20 villages located along the Everest route including : Sanasa, Tashinga, Lausasa, Phungi Thenga, Tengboche, Deboche, Millinggo, Shomare, Pheriche, Dingboche, Ama Dablam Base Camp, Shomare, Pheriche, Dingboche, Chukhung, Thukla, Lobuche, Gorak Shep, Dzonglha, and Kyangjuma.

Table 1 lists all the villages in each area with their trekking type and is based on Gehrig's (2014) study. The main indicator is the number of lodges per village. Those villages that have a red filling have not changed in their trekking type since 2011, while those villages with both, a red and a green filling, have experienced a shift from one tourism type to another. This shift could be either towards a lower or higher trekking location type.

Table 1: SNPZ Trekking village types and the change from 2011 to 2024.

Location/Village	Altitude m	Type 1 Trekking Centre	Type 2 Trekking Main Location	Type 3 Trekking Location	Type 4 Special Location
Lukla	2800				
Farak Area					
Jorsalle	2810				
Monjo	2850				
Chumoa	2790				
Benkar	2730				
Toktok	2750				
Zamphuti (New)	2700				
Phakding	2600				
Chhathawa (New)	2630				
Thadokoshi	2600				

Ghat	2600				
Cheuplung	2600				
Chaurikharka	2640				
Namche					
Thame Route					
Thamo	3520				
Samde	3530				
Tarna	4000				
Maralung (New)	4200				
Lungdhen	4370				
Arya	4360				
Thamethanga	3810				
Thame	3830				
Kongde	4250				
Gokyo Route					
Syangboche	3880				
Khumjung	3790				
Khunde	3840				
Dragnag	4650				
Gokyo	4760				
Fanga	4690				
Machhermo	4470				
Luza	4360				
Lafarma	4310				
Dhole	4070				
Phortse Thenga (New)	3600				
Phortse	3740				
Mongla (New)	3990				
Everest Route					
Sanasa	3600				
Tashinga (New)	3450				
Lausasa	3450				
Phungi Thenga	3310				
Tengboche	3870				
Deboche	3780				
Millinggo (New)	3760				
Pangboche	3950				
Ama Dablam Basecamp (New)	4600				
Shomare	4040				

Pheriche	4310				
Dingboche	4410				
Chukhung	4740				
Thukla	4620				
Lobuche	4930				
Gorak Shep	5160				
Dzonglha	4835				
Kyangjuma (New)	3700				

The table shows minimal changes in trekking village types across most areas. However, many villages (Jorsalle, Monjo, Benkar, and Toktok) along the Farak route shifted from type three to type two, indicating lodge growth and increased tourism. In contrast, Ghat dropped from type two to type four, likely reflecting the rapid transformation of villages in SNPBZ. For instance, Lama Lodge was recorded in Ghat in 2011 but listed in Chhathawa in 2024, despite not physically relocating – highlighting shifting village boundaries and names.

Beyond the Farak route, only Dragnag (Gokyo route), Dzonglha (Everest route), and Thamethanga (Thame route) changed types, each moving from a special location to a trekking location. This likely reflects increased tourist demand due to geography: Dragnag and Dzonglha lie on either side of Cho La Pass, while Thamethange, just outside Thame, may have expanded to accommodate overflow from the increasingly popular Renjo La Pass route.

4.1.2 Lodge Growth and Development

This section analyzes the number of lodges in SNPBZ across 1997, 2011, and 2024 to assess the growth of tourist lodges over time. Comparisons should be made longitudinally within each area, rather than between areas, as they vary in size, altitude, and touristic significance. A longitudinal approach is therefore appropriate to characterize development trends specific to each area. An analysis of lodge numbers between each trekking area portrays the distribution of tourist activity within SNPBZ while the comparison over time permits an interpretation of overall development.

In 2024 the total number of active tourist lodges in SNPBZ was 431. There is a vast difference in the distribution of lodges throughout SNPBZ which is due to various reasons including the size

of each area, their popularity for trekking, and their altitude. Altitude can determine the number of lodges within a specific area because trekkers may either want to spend additional time acclimatizing or limit their time in certain areas due to their high altitudes.

The number of active tourist lodges in SNPBZ has increased by a total of 118 lodges since 2011. Within this 13-year period, there has been an average of nine new lodges constructed annually. The reason the word “active” is used is because some lodges exist within the park however, they are not currently operating. This is especially evident in villages that are not directly along trekking routes, making them less popular amongst tourists. An example would be Khunde which is along the Gokyo route. It is typically a village that tourists visit in a day and then leave while they acclimatize in Namche. To attract more tourists, in September 2024, Khunde established the Khunde Community Homestay Network which consists of 19 homestays to promote tourist activity. It is important to note that not all these homestays are active and many of them remain closed due to a lack of tourists in the area. Out of 19 homestays, only seven were open.

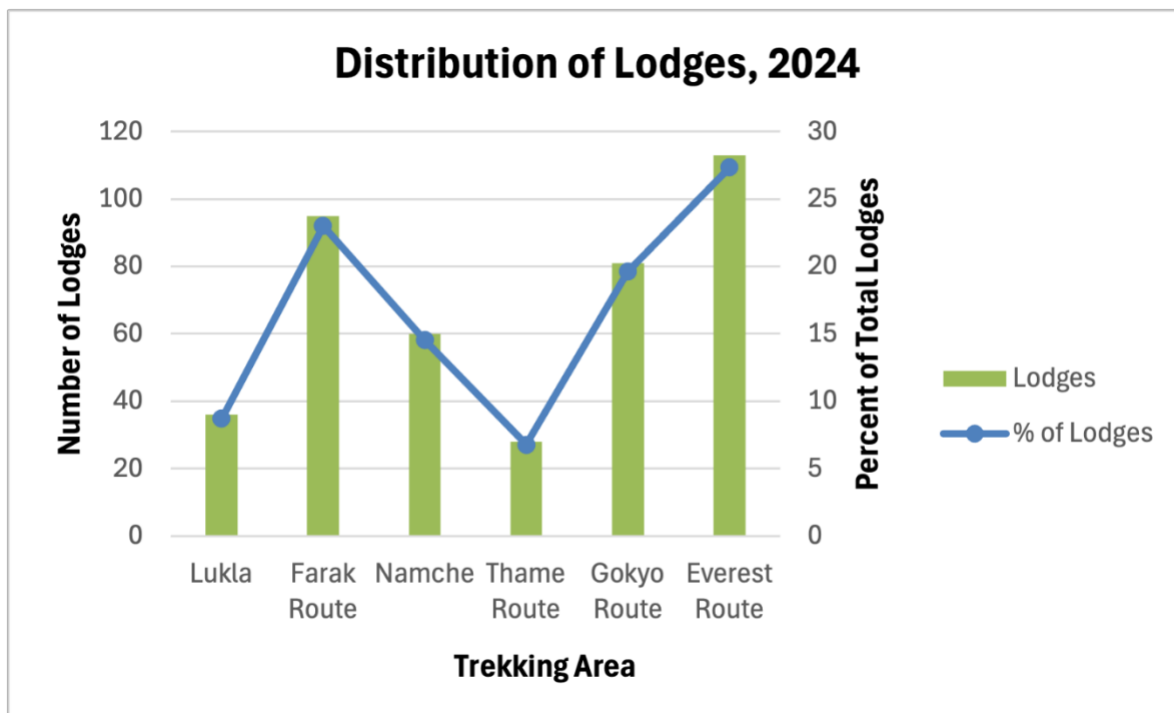


Figure 2: Distribution of lodges throughout SNPBZ in 2024

Figure 2 portrays the distribution of lodges in 2024. Along the primary axis, the number of lodges are shown through the bar graph while the secondary axis shows the total percentage of lodges in each trekking area. Consistent with the data from 2011, the Everest route possess the most lodges in SNPBZ at a total of 113 lodges (26% of all lodges). The two major trekking centres, Lukla and Namche, consist of 36 and 60 lodges respectively. Between Lukla and Namche, the Farak area has 95 lodges, while the Gokyo route has 81 lodges. The Thame route has the least amount of accommodations within SNPBZ at 28 lodges (6% of all lodges).

Just prior to this fieldwork, the Thame region experienced a glacial lake outburst flood (GLOF), due to heavy rain at the end of September 2024, which caused major destruction to the land, infrastructure, and lodges in the Thame area, as shown in *Figure 3*. Approximately 5 lodges were destroyed and/or shutdown due to this natural disaster. Those lodges were not included in this data as they were no longer operational.



Figure 3: Fall 2024 GLOF aftermath

It could be assumed that lodge distribution may identify where tourist activity is most intense, however this may not always be the case, thus it is important to consider the village type and lodge capacities. For example, Lukla has the second smallest distribution of lodges, yet it is a trekking centre in which almost all tourists stay. Lukla is only one village where trekkers may spend only 1-2 nights, while the Everest Route consists of multiple villages where tourists may

spend multiple nights in different villages along the route. This supports why the type of trekking village is important when analyzing this data. In addition, the lodge capacity is important to consider in this case as well. Although the Everest Route may have a greater number of lodges, those lodges may be smaller in size and bed capacity. While Lukla has less lodges, the capacity of those lodges is comparable to those along the Everest route. The average number of beds in each lodge in Lukla is 33 while lodges along the Everest route have only 4.5 more beds, with an average of 38.5 beds per lodge. This is further analyzed in Section 4.1.3.

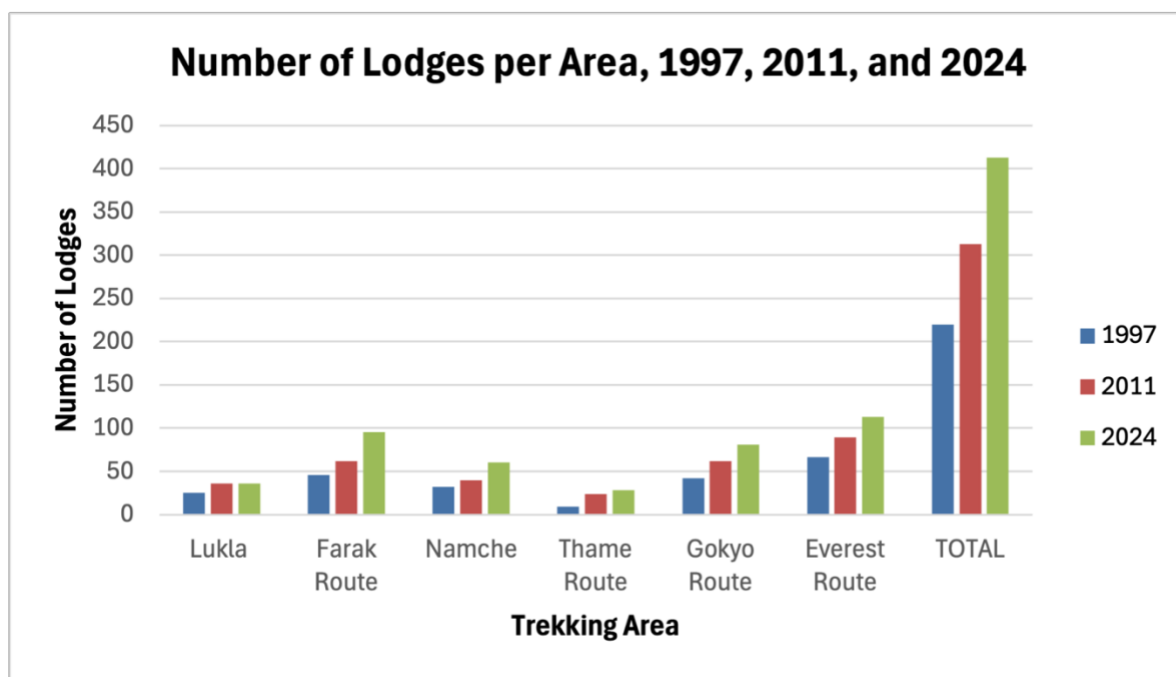


Figure 4: Total number of lodges per area in 1997, 2011, and 2024.

Figure 4 illustrates lodge development in each area between 1997, 2011, and 2024, showing clear growth over the 27-year period. Some areas, such as Lukla and the Thame route, saw most growth between 1997 and 2011, with a plateau afterward. The Thame route may have shown slightly more growth if those 5 lodges destroyed in the Fall 2024 GLOF had been included. In contrast, the Gokyo and Everest routes experienced steady growth across both periods: Gokyo added 20 lodges from 1997 to 2011 and 19 from 2011 to 2024; Everest added 23 and 24 lodges, respectively. The Farak route experienced the most dramatic increase, with 16 new lodges between 1997 and 2011 and 33 from 2011 to 2024. Namche had a modest increase in lodges from 8 between 1997 and 2011, followed by a larger increase of 20 lodges from 2011 to 2024.

Overall, the data reveals a steady increase in lodge development across SNPBZ, with some areas experiencing recent rapid growth (Farak route), while others have stabilized after earlier expansion. The development and establishment of lodges over time in Lukla, Phakding, Namche, the Khumjung, Khunde, and Syangboche complex, Pangboche, Dingboche, Gokyo, and Thame are all illustrated through maps in Appendix C. These maps show the distribution of lodges throughout each village and the relative period of establishment.

Although the data shows changes in the number of lodges over time, patterns of establishment are more complex. For example, Lukla recorded no lodge growth between 2011 and 2017, yet 17 lodges were established during this period – suggesting that new lodges replaced existing ones. For analysis, the number of lodges was prioritized over establishment dates to capture broader development trends. Still, establishment dates provide valuable context for understanding links between tourism, lodge growth, and energy use. These dates are not always reliable as many lodge owners lack formal records, use non-Gregorian calendars, or report ownership changes and name changes as new establishments.

In 1997, approximately 17,000 tourists had visited SNPBZ, and in the year 2011, this number nearly doubled to just over 35,000 visitors (Gehrig, 2014, Baral et al, 2017). This trend in tourist data compared with the development of lodges in SNBPZ between 1997 and 2011 is consistent as both, the number of tourists and lodges, nearly doubled within those 14 years. Meanwhile, in the tourist season of 2023-2024, the number of tourists in SNPBZ was 55,767 (Nepal Government, 2024) which is an increase of approximately 20,000 visitors from 2011 to 2023/2024. Although the rate of growth in tourist visits may vary when comparing 1997-2011 to 2011-2024, it is obvious that there is still substantial growth in the number of tourists visiting SNPBZ thus encouraging the opening of new lodges.

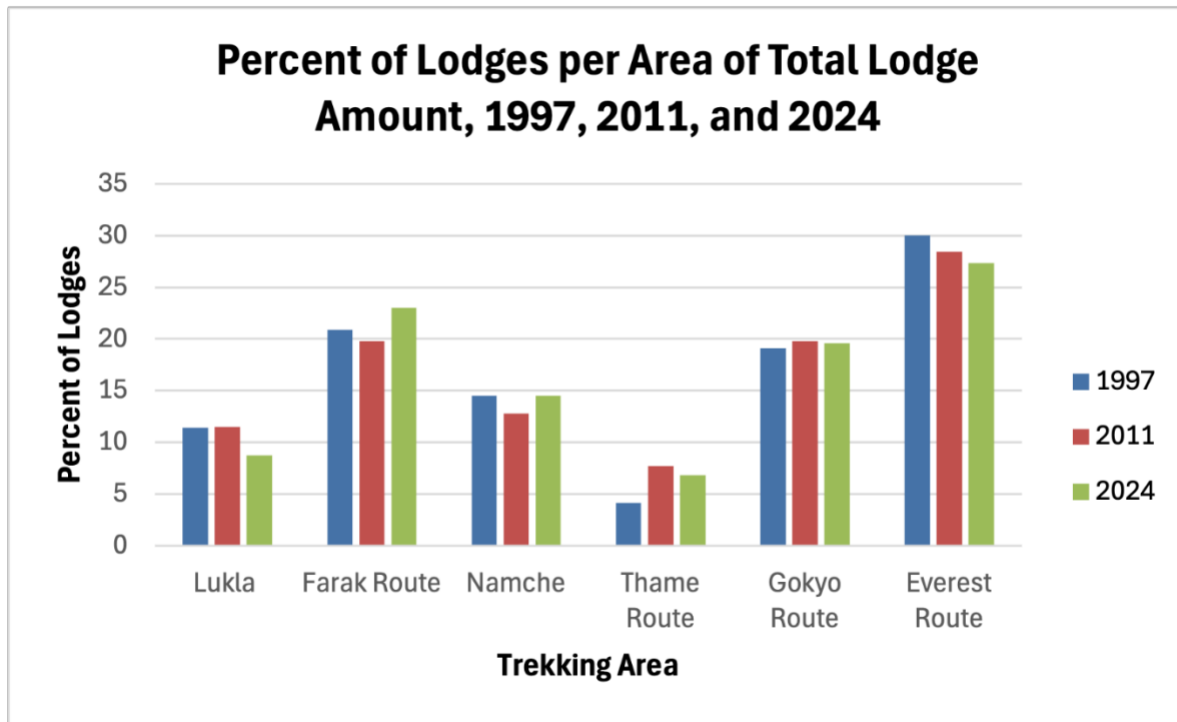


Figure 5: Percent of lodges per area of total lodge amount in 1997, 2011, and 2024.

Figure 5 portrays the percentage of lodges in each trekking area relative to the total number of lodges in SNPBZ in 1997, 2011, and 2024. Over time, it is evident that the distribution of lodges has remained consistent in almost all trekking areas – except for Lukla and the Thame route. Between 2011 and 2024, Lukla had no growth in the number of lodges which has resulted in a decline in the percent of lodges located in this trekking area. Despite an increase in the proportion of lodges, the Thame route experienced a decline in the percent of lodges located along this route. This indicates that while some areas have grown steadily, others have expanded at a slower pace, leading to a shift in the proportional distribution of lodges across the park. Although this graph highlights shifts in lodge distribution, analyzing changes in lodge capacity is key to gaining a full understanding of development over time.

4.1.3 Lodge Capacity Development and Growth

Lodge accommodation capacities were analyzed by recording the total number of rooms and beds in each lodge. These figures reflect development, as they indicate both the number of tourists an area can accommodate and the evolving standards of accommodation. Room types also provide insight into these standards; for example, while dormitories were common in 1997,

they became much less common in 2011 and 2024, illustrating changes to privacy preferences and accommodation standards. Overall, room structures act as useful indicators of change in lodge infrastructure, and tourist demand and expectations.

In 1997, SNPBZ had a total of 3,985 beds, with 20 of those in single rooms, 2,165 in double rooms, and 1,797 in dormitories. At that time, only three different room types were available – single, double, and dormitory. Single rooms contain one bed, double rooms two, and dormitories multiple shared beds. In 1997, most beds were in double rooms and dormitories, with very few private single rooms available. Lower altitude areas such as Lukla, Namche, and the Farak route had more double rooms, while higher altitude areas like Gokyo and Everest had more dormitory style accommodations.

In 2011, SNPBZ had a total of 9,485 beds, with 222 beds in single rooms, 8,848 in double rooms, and 415 in dormitories. In comparison with 1997, it can be observed that there was a substantial decline in the beds in dormitory rooms and an increase in those beds located in double rooms. Dormitories were most common in Namche and along the Everest route with 146 and 152 beds, respectively. It is evident that across the entire park, the most popular room type in 2011 was the double room.

In the 1997 and 2011 studies, only single, double, and dormitory rooms were recorded. However, the 2024 data reveals the emergence of triple rooms as a distinct room type, representing a small but noteworthy shift in lodge infrastructure. While double rooms continue to dominate bed capacity across all areas, triple rooms have become the secondary room type, especially in higher altitude areas like the Gokyo and Everest routes where 66 and 183 beds were in triple rooms, respectively. Triple rooms also outnumber single rooms in lower altitude areas such as Lukla. In 2024, Lukla had a total of 24 beds in triple rooms and only 15 beds in single rooms. Meanwhile, single rooms are secondary to double rooms in Namche and along the Farak and Thame routes. Dormitory rooms have become almost non-existent, especially in Lukla and along the Farak and Thame routes. There was a total of 12,800 beds in 2024 with 325 in single rooms, 12,054 in double rooms, 336 in triple rooms, and 85 in dormitories.

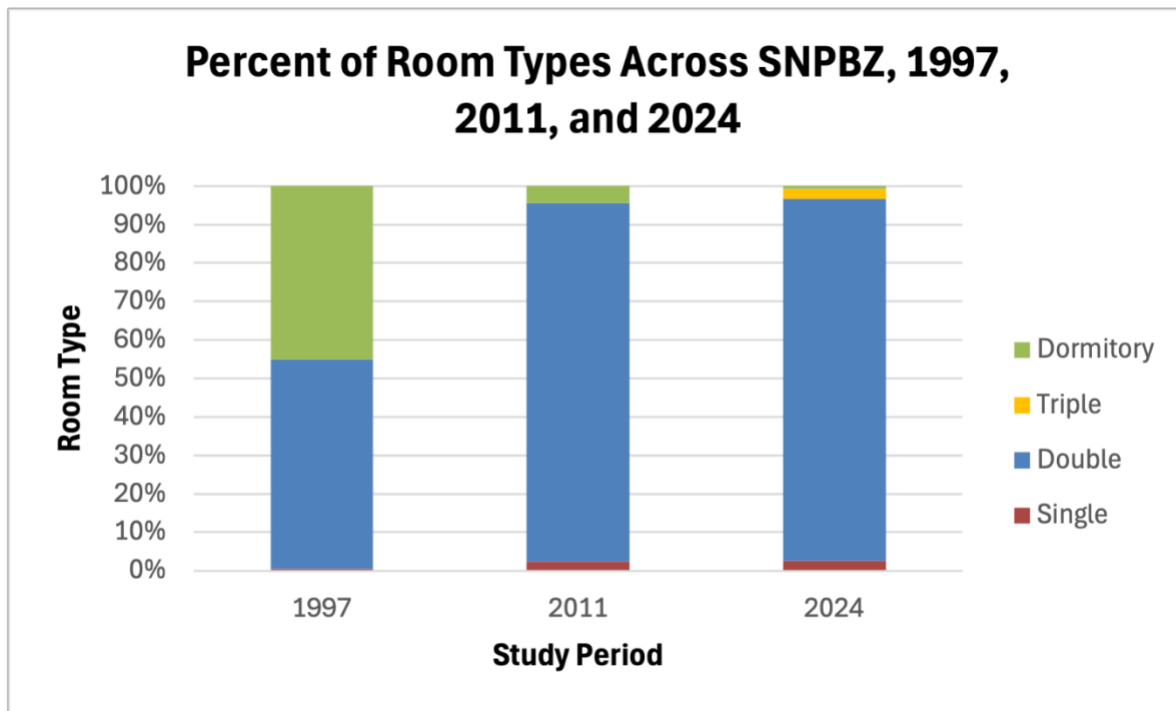


Figure 6: Percent of room types across SNPBZ in 1997, 2011, and 2024.

Over time, double rooms have consistently remained the most common room type across all areas of SNPBZ. While dormitory rooms have nearly disappeared, triple rooms have emerged as a distinct room type between 2011 and 2024. Previously, geographic factors such as altitude influenced room types – higher altitude lodges in 1997 primarily offer dormitory rooms. More recently, however, lodge infrastructure has shifted to prioritize double and triple rooms. These trends are illustrated in *Figure 6* as it portrays this proportional shift in relative numbers across the entire park, in which double rooms accounted for nearly 55% of all room types in 1997, increasing to 94% in both 2011 and 2024.

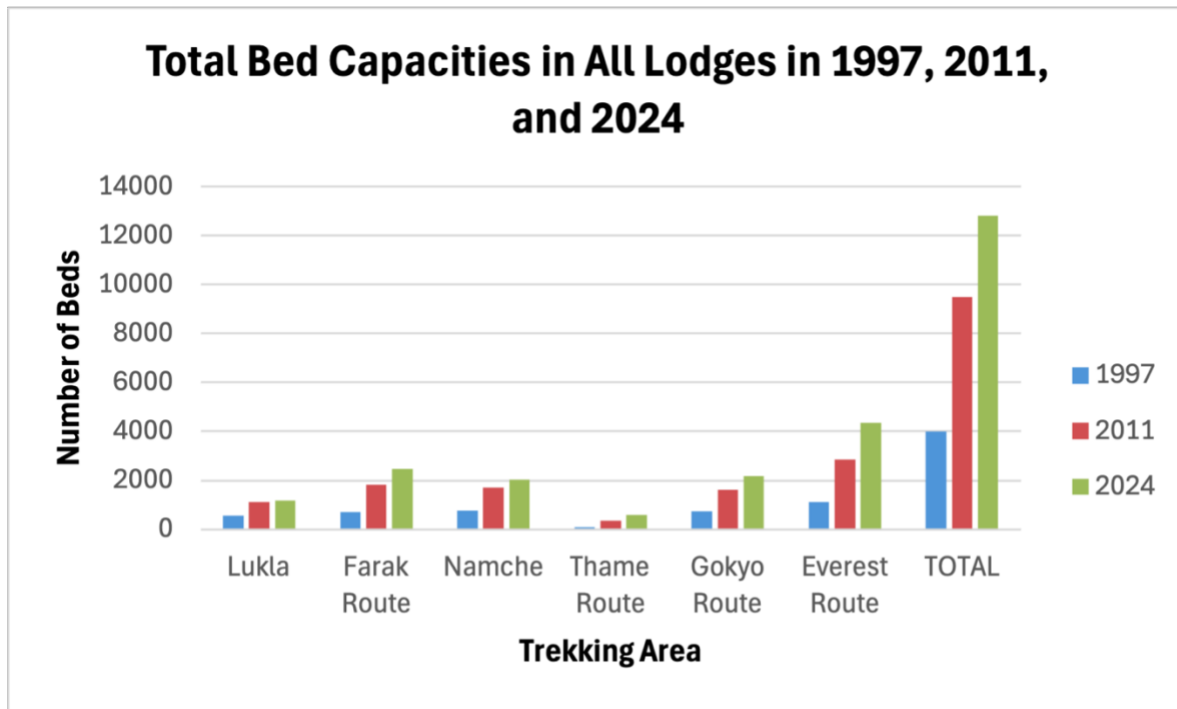


Figure 7: Total bed capacities in all lodges in 1997, 2011, and 2024.

As previously discussed, the total number of beds in SNPBZ has steadily increased over time.

Figure 7 illustrates the total number of beds in each trekking area for each study period.

Throughout time, those areas with the greatest bed capacities were consistently the Everest and Farak routes, and Namche. In 1997, the park had 3,985 beds, with the highest concentrations along the Everest Route (1,108 beds), in Namche (778 beds), and along the Farak route (712 beds). In 2011, there was a total of 9,494 beds which remained concentrated along the Everest (2,853 beds) and Farak (1,844 beds) routes, and in Namche (1,693 beds). This growth continued into 2024, where the total number of beds reached 12,800. Most beds are concentrated along the Everest (4,356 beds) and Farak (2,162 beds) routes. While Namche had 2,041 beds and the Gokyo route had 2,162 beds. This consistent growth in bed capacities highlights the ongoing expansion of lodge infrastructure across all trekking areas.

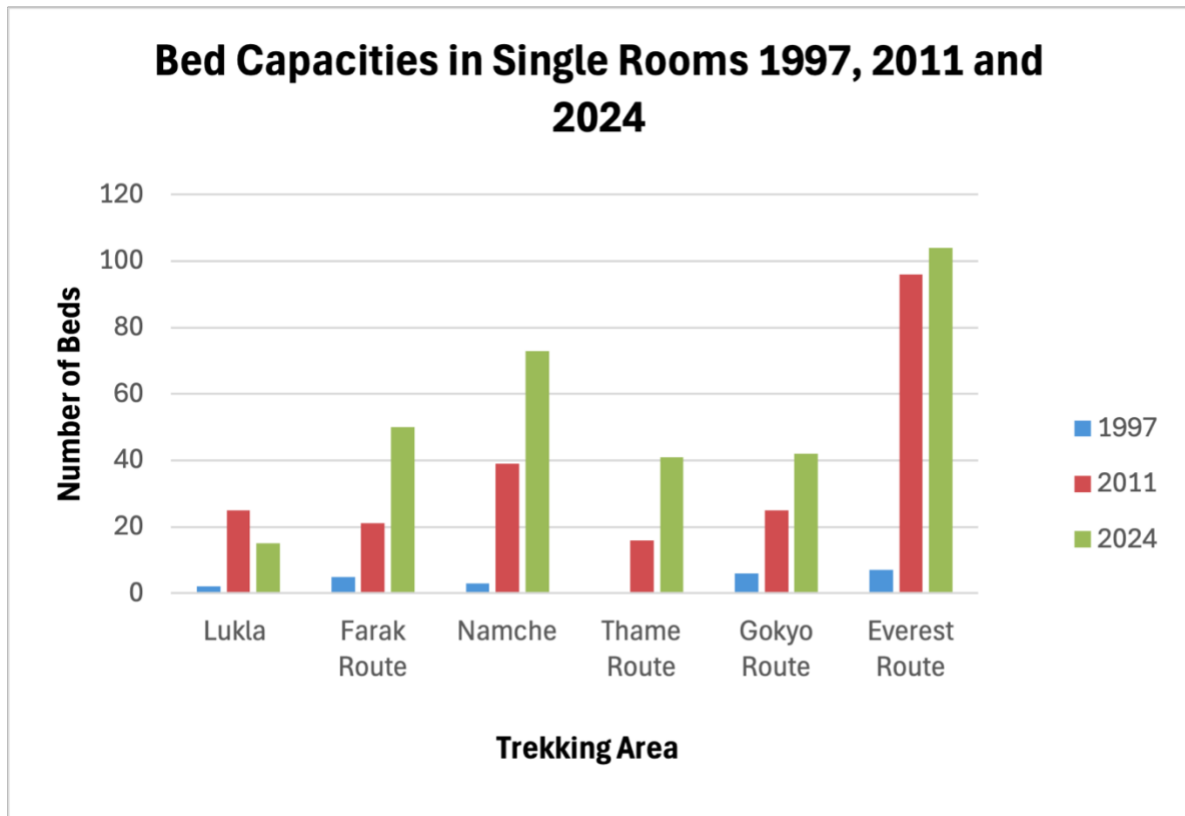


Figure 8: Bed capacities in single rooms in 1997, 2011, and 2024.

Figure 8 portrays the number of beds in single rooms in each trekking area for each period of study. Across all study periods, the number of beds in single rooms increased significantly, reflecting shifts in lodge infrastructure and growing tourist preferences for privacy. In 1997, there were only 23 single beds throughout the entire park, increasing to 222 in 2011, and 325 in 2024. The only trekking area that did not follow this trend was Lukla, where the number of single beds increased from 2 in 1997 to 25 in 2011 and then decreased to 15 beds in 2024.

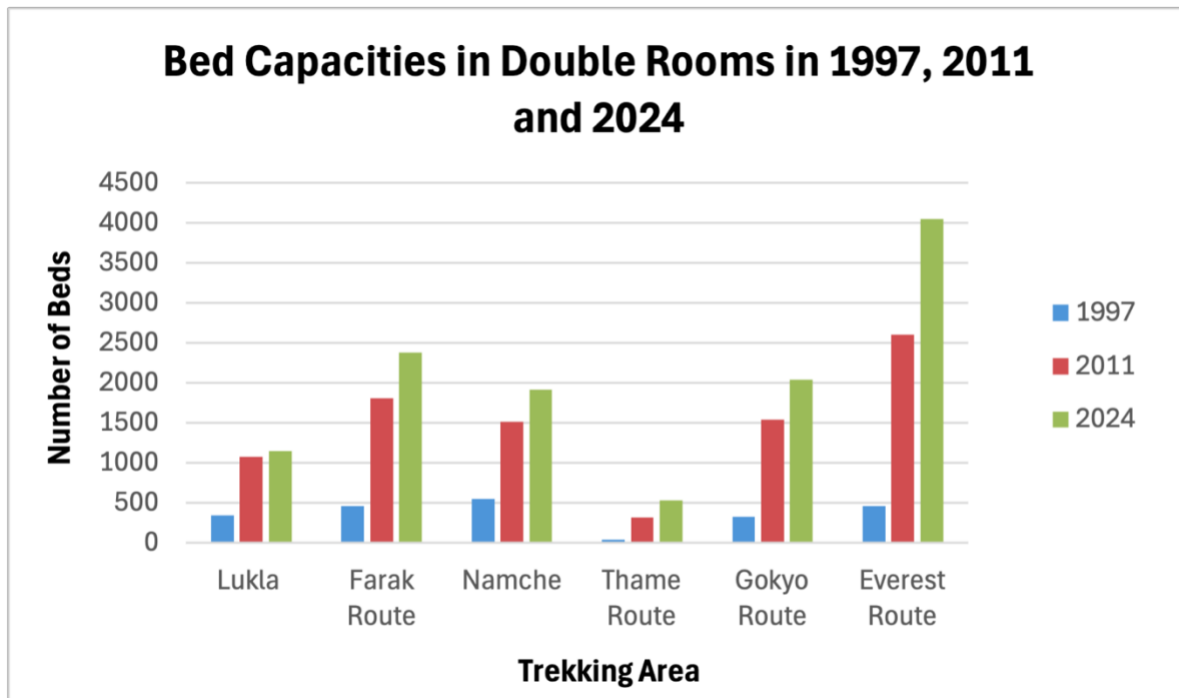


Figure 9: Bed capacities in double rooms in 1997, 2011, and 2024

Figure 9 illustrates the number of beds in double rooms across all trekking areas between 1997 to 2024. During this period, every trekking area experienced growth in double-room capacity, with the most substantial increases occurring between 1997 and 2011. In 1997, Namche had the highest number of double beds (550), which increased to 1,508 by 2011. However, in 2011, the Everest route became the area with the most beds in double rooms at 2,605 beds, up from 458 in 1997. This trend continued in 2024, where the Everest route experienced the most growth and remains the area with the most beds in double rooms, at 4,050 beds. Lukla also saw growth, though at a slower pace, increasing from 339 beds in 1997, to 1,072 in 2011, and 1,150 in 2024. Lukla is important to highlight because although this area had no growth in the number of lodges between 2011 and 2024, it did experience growth in lodge development through an increase in bed capacities.

Figure 10 shows the number of beds in triple rooms in each trekking area across each study period. Triple rooms are a new phenomenon throughout SNPBZ and only one trekking area reported any beds in this room type prior to 2024. In 2011, the Farak route had a total of nine beds in triple rooms.

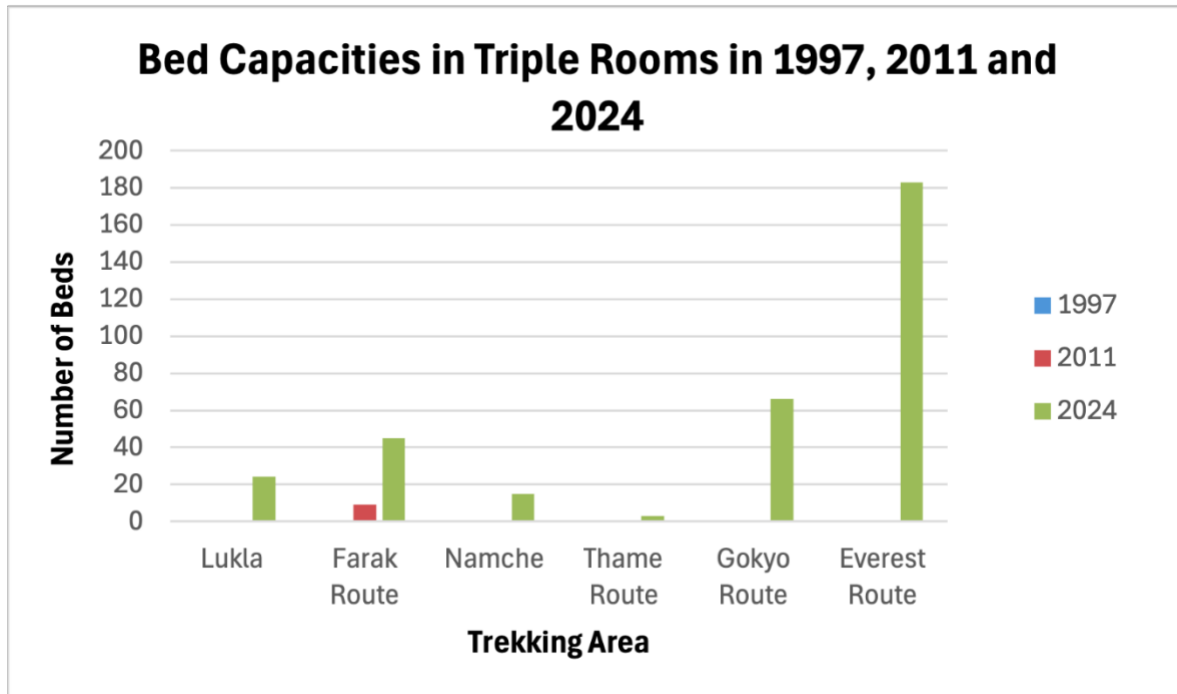


Figure 10: Bed capacities in triple rooms in 1997, 2011, and 2024.

Meanwhile in 2024, every trekking area reported beds in triple rooms. With Lukla reporting 24 beds, the Farak route 45, Namche 15, the Thame route 3, the Gokyo route 66, and the Everest route 183 beds in triple rooms.

Figure 11 shows the number of beds in dormitory rooms in each trekking area across each study period. The data shows a dramatic decline in dormitory accommodations over the study period. In 1997, dormitory beds made up the majority of total capacity in all areas: Lukla had 218, the Farak route 251, Namche 224, the Thame route 58, the Gokyo route 402, and the Everest route 643. These numbers declined in 2011, most notable to just 30 beds in Lukla, 4 along the Farak route, and 19 along the Everest route. In 2024, dormitory rooms were nearly obsolete, with Lukla reporting none, the Farak route had only 4, Namche 35, the Thame route 9, the Gokyo route 18, and the Everest route 19 beds.

Although the total number of beds throughout SNPBZ has increased between 1997 and 2011, the number of beds in each room type has fluctuated and changed through time. There has been an increase in the number of beds in both, single and double rooms. Triple rooms were non-existent in 1997, and only one room with three beds was recorded in 2011. It is apparent that over time,

this room type has become more common. Meanwhile, dormitory style rooms have experienced the opposite with an overall decline since 1997. This room type has now become the least common and has the lowest number of beds.

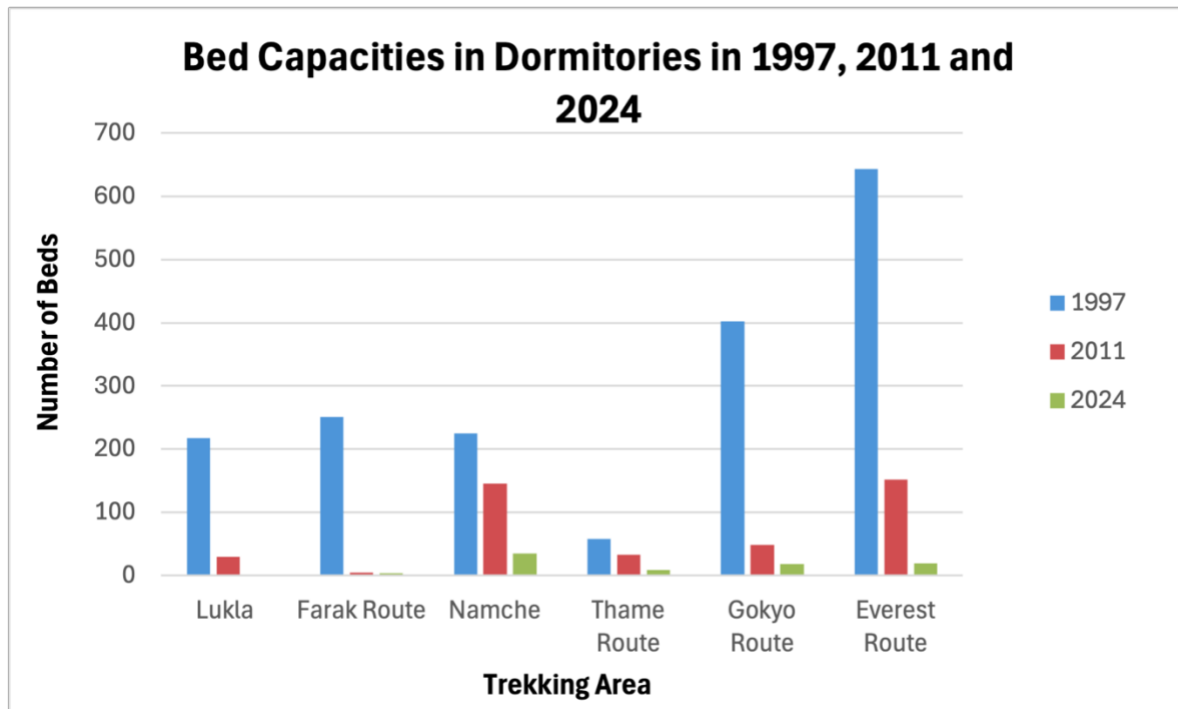


Figure 11: Bed capacities in dormitories in 1997, 2011, and 2024.

Lukla is a notable trekking area because the data reflects that there has been a decrease in the number of beds in both, single and dormitory rooms, while there has been an increase in the number of beds in double and triple rooms. Overall, the area has experienced an increase in the total number of beds from 559 beds in 1997, 1127 beds in 2011, and 1189 beds in 2024. It is important to note these changes in bed capacities in Lukla because it is the only trekking area that did not experience the development of new lodges between 2011 and 2024. Although the number of lodges in Lukla did not change, the capacity of those lodges increased by 62 beds.

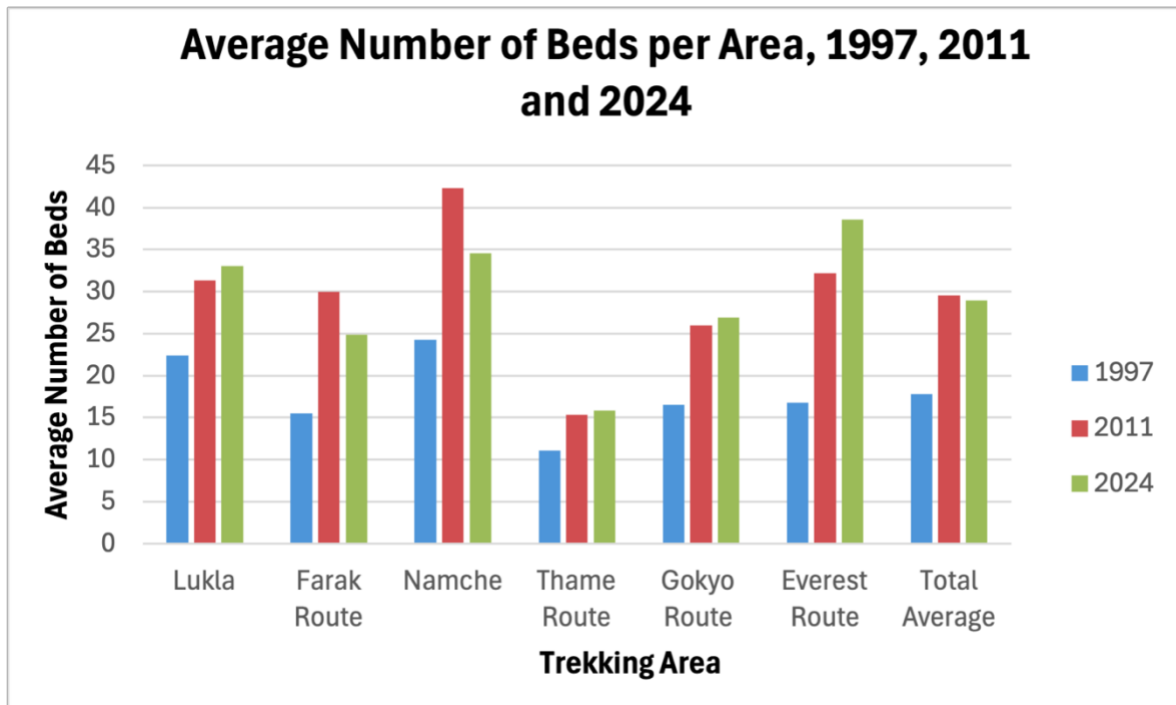


Figure 12: Average number of beds per area in 1997, 2011, and 2024.

Figure 12 shows the total average number of beds in each trekking area across all study periods. Since 1997, the average number of beds has increased in all areas, indicating general growth in lodge capacity. However, between 2011 and 2024, the total average across SNPBZ slightly declined. During this period, all areas except the Farak route and Namche experienced increases in average beds per lodge. This metric is important for identifying change in lodge infrastructure relative to lodge growth. For example, while Namche saw an increase in the total number of lodges and in single, double, and triple room beds, the average beds per lodge decreased – suggesting the construction of smaller-capacity lodges. In contrast, areas with rising averages reflect both lodge growth and expansion in individual lodge capacity. Lukla is an exception here as it has not had an increase in the number of lodges, but an increase in lodge capacity.

The following graphs examine the occupancy of beds throughout the park. Figure 13 shows the total beds occupied in each trekking area during the two main tourist seasons – Spring (March/April) and Fall (October/November) – compared with the total available beds in 2024.

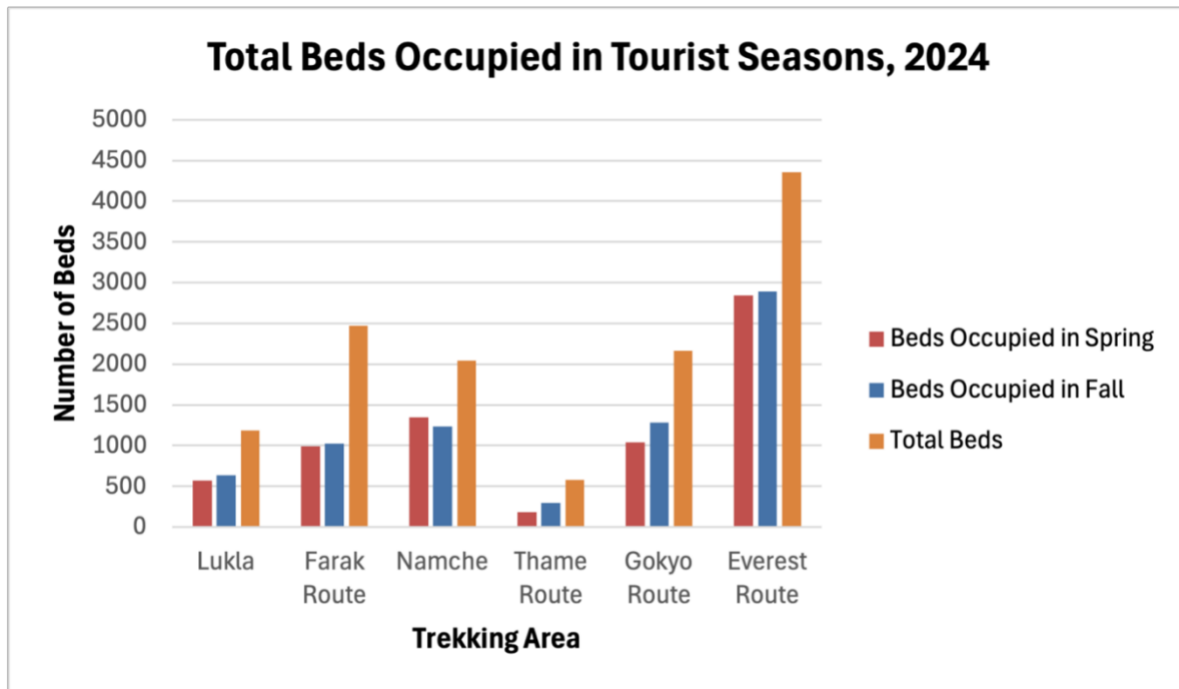


Figure 13: Total beds occupied in 2024 tourist seasons.

The data in this graph may be limited because there is no record of overnight stays which means that all data are based on estimates provided by lodge owners. Based on the survey results, there are a total of 6,965 beds occupied in the Spring season and 7,360 beds occupied in the Fall season. According to locals, it is typical to expect the Spring season to be busier than the Fall; however, the data reflects that the Fall season is indeed busier. In conversations with lodge owners, they expressed that the Spring season is typically busier with expedition teams while the Fall season is busier with trekkers. According to lodge owners, these types of tourists prioritize privacy and rest so often double rooms will only have one person occupying them, while trekkers who visit in the Fall are more likely to share rooms.

In terms of capacity, it is evident that the data show that there are more than enough beds in each trekking area for the number of tourists. Overcapacity is not a problem. However, the trekking season is typically concentrated within a two-week period each season where SNPBZ is most busy. In the Fall season, this is typically from mid-October to the beginning of November. Although the data does not depict overcapacity, during interviews with locals and lodge owners, as well as field observations by the author, it was observed that overcapacity is sometimes a temporary issue. Between mid-October to the beginning of November, some trekkers struggle to

find accommodation due to no vacancies and must sleep in common areas. This is only an issue for very short periods of time throughout the tourist season and does not typically happen in the Spring season.

Due to the lack of data from 1997, a full comparison of bed occupancy across all three study years was not possible. Instead, occupancy rates were compared for the fall seasons of 2011 and 2024, based on available data from the 2011 study. *Figure 14* portrays the total beds and beds occupied during each of these fall seasons.

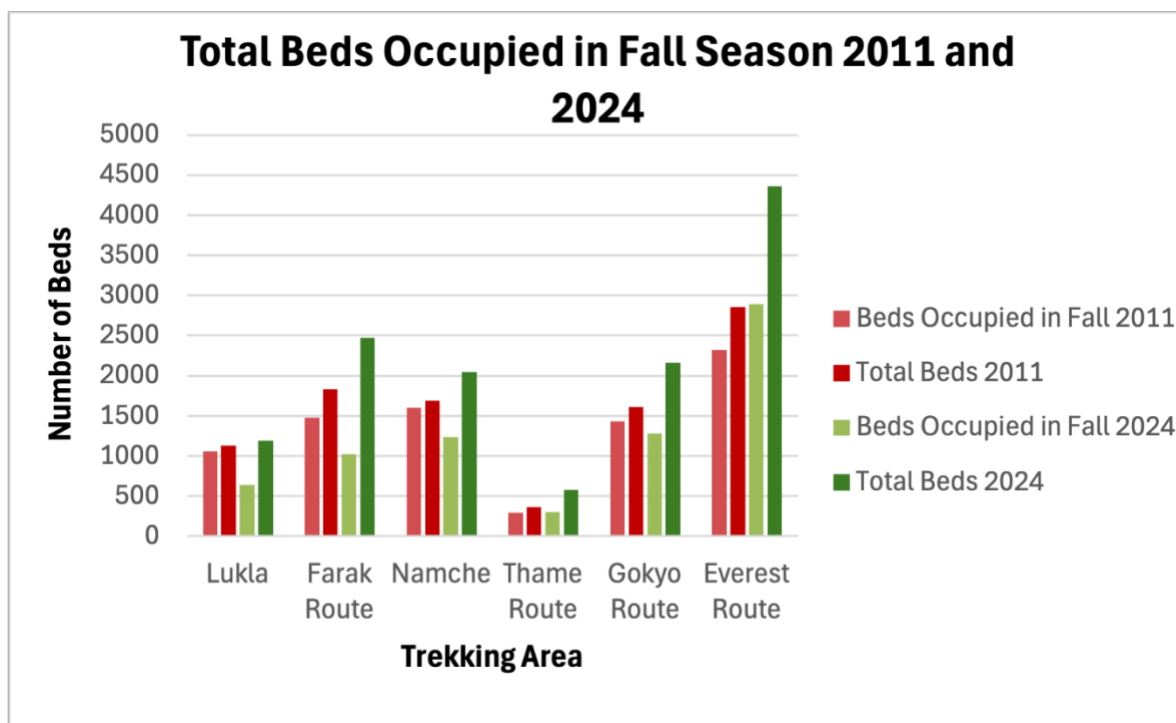


Figure 14: Total beds occupied in Fall season, 2011 and 2024.

While the number of beds, lodges, and tourists increased between 2011 and 2024, occupancy rates declined in most trekking areas. Except for the Everest and Thame routes, all areas experienced lower total occupancy in 2024 compared to 2011. Despite the increased bed supply, demand appears to have decreased, resulting in fewer occupied beds in 2024. This suggests a growing mismatch between supply and demand, with bed capacity exceeding average use during the fall season in most areas. However, interviews and local observations indicate that during peak trekking weeks – particularly from mid-October to early November – temporary overcapacity can still occur, highlighting the continued importance of maintaining sufficient bed availability.

4.2 Results of Lodge Ownership, Management, and Labour Structures

As previously described in Section 2.2.1 socio-cultural data could further stimulate conversations relating to socio-cultural change due to tourism development. These changes relate to the portrayal of lodge ownership and labour organizations which may contribute to the understanding of any imbalances in development, unequal distributions of benefit, and shifts in societal and cultural power. This next section provides a brief analysis on the historical change in lodge ownership, management, and labour structures.

4.2.1 Lodge Ownership and Labour Demographics

In the questionnaire, the question of who runs the lodges offered the options of the owner (and his family) or an external person (e.g., employed manager). For analysis, the term “renters” is used to depict any person who may operate the lodge but not own it – an external person. *Figure 15* shows the percentage of lodges operated by owners versus renters across all trekking areas in 1997, 2011, and 2024. Overall, there was an earlier shift towards more renter-operated lodges although this trend appears to have stabilized between 2011 and 2024. In 1997, 87% of lodges were owner-operated, dropping to 75% in 2011, and remaining unchanged at 75% again, in 2024. Ownership trends have varied across trekking areas. In Lukla, and along the Everest and Thame routes, the proportion of renter-operated lodges increased between 1997 and 2011, and then declined by 2024. Lukla, Namche, and the Everest route saw a consistent decline in owner-operated lodges over the entire study period. Although the park is still dominated by owner-operated lodges, the presence of renters has expanded parkwide – except in Lukla and along the Thame route. Only the Farak and Thame routes experienced an increase in the percentage of owner-operated lodges between 2011 and 2024.

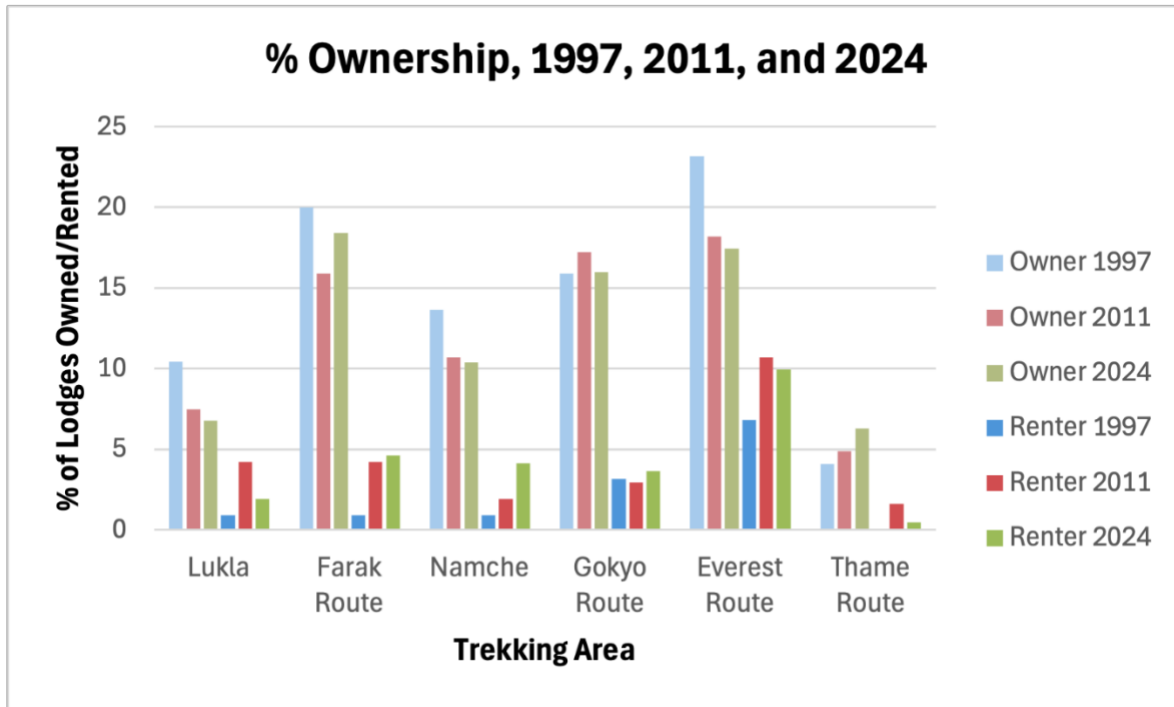


Figure 15: Percentage of lodge ownership in 1997, 2011, and 2024.

As previously noted, some rented lodges may be operated by employed managers. While this information was not recorded in 1997 or 2011, the 2024 survey included questions on ownership and whether lodges were managed by family members or external employees. *Figure 16* shows the number of owner-operated lodges that are managed by hired staff. This characteristic of labour structure is often common for lodges that are commercialized, such as the Everest View Hotel or Mountain Lodges of Nepal. Although relatively few, these lodges are most prevalent in Lukla and along the Farak and Everest routes. In Namche, only one owner-operated lodge is externally managed. Distinguishing this ownership management structure is important as it reflects a shift toward more formal, business-oriented operations resembling Western hospitality models.

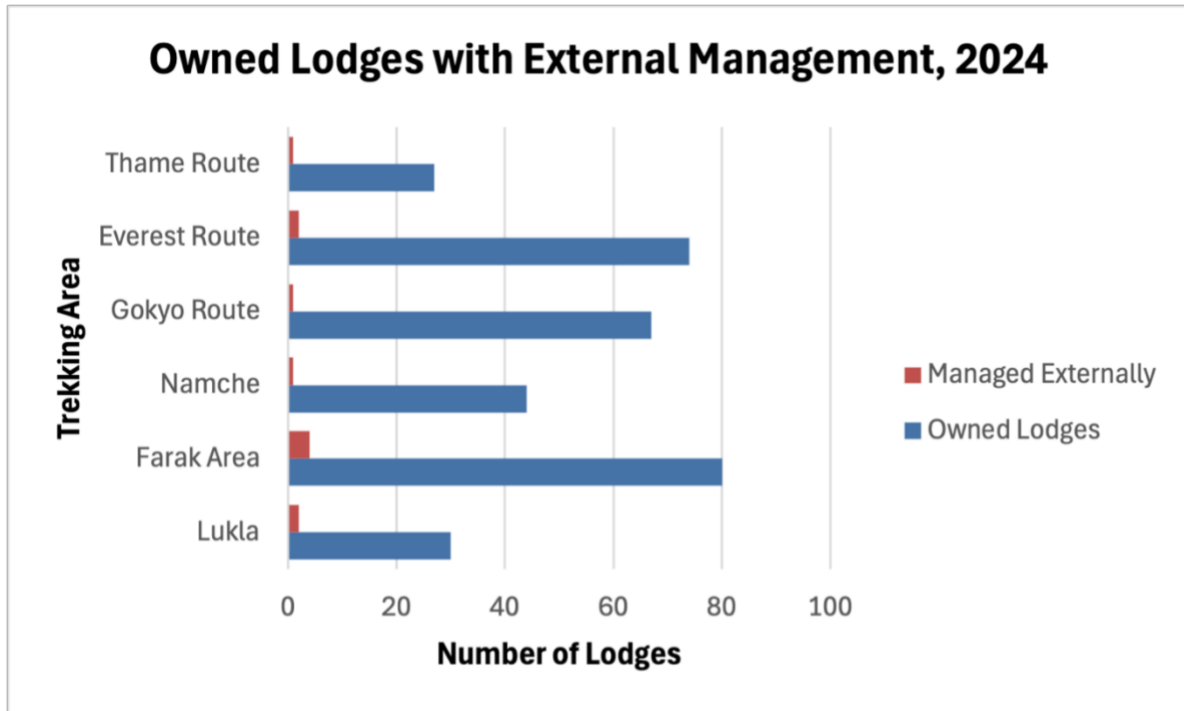


Figure 16: Owner-operated lodges managed by hired staff in 2024.

In addition to asking whether lodges were owned or rented and who operated them, the 2024 questionnaire also asked whether, in the case of rental, the lodge owner was local to the Solukhumbu region. This distinction highlights that rented lodges may still be owned by local residents, separating property ownership from business operation. *Figure 17* portrays the number of rented lodges and how many of those are locally owned. In Namche, all rented lodges are locally owned. In contrast, other trekking areas show more variation. For example, along the Thame route, only two lodges are rented, and just one of those is owned by a local resident.



Figure 17: Rented/managed lodges that are locally owned in 2024.

The following graphs examine the labour composition with the lodges of SNPBZ. The analysis of labour structures is based on whether the labour force in each lodge is made up of family members or hired employees and their gender. In 1997 the labour force consisted of a total of 777 people, by 2011 this number increased to 1534 employees – including family members. By 2024, there was a total of 2256 people in the lodge labour force in SNPBZ.

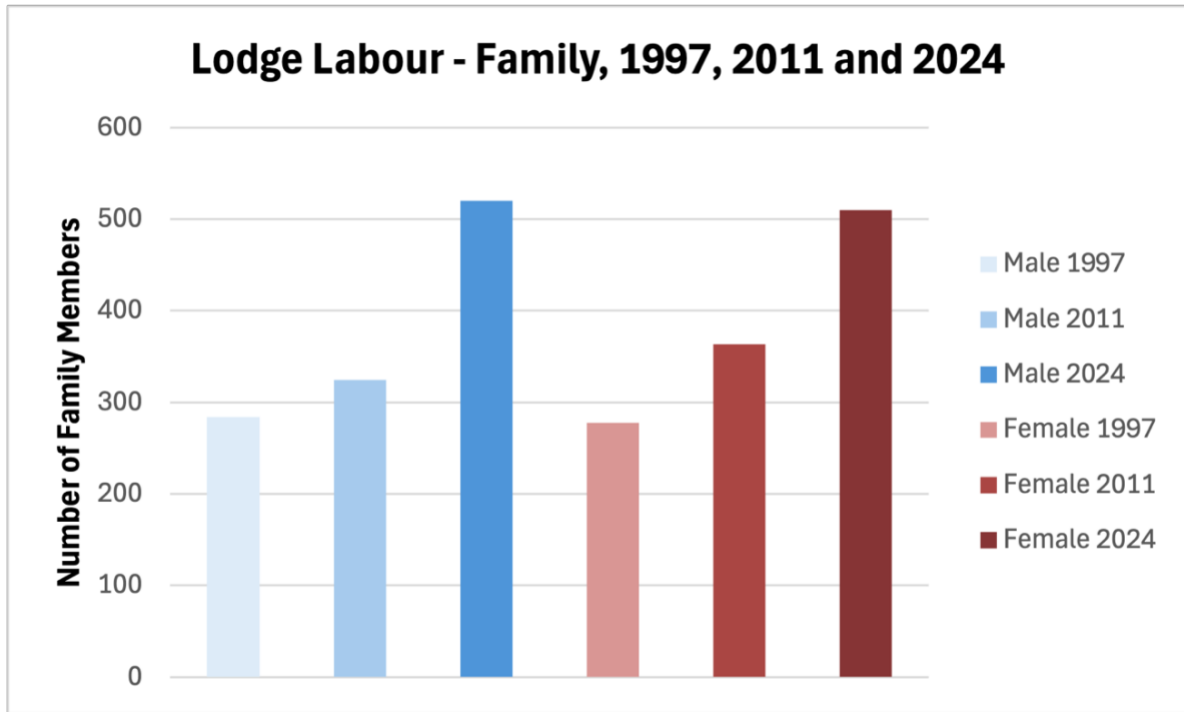


Figure 18: Family involved in lodge labour force in 1997, 2011, and 2024.

Figure 18 portrays the total number and gender of family members that contribute to the lodge labour force of SNPBZ in 1997, 2011, and 2024. Over time, the number of male and female family members working in lodges has consistently increased, with the number of men and women remaining similar. In 1997, 284 male and 278 female family members made up the park workforce. By 2011, women made up most of the familial workforce at 363 women and 324 men. In 2024, the labour force differed in gender by only 10 people where 520 family members were men and 510 were women.



Figure 19: Hired staff in lodge labour force in 1997, 2011, and 2024.

Figure 19 shows the number of employed men and women throughout all SNPBZ in 1997, 2011, and 2024. The number of both, male and female employees, has increased through time. In 1997 the total number of male employees in SNPBZ was 178, this number grew to 472 in 2011, and 748 in 2024. While the number of female employees was much lower at 37 in 1997, 375 in 2011, and 478 in 2024.

When comparing the two labour types – familial and employee-based – it is evident that the number of male and female members working in lodges has remained relatively balanced over time. In contrast, the number of male employees has consistently exceeded that of female employees. This suggests that while family labour roles are more evenly distributed across genders, formal employment in lodges tend to have a higher proportion of males compared to females.

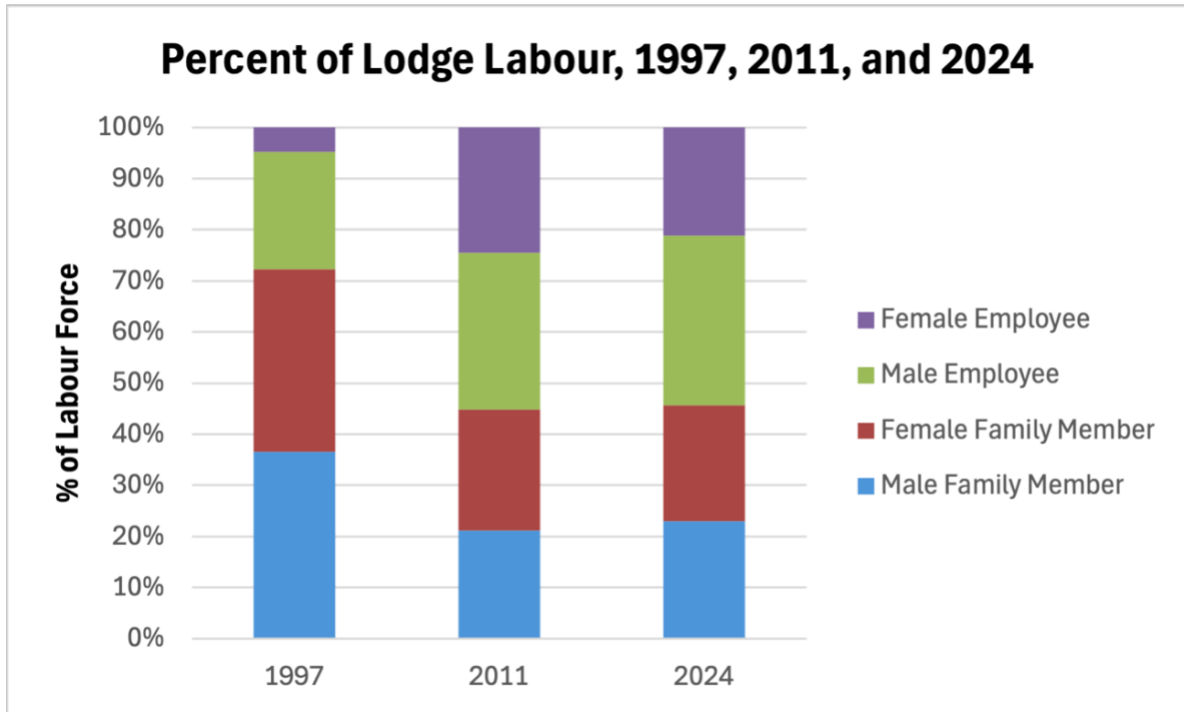


Figure 20: Relative distribution of labour force in 1997, 2011, and 2024.

Figure 20 shows the relative distribution of the labour force in lodges for each year of study across the entire park. It is evident that the number of female employees has increased through time, from making up only 5% of the total labour force in 1997 to 21% in 2024. Meanwhile male employees have become dominate in the labour force since 1997, representing the greatest portion of the labour force in both 2011 and 2024. It appears family members made up most of the workforce in 1997 which changed in 2011 when most of the labour force consisted of employees, this is also observed in 2024.

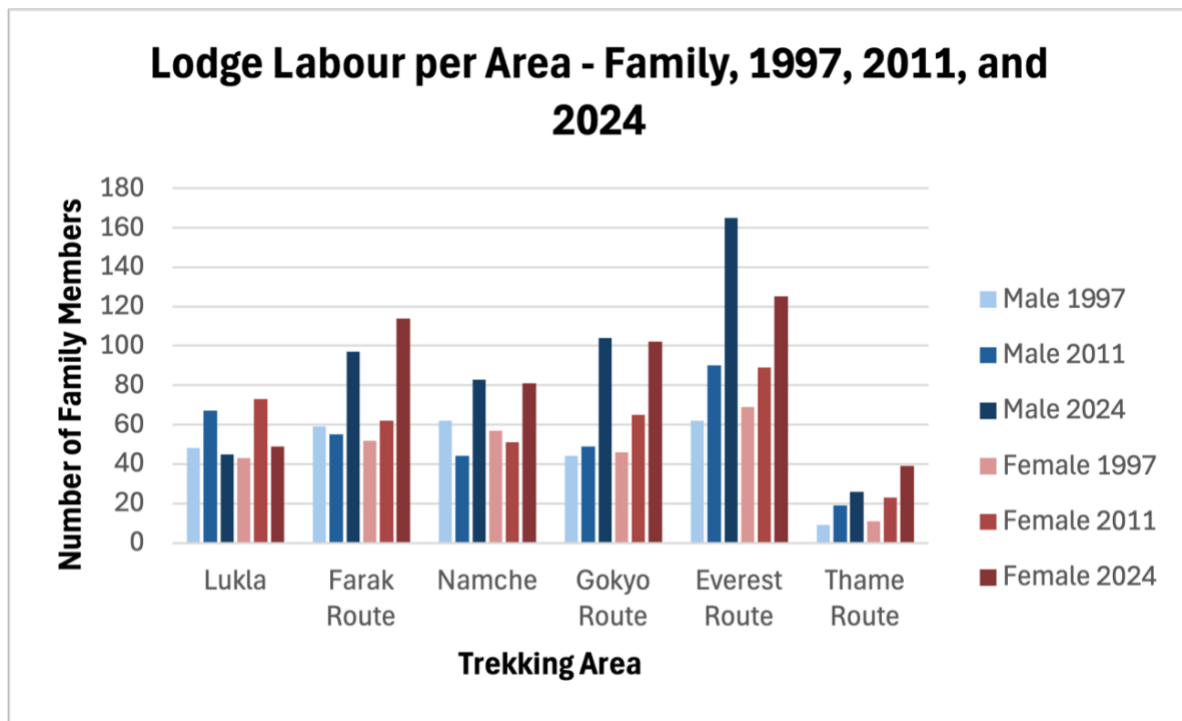


Figure 21: Gender of familial labour force in 1997, 2011, and 2024.

Figure 21 illustrates the number of male and female family members working lodges across all trekking areas in each period of study. As of 2024, Lukla, the Farak route, and the Thame route all had more female than male family members involved in lodge labour. Specifically, Lukla had 49 women and 45 men; the Farak route, 114 women and 97 men; and the Thame route, 39 women and 26 men.

Across all three study periods, the Gokyo, Everest, and Thame routes saw continuous growth in both male and female family labour. The Farak route showed consistent growth among women, while male participation declined in 2011 before rising again in 2024. Lukla followed a different pattern, with both male and female family labour increasing in 2011 before declining in 2024. In contrast, Namche experienced a decline in family labour between 1997 and 2011, followed by an increase in 2024, reaching 83 men and 81 women.

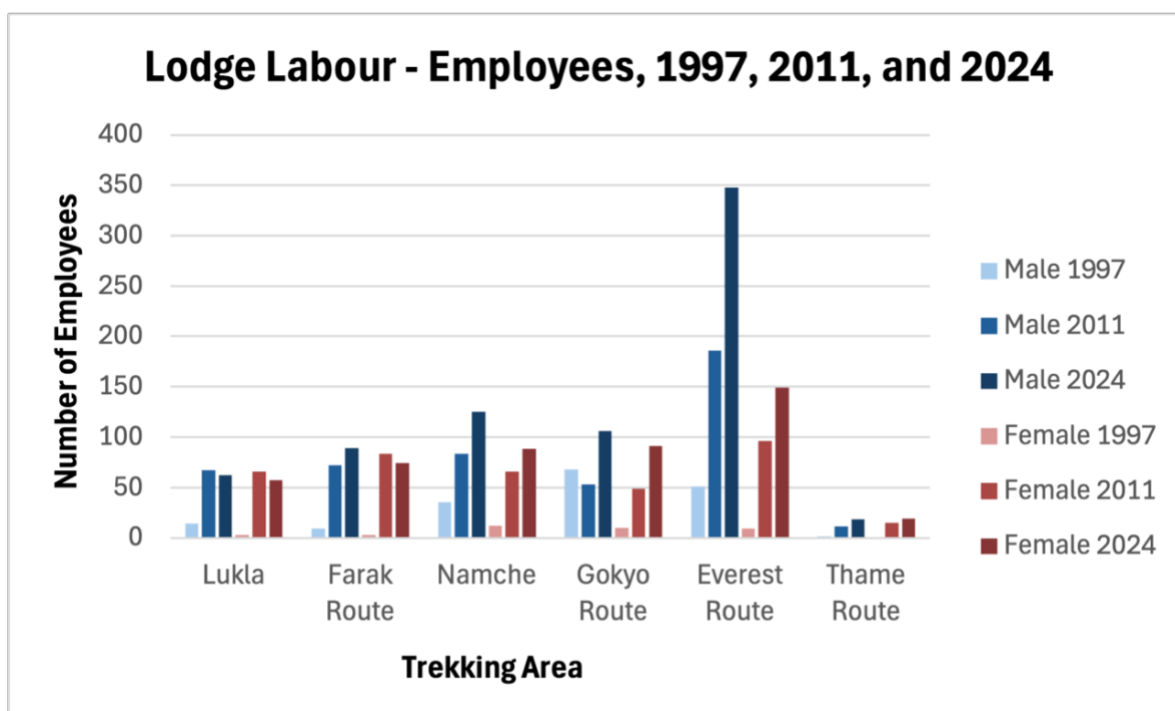


Figure 22: Gender of hired labour force in 1997, 2011, and 2024.

Figure 22 presents the number of male and female lodge employees in each trekking area across all study periods. Between 1997 and 2011, all areas saw growth in both male and female employment, except for the Gokyo route, where male employees decreased from 68 to 53. This upward trend largely continued into 2024, particularly in Namche, and along the Gokyo, Everest, and Thame routes, all of which experienced increases in both male and female staff. However, on the Farak route, only male employment increased during this period, while the number of female employees decreased from 83 to 74. Lukla experienced a decline in both male and female employees between 2011 and 2024, from 67 to 62 men and 66 to 57 women.

Corresponding with the overall growth in the number of lodges, the distribution of the lodge labour force has also increased across all trekking areas. Areas with more lodges – such as Namche, and the Farak and Everest routes, consistently employed larger workforces, including both family members and hired staff.

In 1997, most areas – except the Gokyo route – had more male family member than male employees, a trend mirrored among women, with female family members outnumbering female

employees. Male family labour was more prevalent in Lukla, Namche and along the Farak route, while female family labour dominated along the Gokyo, Everest, and Thame routes.

In 2011, male employees outnumbered male family members in all areas except the Thame route. Female employees dominated female family members in Namche and along the Farak and Everest routes, while female employees outnumbered female family members in Lukla, and along the Gokyo and Thame routes.

In 2024, the labour force became increasingly employee based. Except for the Farak and Thame routes, all areas were dominated by both, male and female employees. Notably, Lukla had more female than male employees, while Namche, and the Gokyo and Everest routes had more male employees than female. These trends suggest a shift towards an increased reliance on hired employees over family labour – particularly in high tourism areas.

4.2.2 Labour Provenance

This section examines the lodge work force and employee place of origin. These graphs will develop an understanding of whether employees are local to the Solukhumbu area.

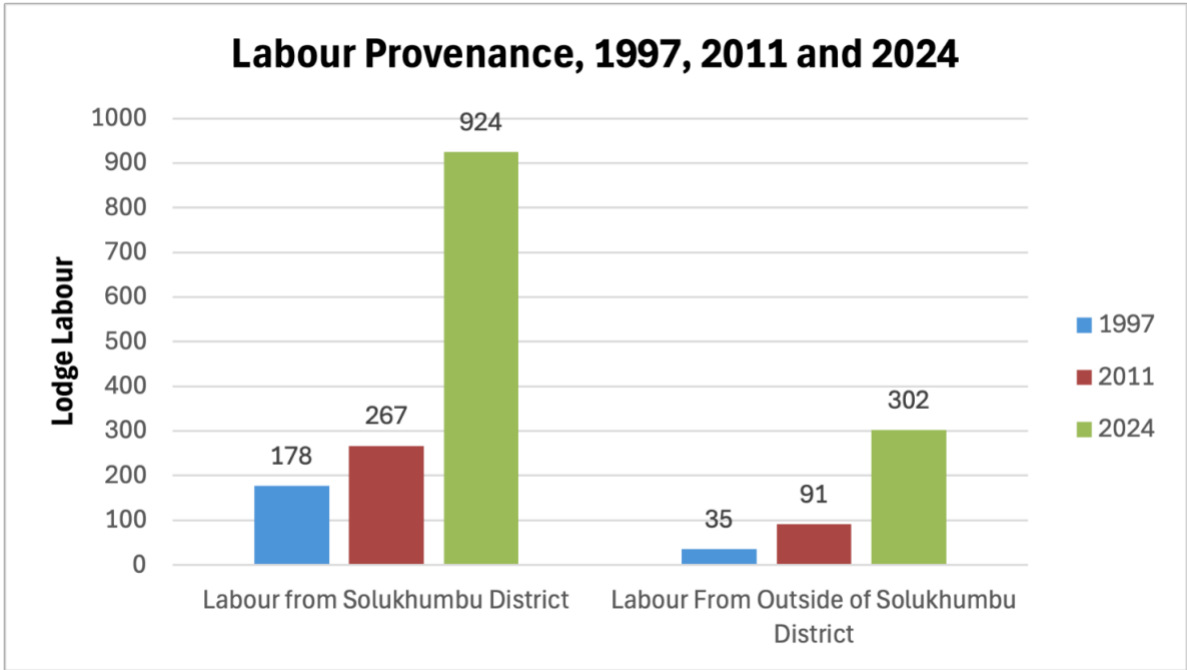


Figure 23: Labour provenance in SNPBZ in 1997, 2011, and 2024.

Figure 23 depicts the number of employees from the Solukhumbu district and the number of employees from outside the district. It is evident that the total number of employees from within and outside of the district has increased throughout time. While most of the employed workforce is made up of people local to the Solukhumbu.

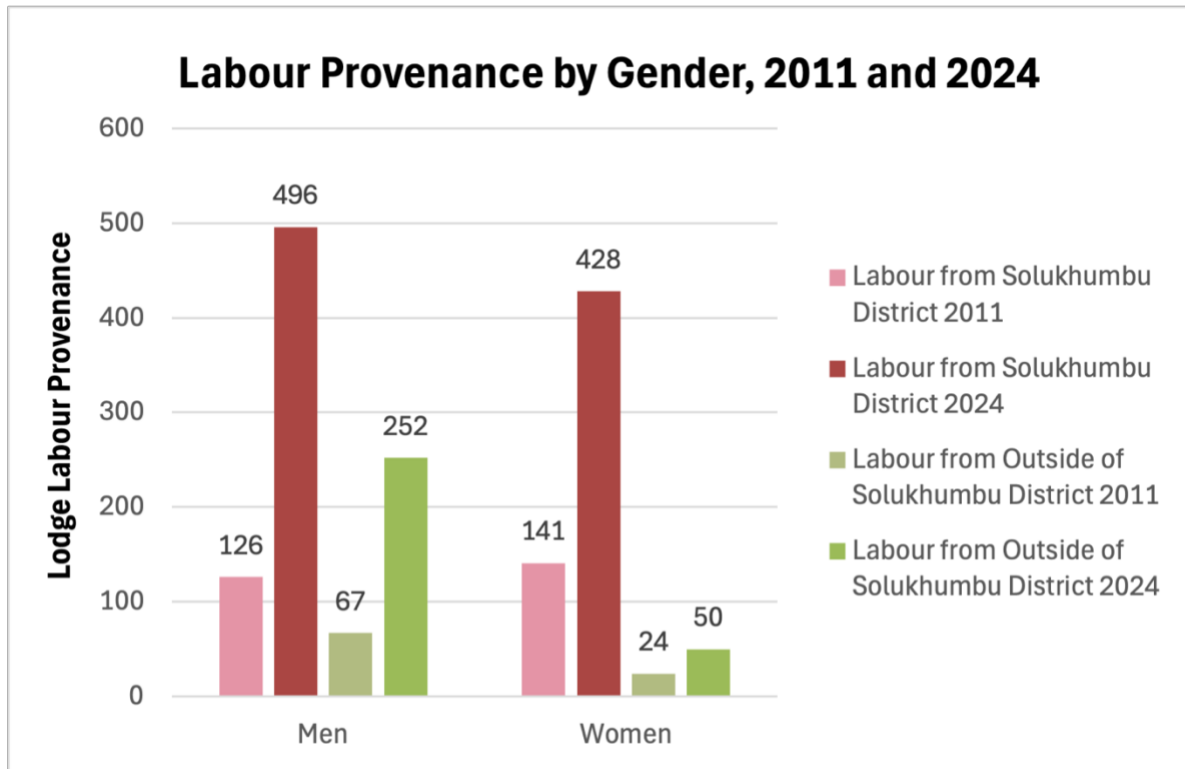


Figure 24: Labour provenance in SNPBZ by gender in 2011 and 2024.

Figure 24 demonstrates the number of male and female employees from within and outside of the Solukhumbu district in 2011 and 2024. The year 1997 could not be included in this comparison because this question was not asked in the 1997 survey. It is apparent that despite gender, most employees are local to the area. The number of locally employed men and women have a slight difference in both 2011 and 2024. In both years, there were more local female employees than local male employees. In comparison, there are more non-local male employees in both 2011 and 2024.

4.3 Results of Energy Consumption Patterns

The following section will examine energy consumption patterns and energy types consumed in tourist lodges. The main types of energy resources consumed are as follows; electricity (from either hydropower or solar panels), water, firewood, animal dung, kerosene, and liquid petroleum gas (LPG).

4.3.1 Electricity Consumption

This next section explores electricity consumption trends of hydro and solar power. It first compares the adoption of hydroelectricity and solar power throughout SNPBZ over time and then looks at the amount of electricity consumed in 2024.

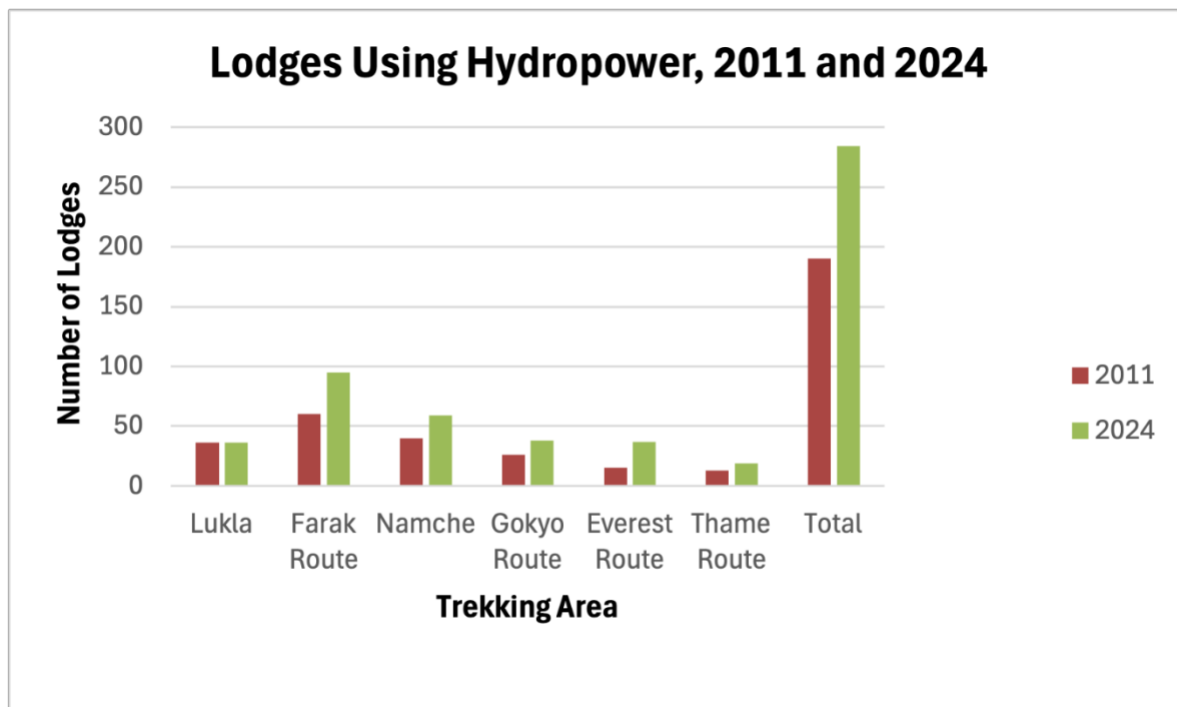


Figure 25: Number of lodges using hydropower in 2011 and 2024.

Figure 25 demonstrates the number of lodges that use hydropower in each trekking area between 2011 and 2024. It is evident that the number of lodges consuming hydropower has increased since 2011. This trend corresponds with the overall growth in the total number of lodges across trekking areas. This is especially apparent since Lukla has not had an increase in any lodges between 2011 and 2024, and there has been no change in the number of lodges consuming hydroelectricity in this area. Both the Namche and Farak routes experienced substantial increases

in lodges using hydropower, with increases of 35 and 19 lodges respectively. The Farak route has experienced the most growth in lodges, so again, this data corresponds to overall lodge growth. These areas have the most access to hydropower based on their geographic location and altitude.

Additionally, the increase in lodges consuming hydropower in the Everest and Gokyo routes also correspond with the growth of lodges between 2011 and 2014. Since 2011, there are 19 new lodges along the Gokyo route and 24 along the Everest route. The number of lodges that consume hydropower along the Gokyo route has increased by 12 lodges and by 22 lodges along the Everest route. In contrast, the Thame trekking route experienced only a modest increase of 9 lodges consuming hydropower. The growth in lodges consuming hydropower is particularly pronounced in lower-altitude areas, such as Lukla, Namche, and the Farak route, where hydropower access is more feasible due to geographic factors.

In addition to hydropower, solar panels were also observed as an alternative to electricity consumption in the SNPBZ. The usage of solar panels was included as questions in both the 2011 and 2024 studies. It is important to note two differences between the questionnaires that could result in limitations of these results. In 2011, the survey asked whether lodges access electricity through solar panels, while the 2024 survey asked if solar panels were used to generate hot water, for both, cooking and/or showers. This means that although a lodge may report the use of solar panels, they could be used for either electricity or solar water heating or both. Since the 2024 questionnaire did not specifically ask whether the lodge used solar panels to generate electricity, assumptions have been made to identify those lodges that do use solar panels for electricity in 2024. These assumptions include:

- Lodge owners were asked whether they use solar panels and whether they use those solar panels to heat water. If the respondent said “yes” to the use of solar panels and “no” to using them to heat water, it is assumed that the solar panels are used for electricity.
- Many villages in SNPBZ do not have access to a hydropower station. Those lodges in village that do not have access to hydropower and who have stated that they use solar panels, are assumed to use solar panels for electricity. This assumption is supported by the author’s observation that all lodges must use electricity because they all have lights and device charging available. Furthermore, in both 2011 and 2024, it is assumed that all

lodges have electricity from either hydropower stations or solar panels because no other method of generating electricity was observed.

A limitation of these assumptions is that those lodges that may use solar panels to heat water and generate electricity are unknown.

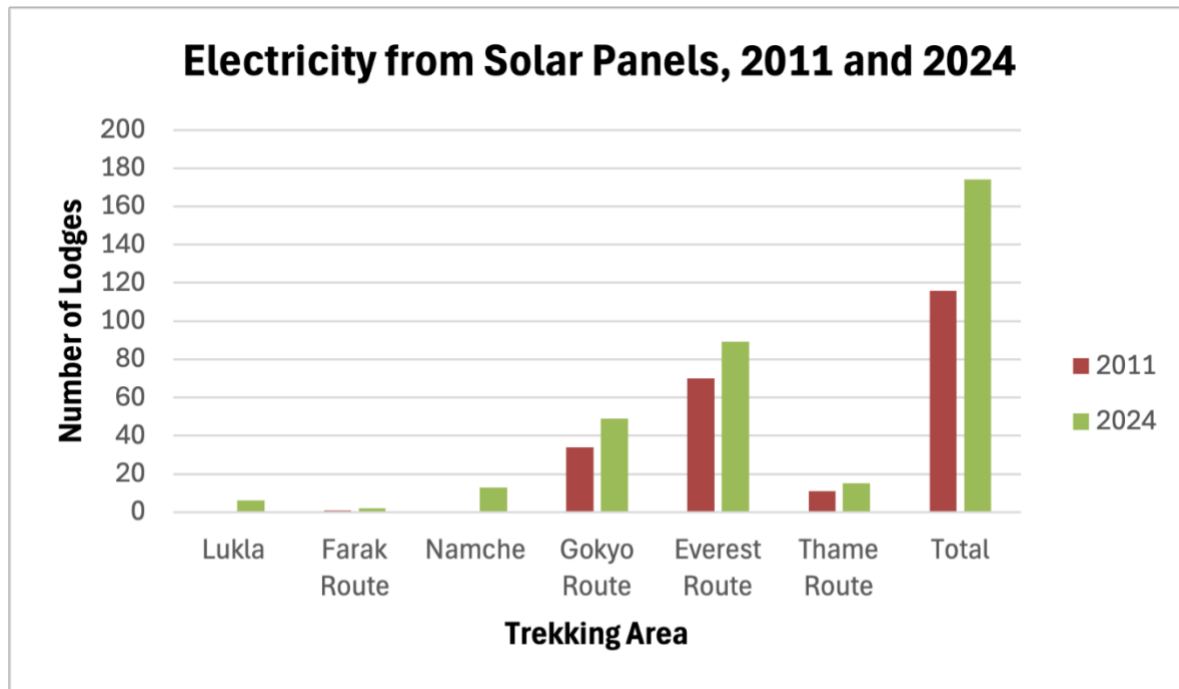


Figure 26: Number of lodges using solar in 2011 and 2024.

Figure 26 portrays those lodges that use electricity from solar panels. There was an overall increase in the number of lodges that consume electricity sourced from solar power. Between 2011 and 2024, the areas that experienced the greatest change in the use of solar power include Lukla, Namche, and the Everest route. In 2011, solar power was nonexistent in Lukla and Namche, and by 2024, a total of 6 lodges in Lukla and 13 in Namche consumed electricity generated by solar power. The Everest route experienced an increase of 19 lodges using solar power. While the number of lodges using solar power along the Gokyo route grew by 15 lodges. Meanwhile, the Farak and Thame routes experienced the least change by only an increase of 1 and 4 lodges consuming solar power, respectively.

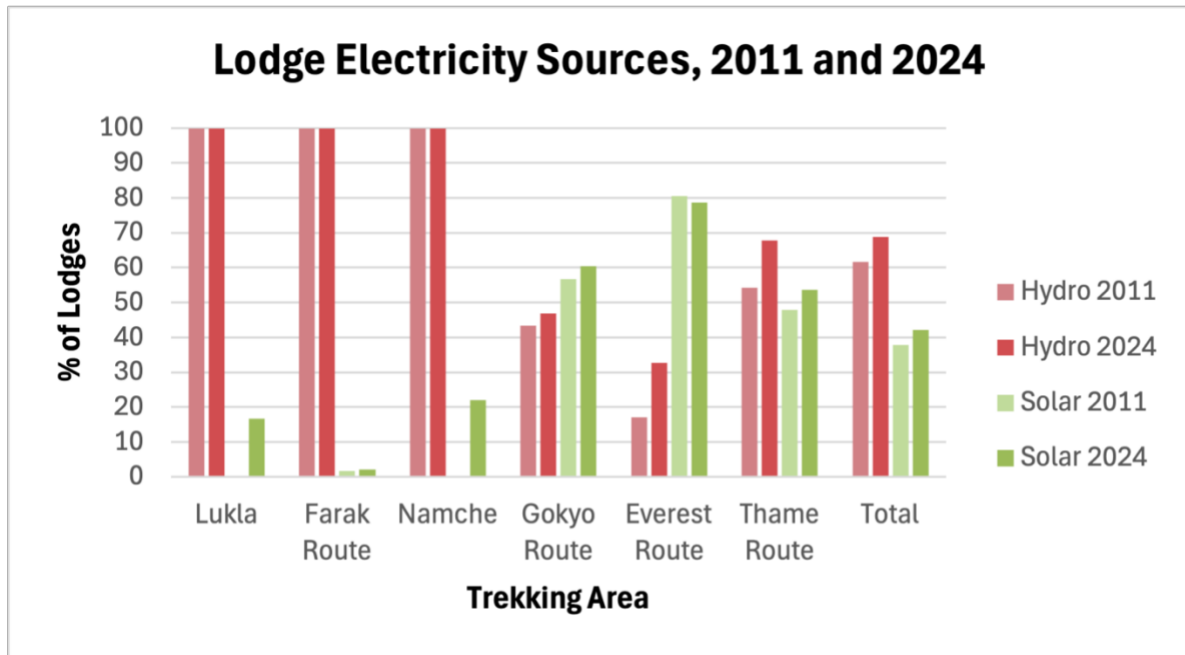


Figure 27: Percent of lodges using hydro and solar power in 2011 and 2024.

Figure 27 portrays the percentage of lodges that source their electricity from hydropower and solar power in 2011 and 2024. It is evident that since 2011, lower altitude areas such as Lukla, Namche, and along the Farak route, have begun to source their electricity from both hydropower and solar power. Concurrently, areas at higher altitudes have greater diversity of both hydropower and solar power. Along the Everest route, there has been a slight decrease in the percent of lodges using solar power. This could be explained by the development of more lodges at lower altitudes along this trekking route that may primarily rely on hydroelectricity. Overall, it is apparent that trekking areas at higher altitudes, like the Gokyo and Everest routes, depend on solar power more than hydropower.

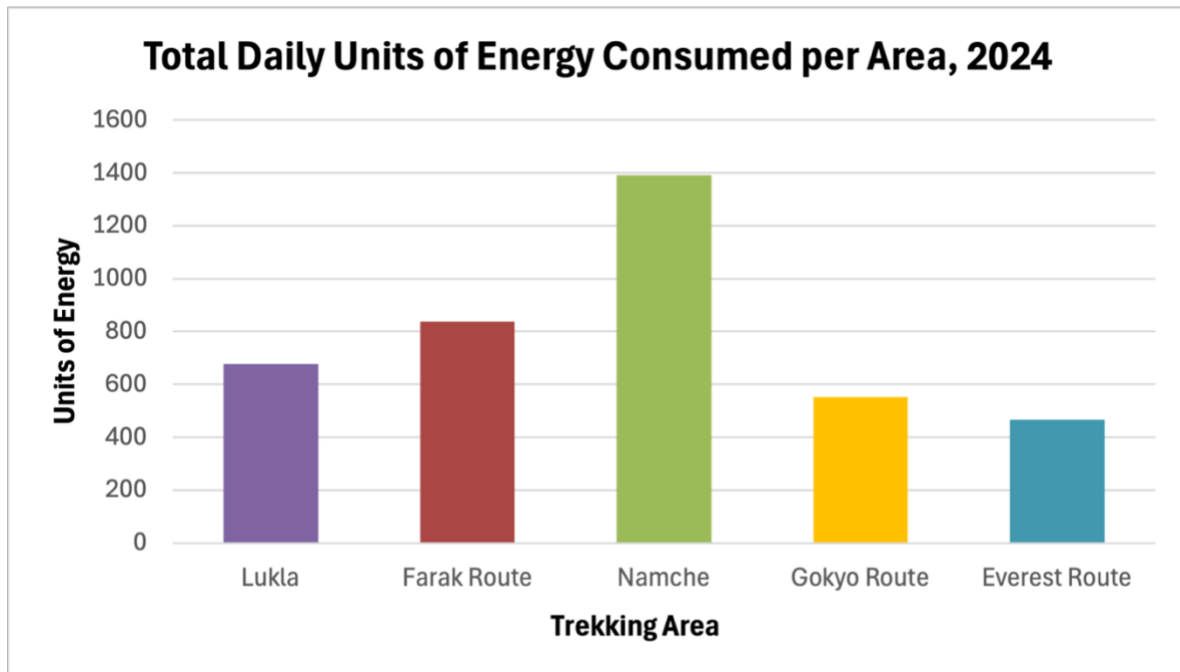


Figure 28: Daily units of electrical energy consumed per area in 2024

Figure 28 depicts the total daily units of energy consumed per area in 2024. The graph portrays that the most daily electricity consumption occurs in Namche (1390 units per day). While the Gokyo (552 units per day) and Everest route (467.5 units per day) experience the lowest daily hydroelectricity consumption.

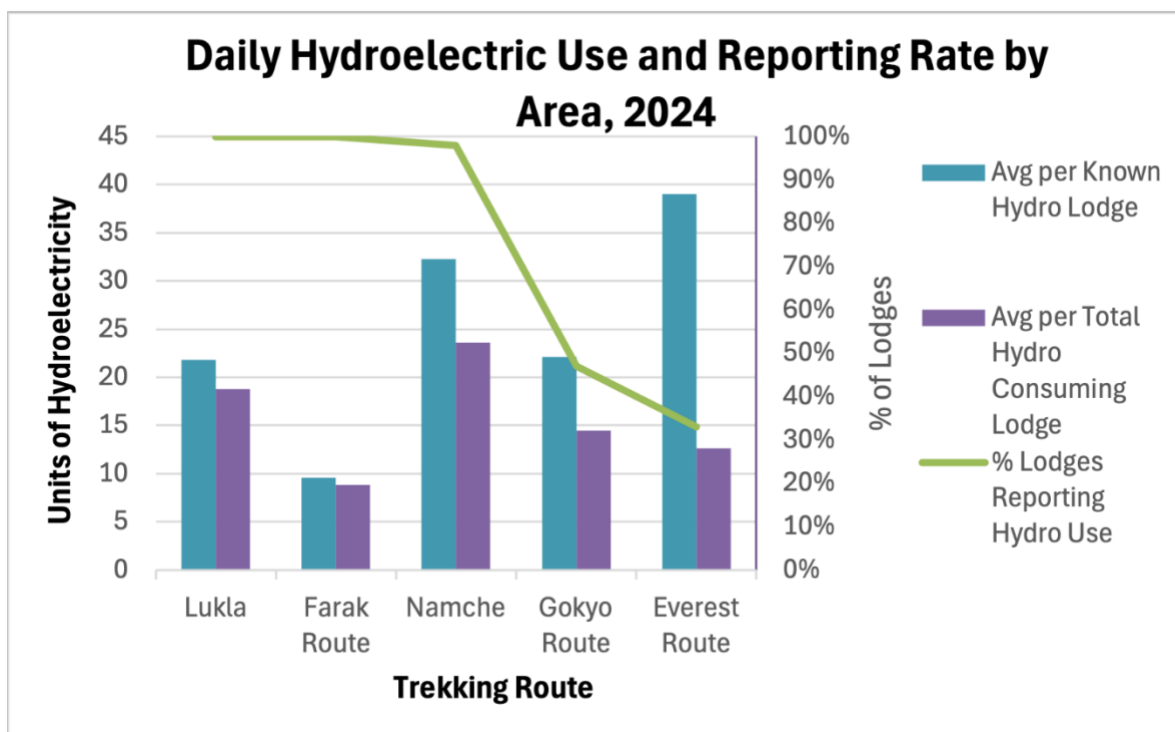


Figure 29: Daily hydroelectricity consumption and reporting rates in 2024.

Figure 29 depicts the average daily hydroelectricity consumption per lodge in SNPBZ and the percentage of lodges that reported their hydroelectricity usage. The blue bars portray the average daily units of hydroelectricity energy consumption per lodge that reported their consumption. The purple bars show the average daily units of hydroelectricity energy consumption per all hydro consuming lodges, regardless of whether they reported their energy usage. This means that the lodge owners reported “yes, the lodge uses hydropower, but we do not know how much.” The green line shows the percent of lodges that use hydroelectricity in the park.

This graph highlights key spatial differences in energy demand. As previously discussed, Lukla, Namche and the Farak route consume the most energy units per day. However, this graph portrays that amongst those lodges that reported their hydropower usage, Lukla and the Farak route have lower average daily consumption compared to the Gokyo and Everest route. This graph portrays that Lukla, and the Farak route rely on hydropower widely, but not heavily, while along the Gokyo and Everest routes, hydropower consumption is less widespread, but where it is used, it is heavily used. While in Namche, there is both, a widespread use of hydroelectricity and a considerable reliance on the energy source.

The average consumption per all lodges in SNPBZ supports the interpretations made based on *Figure 28*. Most lodges along the Gokyo and Everest routes do not use hydroelectricity which indicates limited access to hydroelectricity and that it is not the main source of electricity. While in Lukla, Namche, and along the Farak routes, most lodges do consume hydroelectricity, and it is the dominant source of electricity as there is greater accessibility.

The Thame route uses a level system for hydroelectricity consumption which is why it was not included in the above analysis. Based on a conversation with the local electricity company in Thame the level systems depicted in *Figure 29* are described as follows:

Level 1:

- 100 watts (0.1 kilowatts) for 100NPR per month.
- Only for lights.
- Typically for buildings where livestock may be housed.

Level 2:

- 1250 watts (1.25 kilowatts) for 13,000NPR per month.
- This level of energy consumption can accommodate an electric heater (approximately 1000 watts per month), lights (250 watts per month), and cooking.
- This level is for personal use, hence why it is cheaper.

Level 3:

- A flat rate of 1,300NPR per month and an additional 16NPR per unit of energy consumed.
- The rate for energy unit changes to 6NPR per unit between the hours of 9pm and 5am.
- This level is typically used for commercial energy use.
- Allows for a maximum of 6000 watts (6 kilowatts) of energy to be used monthly.

Level 4:

- A flat rate of 2,000NPR per month and an additional 16NPR per unit of energy consumed.
- This level is normally used for a bakery or café.
- Allows for a maximum of 9000 watts (9 kilowatts) of energy to be used monthly

The level system continues up to Level 7, however, these levels are not described in this thesis as they are unrelated to the scale of energy consumption in tourist lodges. As previously stated, the

employees at the energy company expressed that most tourist lodges would consume electricity at Level 3.

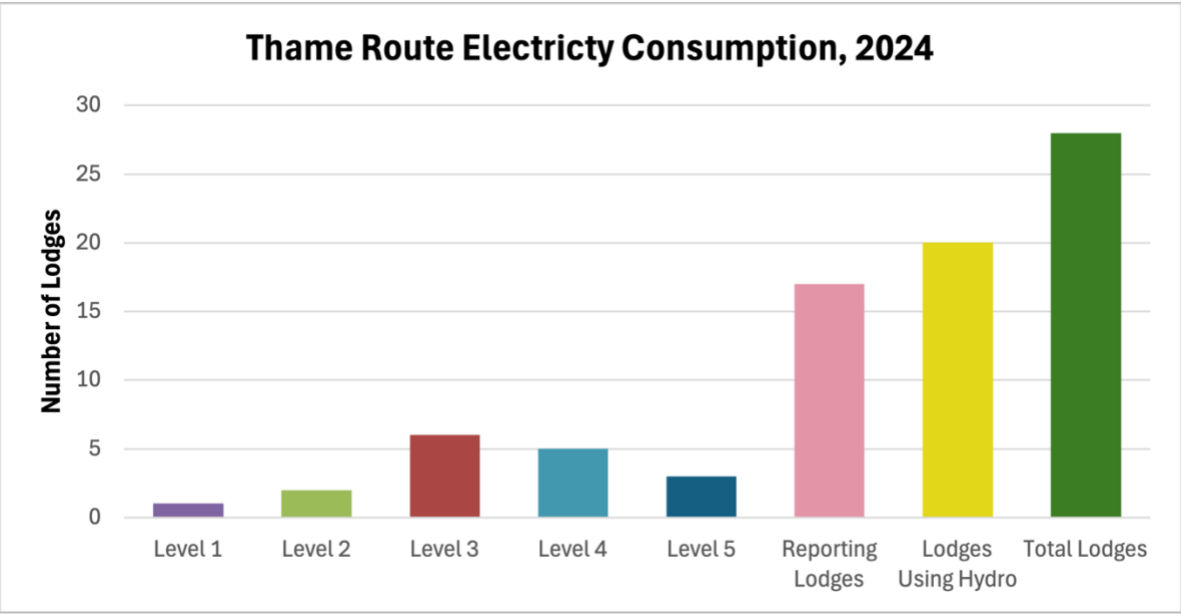


Figure 30: Electricity consumption along the Thame route in 2024.

Figure 30 shows the hydroelectricity consumption levels reported by lodges along the Thame trekking route. Of the 28 lodges in the area, 20 reported using hydropower, and 17 of those specified their consumption level. The lodges that provided specific consumption levels were concentrated in the villages of Thamo, Samde and Thame, all located below 4000 meters and with higher lodge density. Two lodges in Thame reported a Level 1 and a Level 2 consumption. While only one lodge in Thamethanga (also below 4000m) reported a Level 2 consumption. Those lodges that consume electricity at a Level 5 are all located in Thamo which is at the lowest altitude and geographically closest to Namche. In contrast, lodges situated above 4000 meters do not consume hydroelectricity at all. This pattern suggests that, although this trekking area has access to the largest hydropower station within SNP, hydroelectricity along the Thame route is geographically constrained to lower-altitude areas and that energy consumption at commercial levels (higher than Level 2) is closely tied to tourism activity.

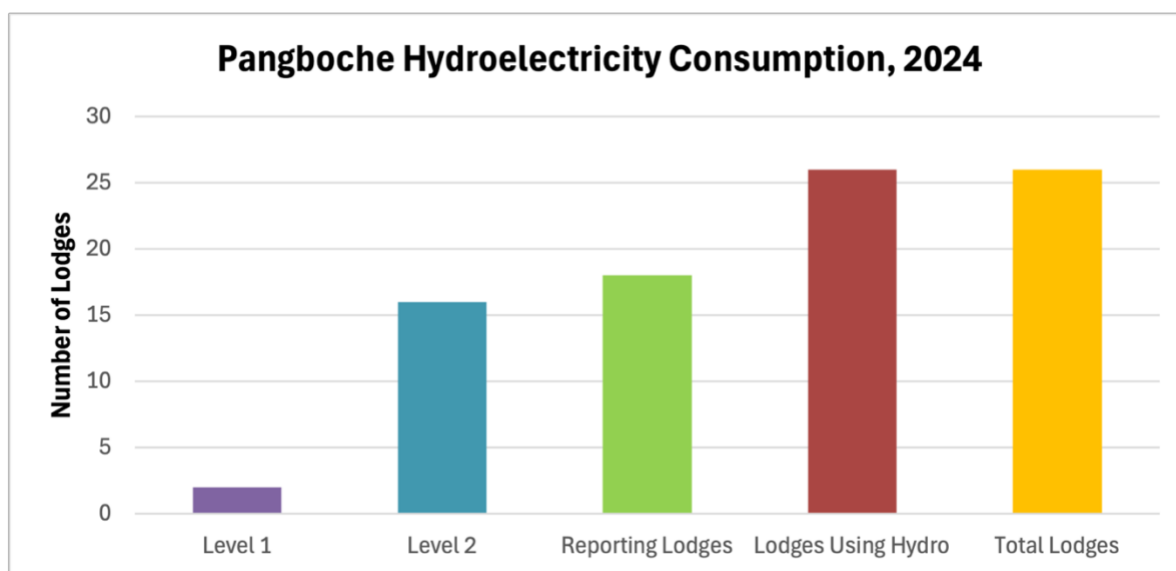


Figure 31: Hydroelectricity consumption in Pangboche in 2024.

Figure 31 illustrates hydroelectricity consumption in Upper and Lower Pangboche, a village located along the Everest trekking route and the highest altitude village (3985 meters) with access to hydroelectricity. All 26 lodges in Pangboche reported that they use hydroelectricity; however, only 18 lodge owners were able to specify their level of consumption. Unlike the level system observed along the Thame route, Pangboche uses a two-tiered hydroelectricity payment system: Level One (500 NPR/month) and Level Two (1000 NPR/month). Despite this structure, none of the respondents could clearly explain the distinction between the two levels. Most lodges reported using Level Two, suggest that a higher level of hydropower access is the standard in this village.

4.3.2 Fuel-based Energy Consumption

In 1997, Mattle (1999) expressed that the traditional energy source of firewood was the most important energy source in the Khumbu region. However, over time, this has changed such that alternative energy resources such as electricity and liquid petroleum gas are now the primary sources of energy (Sun et al, 2024). For comparison and to identify the patterns of change amongst energy source consumption, the importance of four major energy sources (firewood, dung, kerosene, and liquid petroleum gas) are examined throughout this chapter. Firstly, each energy source will be individually analyzed, beginning with firewood. All energy resource analyses will follow the same structure; the change of firewood use in all areas of SNPBZ

between each study is first examined, followed by the change in average consumption per area, and then the relative differences per area and their changes through time. Lastly, two boxplots will be compared (2011 and 2024 data) to understand the distribution of firewood use between each trekking area. This analysis was not available for the 1997 data as only a summary of the data is accessible.

4.3.2.1 Firewood Consumption

It is important to note that the kilograms of firewood recorded are estimates of consumption and not exact measurements. These estimates are based on lodge owner's gauge of the number of baskets, therefore kilograms, of firewood used per day. All estimates are based on the consumption of firewood during the tourist season (March/April and October/November). During the summer months, less firewood is required due to a lesser demand whereas the tourist season creates a demand for heated rooms and more cooking.

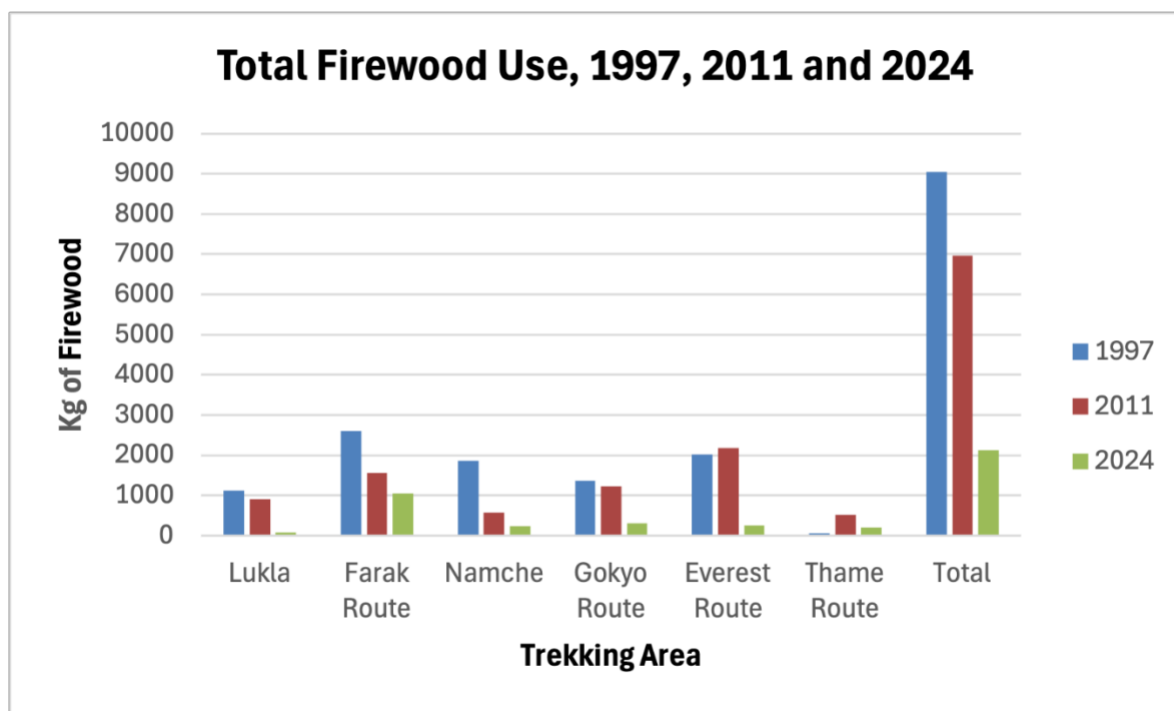


Figure 32: Total firewood consumption per area in 1997, 2011, and 2024.

Figure 32 portrays the total firewood use in each trekking area between 1997, 2011, and 2024. Between the three periods of study, it is evident that the total consumption of firewood throughout SNPBZ has decreased. Since 1997, the total park consumption has dropped by nearly 7000kg of firewood – from approximately 9000kg in 1997 to just over 2000kg in 2024.

Firewood use has decreased across all trekking areas, with no observed growth in consumption between 2011 and 2024. This decline was most notable in Lukla and along the Gokyo and Everest trekking routes. Within this 13-year time frame, Lukla reduced firewood consumption from 915kg per day to 82kg and the Gokyo region decreased daily firewood use from 1230kg to 312kg. The Everest route experienced the most drastic change from a consumption level of 2170kg of firewood per day in 2011 to only 249kg in 2024. The data suggests that firewood is no longer the primary energy resource throughout the park.

Figure 33 reveals the trekking areas that firewood consumption is most concentrated within the park. The total kilograms of firewood used per area is shown along the primary axis while the secondary axis portrays the percentage difference of firewood use in each area to the average consumption in all of SNPBZ using the black t-bars. The average daily firewood consumption per lodge in all of SNPBZ in 1997 was 41kg, in 2011 it was 22kg, and in 2024, it was 6kg. Throughout these three data sets, it is evident that firewood use is concentrated in lower altitude areas, specifically the main trekking centres of Namche (1997), Lukla (2011) and the Farak route (2024).

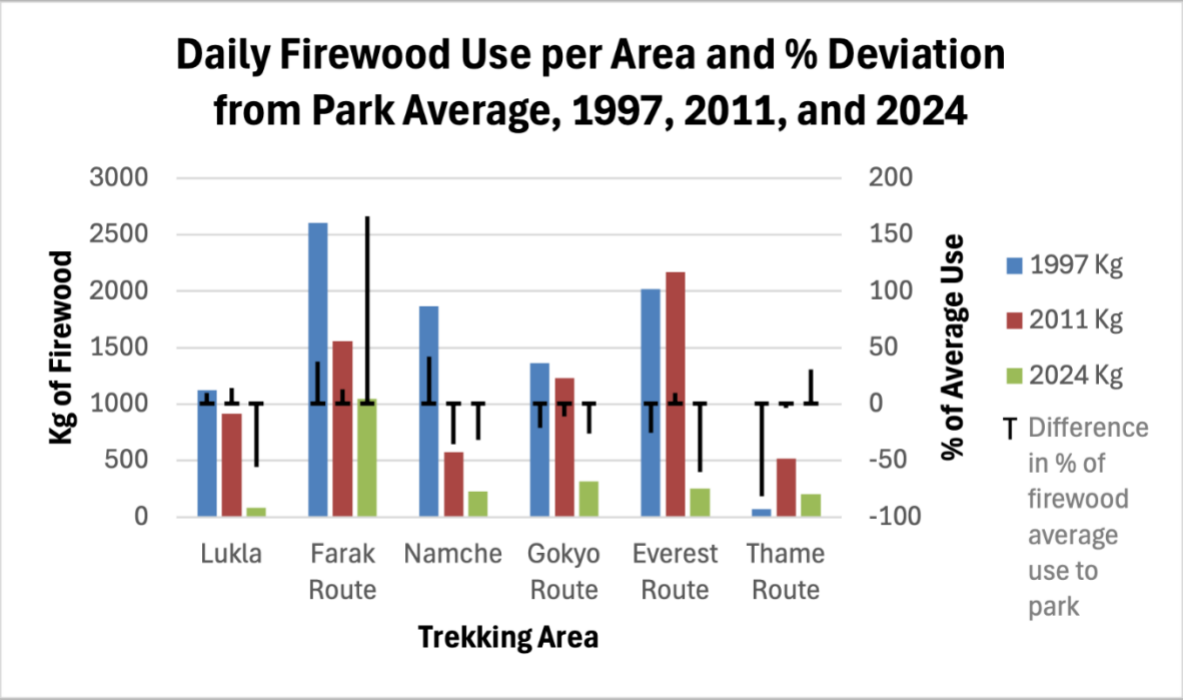


Figure 33: Daily firewood consumption per area and deviation from park average in 1997, 2011, and 2024.

Between 1997 and 2011, Namche's firewood consumption pattern reversed entirely. In 1997, firewood use was most concentrated in this area (42% more than the park average) while in 2011, it was the least concentrated in Namche (35% less than the park average).

In 2024, the Farak route stood out for its exceptionally high consumption, exceeding the park average by 166%. The only other trekking area to consume above the park average was the Thame route. As shown in *Figure 32*, firewood use along the Thame route had previously remained below the park average in both 1997 and 2011. Although average consumption in this area decreased in 2024, its relative use may have been high than in other areas due to limited resource access following the glacial lake outburst flood in September 2024. Meanwhile, higher altitude areas (Gokyo and Everest routes) consumed much less firewood compared to the average consumption of the park. The data portrays that the Gokyo and Everest routes hardly deviated from the average consumption of the entire park across all data sets. This trend is represented through the black T-bars that show each area's deviation from the park-wide average in percentages.

4.3.2.2 Animal Dung Consumption

Animal dung is a traditional energy source that is prominently used throughout SNPBZ for cooking and heating in higher altitudes. Similar to firewood, there are no instruments to measure animal dung use, so all data points are based on consumption estimates by lodge owners. The per day consumption recorded by lodge owners is the estimated use of dung during the busy season. The per day consumption of all energy resources in this study (i.e. electricity, dung, kerosene, LPG, firewood, and water) are all based on estimated consumption during the busy season. The seasonality is important to consider in these questions because it portrays how tourism influences consumption rather than local consumption use during the off-season.

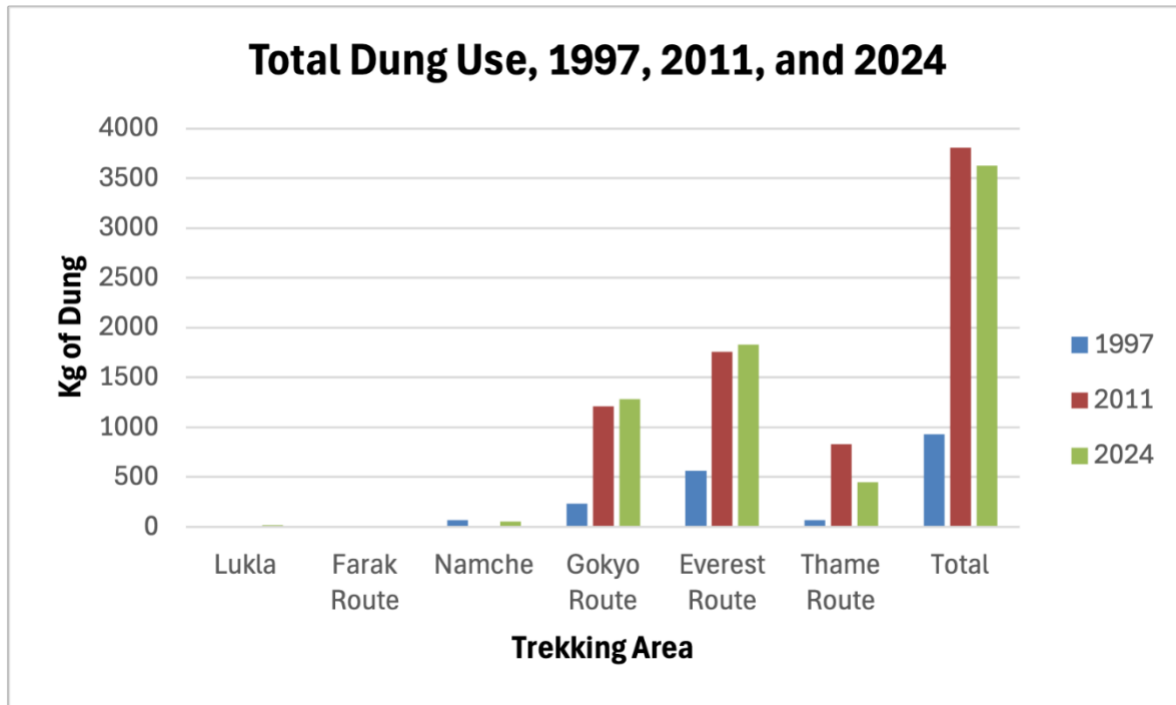


Figure 34: Total dung consumption per area in 1997, 2011, and 2024.

Figure 34 portrays the daily total dung use of each trekking area in 1997, 2011, and 2024. Dung use was concentrated in higher-altitude areas, particularly along the Gokyo and Everest routes, while lower-altitude regions such as Lukla, Namche, and the Farak area consistently reported little to no use. Between 1997 and 2011, dung consumption increased significantly in all high-altitude areas. The Gokyo and Everest routes maintained this high level of use through 2024, while the Thame route showed a spike in 2011 followed by a modest decline. The temporary increase in dung use along the Thame route may be linked to lodge expansion or increased tourism between 1997 and 2011, followed by stabilization in 2024.

Figure 35 portrays the daily dung consumption of each trekking area relative to the average consumption of the entire park. The trekking area with the highest relative dung use varied across the three study periods.

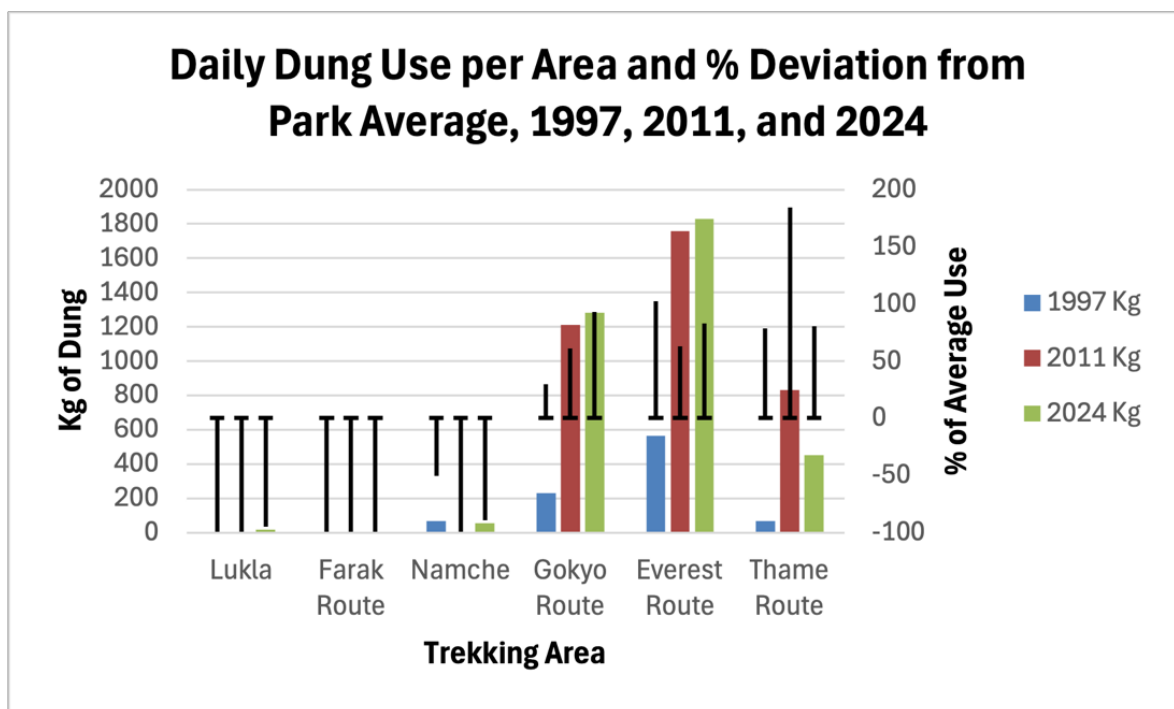


Figure 35: Daily dung consumption per area and deviation from park average in 1997, 2011, and 2024.

In 1997, consumption was most concentrated along the Everest route where consumption exceeded the park average by 102%. By 2011, the Everest route remained above average at 62%, while the Thame route consumed 184% more than the park average. This spike in dung consumption could be associated with the development of lodges in this area. The Gokyo route had the greatest consumption of dung in 2024, using 93% more than the park average. Despite some fluctuations, dung consumption has remained consistently concentrated at higher altitudes, along the Everest and Gokyo routes. Meanwhile, lower-altitude areas such as Lukla, Namche and the Farak route have shown little to no dung use across all three study periods. These patterns reflect both the geographic distribution of livestock availability and the ongoing reliance on traditional energy sources in regions where alternatives are less accessible.

4.3.2.4 Kerosene Consumption

Per lodge kerosene use was recorded in litres based upon consumption estimates given by lodge owners. In 2024, kerosene consumption was low in all areas except for the Gokyo and Everest routes. Many lodge owners expressed that a minimal amount of kerosene is used daily to help spark fires.

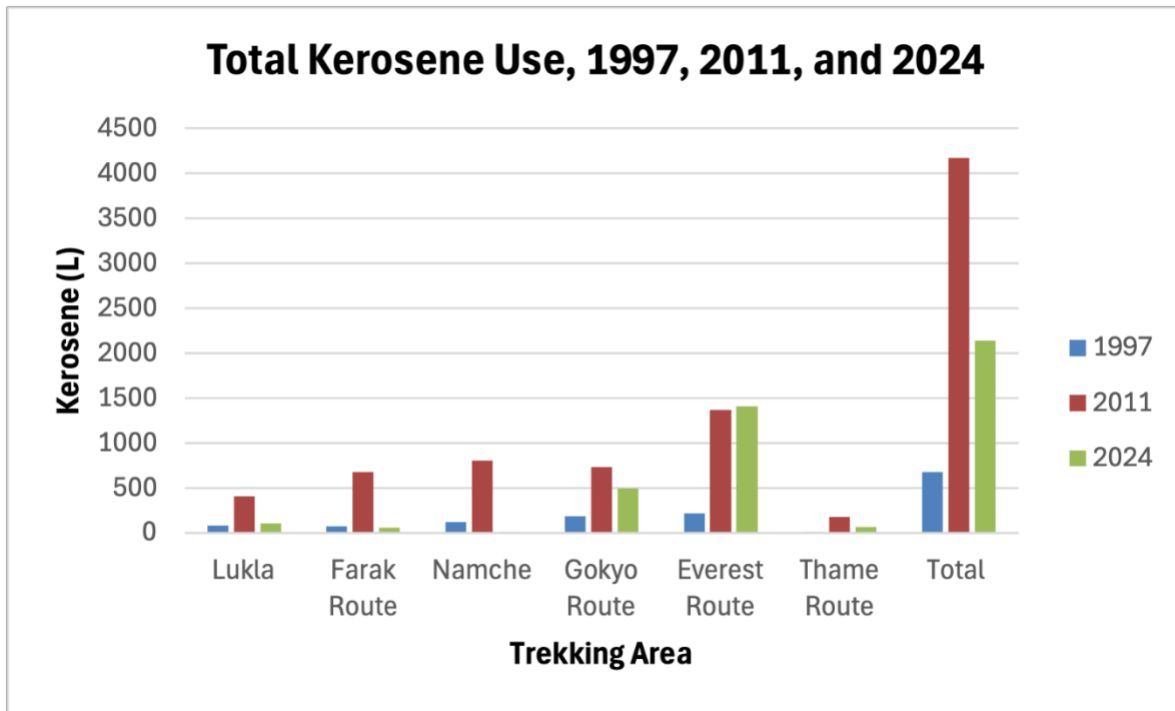


Figure 36: Total kerosene consumption per area in 1997, 2011, and 2024.

Figure 36 shows total kerosene consumption across each trekking area for 1997, 2011, and 2024. Kerosene use increased significantly between 1997 and 2011 across most areas, followed by a noticeable decline in 2024. The Everest route was an exception, with kerosene use rising from 218L in 1997 to 1366L in 2011, and then increasing only slightly to 1,409L in 2024. In contrast, Namche, which used a substantial amount of kerosene in 2011, reported no kerosene consumption in 2024. The Thame route, which had no reported kerosene use in 1997, demonstrated a small increase in 2011 followed by a decline in 2024.

Figure 37 compares the total daily kerosene consumption of each trekking area and the percentage deviation of consumption from the park-wide average for each trekking area in 1997, 2011, and 2024. The secondary axis depicts the percentage deviation of each area's daily kerosene consumption from the park average. The average consumption throughout the entire park in 1997 was 3L per lodge per day, in 2011 it was 13L, and in 2024 the average per lodge park consumption was 5L. Over time, kerosene consumption has become concentrated in the higher altitude Gokyo and Everest routes. In 2024, the Everest route consumed 144% more kerosene than the park average, while the Gokyo route consumed 24% more.

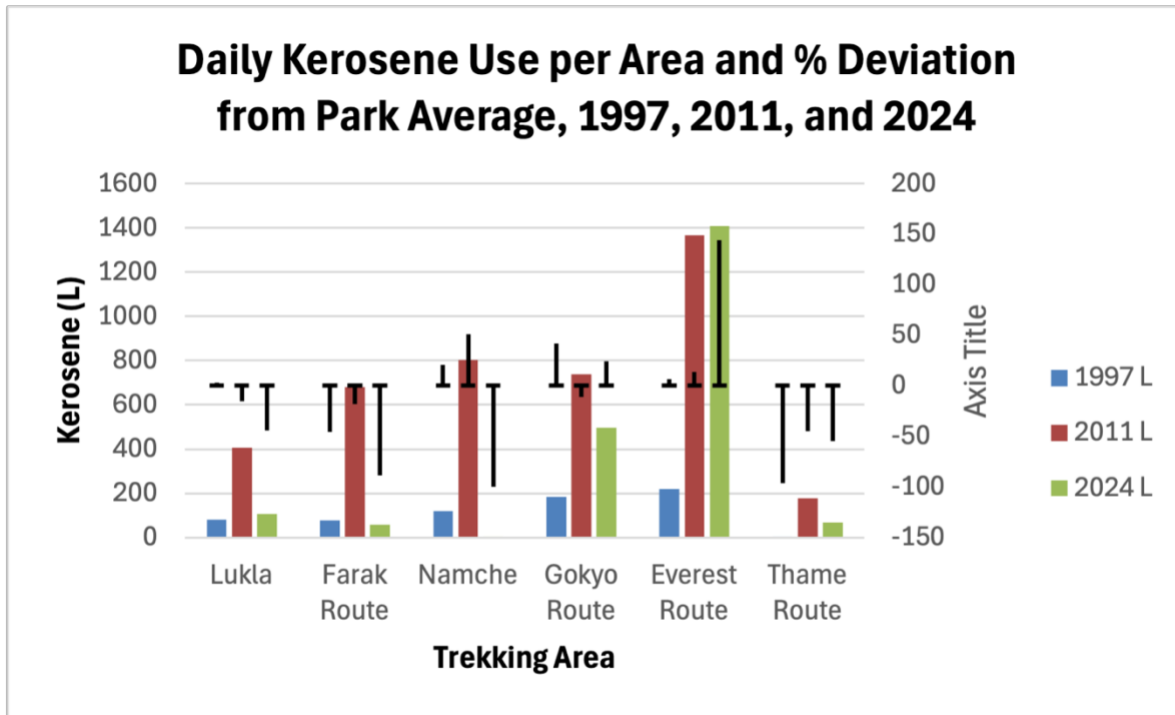


Figure 37: Daily kerosene consumption per area and deviation from park average in 1997, 2011, and 2024.

The data reflects shifting patterns of kerosene reliance across the park. In 2011, Namche consumed 51% more kerosene than the park average, but by 2024, kerosene use in this area was nearly 100% less than the park average. Meanwhile, the Everest route had consistently consumed kerosene relative to the park average until 2024, when kerosene use substantially increased. Consistent over all three study years, lower altitude areas such as Lukla, and the Farak and Thame routes, reported kerosene below the park average.

4.3.2.4 Liquid Petroleum Gas Consumption

Liquid petroleum gas (LPG) was introduced in the 1990s as an alternative energy to firewood and kerosene (Sun et al, 2024). In the 2024 study, lodge owners were to estimate their daily LPG consumption based on the number of 30L canisters used per month. Since comparable data was not collected in the 1997 and 2011 surveys, this section focuses solely on LPG consumption patterns in 2024.

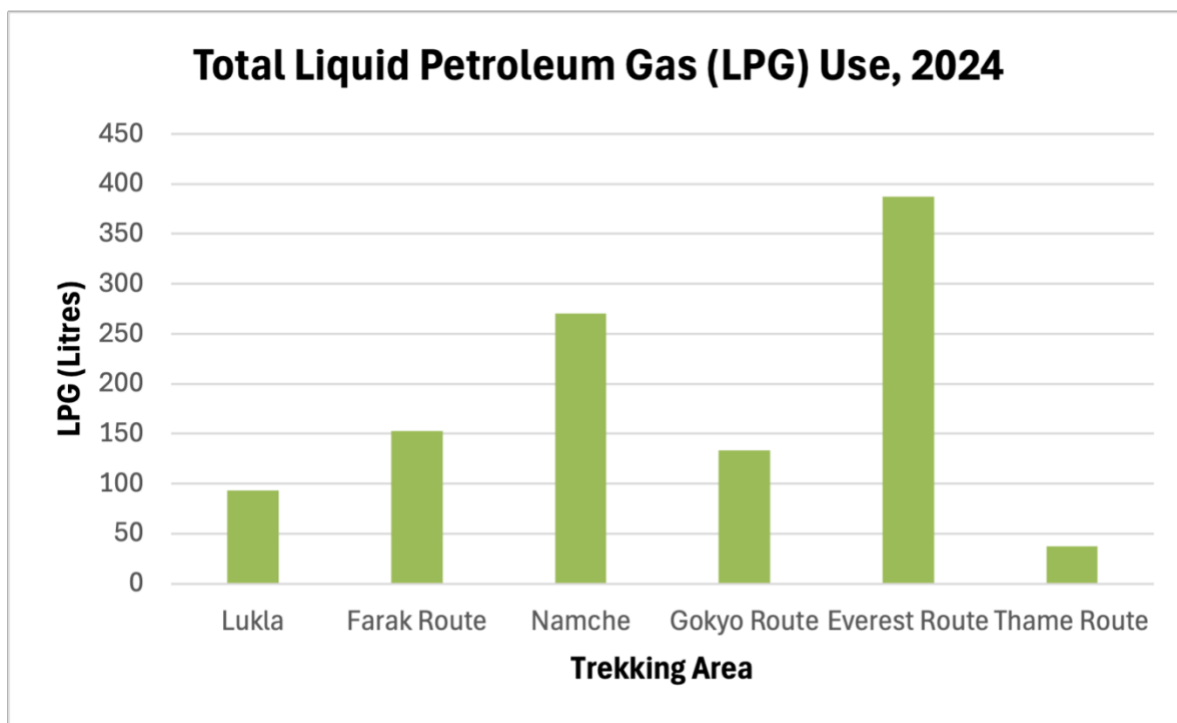


Figure 38: Total LPG consumption per area in 2024.

Figure 38 illustrates the total daily use of LPG in each trekking area. It is evident that LPG consumption is concentrated in Namche (270L) and along the Everest route (387L), while the Thame route reports the lowest use at 38L per day. The Farak and Gokyo routes show relatively similar levels of consumption, at 153L and 133L per day, respectively.

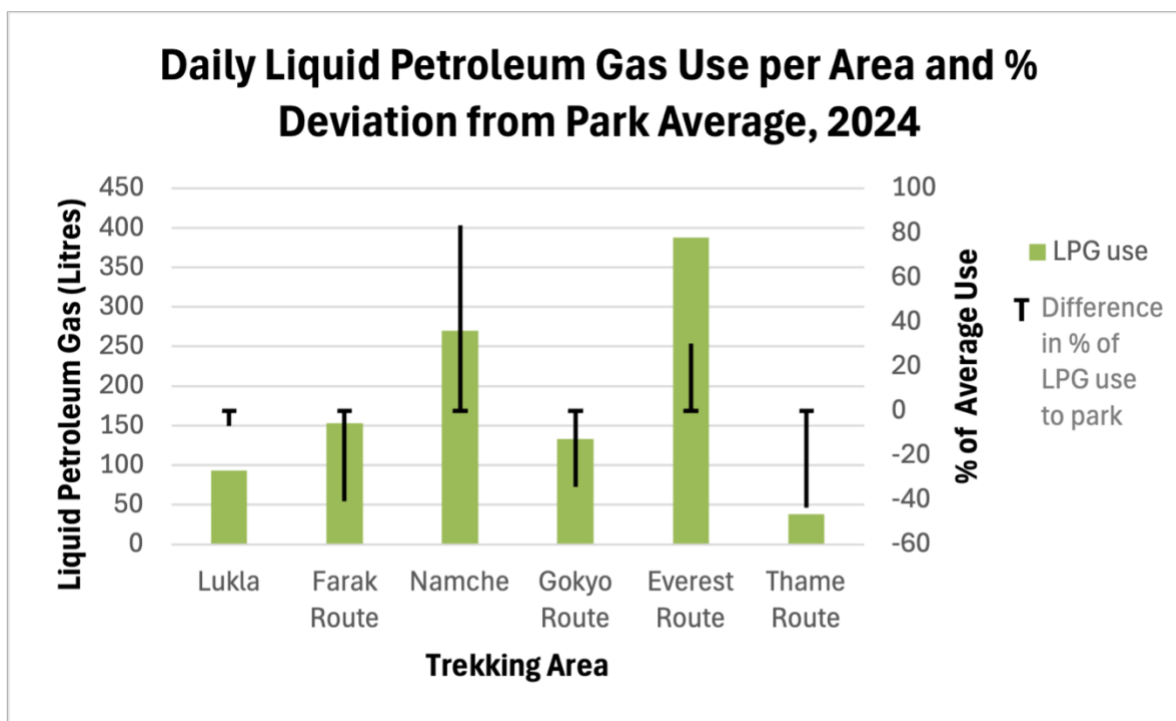


Figure 39: Daily LPG consumption per area and deviation from park average in 2024.

Figure 39 illustrates those areas that have the greatest reliance on LPG compared to the average consumption of the entire park. The total LPG use of each trekking area is depicted along the primary axis and the secondary axis shows the percent difference in consumption compared to the park average. The average daily LPG use across SNPBZ is 2.8L per day. Namche and the Everest route are the only two areas that consume more LPG than the park average, with Namche using 80% LPG compared to the rest of the park, and the Everest route using 30% more. Meanwhile, all other areas use less LPG than the park average. Lukla consumes closest to the park average at just 7% less. The Thame area has the lowest consumption of LPG, using 44% less than the rest of the park compared to the average.

4.3.2.5 Relationship Between Fuel-based Energy Sources

The objective of this longitudinal analysis is to examine energy consumption patterns, and the energy types consumed in tourist lodges throughout SNPBZ. Through the different trends and patterns in energy consumption already identified in the data, it is evident that the use of these energy types (firewood, animal dung, kerosene, and LPG) is related and that changes in energy consumption have occurred over time. As energy consumption patterns have evolved between 1997, 2011, and 2024, the data can reflect how energy types may have replaced one another and

how reliance on certain resources has varied, especially in specific locations throughout the park. It is difficult to assess these changes in energy consumption when all energy resources are measured by different units - litres and kilograms. For this reason, a comparison must be made between all energy resources through a uniform unit of measurement. *Table 2* portrays the total energy consumption of each trekking area in 1997, 2011, and 2024 in Joules.

Table 2: Total energy consumption of each trekking area in Joules in 1997, 2011, and 2024.

Use of Different Energy Sources per Area (in Joules)				
In Joule (J)	1kg Wood = 15,000,000 J	1kg Dung = 17,000,000 J	1L Kerosene = 37,800,000 J	1L LPG = 25,000,000 J
1997	Firewood	Animal Dung	Kerosene	LPG
Lukla	16,875,000,000	0	3,024,000,000	0
Farak Route	39,060,000,000	0	2,929,500,000	0
Namche	27,975,000,000	1,139,000,000	4,536,000,000	0
Gokyo Route	20,400,000,000	3,927,000,000	6,974,100,000	0
Everest Route	30,225,000,000	9,605,000,000	8,240,400,000	0
Thame Route	1,005,000,000	1,156,000,000	37,800,000	0
2011				
Lukla	13,725,000,000	0	15,403,500,000	0
Farak Route	23,325,000,000	85,000,000	25,666,200,000	0
Namche	8,625,000,000	0	30,391,200,000	0
Gokyo Route	18,450,000,000	20,621,000,000	27,858,600,000	0
Everest Route	32,550,000,000	29,920,000,000	51,634,800,000	0
Thame Route	7,725,000,000	14,110,000,000	6,690,600,000	0
2024				
Lukla	1,230,000,000	272,000,000	3,999,247,560	2,328,750,000
Farak Route	15,690,000,000	0	2,192,475,600	3,824,250,000
Namche	3,420,000,000	918,000,000	22,906,800	6,750,000,000
Gokyo Route	4,680,000,000	21,777,000,000	18,797,070,600	3,334,625,000
Everest Route	3,735,000,000	31,059,000,000	53,271,910,440	9,676,500,000
Thame Route	6,742,500,000	7,641,500,000	2,608,200,000	939,750,000

For further understanding of the data portrayed in *Table 2*, the percent of energy sources consumed in each area across time is shown in *Figure 40*. This figure demonstrates the percentage of each energy source used of the total energy consumed in each trekking villages across all three studies. *Figure 40* does not consider the number of lodges per area, it only accounts for the total consumption reported by lodge owners. The change of energy source per area is depicted by showing the relationship between the four main energy sources – firewood,

animal dung, kerosene, and LPG. Again, it is important to note that data was not collected for LPG consumption in the 1997 and 2011 studies, so the relationship between LPG and all other energy resources is unknown during those time periods. Due to this, LPG will only be observed for changes to energy resource relationships in 2024. The following analysis will examine energy consumption patterns and the relationship between energy resources based on each trekking area to understand how energy relationships have changed over time. The graph will be examined left to right, beginning with Lukla and ending with the Thame route.

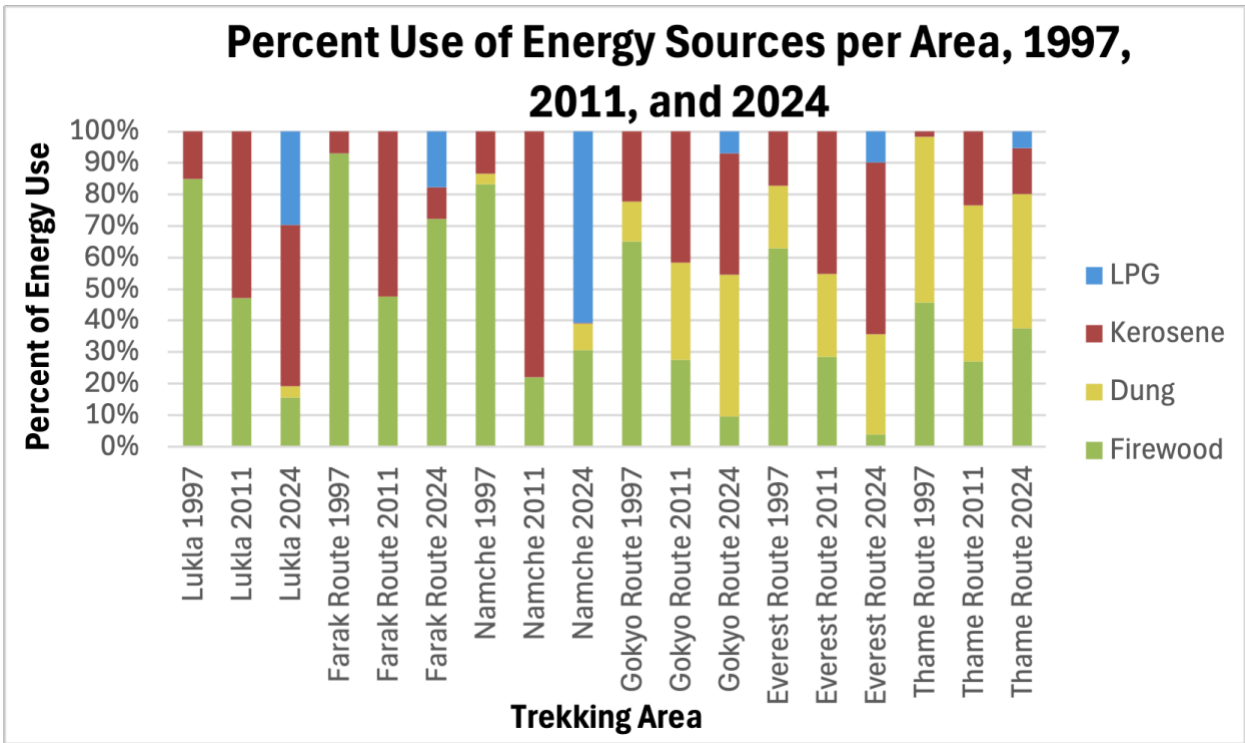


Figure 40: Percent use of each fuel-based energy source per area in 1997, 2011, and 2024.

In 1997, firewood was the primary energy source in Lukla, accounting for 85% of total consumption, with kerosene making up the remaining 15%. Dung was not used in either 1997 or 2011. By 2011, firewood consumption dropped to 47%, while kerosene use rose to 52%. This change represents a clear shift in resource dependence. This trend continued in 2024, with kerosene still comprising 51% of the total energy supply. However, energy resources became more diversified as LPG accounted for 30% and dung for 3.5% of the energy mix. Meanwhile, firewood use declined further to 15.5%. These changes in energy consumption indicate a steady

decline in firewood dependence, a consistent reliance on kerosene, and a diversified energy resource based in Lukla.

The Farak route has shown fluctuating patterns of energy use over time. In 1997, firewood accounted for 93% of total energy consumption, with kerosene making up the remaining 7%. Dung was not used. In 2011, firewood use dropped to 48%, while kerosene increased to 52%, becoming the dominate energy source. Dung was used in 2011, but only a minimal amount, accounting for only 0.17% of the energy mix. This shift was temporary, and in 2014, energy use resembled the 1997 pattern, with firewood again as the primary source at 72%. Kerosene use declined to 10% and dung was no longer used in the area. LPG emerged as secondary energy source, contributing to 18%. These changes in energy consumption suggest that, despite a brief shift toward kerosene, the Farak route continues to rely heavily on firewood.

Over time, Namche has transitioned their energy supply from a primary reliance on firewood to kerosene, and more recently to LPG. In 1997, 83% of all energy was sourced from firewood while kerosene made up 14% of the energy supply and dung the remaining 4%. The dependence on firewood significantly decreased by 2011, shrinking to 22%, while kerosene consumption increased to 78%, becoming the dominant resource. Dung was not used in 2011. However, in 2024, kerosene made up less than 1% of the energy mix, with a new reliance on LPG as the dominant energy source at 61%. Firewood and dung consumption both increased to 31% and 8% respectively. This progression demonstrates Namche's evolving energy landscape and its transition through three distinct phases of energy reliance.

The Gokyo route has seen shifting patterns in energy reliance, transitioning from firewood towards dung and kerosene. In 1997, firewood accounted or 65% of total consumption, followed by kerosene at 22%, and dung at 13%. By 2011, firewood use declined to 28%, while kerosene rose to 42% and dung to 31%. This trend continued in 2024 as firewood use continued to decrease to 9%, dung increased to 45%, and kerosene reduced slightly to 39%. LPG also entered the energy supply, contributing to 7%. These changes reflect a sustained move away from firewood, with a growing dependence on dung and kerosene as primary energy sources.

The Everest route has shown a gradual transition from firewood to kerosene as its primary energy source. In 1997, firewood represented 63% of the energy supply, followed by dung at 20% and kerosene at 17%. In 2011, firewood use dropped to 29%, while dung rose to 26% and kerosene to 45%. This trend continued in 2024, as firewood decreased to 4% while dung increased to 32% and kerosene to 55%. LPG represented 9% of the total energy supply.

Thame is the only trekking area where firewood was never the primary energy resource. Dung has consistently been the dominant energy source across the three study years. In 1997, dung made up 53% of the energy supply, followed by firewood at 46% and kerosene at 1%. By 2011, kerosene use increased to 23% while firewood decreased to 27%. Dung remained the primary resource at 49%. In 2024, kerosene consumption declined to 15% and firewood increased to 38%. Again, dung remained the primary resource at 42%. LPG also entered the energy mix, representing 5% of total energy supply. These patterns show that while reliance has shifted between firewood and kerosene, dung has remained the most consistently used resource along the Thame route.

Across the study period, nearly all trekking areas showed a shift from firewood as the primary energy resource. The exception is the Farak route, where a brief transition from firewood to kerosene occurred in 2011, followed by a return to firewood by 2024. In the trekking centres of Lukla and Namche, energy dependence pulled away from firewood to kerosene and LPG. In higher altitude areas such as the Gokyo and Everest routes, firewood was replaced by a greater reliance on kerosene and dung, with dung being the primary resource in Gokyo and kerosene in Everest. While kerosene and firewood use has fluctuated along the Thame route, the area has consistently relied on dung as its primary energy source across all three study periods.

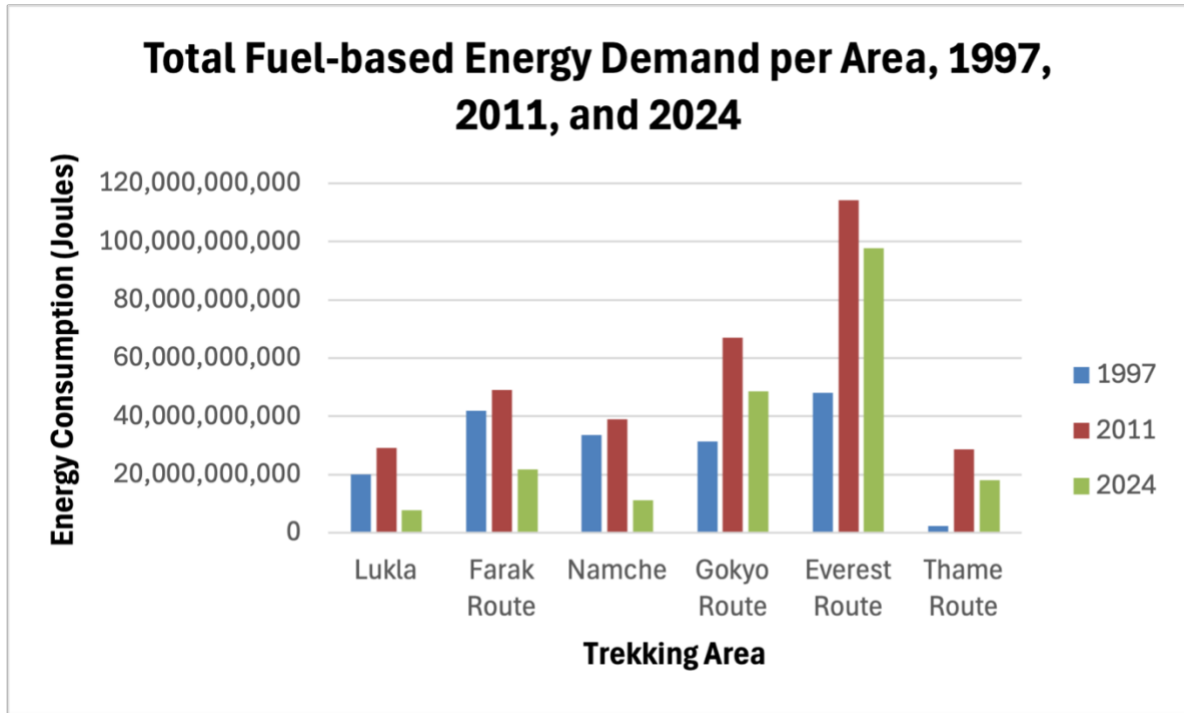


Figure 41: Total fuel-based energy demand in joules per trekking area in 1997, 2011, and 2024.

Figure 41 illustrates the total raw energy demand (in joules) across each trekking area for 1997, 2011, and 2024. This graph excludes hydro and solar electricity consumption and includes only fuel-based resources (e.g., firewood, dung, kerosene, and LPG) converted to joules. Between 1997 and 2011, total energy demand increased in every trekking area. However, from 2011 to 2024, energy demand declined substantially across all areas. This decrease may reflect a shift away from traditional fuel sources toward greater reliance on electricity as depicted in Figure 27.

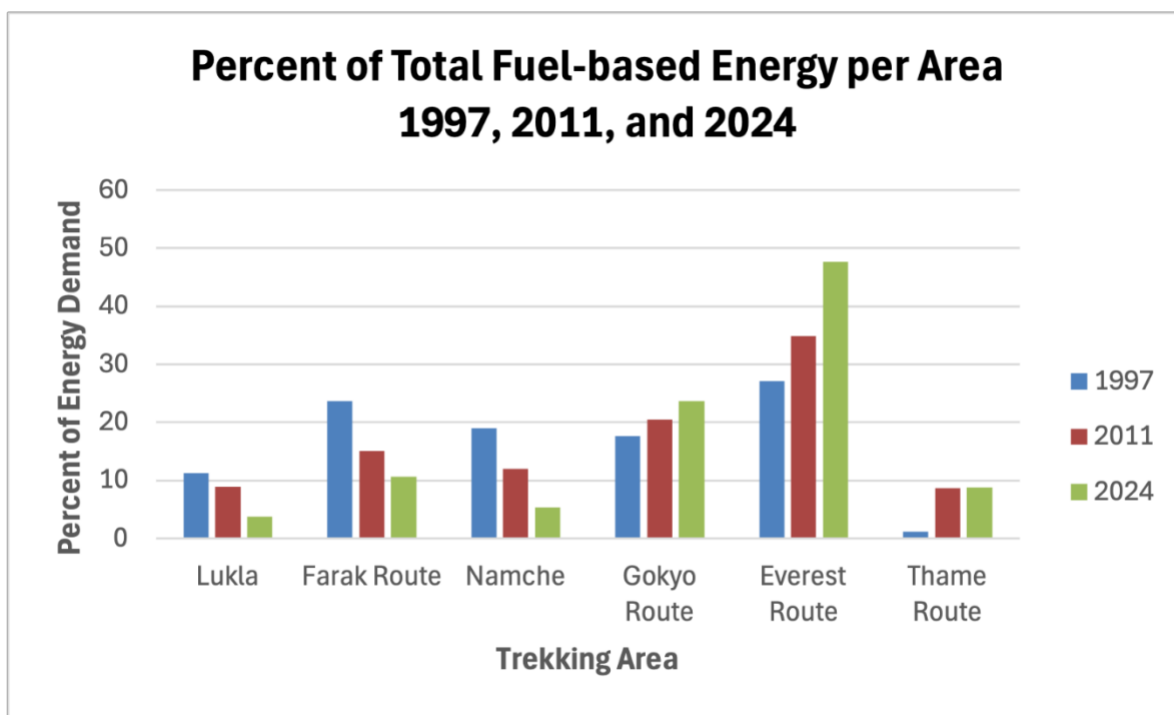


Figure 42: Percent of total fuel-based energy consumption per area in 1997, 2011, and 2024.

Figure 42 portrays the data in Figure 41 in relative numbers. It is evident that through time, lower altitude areas such as Lukla, Namche, and the Farak route have decreased consumption of fuel-based energy resources while higher altitude areas such as the Gokyo, Everest, and Thame routes have progressively increased their consumption.

4.3.3 Water Consumption

The change of lodges' water consumption was compared using the data from 1997, 2011 and 2024. However, the data collected in 1997 was recorded differently than the data from 2011 and 2024. In 1997, the amount of water consumed was recorded by counting the transportation of water canisters per lodge. The data also does not specify for which period this information was collected. Since water use varies significantly during high and off-season, it is assumed that the measured values are estimated average values of the tourist season. The data collected in 2011 and 2024 are not exact measured values of water consumption because there is no equipment used to measure actual water consumption within lodges in SNPBZ. Due to this, the data is based on litre estimates of daily water consumption by lodge owners. There is variability between data collection because in 2011 and 2024, most lodges in the park used running water rather than water cannisters. Additionally, it is assumed that in 1997, all lodges in the park responded to the

survey question regarding litres of water consumed. It is known that in 2011, all lodges responded to this question, and in 2024, only 246 lodges participated in this question. Participation is based on the lodge owner's ability to answer the question. Many lodge owners simply did not know their water consumption due to the easy accessibility and flow of water.

Figure 43 compares the total daily water consumption in each trekking area between 1997, 2011, and 2024. It is crucial to recognize that this data is limited by the lower participation rate in 2024. While the graph demonstrates that 2011 had the highest total water consumption, this may reflect the higher number of survey responses in 2011 (67 more lodges) compared to 2024, rather than an actual decrease in consumption. Among the trekking areas surveyed, Namche, and the Everest and Gokyo routes, provide the strongest basis for longitudinal comparison of water consumption. Although not all lodges responded in 2024, the number of respondents in 2024 for the three areas is comparable to that of 2011. Notably, along the Gokyo and Everest routes, there is an increase in total water consumption between 2011 and 2024. Since only 58 lodges along the Gokyo route, and 87 lodges along the Everest route responded in 2024, while 62 and 89 lodges, respectively, responded in 2011, the data suggests that there has been an increase in per-lodge water use over time in higher altitude areas.

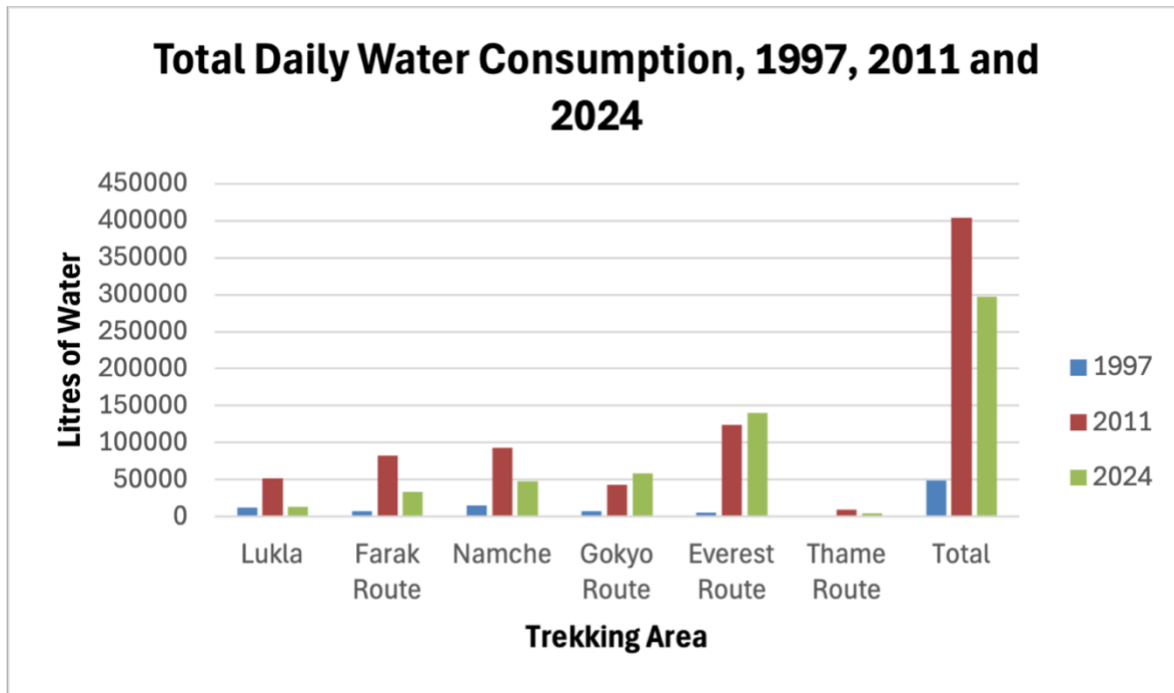


Figure 43: Total daily water consumption per area in 1997, 2011, and 2024.

Meanwhile, it is evident that in all other trekking areas, daily water consumption has decreased since 2011. This trend is the opposite of the pattern observed between 1997 and 2011, in which water consumption increased across all areas. The increase in daily water consumption between 1997 and 2011 is attributed to the number of lodges in each area; the more lodges in one area, the greater the daily water consumption. However, this explanation no longer applies to the 2024 data. For example, in Namche, daily water consumption declined by approximately 45,000 litres despite comparable numbers of respondents. Although the data is limited by lower participation in 2024, this trend is also visible in Lukla, and along the Farak and Thame routes. It can be said that the greatest water consumption occurs along the Everest route in both 2011 and 2024. While the second highest rate of consumption in 2011 occurs in Namche, the trekking area that has the second greatest water use in 2024 is the Gokyo route.

Figure 44 shows the total amount of water use in 1997, 2011, and 2024 per area on the y-axis. On the secondary axis, the relative difference to the overall park average is illustrated. This depicts the relationship between total water use per area and the water use of entire park. The total average water consumption per lodge in all SNPBZ is 222.5L in 1997, 1289.5L in 2011, and

1209.5L in 2024. This graph distinguishes those trekking areas that consumed the most/least water compared to the rest of the park in each year of data collection.

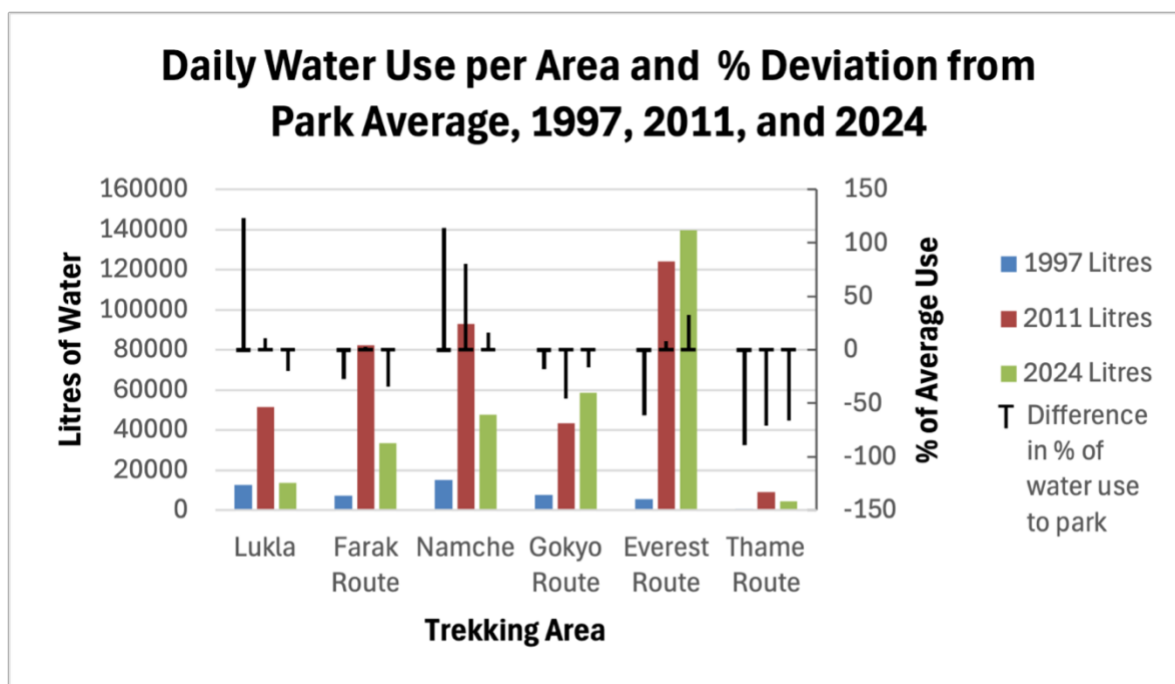


Figure 44: Daily water consumption per area and deviation from park average in 1997, 2011, and 2024.

It is apparent that in 1997, the tourist centres of Lukla and Namche use significantly more water compared to all other areas. The number of lodges in each area also explains the data. Although Namche has more lodges than Lukla in 1997, Lukla has a greater percent of consumption (123.6%) meaning that lodges in Lukla consume more water on average. In 2011 and 2024, this completely changed, and it is obvious that lodges in Lukla consume water comparatively to that of the park average in both years. While in 2011, lodges in Namche took first place in consuming the most water, at a consumption rate of 80.5% greater than the rest of SNPBZ. Meanwhile, in 2024, those lodges along the Everest route (32.9% greater than the average) consumed the most water. Across the three data sets, the area that has remained most consistent in water consumption compared to that of the overall park average is the Thame route. From 1997 to 2024, this area has consumed water substantially below the overall park average.

Chapter 5: Discussion

The data portrays varying development and energy consumption patterns within each trekking area of SNPBZ, reflecting park-wide transitions in lodge growth and energy use trends. The main objective of this study is to characterize the growth of tourist lodges and to examine energy consumption patterns and the energy types consumed in tourist lodges. These objectives aim to document the establishment, growth, and history of tourist lodges within SNPBZ through a resource management perspective.

5.1 Lodge Growth and Development Patterns

The data establishes that as of 2024, lodges are widely distributed throughout the park, with the greatest concentration, in descending order, in the following trekking areas; Everest, Farak, Gokyo, Namche, Lukla, and Thame. This concentration of lodges has remained consistent since 1997. As previously discussed, to thoroughly establish an understanding of lodge development and tourism activity within the park, a connection must be made between the growth in both, lodge numbers and capacities (e.g., Lukla, an area that experienced no growth in the number of lodges but had an increase in bed capacities). The average per lodge bed capacity in each trekking area, in descending order is as follows; Everest, Namche, Lukla, Gokyo, Farak, and Thame. Between 1997 and 2024, all trekking areas experienced growth in both the number of lodges and bed capacity, except Lukla, which saw no increase in lodges from 2011 to 2024.

These results indicate that the importance of the trekking location may have greater influence on lodge development than altitude. Type 1 trekking centres such as Lukla and Namche may have less lodges compared to regions such as Gokyo and Everest, however they have the greatest capacities. These greater capacities are associated with the various services and amenities in these trekking centres such as banks, a hospital, and an airport, as well as attractions such as restaurants, shops, adrenaline activities (i.e. Everest bungee) and more. The exception is the Everest route which does not have any Type 1 trekking centres, but it is the most popular trekking route due to its main attraction - Everest Base Camp – generating a greater demand for lodge development. Previous studies have identified that most lodges are located at elevations between 2600m and 3000m, with approximately 180 lodges at altitudes greater than 3000m (Sun

& Watanabe, 2021). Meanwhile, as of 2024, a total of 282 lodges are located above 3000m and most tourist lodges are located along the Everest route, where the average lodge sits at 4300m above sea level. This further supports that the trekking centre type and attraction of each trekking route greater influences lodge growth and development than altitude. However, altitude does influence the length of stay for tourists in each trekking area, meaning that the concentration of lodges and lodge capacity along the Everest route could also be associated with acclimatization.

Nepal (2005) identified that there is a progression of growth in the number of tourists and lodges into different settlements, particularly due to Type 1 trekking centres such as Lukla and Namche reaching their development capacities. This phenomenon is described as the spill effect, which is reflective in the data as both, Lukla and Namche experienced minimal growth in the number of lodges across the three time periods, while trekking areas such as the Farak route had rapid expansion in the number of lodges (i.e. an increase of 106.5% from 1997 to 2024). This spill effect is also evident in the transition of four villages along the Farak route from Type three trekking locations to Type two main locations. A similar effect has been seen in areas such as the Gokyo route in which the growth in the number of lodges (i.e. an increase of 95% from 1997 to 2024) and their capacities (i.e. an increase in beds of 196%) have progressively increased. This is an area that was once considered a strategic location, established as a terminal point for trekkers in response to the increasing demand for accommodation (Nepal, 2005). In the present day, Gokyo has become a growing trekking location that is enticing to tourists due to the beautiful Gokyo Lake and the view of some of the world's tallest mountains from Gokyo Ri. As reflected in this data, Nepal et al (2002) noted that lodge construction has increased in locations between trekking centres and in the periphery because of the expansion in trekking. Across the entire study, 16 new villages have been established throughout SNPBZ, suggesting that this trend in the development of new lodges in peripheral villages still rings true.

The Farak route is located between Lukla and Namche where the area has a high concentration of lodges, but limited capacities compared to other trekking routes. Fifty four percent of all lodges located along the Farak route were established between the 2011 and 2024 studies, further supporting the finding that newly developed lodges have lower capacities compared to pre-existing lodges. Similarly, this trend was identified in the 2011 data (Gehrig, 2014), in which it

was observed that newer lodges have smaller capacities while older lodges are larger and have only expanded their capacities through time.

The change in capacity of newly developed lodges can also be associated with tourist demand preferences and the evolution of lodge infrastructure. The data depicts the gradual transition of room standards shifting from shared dormitories to private single, double, and triple rooms (i.e. 45% of all beds were in dormitories in 1997 while in 2024, only 3% of beds were in dormitories). The transformation of tourist lodges is due to both, an increase in the number of tourists and the diverse demographics of tourists creating a demand for enhanced quality standards in lodge accommodation (Sun & Watanabe, 2021).

Between 1997 and 2011, tourist arrivals more than doubled at a growth rate of 106%, while the number of lodges grew by just 41%. This mismatch in growth likely contributed to the high occupancy rates in 2011. However, from 2011 to 2024, although tourist numbers continued to rise (57%) the relative difference between tourist and lodge growth narrowed, with lodges increasing by 38%. This shift suggests a slowdown in the rate of tourist growth compared to lodge development, which provides explanation for the observed decline in 2024 occupancy rates. Despite absolute growth in both tourists and lodges, the capacity added through new lodges may have outpaced demand on a per-lodge basis, especially if growth was unevenly distributed or if tourist behaviour shifted.

The literature depicts historical patterns in the relationship between the rate of tourism activity and lodge growth. Between 1980 and 1997, the number of lodges and overnight capacities grew at a faster rate than tourist flow (Nepal et al, 2002). While more recently, between 1997 and 2019, the rate of visitors increased greater than the rate of lodge development (Sun et al, 2024). The findings from this study suggest that while both tourism and lodge development continue to grow, the rate of tourist growth has slowed more significantly than the rate of lodge expansion. This indicates a shift in the relationship between supply and demand, with development now proceeding at a relatively higher pace in comparison to tourist activity than in previous years. This new activity in the rate of lodge development and tourist activity may be partially influenced by two distinct events: the 2015 earthquake and the COVID-19 pandemic.

Although both events negatively impacted the flow of tourist arrivals in Nepal (Paudel et al, 2024), the tourism economy quickly recovered after both crises. The 2080/081 (2023/2024) Sagarmatha National Park Annual Report indicates that between 2015 and 2021, tourist numbers in SNPBZ declined sharply, dropping from 54,854 in 2015/16 to just 3,763 in 2019/20. This period was marked by a steady decrease in arrivals, with the most significant drop occurring between 2018/19 and 2019/20. Tourist numbers began to recover slightly after 2020/21 but remained well below pre-2015 levels. By 2021/22, arrivals rebounded to 58,660, exceeding pre-2015 tourist flow (Government of Nepal, 2024).

It is evident that the 2015 earthquake impacted the flow of tourism, however, the tourist economy was on a trajectory toward recovery. This is also supported by semi-structured interviews conducted by the author, in which local lodge owners expressed that tourist activity had returned to normal by the following season. The COVID-19 pandemic had even bigger implications on the flow of tourism, causing it to substantially decrease from 32,637 arrivals in 2017/18 to just 3,763 in 2019/20. Although both events have negatively impacted tourist activity in SNPBZ they cannot be completely accountable for the slowed growth in tourist numbers during a period of continued lodge development.

Even between the 2022/2023 and 2023/2024 seasons, there was a decrease from 59,667 to 55,767 tourists visiting the park and no associated crises. In 2019, many lodge owners expressed that they did not want to expand their lodges due to both, the high cost of construction and the risk of losing money if tourist numbers did not rise (Sun & Watanabe, 2021). This is particularly notable given that most lodge development occurred between 2019 and 2024, with 94 lodge owners reporting that their lodges were established within this period. Based on the tourism figures reported by the Government of Nepal, it appears that after the 2021/22 season lodge owners anticipated tourist arrivals to continue to exceed pre-2015 levels, hence the development of more lodges. However, the flow of tourism did experience a slight decrease in the 2023/24 season which is reflective in both the data and observations expressed by lodge owners during the fieldwork.

While the findings highlight continued lodge development between 2011 and 2024, this growth occurred during a period of fluctuating tourist flows and slowing arrival rates – suggesting that infrastructure expansion may be shaped more by expectations of future growth than by actual demand. Despite earlier reports of hesitancy toward expansion due to high construction costs and financial risk, many new lodges were established post COVID-19. This raises questions about how lodge owners interpret market signals and assess development risks, particularly in the absence of formal forecasting mechanisms. Further inquiry is needed to better understand the role of expectations, risk perception, and informal knowledge systems in shaping development in protected areas.

Additionally, this study did not include data on tourist motivations or decision making, which limits insight into additional factors that may be influencing occupancy and visitation patterns. Anecdotally, in conversations with individuals outside Nepal – particularly in Canada – concerns about waste accumulation in SNPBZ were frequently raised, often as a reason not to travel to the region. This suggests that the destination image may be increasingly shaped by external perceptions of environmental degradation, regardless of whether these perceptions reflect the current reality of the park.

5.2 Shifts in Energy Consumption

The following section explores the transformation of the energy mix over time in which there has been a decreased reliance on firewood and an increased dependence on alternative energy sources. It examines the adoption of electricity throughout the park and the park-wide pressure on fuel-based resources.

5.2.1 Transformation of the Energy Mix

Over the 27-year study period, energy consumption patterns across SNPBZ have undergone a significant transformation. All trekking areas have reduced their reliance on firewood to some extent, but the adoption of alternative energy sources has varied by region. In general, lower altitude areas such as Lukla and Namche have moved more quickly toward LPG and diversified resources – where Namche has eliminated the use of kerosene – while higher altitude areas such

as Everest, Gokyo and Thame continue to rely on sources such as dung and kerosene. Traditional energy sources such as dung and firewood are commonly used for heating meanwhile, alternative energy sources such as kerosene and LPG are used for cooking and showers. Additionally, hydroelectricity and solar power are also considered alternative energy sources used for cooking, showers, lighting, and power.

Historically, firewood use has remained highest at lower altitudes in main trekking centres while trekking routes at higher altitudes exhibit less reliance on firewood. This is most likely due to a combination of factors including geographic accessibility to forests, local abundance of firewood and regulatory enforcement (Garbarino et al, 2014). As expressed by lodge owners during the 2024 field study, the shift away from firewood consumption is related to restrictions on firewood collection such that wood may only be cut for a certain number of days per year. This downward trend in firewood consumption reflects increased regulation of wood collection, the rising availability of other energy resources, and shift in lodge infrastructure – all patterns also noted by Sun et al. (2024). The Farak route is the exception, whereby the area experienced such an increase in firewood consumption between 2011 and 2024 (from 47.5% firewood use to 72.3%) that the region primarily relies upon firewood as an energy resource. As previously described, this dramatic increase in firewood consumption may be related to the development of lodges within this trekking area. Additionally, the Farak route is in the buffer zone, meaning that it has greater geographic access to forest resources and limited firewood collection restrictions (Sun et al, 2024). More recently, lodge owners in Phakding expressed that previously, only two people per household could collect firewood for two weeks each year, however, as of 2024 only one person per household can collect firewood for only one week each year. Due to this increase in firewood restrictions, field observations imply that wood may be outsourced to areas in the lower Solukhumbu.

The data reveals that as reliance on firewood decreased, the consumption of kerosene rose and then fell. It is apparent that as trekking routes shifted away from firewood, they increased their reliance on kerosene, however, once LPG was introduced into the energy mix, kerosene consumption declined. It is important to note the level of kerosene consumption throughout each trekking area. The data highlights that kerosene use has become more spatially concentrated over

time. While its overall importance as an energy source may be declining, specific areas – particularly at higher altitudes (Everest and Gokyo) – continue to rely on it more heavily than others, suggesting uneven transitions in energy access and lodge infrastructure across the park. Overall, the park-wide reduction in kerosene consumption is likely correlated to the increasing accessibility of LPG (Aubriot et al, 2019; Sun et al, 2024). Additionally, kerosene is typically imported to the Solukhumbu region from Kathmandu and has high seasonal price fluctuations (Gehrig, 2014) which may also contribute to the move away from kerosene as a primary energy source.

Dung has become nearly non-existent in lower altitude areas, while it has been consistently relied upon in higher altitude areas such as Everest, Gokyo and Thame. This distinguished geographic reliance on dung is due to the location of animal husbandry activities which mainly occur at higher altitudes in the core zone (Sun et al, 2024). Despite this dependence on dung, the park-wide dependence has decreased between 2011 and 2024. These trends suggest that dung remains a primary energy resource at higher altitudes, likely due to limited access to other energy resources. In addition, the average per lodge consumption of dung has recently decreased which may be indicative of a shift away from traditional energy sources to alternatives such as electricity and LPG.

This study only has data for LPG consumption for the year 2024, however, other research has noted that between 2017 and 2019, this resource was used by 99% of lodges (Sun et al, 2014). It is important to note that this statistic is limited to the sample size of the study in which only 76% of all lodges in SNPBZ were examined. The data reveals that the greatest total consumption of LPG occurs along the Everest route while the greatest per lodge consumption is distributed between Namche, Everest, and Lukla, followed by Gokyo. LPG is primarily used for cooking, and its higher concentration along the Everest route may reflect of both, its role as an alternative to firewood and the increased energy demand at higher altitudes. In these areas, water boils at lower temperatures, requiring longer cooking times and thereby increasing reliance on efficient energy sources like LPG. Despite the high concentration of LPG consumption along the Everest route, as reflected in the data and in previous studies, LPG is primarily used at altitudes below 4000m (Sun et al, 2024). Namche's high consumption of LPG may be connected to its role as the

main trekking location in SNPBZ which means that it has both, the greatest demand of energy resources through tourism, and the greatest supply since LPG is regularly transported as Namche acts as the main LPG collection and distribution centre (Sun et al, 2024). In contrast, the Thame route's limited LPG use may reflect its proximity to hydroelectricity plants and its lower tourist activity, both of which likely decreases the demand for alternative energy resources such as LPG. In addition, the increase in the number of showers in lodges throughout the park may also be influential to the consumption of LPG because those showers that are not heated by solar power typically use LPG.

5.2.2 Electricity Adoption through Hydro and Solar Power

The varying shifts in energy consumption through SNPBZ is evidently influenced by the availability and regulation of resources. In addition to the use of firewood, dung, kerosene, and LPG, the consumption of hydroelectricity and solar power have become increasingly more common throughout SNPBZ.

With the growing adoption of both, hydroelectricity and solar power, the data shows that the reliance on either electricity source is influenced by geographic location and altitude.

Higher-altitude areas, such as the Gokyo and Everest routes, are more likely to rely on solar power, which contrasts with lower-altitude areas that have greater access to hydropower. This distinction supports a general interpretation: lodges at lower altitudes tend to use hydropower, while those at high altitudes use solar power. Similar patterns have been observed in other studies in which tourism facilities located below 4000m predominantly use hydroelectricity due to the greater presence of hydropower plants at lower altitudes. While tourism facilities located higher than 4000m have a greater reliance on solar power (Sun et al, 2024).

Despite this pattern, in addition to hydroelectricity, lodges at lower altitudes have increasingly adopted the use of solar power. Between 2011 and 2024, it can be observed that there has been a growing reliance of electricity from both solar panels and hydropower. The 2011 study described that generally, lodges do not invest in additional electrical supply because if energy needs are covered by hydropower stations, there is no incentive to invest in private solar panels (Gehrig, 2014). This is evident in the 2024 data along the Farak and Thame routes, where there was

limited growth in solar power adoption. This is most likely because both areas have access to hydroelectricity, reducing the need for alternative energy sources. Additionally, the geographic location of Thame limits the need for solar power because the largest hydropower plant in the park is in the Thame region (Sun et al, 2024).

As observed by Gehrig (2014), the increase in electricity from both, hydro and solar power, could be due to the higher demand in electricity consumption presented by tourists. This observation is justified by informal conversations the author had with tourists who had visited SNPBZ in 2019 and again in 2024. These tourists stated that many amenities like Wi-Fi and device charging available in 2024, were not available five years earlier. Tourist influence is also depicted along the Thame route, where most lodges reported using hydroelectricity at a Level three or higher, indicating commercial-level energy use likely required to accommodate tourism activity.

Additionally, the reliability of electricity sources could also play a role in this pattern. As observed by the author in the Thame region, access to hydroelectricity was greatly impacted due to the GLOF in September 2024. Lodge owners throughout the park expressed that solar power infrastructure is expensive and dependent on sun exposure; however, it is often used as a backup to hydroelectricity. This observation was also noted by Sun et al. (2024). Combined with an increase in tourist demand for electricity, the adoption of solar power could also possibly be a result of climate change impacts and energy source reliability. Research has found that natural disaster such as GLOFs impose severe risks to energy infrastructure such as hydropower plants, suggesting that a diverse mix of renewable energy sources (wind, solar, and hydro, combined with battery storage) are solutions to reliable, clean energy access (Scott et al., 2023).

In addition to highlighting the spatial distribution of electricity types across different altitudes, the data also reveals distinct patterns in the amount of electricity consumed. In high altitude trekking areas such as the Everest and Gokyo routes, electricity consumption is much less than lower altitude areas like Lukla, Namche, and the Farak route. It is crucial to consider the importance of the trekking area type and its geographic location to understand the differences in electricity consumption levels. Higher altitude areas have limited access to hydropower plants,

reducing their access to hydroelectricity while lower altitude areas are geographically located near hydropower stations.

In high altitude villages such as Pangboche, located along the Everest route, hydroelectricity is used widely, however, many lodge owners notes that the supply is unreliable and is primarily used for lighting. This indicates that, while hydropower is the main source of electricity in Pangboche, it may not be sufficient to meet the full range of energy needs required to support tourism operations. This further emphasizes the need for sustainable energy diversification throughout SNPBZ. Overall, the patterns of electricity adoption in SNPBZ reflect an intricate interaction between geography, infrastructure access, and the reliability of energy systems, with hydro and solar power supporting an ongoing shift toward more sustainable resource use.

5.2.3 Park-Wide pressure on Fuel-based Resources

Between 1997 and 2011, energy demand increased across all trekking areas, reflecting a period of higher overall resource consumption. In contrast, from 2011 to 2024, energy use declined substantially throughout the entire park. This trend reflects a broader shift from traditional fuels toward more efficient sources like hydro and solar power. Coincidingly, overall resource pressure in the park appears to have decreased, as indicated by a reduction in water consumption across most trekking areas. However, higher altitude regions remain an exception, where water is often kept running to prevent freezing, resulting in elevated consumption levels. Together, these shifts suggest a trend toward more sustainable resource use in SNPBZ, although geographic disparities and altitude related constraints continue to shape the pace and distribution of this transition.

However, these reductions in resource demand within the park may mask a shifting environmental pressure to neighbouring regions. As firewood collection becomes more restricted within SNPBZ, reports from lodge owners in Phakding suggest that firewood is increasingly being sourced from areas in the lower Solukhumbu. This externalization of resource extraction highlights a potential trade-off: while sustainability gains may be occurring within the park boundaries, they may simultaneously be displacing ecological burden elsewhere. As such, the observed decline in park-wide fuel consumption may not fully reflect the broader environmental footprint of tourism-driven energy use.

5.3 The Intersection of Tourism, Lodge Growth, and Energy Consumption

This study reveals an interconnected relationship between tourism, lodge infrastructure development and energy consumption in SNPBZ, where patterns of energy use are shaped by both the geographic distribution and growth trajectory of lodges.

5.3.1 Energy Demand and Lodge Development

The data portrays that at lower altitudes, lodges primarily consume LPG, kerosene, and hydroelectricity, while at higher altitudes the dominate energy resources are dung, kerosene and solar. When examining the per lodge hydroelectricity consumption of each trekking area, it is evident that hydropower is widely adopted across low altitude areas, but the per lodge consumption remains relatively modest. In contrast, at higher altitudes, hydropower access is more limited, yet those lodges that do use it tend to consume significantly more on a per lodge basis. Namche is the exception where there is both, a widespread use of hydroelectricity and a considerable reliance on the resource. The trekking area type is relevant because those areas at lower altitudes that mainly rely on hydroelectricity all contain Type 1 trekking locations (Lukla, Namche, and Phakding). Type 1 trekking centres offer more amenities to tourists; thus, it is implied that they would consume more energy. Additionally, Namche is a prime example of the relationship between lodge infrastructure development and energy demand as this area uses a significant amount of energy – whether the source is electricity or combustion-based – and has high tourism capacity.

An assumption could be made that along the Gokyo and Everest routes, greater electricity consumption occurs due to higher altitudes requiring more energy for cooking and lighting compared to lower altitudes (Bhatt et al, 2016). This observation is also applicable to combustion-based resources. This may be attributed not only by altitude, but also since lodges in these regions tend to be larger in size and designed to accommodate higher volumes of trekkers, amplifying their total energy demand.

This is reflected in the data as over time, there has been decreasing reliance on combustion-based resources such as LPG, kerosene, dung and firewood in low altitude areas (Lukla, Farak and Namche). Meanwhile, high altitude areas (Everest, Gokyo, and Thame) have experienced an increasing reliance on combustion-based energy sources. The decline in combustion-based resource consumption between 2011 and 2024 is most likely associated with the adoption of hydroelectricity and solar power amongst low altitude villages in SNPBZ.

This overall decline in combustion-based energy use between 2011 and 2024 appears to reflect a broader infrastructural shift in lower-altitude trekking centres, where improved access to electricity, through both hydropower and solar technologies, has enabled a transition away from traditional fuels, as supported by the literature (Sun et al., 2024). Hence, location, and inherently altitude, as well as touristic importance may influence both, hydroelectricity and combustion-based resource consumption.

5.3.2 Tourism Recovery, Development Risk, and Energy Trade-offs

There is a clear connection between tourism, lodge development, and the adoption of clean energy in SNPBZ. The data may suggest that without the economic benefits of tourism, lodges cannot afford the consumption of green energy sources. These findings support the argument that tourism is necessary to financially support the transition towards sustainable energy. Although dependent upon the geographic location and associated barriers, the literature shows a consistent relationship between the economic benefits of tourism and investment in clean energy in which the tourism industry and clean energy are interconnected (Demirkale & Duran, 2025). For example, Australia has a bidirectional relationship between clean energy and tourism in which tourism promotes clean energy and vice versa. Meanwhile, in areas such as China, investment in clean energy resulted in an increase in tourism revenues (Demirkale & Duran, 2025).

As discussed previously, spatial differences in energy source adoption are influenced not only by geography, but also by economic conditions driven by tourism flows. As identified by Ghimire & Kim (2018), the economic barriers of renewable energy adoption in Nepal include a lack of funds and a high capital cost. Since tourism greatly contributes to the economy, there could be a link between the adoption of renewable energy and tourism revenues. This is evident through an

approximate decrease of \$15,000 USD in tourism revenues between 2021/22 and 2022/23 (Government of Nepal, 2024) and the increased reliance on firewood in areas that experienced greater lodge development such as the Farak route.

This further poses a development risk within SNPBZ as lodge owners previously expressed hesitation over lodge expansion and uncertainty in the flow of tourist arrivals. This concern could extend towards energy investment behaviours due to unpredictable tourism revenues. Many lodge owners in Namche expressed that they are reluctant to invest in solar energy infrastructure due to its high cost, however, there is an appeal in the case of natural disaster and other energy sources become unavailable. Inconsistency in tourist flows and unpredictable profits may influence energy consumption patterns and transitions, connecting to broader ideas of adaptive capacity in which uncertainty results in limited, traditional energy infrastructure.

Despite this, the research has shown a positive correlation between investment in clean energy and an increase in tourist activity suggesting that the adoption of sustainable energy infrastructure may influence greater tourism revenues (Demirekale & Duran, 2025). In the case of SNPBZ, it is important to consider the economic and environmental barriers to clean energy adoption. This raises important questions about the long-term viability of energy transitions in SNPBZ, particularly because tourism is so heavily relied upon for economic prosperity, inherently making it the primary mechanism for financing sustainable energy infrastructure.

5.3.3 The Feedback Loop Between Tourism, Lodge Infrastructure, and Energy Transitions

The relationship between tourism, lodge development, and energy transitions proposes a positive feedback loop framework in which a slowed rate in tourism results in reduced income for lodge owners, simultaneously limiting investment in alternative energy and increasing reliance on cheaper, traditional resources. This results in additional pressure on natural resources and environmental degradation, reducing the environmental quality that tourism depends on in SNPBZ, with the potential to further threaten visitor satisfaction and arrival rates. While this feedback loop may manifest differently depending on local tourism levels and governance structures, its foundation poses a systematic risk to sustainable development across the park.

This feedback loop highlights the interdependent relationship between sustainable tourism levels and sustainable resource use. If lodge development continues at historical rates while tourist arrivals stagnate or decline, clean energy investments may remain out of reach for lodges operating at low occupancy. This could result in the park experiencing an unintentional shift back toward high fuel-based consumption due to economic necessity. This highlights the critical role of aligning tourism flows, development regulation, and energy resource governance in long-term destination planning.

This economic dynamic of tourism, lodge infrastructure, and energy accessibility could also relate to the unequal distribution of the economic benefits of tourism throughout SNPBZ. Those areas with greater tourism activity experience the economic benefits of tourism (Sun & Watanabe, 2021), thus they are more likely to invest in better infrastructure to accommodate for tourism demands and energy accessibility as explored in the literature (Calvert, 2016; Jamal & Dredge, 2014). Meanwhile, areas that do not have high rates of tourist activity are more susceptible to fall into this positive feedback loop. Tourism is not only a pressure on energy resources, but it can also act as a driver towards sustainable infrastructure, but only if it is stable, well-managed, and supported.

5.3.4 Externalized Resource Pressure and the Park Boundary Illusion

Although the data suggests a park-wide transition toward cleaner energy – including increased use of LPG, hydro, and solar power, along with a decline in firewood consumption – it also indicates that resource pressures may be shifting beyond park boundaries. Similarly, in protected areas around the world in places such as the Amazon, Tibet, and China, parks have spillover effects which impact adjacent areas and offset conservation efforts particularly relating to forest degradation (Dou et al, 2018; Shen et al, 2022; Cao et al, 2025).

In conversations with other researchers in SNPBZ, it was observed that the increase in firewood collection regulations in villages such as Phakding has resulted in the externalization of deforestation to nearby areas outside of the buffer zone in the lower Solukhumbu. The data reveals that despite increased restrictions within the park and buffer zone, the Farak route has

increased firewood consumption which may signal that the resource is coming from outside of the area.

The combination between energy transitions, consumption patterns, and regulations throughout SNPBZ may be masking broader ecological trade-offs outside the park boundary. To fully understand the implications of energy use in SNPBZ, impacts must be examined not only within park boundaries but also across the broader systems that sustain park tourism. Without this wider lens, park-level sustainability may be achieved at the expense of surrounding ecosystems.

5.4 Labour Structures and Sociocultural Change

Lodge ownership and labour structures are important indicators of community-based tourism development, as they demonstrate how tourism is embedded in local livelihoods and whether revenues remain within the community (Gehrig, 2014). Although labour dynamics fall outside the formal objectives of this study, they are included here to contribute to the longitudinal understanding of tourism change in SNPBZ.

As in 2014, lodges in the park are still predominantly owner operated, however, the number of rental operations has increased park wide. This trend has continued through 2024. Individuals renting and managing lodges are largely from the Solukhumbu area, suggesting that despite property ownership, the tourism economy remains rooted in local participation. This trend coincides with observations made by Sun & Watanabe (2021), in which more individuals are moving away from the trekking profession towards lucrative jobs in the tourist accommodation sector. This was also evident through field observations in which many lodge owners previously acted as climbing sherpas. These patterns align with overall lodge growth, indicating that more local residents are entering the accommodation sector, either as owners or renters.

Between 2011 and 2024, lodge labour structures have transitioned from family-run models to more employee-based systems. In 1997, lodges were primarily operated by family members. However, by 2011, hired staff had become the dominant labour force – a pattern that continued in 2024. This trend supports Gehrig's (2014) idea that as the number of lodges increases, so does the demand for labour. Although the data depicts that most hired staff are local to the

Solukhumbu, Sun and Watanabe (2021) further noted that many of the workers meeting this demand come from outside the park, suggest the tourism economy is both locally embedded and regionally linked.

Labour demand reflects the spatial distribution of tourism development: areas with the greatest concentration of lodges – such as Namche, the Farak route, and the Everest route – consistently maintain the largest workforces, including both family members and hired employees.

Gender patterns also reveal important social dynamics. While male and female family member remain relatively balanced in number, hired staff lean towards male. Among hired employees, the majority were local to the Solukhumbu area in both 2011 and 2024. Notably, more women than men report being local to the area, suggesting that men are more likely to migrate for employment. This may reflect traditional gender roles in which women stay closer to home, particularly in hospitality-related work, while men pursue opportunities outside of their home villages.

These trends not only reflect shifts in lodge operations but also speak to broader questions of sustainability, including who benefits from tourism growth and how labour structures evolve in response to increased demand.

5.4 Framing the Findings: Tourism Lifecycle, Carrying Capacity, and Sustainable Development

The data identifies key topics of discussion that places SNPBZ within the sustainable tourism frameworks identified in the literature. The following section explores how the data positions SNPBZ in Butler's Tourism Area Lifecycle (TALC) model. It then proceeds to explore sustainable development and the carrying capacity of the park.

5.4.1 Tourism, Lodge Development, and Energy Consumption as Indicators of Destination Lifecycle Stages

The study reveals emerging characteristics of the park that align with the consolidation lifecycle stage. When looking at the data individually, it is evident that over time there has been changes in both, lodge development and trends in energy consumption. However, to further understand the implications of change, the relationship between these variables and tourist activity needs to be analyzed comprehensively.

Aligning with the characteristics of the consolidation stage of Butler's Tourism Lifecycle (1980) tourism is the major source of economic revenue throughout SNPBZ in which over 85% of the population engages with the industry (Boustead & Bhatta, 2021). The relationship between tourist activity and lodge development depicts that there has been a shift in the relationship between supply and demand in which the rate of tourist arrivals has slowed compared to the rate of lodge development. Although both tourism and lodge development continue to grow, the relative slowdown in tourist growth compared to infrastructure expansion suggests a shift in the supply-demand relationship, this may indicate a decoupling between tourism growth and lodge expansion. Additionally, the number of annual tourists and migrant workers has outnumbered the local population in the park (Boustead & Bhatta, 2021) further signalling a transition towards consolidation.

These observations must also be combined with energy consumption behaviours to create a holistic portrayal of destination lifecycle evolution. As energy use patterns have fluctuated over time, many changes in resource consumption have been influenced by restrictions and regulations placed by park management. This could be indicative of a park transition towards the consolidation stage because changes in energy consumption reflects changes in the industry. This could also be linked to land use change in which tourism has influenced a decrease in shrubland coverage and an increase in rock and soil area due to the intensification of agriculture and pressure on natural resources such as fuelwood (Garrard et al, 2016).

Despite these indicators of a transition towards the consolidation stage, local perspectives on tourism remain positive suggesting that SNPBZ has not quite yet approached the consolidation

stage. In response to tourist flows, both local communities and tourists in SNPBZ reported that they were satisfied with the level of tourism (Boustead & Bhatta, 2021). Additionally, Sacareau (2009) observed that the “touristification” has not deterred tourism but has rather encouraged it, further noting that “too many tourists do not kill tourism.” Although this observation may suggest that SNPBZ is still in the development lifecycle stage, this is outdated, and further investigation is required to truly understand how excessive numbers of tourists may impact the flow of tourist arrivals, and inherently, the destination lifecycle stage.

The data also reveals emerging characteristics associated with the stagnation stage, including lower occupancy rates in lodges, the expansion of development into peripheral areas, and increasing reliance on external resources due to regulatory constraints. Together, these trends, particularly the positive feedback loop previously identified, point to the environmental, economic, and social issues characterized by the stagnation stage.

However, it is evident that SNPBZ has not yet reached full stagnation as it does not exhibit all defining attributes of this stage. These characteristics include the dominance of artificial attractions over natural and cultures ones, and a clear detachment of the destination from its geographic and cultural context. Given the unique geographical setting and identity as a high-altitude protected area, it is arguably unlikely that it will ever fully reach the stagnation stage as described in Butler’s model. However, early signs of sustainability pressure are becoming increasingly visible, suggesting the potential for stagnation-like dynamics to emerge if current development patterns continue haphazardly.

Despite the unlikeliness of SNPBZ adopting the characteristics of stagnation, there is the possibility of the destination experiencing the decline stage due to rapid, haphazard development and corresponding climate change impacts. This has happened in various mountain destinations such Peru due to the rapid retreat of the Pastoruri Glacier and in Bolivia, where the Chacaltaya Glacier has completely disappeared (Palomo, 2017). Without sustainable development interventions, SNPBZ is faced by similar risks of tourism decline and intensive environmental degradation, posing additional economic impacts.

5.4.2 Sustainable Development and Carrying Capacity

As SNPBZ begins to exhibit characteristics of the consolidation and stagnation stage, the future of sustainable development and the carrying capacity of the destination comes into question.

The data and literature suggest that without tourism revenue, lodges may struggle to afford clean energy sources. Tourism supports access to greener infrastructure, and over time, SNPBZ has shown a transition toward cleaner energy. This is evident as tourism has increased over time, hydropower and LPG become widely adopted throughout the park while reliance on resources such as firewood and kerosene has decreased. It appears that lodges rely on steady visitor flows to afford this transition to cleaner energy. To maintain this progress, consistent tourism flows are essential. There is a mutually reinforcing relationship in which tourism enables sustainable development and sustainability ensures the long-term viability of the tourism industry. However, when this relationship is strained by a reduced rate of tourist arrivals, revenue generation becomes unpredictable which has the potential to hinder energy transitions and reinforce dependence on traditional, cheaper resources like firewood. This relationship has the potential to impact the adaptive capacity of SNPBZ as sustainable development is dependent on fluctuating flows of tourism.

To better understand the park's development trajectory of SNPBZ, it is essential to consider carrying capacity. As Martin & Usyal (1990) identify, there is a dynamic relationship between the concept of carrying capacity and tourism lifecycle stages in which the carrying capacity of a destination is different at each stage. While the data in this study situates SNPBZ between the development and consolidation stages, with signs of emerging stagnation, it primarily reflects the demand side of resource use. This includes patterns of energy consumption within lodges but does not capture the supply of these resources which entails the availability, reliability, and ecological limits of energy resources. Without knowing how much energy can be sustainably sourced, it is difficult to determine whether current levels of development exceed the park's carrying capacity or to assess the stage of lifecycle progression accurately. This presents a gap in which the carrying capacity cannot be accurately gauged without understanding both the pressures placed on the park and the park's ability to withstand them. This gap could be

addressed through further research that explore the supply side of energy access within the park. This is further discussed in the conclusion.

5.5 Natural Disaster and Climate Change

Alongside the questionnaire, approximately 14 lodge owners were interviewed regarding their perspectives on how natural disaster and climate change impacts the accessibility of energy resources and the flow of tourism throughout SNPBZ. All semi-structured interviews had recurring themes and observations that natural disasters have impacted energy accessibility but not the flow of tourism. This next section explores the observations made by local lodge owners about the relationship between natural disasters and climate change to energy consumption and tourism activity.

5.5.1 Natural Disaster, Climate Change, and Energy

Despite climate change being outside the scope of this study, perspectives on natural disaster and climate change provide further insight on the relationship between tourism, development, and energy within SNPBZ. In September 2024, SNPBZ and surrounding areas experienced heavy rain at the end of a late monsoon season, resulting in various landslides and a glacial lake outburst flood. This event damaged hydroelectricity infrastructure and energy transportation routes. Hydropower was inaccessible in low altitude areas for over 3-weeks, forcing lodge owners to rely on other forms of energy, with many reporting that they shifted reliance to solar power, especially for lighting. Similar studies have made observations such that climate change has increased the frequency of natural disasters such as GLOFs which has resulted in recurring damages to hydropower stations in mountain areas such as in Bhutan (Palomo, 2017; Scott et al, 2023). This further emphasizes the threat that climate change and natural disaster poses on the distribution of energy in mountain areas. Although the data in this study depicts an increase in the adoption of solar power consumption throughout SNPBZ, lodge owners in lower altitudes expressed that solar power is typically used in the case of an emergency. Solar is often regarded as unreliable and uncommon compared to other energy sources.

Due to the vulnerability of the area to natural disaster, most lodges expressed that they reserve energy resources for emergency situations in which accessibility is impacted. When faced by resource scarcity due to natural disasters, lodges typically lean on one another and share stocked energy resources (i.e., LPG and kerosene). This preparation has allowed some lodge owners to feel as though natural disaster does not impact them energy-wise.

When disaster strikes, road conditions are impacted, making the transportation of resources difficult, and often making energy resources more expensive. Lodge owners have expressed that during disaster, the cost of energy nearly doubles. In combination with financial restrictions to energy access, lodge owners expressed that the lodges are not “saving money” despite the increase in both tourists and the facilities to accommodate them. It was expressed in interviews that tourists do not want to pay increasing prices for expected services and amenities. These cost burdens, combined with rising energy insecurity, challenge the financial viability of continued investment in clean energy infrastructure, especially for lower-income lodges.

These observations highlight a layered form of energy vulnerability: infrastructure-dependent systems such as hydropower are exposed to physical disruption, while alternatives like solar are seen as insufficient for primary use. These considerations regarding solar and hydropower revealed by the data are also noted in various studies as barriers to renewable energy adoption in Nepal (Ghimire & Kim, 2018). Meanwhile, other energy sources such as LPG, kerosene, and dung become more expensive due to accessibility of transport routes. In response, lodge owners adopt informal preparation strategies, such as storing and sharing energy resources. However, these adaptation tactics do not offer long-term solutions to consistent and reliable energy accessibility, especially as financial constraints and rising costs during crises further limit resource access.

Globally, there has been an increasing adoption of solar power for electricity in mountain areas throughout Central Asia, the Alps, the Andes, and the Canadian Rockies (Scott et al, 2023). However, the accessibility of energy through solar power can be impacted by climate change impacts such as changes in cloud coverage (Scott et al, 2023). As further described in the following section, weather variability is common in the Solukhumbu which, as experienced by

lodge owners in SNPBZ, can inherently make solar power an unreliable energy source. In addition, as demonstrated during the Fall 2024 GLOF, hydropower has also become vulnerable to the risks of climate change.

5.5.2 Natural Disaster, Climate Change, and Tourism

Many lodge owners expressed that tourism quickly recovers post natural disaster. After the earthquake in 2015, some lodge owners observed that the flow of tourism resumed normal activity within just 2-months after the disaster. These observations were evident in tourist records that portrayed a quick rebound of activity shortly after April 2015 (Government of Nepal, 2024). However, many lodge owners have highlighted changes in the climate itself through time, noting seasonal changes in temperatures and weather conditions which may impact the variability in tourist arrivals. Compared with historically snowy winters, one lodge owner expressed that winters have been characterized by minimal snowfall and dry conditions. Another lodge owner noted that temperatures have also varied over time. The water in their lodge was consistently frozen during the 2023 fall season while in 2024, the water did not freeze.

In relation to the flow of tourism, lodge owners suggested that it is not natural disaster that impacts tourist activity but weather patterns that impact the accessibility of SNPBZ which prevents tourists from travelling to the park. SNPBZ is most accessed through the Tenzing-Hillary Airport in Lukla, where tourists fly in from Kathmandu or Ramechhap. These flights are weather dependent and with varying weather patterns, flights to and from Lukla can be delayed for days on end. Many lodge owners expressed that the inconsistency of flights arriving in Lukla results in either very low or high arrivals. When flights are not available into Lukla, another travel option for tourists going to SNPBZ is jeeps, however, many roads have become inaccessible due to landslides. This highlights the impact of the combination of weather variability and natural disaster on tourist flows into SNPBZ.

Noting that weather variability is often a symptom of climate change (Thornton et al, 2014), the inconsistent and unreliable flights going to and from Lukla could be connected to climate change. The perspectives of lodge owners on weather variability and tourist flows could suggest that climate change may play a role in the flow of tourism activity within SNPBZ. When

selecting their trekking location, many tourists consider weather variability in their travel plans, allotting additional time for potential delays in travel when going to SNPBZ. Tourists who do not have flexible schedules often choose more accessible trekking areas such as the Annapurna region or must pay additional costs for helicopter transport to SNPBZ. This portrays the additional strain that weather variability imposes on the tourism industry in SNPBZ, hinting that climate change will have implications on tourism. This is evident in other mountain regions throughout the world in which weather variability in snowfall and temperature has influenced tourism flows (Steiger et al., 2024).

The impacts of climate change on tourism in Nepal have been noted in various studies, highlighting bad weather that delayed flights for multiple day in Lukla in November 2010, an unexpected snowstorm along the Annapurna Circuit that killed more than 30 people in 2014, and more (KC et al, 2021). Studies on mountain tourism in Canada have identified that climate change may positively impact tourism in the short-term due to warmer temperatures increasing the length of tourist seasons, however, the long-term effects on tourism are negative as climate change will result in the permanent degradation of ecosystems and glaciers (Scott et al, 2007). Similar studies in Nepal have also identified that climate change has removed barrier to trekking tourism as warmer temperatures mean longer trekking seasons (KC et al., 2015). Despite the potential of growth in tourism due to warmer temperatures, weather variability, as demonstrated in Nepal, holds the potential to impact tourism in the present day.

While natural disaster has not caused long-term reductions in tourism, increasing climate variability appears to be influencing access, cost, and planning behaviour amongst tourists. These findings point to the need for greater integration of climate resilience planning on both tourism and energy infrastructure within SNPBZ.

Chapter 6: Conclusion

The main goal of this thesis is to understand how tourism has influenced lodge development and energy use patterns and energy types within lodge accommodations in SNPBZ over time.

Through a longitudinal analysis, this research aims to meet the following objectives:

- To characterize the growth of tourist lodges
- To examine energy consumption patterns and energy types consumed in tourist lodges

Over time, the development of tourist lodges has remained relatively consistent with the greatest concentration of lodges being along the Everest, Farak, and Gokyo routes. Compared to lodge concentration, bed capacities are greatest in Lukla, Namche, and along the Everest route. The growth and spatial patterns identified in this thesis indicate that both, trekking importance and altitude, have an influence on lodge growth.

Energy patterns have revealed that the park has shifted away from traditional energy sources towards alternative resources such as LPG, hydroelectricity, and solar power. However, the data identifies that energy consumption varies based on geographic location, with the influencing factor being altitude. Where areas at altitudes lower than 4000m typically rely on LPG and electricity while areas at higher altitudes depend on dung and kerosene. Altitude influences energy use both through accessibility constraints and increased energy requirements for daily operations. Overall, through time the park has reduced total consumption of fuel-based energy as it has shifted towards more sustainable resource use.

The relationship between energy use, tourist flows, and lodge development appears to be interdependent. Although there has been an increase in both, tourist flows and lodge development, the relative difference of this growth has narrowed in which the rate of lodge development has remained consistent while the rate of tourist activity has decreased. Those areas that have experienced substantial lodge development combined with lower tourist occupancy have exhibited a shift back towards traditional energy sources, as evident along the Farak route. With increasing regulations within the park, patterns such as this may impose negative impacts on neighbouring areas through deforestation, as resource pressure is imposed outside of SNPBZ. This dynamic risks externalizing environmental degradation as resource pressure may be

displaced to areas outside SNPBZ while appearing sustainable within park boundaries. It is evident that the economic benefits of tourism are necessary for the prosperity of sustainable energy adoption. Without these benefits, a positive feedback loop may occur in which traditional energy resources, such as firewood, become the primary resource once again.

With a declining rate of tourist activity, despite a growth in absolute numbers, SNPBZ is portraying characteristics of both, the consolidation and stagnation stages of Butler's TALC model. Although the park has yet to fully reach either lifecycle stage, these emerging attributes should be considered carefully as they may reflect the sustainability pressures of haphazard development.

This study contributes a spatially and temporally grounded understanding of tourism infrastructure and energy transitions in SNPBZ. It is especially unique within the literature because it provides a complete consensus of all active tourist lodges throughout the park. Through the intersection of local perspectives, longitudinal data, and tourism lifecycle theory, it highlights the complex relationship between resource consumption, tourist activity, and sustainability throughout the park.

However, the study is limited by its reliance on self-reported data from lodge owners, many of whom lacked records on tourist activity and energy consumption. This absence of records also limits the consensus as some lodge owners were unable to answer survey questions simply because they did not know the answers. Additionally, the research only assessed the demand for energy, not the supply, limiting insights into the park's carrying capacity. To avoid future limitations in similar studies with recall bias, future studies should collaborate with local electrical companies and energy distributors to better understand the demand of energy resources within the park. Additionally, future projects could encourage record-keeping within lodges to enhance the quality of research and benefit lodge business practices.

6.1 Recommendation for Policy and Practice

Despite the adoption of LPG, solar, and hydropower over time, it remains uncertain whether these practices can be sustained under variable economic and environmental conditions, particularly given inconsistent tourist flows and climate change. Sustainable and reliable access to clean energy sources and infrastructure is critical throughout SNPBZ. Building on existing studies (Sun et al, 2024; Scott et al, 2023), it is recommended that decentralized off-grid renewable energy sources, such as solar with battery storage, be further developed, particularly in high-altitude areas above 4000m where access is limited. Diversifying the energy mix in these regions to include options such as wind energy could also enhance resilience.

While many lodge owners have developed informal strategies to manage energy shortages during natural disasters, there is currently no formal government-supported energy disaster response within the park. The development of community-based disaster risk and resilience planning, with a focus on energy access, is required to reduce vulnerability and support local livelihoods.

Given the close link between tourism and energy, policy makers should integrate renewable energy investment incentives into tourism development frameworks. This would support clean energy adoption while reinforcing the mutual benefits of sustainable tourism and energy transitions.

To guide future lodge development and reduce economic risk, the government should establish regulations that align new tourism infrastructure with actual visitor trends, thereby avoiding over development in low-demand areas.

Finally, to avoid shifting environmental pressures beyond park boundaries, it is recommended that resource management policies be extended to areas adjacent to SNPBZ. This would reduce the risk of deforestation and resource depletion being displaced onto surrounding communities and ecosystems.

6.2 Further Research

Future research should investigate the supply side dynamics of energy access in SNPBZ, including ecological regeneration rates, infrastructure constraints, and the long-term viability of alternative energy systems. Supply-side data could also be collected through data that depicts the delivery frequency of resources throughout the park. These insights would contribute to a more comprehensive understanding of the park's carrying capacity and adaptive resilience under changing environmental and economic conditions.

Additionally, since tourism-related resource pressures may be displaced beyond park boundaries, there is a need to assess the broader regional implications of development within SNPBZ. This includes understanding how protected areas dynamics influence resource use, environmental degradation, and livelihoods in adjacent communities.

Lastly, there should be further exploration of development projects, market signals, and the role of local governance in shaping sustainable trajectories. Understanding how institutional capacity and community-level planning influence energy access, infrastructure resilience, and equitable development can offer valuable insights to guide future policy and investment in high-altitude mountain destinations.

If this study were to extend the longitudinal analysis in the future, it could be interesting to distinguish the types of solar power used by lodge owners throughout the park. In hindsight, data analysis would have been more efficient and telling with the distinction between the use of solar photovoltaic devices, solar cookers, and solar batteries. This longitudinal study offers an in-depth data set that highlights major environmental, economic, and sociocultural change over time in SNPBZ. Future studies could use this data to explore relationships between variables such as the decline of fuel-based resources and whether the adoption of electricity is correlated.

This thesis highlights the delicate balance between tourism development, resource management, and sustainability in high-altitude protected areas. As SNPBZ moves through varying stages of its development trajectory, understanding the connections between tourism, energy use, and development is essential for managing growth that is both sustainable and equitable. The future

of the park will depend not only on internal decision-making but also on how development pressures and policies affect the surrounding regions and communities. There must be a stronger emphasis on research and policy that recognizes the intertwined relationship between tourism and clean energy access to support environmentally and economically sustainable development. Moving forward, holistic, place-based research that is rooted in local knowledge will be vital in shaping more resilient, adaptive approaches to managing high altitude destinations like SNPBZ.

References

- Amin, S. B., Kabir, F. A., & Khan, F. (2020). Tourism and energy nexus in selected South Asian countries: A panel study. *Current Issues in Tourism*, 23(16), 1963–1967.
<https://doi.org/10.1080/13683500.2019.1638354>
- Apollo, M. (2017). The true accessibility of mountaineering: the case of the High Himalaya. *Journal of Outdoor Recreation and Tourism*, 17(1), 29–43.
<https://doi.org/10.1016/j.jort.2016.12.001>
- Aubriot, O., Faulon, M., Sacareau, I., Puschiasis, O., Jacquemet, E., Smadja, J., André-Lamat, V., Abadia, C., & Muller, A. (2019). Reconfiguration of the Water–Energy–Food Nexus in the Everest Tourist Region of Solukhumbu, Nepal. *Mountain Research and Development*, 39(1), R47–R59. <https://doi.org/10.1659/MRD-JOURNAL-D-17-00080.1>
- Baptista, I. (2018). Space and energy transitions in sub-Saharan Africa: Understated historical connections. *Energy Research & Social Science*, 36, 30–35.
<https://doi.org/10.1016/j.erss.2017.09.029>
- Bhatta, S., Boustead, R., & Luger, K. (2022). The Highest Mountain in the Shadow of Climate Change: Managing Tourism and Conservation in a World Heritage Site: Sagarmatha National Park, Nepal. In M.-T. Albert, R. Bernecker, C. Cave, A. C. Prodan, & M. Ripp (Eds.), *50 Years World Heritage Convention: Shared Responsibility – Conflict & Reconciliation* (pp. 281–294). Springer International Publishing.
https://doi.org/10.1007/978-3-031-05660-4_22
- Bhochhibhoya, S., Pizzol, M., Achten, W. M. J., Maskey, R. K., Zanetti, M., & Cavalli, R. (2017). Comparative life cycle assessment and life cycle costing of lodging in the Himalaya. *The International Journal of Life Cycle Assessment*, 22(11), 1851–1863.
<https://doi.org/10.1007/s11367-016-1212-8>
- Bhochhibhoya, S., Pizzol, M., Marinello, F., & Cavalli, R. (2020). Sustainability performance of hotel buildings in the Himalayan region. *Journal of Cleaner Production*, 250, 119538.
<https://doi.org/10.1016/j.jclepro.2019.119538>
- Bhuiyan, M. A., Paiano, A., & Crovella, T. (2024). Exploring the nexus between economic and environmental issues in the tourism sector at the country level. A replicable framework. *Heliyon*, 10(5), e26510. <https://doi.org/10.1016/j.heliyon.2024.e26510>

- Bishwokarma, D., Harper, J., & Nepal, S. (2023). Sustainable tourism in practice: synthesizing sustainability assessment of global tourism destinations. *International Journal of Sustainable Development & World Ecology*. DOI: 10.1080/13504509.2023.2183527
- Bodach, S., Lang, W., & Auer, T. (2016). Design guidelines for energy-efficient hotels in Nepal. *International Journal of Sustainable Built Environment*, 5(2), 411–434.
<https://doi.org/10.1016/j.ijsbe.2016.05.008>
- Boustead, R., & Bhatta, S. (2021). Assessment of the social impacts of community based tourism: a baseline survey in the Sagarmatha (Everest) National Park Region, Nepal. *Zeitschrift für Tourismuswissenschaft*, 13(2), 268-302.
- Bridge, G., Bouzarovski, S., Bradshaw, M., & Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, 53, 331–340.
<https://doi.org/10.1016/j.enpol.2012.10.066>
- Britton, S. G. (1982). The political economy of tourism in the third world. *Annals of Tourism Research*, 9(3), 331–358. [https://doi.org/10.1016/0160-7383\(82\)90018-4](https://doi.org/10.1016/0160-7383(82)90018-4)
- Butler, R. W. (1999). Sustainable tourism: A state-of-the-art review. *Tourism Geographies*, 1(1), 7–25. <https://doi.org/10.1080/14616689908721291>
- Butler, R.W. (1993). Tourism - an evolutionary perspective. In *Tourism and Sustainable Development: Monitoring, Planning, Managing*, ed. J.G. Nelson, R.W. Butler and G. Wall, pp. 27-44. Waterloo, Ontario: University of Waterloo (Department of Geography Publication 37).
- Butler, R. (1980). The concept of a tourist area cycle of evolution: implications for management of resources. *Canadian Geographer*, 24(1). 5-12. <https://doi.org/10.1111/j.1541-0064.1980.tb00970.x>
- Butler, R. (2015). The evolution of tourism and tourism research. *Tourism Recreation Research*, 40(1), 16–27. <https://doi.org/10.1080/02508281.2015.1007632>
- Byers, A. (2005). Contemporary Human Impacts on Alpine Ecosystems in the Sagarmatha (Mt. Everest) National Park, Khumbu, Nepal. *Annals of the Association of American Geographers*, 95(1), 112–140.
- Cao, Z., Shao, M., Lu, Z., Dong, C., Ma, C., & Yao, P. (2025). Quantitative assessment of ecological conservation effectiveness and spillover effects of China's first group of

- national parks. *Biological Conservation*, 308, Article 111242.
<https://doi.org/10.1016/j.biocon.2025.111242>
- Calvert, K. (2016). From ‘energy geography’ to ‘energy geographies’: Perspectives on a fertile academic borderland. *Progress in Human Geography*, 40(1), 105–125.
<https://doi.org/10.1177/0309132514566343>
- Colasante, A., D’Adamo, I., De Massis, A., & Italiano, S. (2024). An exploratory study of stakeholder views on the sustainable development of mountain tourism. *Sustainable Development (Bradford, West Yorkshire, England)*. <https://doi.org/10.1002/sd.2878>
- Demirkale, O., & Duran, N. (2025). Quantile granger causality between clean energy and tourism stock indices: evidence from regional markets. *PloS One*, 20(6). DOI: <http://dx.doi.org.proxy.lib.uwaterloo.ca/10.1371/journal.pone.0326256>
- Dhananjayan, P., Joshi, S. R., Rajbhandari, U., & Gyeltshen, M. (2023). Capacity Needs Assessment for Implementation of Renewable Energy and Energy Efficiency in the Cardamom Value Chain of Nepal’s Mountain Regions: Results of a Survey Study. *Green and Low-Carbon Economy*. <https://doi.org/10.47852/bonview3202672>
- Dou, Y., da Silva, R.F.B., Yang, H. & Liu, J. (2018). Spillover effects offsets the conservation effort in the Amazon. *Journal of Geographical Sciences*, 28(11), 1715-1732.
<https://doi.org/10.1007/s11442-018-1539-0>
- Eber, S., ed. (1992). Beyond the Green Horizon: A Discussion Paper on Principles for Sustainable Tourism. Godalming, UK: Worldwide Fund for Nature.
- Garbarino, M., Lingua, E., Marzano, R., Urbinati, C., Bhujju, D., & Carrer, M. (2014). Human interactions with forest landscape in the Khumbu valley, Nepal. *Anthropocene*, 6, 39–47.
<https://doi.org/10.1016/j.ancene.2014.05.004>
- Garrard, R., Kohler, T., Price, M. F., Byers, A. C., Sherpa, A. R., & Maharjan, G. R. (2016). Land Use and Land Cover Change in Sagarmatha National Park, a World Heritage Site in the Himalayas of Eastern Nepal. *Mountain Research and Development*, 36(3), 299–310.
<https://doi.org/10.1659/MRD-JOURNAL-D-15-00005.1>
- Gehrig, R. (2014). Lodge development in Sagarmatha National Park, Nepal. A comparative study of lodges (1997 and 2011). [Master’s Thesis]. University of Bern.

- Ghimire, L. P., & Kim, Y. (2018). An analysis on barriers to renewable energy development in the context of Nepal using AHP. *Renewable Energy*, 129(1), 446-456.
<https://doi.org/10.1016/j.renene.2018.06.011>
- Gill, A., & Williams, P. (1994). Managing growth in mountain tourism communities. *Tourism Management*, 15(3), 212–220. [https://doi.org/10.1016/0261-5177\(94\)90107-4](https://doi.org/10.1016/0261-5177(94)90107-4)
- Godde, P., Price, M., & Zimmerman, F. (2000). Tourism and development in mountain regions: moving forward into the new millennium. *Tourism and Development in Mountain Regions*. CABI Publishing; 1999:1-25. doi:10.1079/9780851993911.0001
- Gouvis, D., Kyriakaki A., & Maroudas, L. (2004). A community approach to mountain adventure tourism development. *Anatolia*, 15(1). 5-18. DOI: 10.1080/13032917.2004.9687141
- Government of Nepal. (2024). *2080/081 Annual Report Sagarmatha National Park*. Ministry of Forests and Environment. Department of national Parks and Wildlife Conservation. Retrieved from <https://www.snp.gov.np/document/Annual%20Report%202080-081>
- Grêt-Regamey, A., & Weibel, B. (2020). Global assessment of mountain ecosystem services using earth observation data. *Ecosystem Services*, 46, 101213.
<https://doi.org/10.1016/j.ecoser.2020.101213>
- He, H., Shen, L., Wong, S. W., Cheng, G., & Shu, T. (2023). A “load-carrier” perspective approach for assessing tourism resource carrying capacity. *Tourism Management*, 94, 104651. <https://doi.org/10.1016/j.tourman.2022.104651>
- Hussain, A., Sarangi, G. K., Pandit, A., Ishaq, S., Mamnun, N., Ahmad, B., & Jamil, M. K. (2019). Hydropower development in the Hindu Kush Himalayan region: Issues, policies and opportunities. *Renewable and Sustainable Energy Reviews*, 107, 446–461.
<https://doi.org/10.1016/j.rser.2019.03.010>
- Jamal, T., & Dredge, D. (2014). Tourism and community development issues. *R. Sharpley and D. Telfer, Tourism and Development. Concepts and Issues, Second Edition*. London: Channel View, 2014, 178-204.
- Jefferies, B. E. (1982). Sagarmatha National Park: The Impact of Tourism in the Himalayas. *Ambio*, 11(5), 274–281.
- Katircioglu, S. T. (2014). International tourism, energy consumption, and environmental pollution: The case of Turkey. *Renewable and Sustainable Energy Reviews*, 36, 180–187.
<https://doi.org/10.1016/j.rser.2014.04.058>

- Katircioglu, S. T., Feridun, M., & Kilinc, C. (2014). Estimating tourism-induced energy consumption and CO₂ emissions: The case of Cyprus. *Renewable and Sustainable Energy Reviews*, 29, 634–640. <https://doi.org/10.1016/j.rser.2013.09.004>
- Katsoulakos, N. M., & Kaliampakos, D. C. (2016). Mountainous areas and decentralized energy planning: Insights from Greece. *Energy Policy*, 91, 174–188. <https://doi.org/10.1016/j.enpol.2016.01.007>
- K C, A., & Thapa Parajuli, R. B. (2015). Climate Change and Its Impact on Tourism in the Manaslu Conservation Area, Nepal. *Tourism Planning & Development*, 12(2), 225–237. <https://doi.org/10.1080/21568316.2014.933122>
- KC, R., Giri, I., & Khadka, U. (2021). Climate change and possible impacts on travel and tourism sector. *Journal of Tourism and Himalayan Adventures*, 3(1), 54-62. <https://doi.org/10.3126/jtha.v3i1.39117>
- Khan, I., & Hou, F. (2021). The dynamic links among energy consumption, tourism growth, and the ecological footprint: The role of environmental quality in 38 IEA countries. *Environmental Science and Pollution Research International*, 28(5), 5049–5062. <https://doi.org/10.1007/s11356-020-10861-6>
- Lea, J. (1988). *Tourism development in the Third World*. London: Routledge
- Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. *Nature climate change*, 8(6), 522-528.
- Martin, B. S., & Uysal, M. (1990). An examination of the relationship between carrying capacity and the tourism lifecycle: Management and policy implications. *Journal of Environmental Management*, 31(4), 327–333. [https://doi.org/10.1016/S0301-4797\(05\)80061-1](https://doi.org/10.1016/S0301-4797(05)80061-1)
- Mattle, B. (1999). “Dynamik in Der Entwicklung von Lodgbetrieben, Energieverbrauch Und Arbeitsplätzen 1997 - Everest Nationalpark, Khumbu, Nepal”. Universität Bern.
- Milupi, I. D., Somers, M. J., & Ferguson, W. (2017, August 1). *A REVIEW OF COMMUNITY-BASED NATURAL RESOURCE MANAGEMENT*. | *Applied Ecology & Environmental Research* | EBSCOhost. https://doi.org/10.15666/aer/1504_11211143
- Mukwada, G. & Mutana S. (2018). Mountain-route tourism and sustainability. A discourse analysis of literature and possible future research. *Journal of Outdoor Recreation and Tourism*, 24, 59 – 65. <https://doi.org/10.1016/j.jort.2018.08.003>

- Nepal, R., Irsyad, I., & Nepal, S. (2019). Tourist arrivals, energy consumption, and pollutant emissions in a developing economy-implications for sustainable tourism. *Tourism Management* 72(1). 145 – 154. <https://doi.org/10.1016/j.tourman.2018.08.025>
- Nepal, S. K. (2008). Tourism-induced rural energy consumption in the Annapurna region of Nepal. *Tourism Management*, 29(1), 89–100. <https://doi.org/10.1016/j.tourman.2007.03.024>
- Nepal, S. K., & Chipeniuk, R. (2005). Mountain Tourism: Toward a Conceptual Framework. *Tourism Geographies*, 7(3), 313–333. <https://doi.org/10.1080/14616680500164849>
- Nepal, S. (2022a). Tourism impacts – past trends and future trajectories. In Ioannides, D. & Stoffelen, A. (eds.) *Handbook on Tourism Impacts – Social and Environmental Perspectives*. Edward Elgar, pp. 20-34. <https://tasc-dr.squarespace.com/relevant-publications-1>
- Nepal, S. K. (2022b). The Quest for Sustainable Tourism in Nepal. *Current History*, 121(834), 147–153. <https://doi.org/10.1525/curh.2022.121.834.147>
- Nepal, S. K. (2002). Mountain Ecotourism and Sustainable Development. *Mountain Research and Development*, 22(2), 104–109. [https://doi.org/10.1659/0276-4741\(2002\)022\[0104:MEASD\]2.0.CO;2](https://doi.org/10.1659/0276-4741(2002)022[0104:MEASD]2.0.CO;2)
- Nepal, S.K., Verkoeyen, S. & Karrow, T. (2015). The end of sustainable tourism? Re-orienting the debate. In Hughes, M., Weaver, D. & Pforr, C. (eds), *The practice of sustainable tourism: Resolving the paradox* (pp. 52–65). Routledge
- Nepal, S. K., Kohler, T., & Banzhaf, B. R. (2002). *Great Himalaya: Tourism and the Dynamics of Change in Nepal*. Swiss Foundation for Alpine Research.
- Nepal, S. K. (2015). Irish pubs and dream cafes: Tourism, tradition and modernity in Nepal's Khumbu (Everest) region. *Tourism Recreation Research*, 40(2), 248–261. <https://doi.org/10.1080/02508281.2015.1047625>
- Nepal, S. (2016). Tourism and change in Nepal's Mt Everest region. In H. Richins & J. Hull (Eds.), *Mountain tourism: experiences, communities, environments, and sustainable futures* (pp. 270-280). CAB Publications.
- Nepal, S. K. (2000). Tourism in protected areas: The Nepalese Himalaya. *Annals of Tourism Research*, 27(3), 661–681. [https://doi.org/10.1016/S0160-7383\(99\)00105-X](https://doi.org/10.1016/S0160-7383(99)00105-X)

- Nepal, S. (2005). Tourism and Remote Mountain Settlements: Spatial and Temporal Development of Tourist Infrastructure in the Mt. Everest Region, Nepal. *Tourism Geographies*, 7(2), 205-227. <https://doi-org.proxy.lib.uwaterloo.ca/10.1080/14616680500072471>
- Ngwira, P. M., Mbaiwa, J. E., & Kolawole, O. D. (2013). *Community based natural resource management, tourism and poverty alleviation in southern Africa: What works and what doesn't work*. Chinese Business Review, 12(12), 789-806. <https://ubrisa.ub.bw/handle/10311/1315>
- Palomo, I. (2017). Climate change impacts on ecosystem services in high mountain areas: a literature review. *Mountain Research and Development*, 37(2), 179-187. <https://doi.org/10.1659/MRD-JOURNAL-D-16-00110.1>
- Paudel, T., Li, W., Tiwari, S., & Dhakal, T. (2023). Exploring the Influencing Factors and Arrival Patterns of Inbound Tourism in Nepal. *Tourism Planning & Development*, 22(3), 408-427. <https://doi-org.proxy.lib.uwaterloo.ca/10.1080/21568316.2024.2357287>
- Proietti, S., Sdringola, P., Castellani, F., Astolfi, D., & Vuillermoz, E. (2017). On the contribution of renewable energies for feeding a high altitude Smart Mini Grid. *Applied Energy*, 185, 1694–1701. <https://doi.org/10.1016/j.apenergy.2015.12.056>
- Sacareau, I. (2009). Changes in environmental policy and mountain tourism in Nepal. *Revue de Géographie Alpine*, 97(97–3). <https://doi.org/10.4000/rga.1031>
- Sagarmatha National Park. (2016). *Management plan: Sagarmatha National Park and its Buffer Zone 2016–2020*. SNP, Ministry of Forests and Soil Conservation, Department of National Parks and Wildlife Conservation, Government of Nepal.
- Scott, C., Khaling, S., Shrestha, P., Riera, F. S., Choden, K., & Singh, K. (2023). Renewable electricity production in mountain regions: toward a people-centered energy transition agenda. *Mountain Research and Development*, 43(1), A1-A8. <https://doi.org/10.1659/MRD-JOURNAL-D-21-00062>
- Scott, D., Jones, B., & Konopek, J. (2007). Implications of climate and environmental changes for nature-based tourism in the Canadian Rocky Mountains: a case study of Waterton Lakes National Park. *Tourism Management*, 28(2), 570-579. <https://doi.org/10.1016/j.tourman.2006.04.020>

- Scott, D., & Gössling, S. (2021). Destination net-zero: What does the international energy agency roadmap mean for tourism? *Journal of Sustainable Tourism*, 30(1), 14–31. <https://doi.org/10.1080/09669582.2021.1962890>
- Schmeller, D. S., Urbach, D., Bates, K., Catalan, J., Cogălniceanu, D., Fisher, M. C., Friesen, J., Füreder, L., Gaube, V., Haver, M., Jacobsen, D., Le Roux, G., Lin, Y.-P., Loyau, A., Machate, O., Mayer, A., Palomo, I., Plutzer, C., Sentenac, H., ... Ripple, W. J. (2022). Scientists' warning of threats to mountains. *Science of The Total Environment*, 853, 158611. <https://doi.org/10.1016/j.scitotenv.2022.158611>
- Schorner, B. (2010). Sustainable mountain tourism development illustrated in the case of Switzerland. *SPNHA Review*, 6(1). 88 – 108. Available at <https://scholarworks.gvsu.edu/spnhareview/vol6/iss1/7>
- Selvanathan, E. A., Jayasinghe, M., & Selvanathan, S. (2021). Dynamic modelling of inter-relationship between tourism, energy consumption, CO2 emissions and economic growth in South Asia. *International Journal of Tourism Research*, 23(4), 597–610. <https://doi.org/10.1002/jtr.2429>
- Sgroi, F. (2020). Forest resources and sustainable tourism, a combination for the resilience of the landscape and development of mountain areas. *Science of the Total Environment*, 736. 1-5. <https://doi.org/10.1016/j.scitotenv.2020.139539>
- Shen, Y., Liu, G., Zhou, W., Liu, Y., Cheng H., & Su, X. (2022). Protected areas have remarkable spillover effects on forest conservation on the Qinghai-Tibet Plateau. *Diversity & Distributions*, 28(12), 2944-2955. <https://doi.org/10.1111/ddi.13466>
- Spoon, J. (2012). Tourism, persistence, and change: Sherpa spirituality and place in Sagarmatha (Mount Everest) National Park and Buffer Zone, Nepal. *Journal of Ecological Anthropology*, 15(1), 41-57. <https://doi.org/10.5038/2162-4593.15.1.3>
- Steiger, R., Knowles, N., Pöll, K., & Rutty, M. (2024). Impacts of climate change on mountain tourism: a review. *Journal of Sustainable Tourism*, 32(9), 1984–2017. <https://doi.org/10.1080/09669582.2022.2112204>
- Sun, Y., & Watanabe, T. (2021). Tourism-Related Facility Development in Sagarmatha (Mount Everest) National Park and Buffer Zone, Nepal Himalaya. *Land*, 10(9), Article 9. <https://doi.org/10.3390/land10090925>

- Sun, Y., Nepal, S., & Watanabe, T. (2024). Tourism-generated energy use characteristics and transitions in the Himalayan region of Nepal. *Tourism Geographies*, 26(7), 1111-1133. <https://doi.org/10.1080/14616688.2024.2412542>
- Sun, Y., & Watanabe, T. (2021). Tourism-Related Facility Development in Sagarmatha (Mount Everest) National Park and Buffer Zone, Nepal Himalaya. *Land*, 10(9), Article 9. <https://doi.org/10.3390/land10090925>
- Thornton, P., Ericksen, P., Herrero, M., & Challinor, A. (2014). Climate variability and vulnerability to climate change: a review. *Global Change Biology*, 20(11), 3313-3328. <https://doi-org.proxy.lib.uwaterloo.ca/10.1111/gcb.12581>
- UNESCO. (2024). *Sagarmatha National Park, Nepal*. UNESCO World Heritage Convention. <https://whc.unesco.org/en/soc/4498/>
- United Nations. 2012. The Future We Want: Resolution Adopted by the General Assembly on 27 July 2012 (A/RES/66/288). <https://sustainabledevelopment.un.org/futurewewant.html> accessed on June 4, 2024.
- United Nations. 1993. Earth Summit Agenda 21: The United Nations Programme of Action from Rio. New York, NY: United Nations.
- United Nations. (2015). Transforming our world: the 2030 agenda for sustainable development. Resolution adopted by the General Assembly on 25 September 2015. <https://documents.un.org/doc/undoc/gen/n15/291/89/pdf/n1529189.pdf?token=UjX4EVh0PPBSR60P92&fe=true>
- Wehrli, A. (2014). Why Mountains Matter for Sustainable Development. *Mountain Research and Development*, 34(4), 405–409. <https://doi.org/10.1659/MRD-JOURNAL-D-14-00096.1>
- World Bank Group. (2025). *International tourism, number of arrivals*. Retrieved from: <https://data.worldbank.org/indicator/ST.INT.ARVL?end=2020&start=1997>
- World Travel & Tourism Council. (2024). *Economic impact research*. Retrieved from: <https://wttc.org/research/economic-impact>

Appendix A: 2024 Survey

KHUMBU LODGE SURVEY 2024

1. General Information

1.1 Date of survey and of interview:

1.2. Name of place/village:

1.3. Altitude of place/village:

1.4. Name of Lodge:

1.5. Year when lodge was built:

1.6. Is the lodge owned or rented?

2. Specific Information

2.1. Who runs the lodge: the owner (and his family) __; external persons (e.g. employed manager) __?

2.2. Does the person who runs the lodge, own it or do they rent it? If rented, who owns it?
Are they local?

2.3. In either case: how many people work at the lodge?

	No. of members of the lodge-running family	No. of other people (employed)	If other people employed: from which District in Nepal, do they come from?
Men			
Women			
Total			

2.4. How many rooms are available to tourists in the lodge?

2.5. Are dormitory style rooms available in the lodge?

2.6. What is the number of beds/sleeping places in your lodge in total, and how many of them are occupied on average, in the main tourist season?

	Total number of beds/sleeping places	Thereof occupied in Spring tourist season	Thereof occupied in Fall tourist season
In single rooms			
In double rooms			
In dormitory room (if available)			
Total			

2.7. Does the lodge have (one or several) showers: yes __, no __?

2.8. If answered yes to previous question, what is the heating source for the shower?

3. Specific information to be collected from each lodge on resource and energy use (in main tourist season)

3.1. What resources are primarily used in the lodge?

- Water
- Firewood
- Animal dung
- Kerosene
- Solar panels
- Electricity
- Liquid petroleum gas (LPG)
- Hydropower
- Biogas
- Any other sources please list

3.2. When was the village electrified?

3.3. How many litres of water do you use per day ____ liters/day?

3.4. How many kg's of firewood do you use per day ____ kg/day?

3.5. How many kg's of animal dung do you use per day ____ kg/day?

3.6. How many litres of kerosene do you use per day ____ litres/day?

3.7. How many watts of electricity do you use per day ____ watts/day?

3.8. How many kilograms of LPG do you use per day ____ kg/day?

3.9. How many m³ of biogas do you use per day ____ m³/day?

List daily measurement of any other energy sources not included in questionnaire.

3.10. Do you use solar panels to generate hot water?

3.11. What source of energy do you use to generate hot water for showers?

3.12. What source of energy do you use to generate hot water for cooking?

Appendix B: 2011 Survey

KHUMBU LODGE SURVEY 2011

1. General Information

1.1 Date of survey and of interview:

1.2. Name of place/village:

1.3. Altitude of place/village:

1.4. Name of Lodge:

1.5. Year when lodge was built:

2. Specific Information

2.1. Who runs the lodge: the owner (and his family) __; external persons (e.g. employed manager) __?

2.2. In either case: how many people work at the lodge?

	No. of members of the lodge-running family	No. of other people (employed)	If other people employed: from which District in Nepal do they come from?
Men			
Women			
Total			

2.3. What is the number of beds/sleeping places in your lodge in total, and how many of them are occupied on average, in the main tourist season?

	Total number of beds/sleeping places	Thereof occupied in main season
In single rooms		
In double rooms		
Total		

2.4. Does the lodge have (one or several) showers: yes __, no __?

3. Specific information to be collected from each lodge on resource and energy use (in main tourist season)

3.1. How many litres of water do you use per day ____ liters/day?

3.2. How many kg's of firewood do you use per day ____ kg/day?

3.3. How many kg's of animal dung do you use per day ____ kg/day?

3.4. How many litres of kerosene do you use per day ____ litres/day?

3.5. Do you use solar panels to generate hot water?

What other sources of energy do you use in your lodge in the main tourist season?

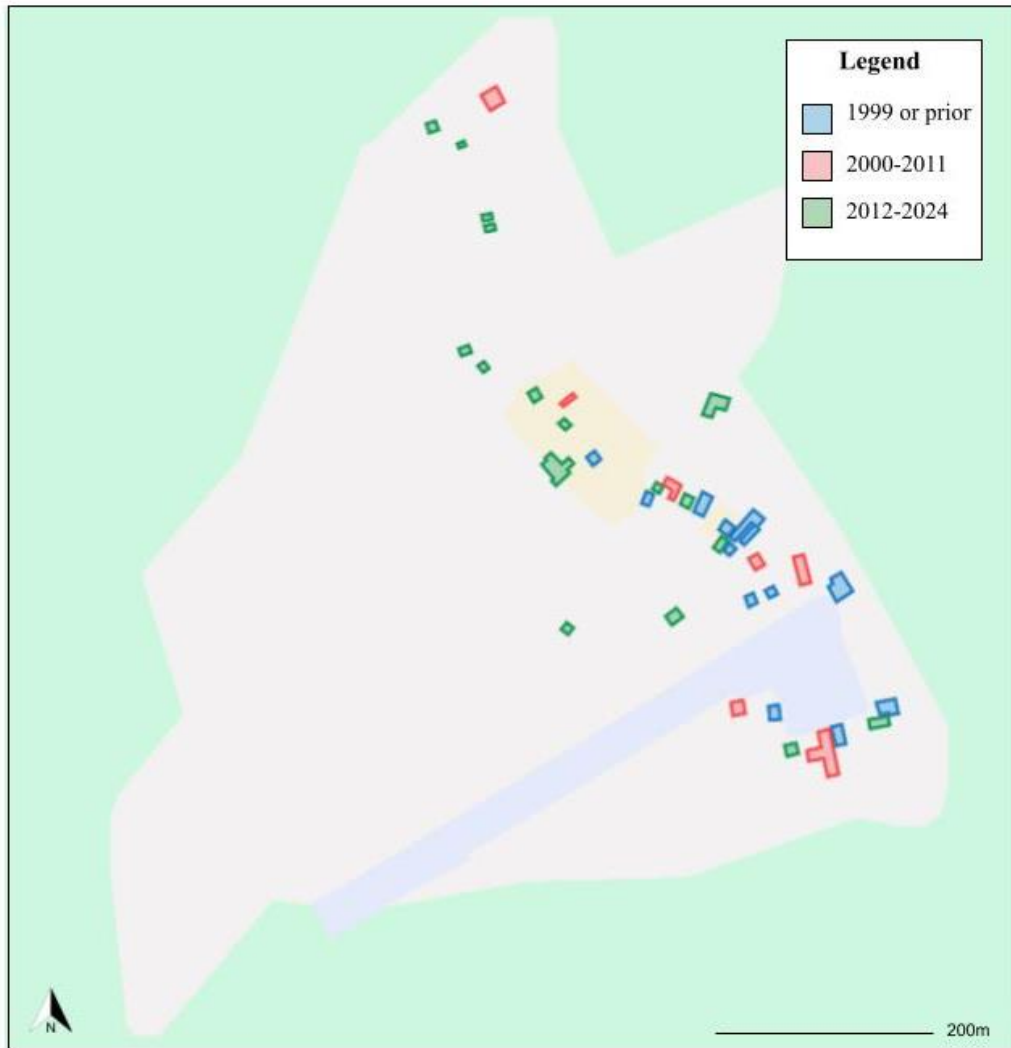
3.6. Electricity from hydropower

3.7. Electricity from solar panel

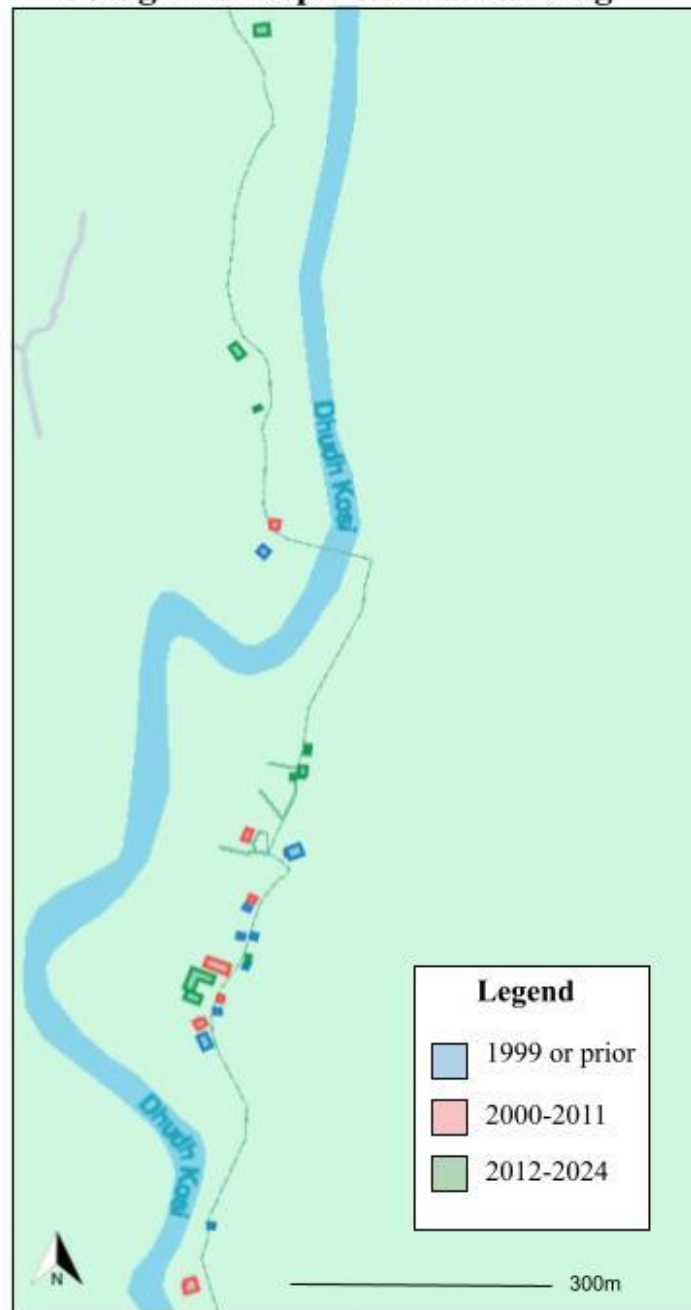
3.8. Biogas/other sources of energy

Appendix C: Lodge Distribution Maps

Lodge Development in Lukla



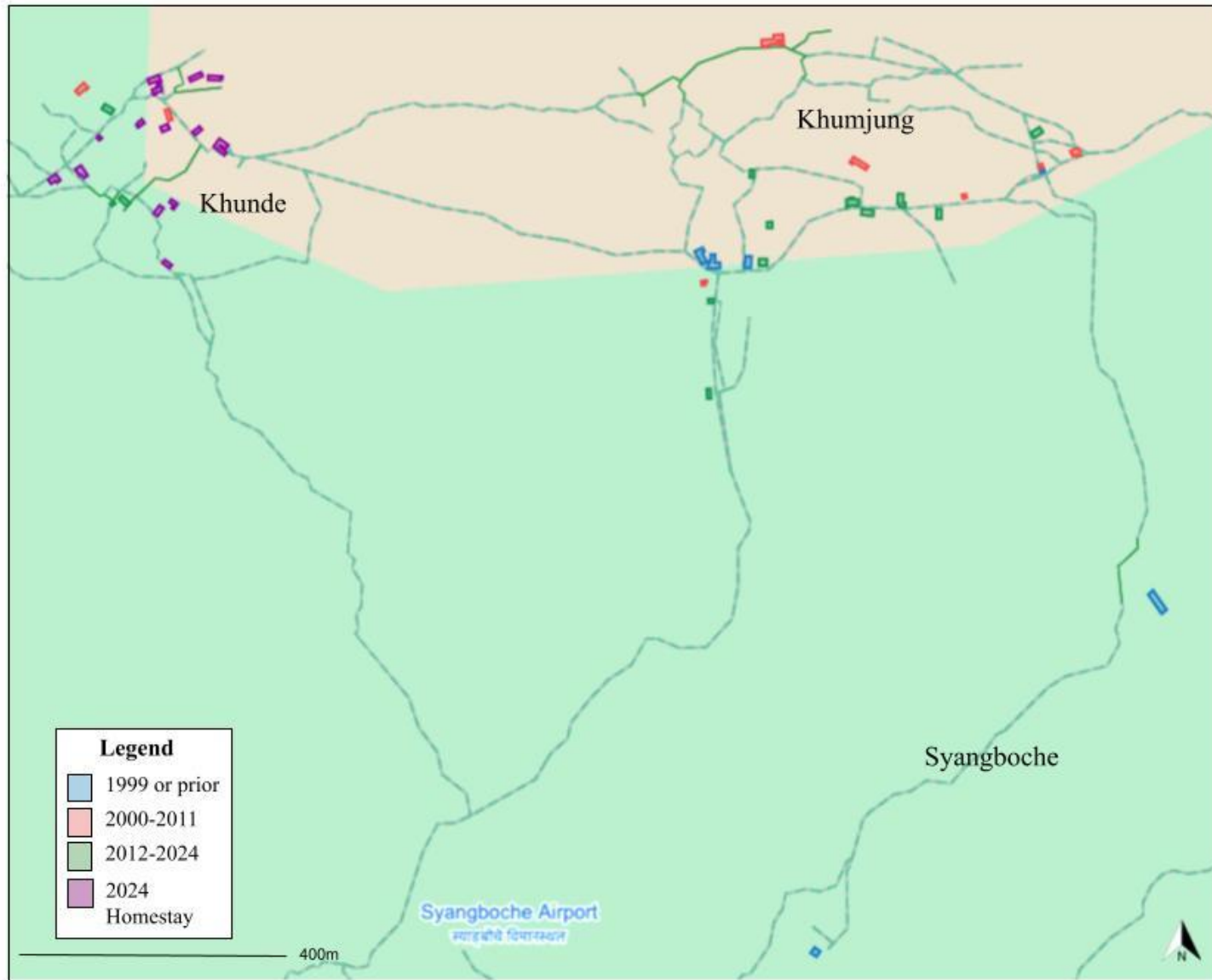
Lodge Development in Phakding



Lodge Development in Namche



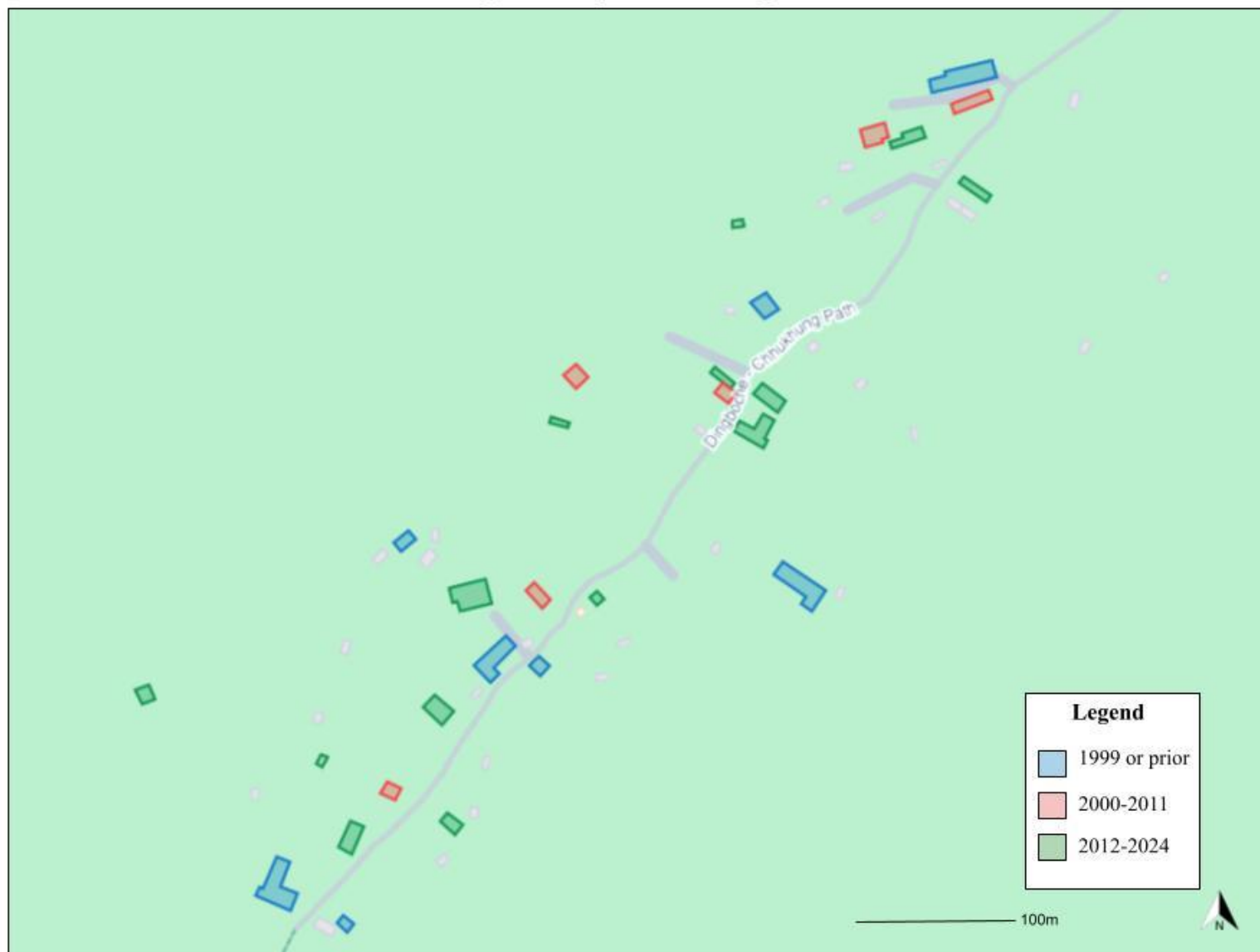
Lodge Development in Khumjung, Khunde & Syangboche



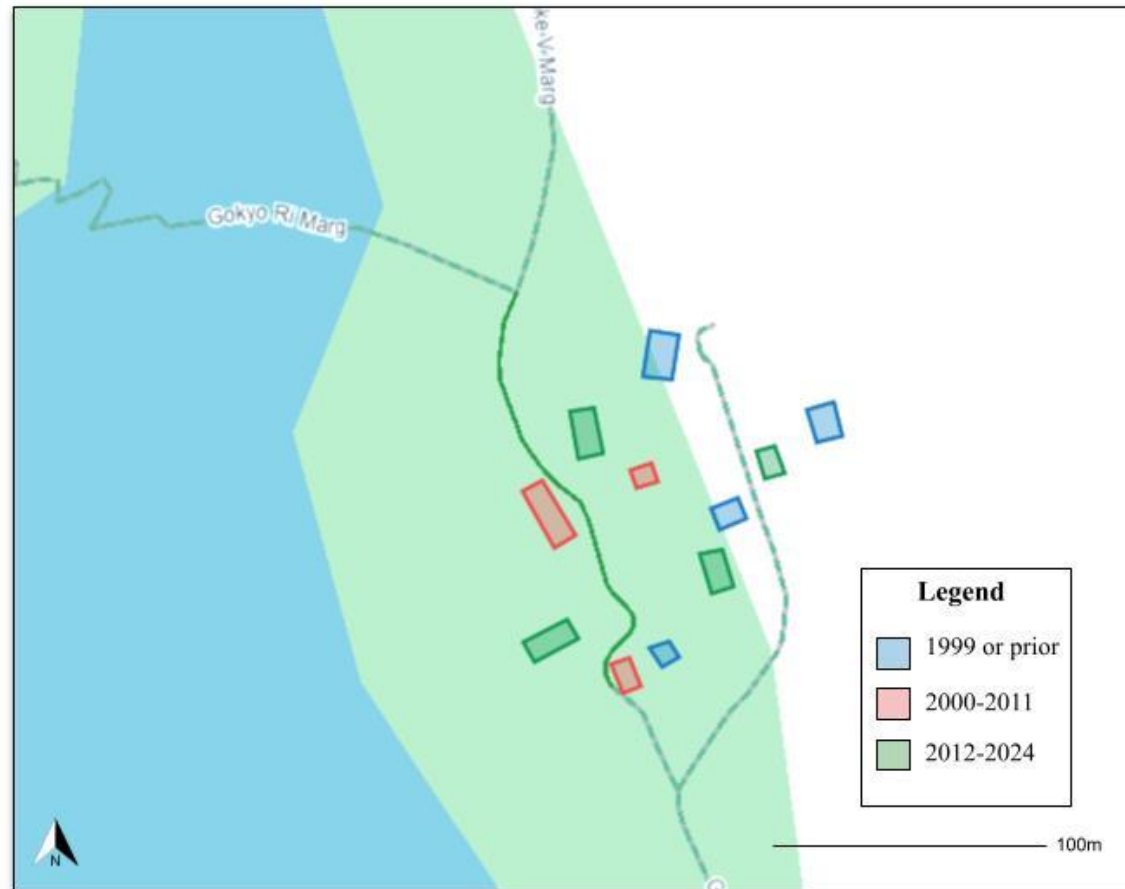
Lodge Development in Pangboche



Lodge Development in Dingboche



Lodge Development in Gokyo



Lodge Development in Thame

