Chapter

# The Relationship between Land Use and Climate Change: A Case Study of Nepal

*Pawan Thapa*

## Abstract

Land Use and Climate change are interrelated to each other. This change influences one another at various temporal and spatial scales; however, improper land uses are the primary causal factor on climate change. It studies relevant literature and Nepal's case to assess the relationship between land use and climate change. Similarly focuses on how land-use impacts climate change and vice versa. In recent centuries land-use change significant effects on ecological variables and climate change. Likewise, understanding the research on both topics will help decision-makers and conservation planners manage land and climate.

**Keywords:** Land-use (LU), Climate Change, Review, Relationship

## 1. Introduction

During the few decades, land use and climate changes are two major global issues, and proper research highly demands finding their relationships and impacts for the future. However, the causes and consequences of human-induced climate change and land-use activities have rarely study independently earlier [1–3]. Researchers and stakeholders understand that these are closely linked to affect each other [4–6]. Begin comprehensive research on land use as one of the causal factors for climate change and vice versa. A concerted multidisciplinary effort needs to study this process, including socioeconomic and natural science [7, 8].

Land-use change is a process by which human activities transform the natural landscape. It refers to how the land used had transformed economic activities [9, 10]. Land-use change is responsible for increases in the human population, deforestation, food types, and demand for energy and fiber. Climate change involves global warming, precipitation, natural disasters like floods, storms, and droughts [11, 12]. Land-use impacts climate through deforestation and rapid population growth, whereas climate change impacts land use through unpredictable heavy rainfall and increasing temperature. The climate change effects on land use perceived by land use altered and land management strategies to mitigate climate change's adverse effects. For example, climate change affects crop production, which leads to land-use change. Both changes in driving forces vary in time and space. Land-use change (LUC) is fundamental to global adjustment that directly influences climate change. This review current practices in assessing land-use change related to climate change [13, 14].

Developing countries are the most affected by changes in climate and land use. They cannot prevent and respond to its impacts due to a lack of multiple factors

[7, 15, 16]. That increases devastating impacts and the rise of vulnerable groups on communities. Around 2030, climate change will affect the poorer significantly by rising death rate, malnutrition, tropical diseases, and urban heat stress [17–20]. Also, climate and land-use change contribute to natural disasters. Several studies justify this impact significantly by developing countries while limited resources, technology, and budget for combating and resilience.

## 2. Land-use effects on climate change

Humans have to change the land cover for centuries, but recent change rates are higher than ever [21–24]. Land-use change reflected in land cover change, the main component of Climate change, affects land-use decisions [8, 25–27]. It is pre-dominated by deforestation for cultivated land and then other land-use types like built-up industrial areas. Land use and land-cover change (LULCC) impact weather and climate at the synoptic scales and the mesoscale [28]. LULCC study provides essential data support for the research of human activities on environmental change [29–31].

Last three centuries, many developing countries are moving through transition economics, increasing demand for food and energy due to a growing population that has caused deforestation, cropland increased, and urbanization [32]. Several studies in China found that cropland area increased and forest decreased, a similar trend of cropland sharp raised and forest area declined in India, Nepal, and other South Asia [33, 34]. Every country from Asia, Africa, and Europe has faced land-use change due to economic and population growth. Since the past few decades, land-use change impacts on climate. The significant contribution is the precipitation cycle at a local and regional level [25, 35]. Climate change brings unpredictability of rainfall and extreme weather events, which will increase risk in the long term.

## 3. Climate change effects on land use

Climate change adversely impacted food security, terrestrial ecosystems, land degradation, and land use [36, 37]. Similarly, it is a significant driver for land degradation processes, which results in a land-use change. In many lower-latitude regions, yields of some crops (e.g., maize and wheat) have declined. In contrast, in many higher-latitude areas, yields of some plants (e.g., maize, corn, and sugar beets) have increased over recent decades [38]. Deforestation means land surface air temperature has increased from the growth of industries than the global land and ocean temperature [37].

Southeast Asia's wet and dry soil conditions affect climate and the result of alter in land use [39]. Similarly, increasing temperature and precipitation will increase warmer and shorter winters; this changes land-use patterns in many places. Climate change creates stresses on land, risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems [40]. Increasing impacts on land projected under all future regions will face higher risks, while some areas will face risks previously not anticipated [41, 42]. In most cases, the climate response to land use and land-cover change may even exceed the contribution from increasing deforestation and land degradation.

## 4. Case studies on systems for climate change and land use in Nepal

Climate change and improper land use are significant in Nepal. Every year experience changes in temperature and precipitation faster than the global average.

Unplanned urban growth and terrain expose a range of climate risks and water-related disasters. Rapid snow and ice melt in the mountains and heavy rainfall in the foothills during the monsoon season. Around half of the greenhouse gas emits from agriculture, energy, land-use change, forest, and industries [43, 44]. Climate change and unplanned urban growth are severe issues as this placed fourth globally for vulnerability to climate change. Also, it ranked ninth most impacted countries by climate between 1999 and 2018 [45]. More than eighty percent of property loss and lives are related to climate hazards [33, 46–48]. A dependency on agriculture and tourism for income and livelihood made Nepalese people highly sensitive to climate change and land use. The land-use change key drivers of climatic factors are rainfall and temperature.

The map illustrates the Land Surface Temperature (LST) of Nepal of 2020 in **Figure 1**. The Land Surface Temperature (LST) data retrieves at 1 km pixels via a split-window algorithm and at 6 km grids by the day/night algorithm (NASA, Data Products: MODIS Land Surface Temperature (MOD 11), n.d.). The earth science data type for MODIS LST is MOD11A2 of an eight-day compositing period. It provides values at a per-pixel basis at 500 meters (m) spatial resolution [49]. It shows the highest with 34.1 for the majority party on the middle and lower part, i.e., Hilly and Terai regions of Nepal, whereas a lower value of −16.1 on the upper area, the Himalayan part. Low vegetation due to either snow cover or glaciers. Therefore, the slight variation in the surface temperature and driving factors are rapid increases in urbanization, the land cover by impervious land surfaces such as concretes. Land cover change can alter the thermal properties and surface radiation, which varies the urban area's humidity [50, 51]. Higher elevation is one factor in the spatial variation of temperature [52, 53]. The result shows the temperature decreases from the north direction (**Figure 1**).

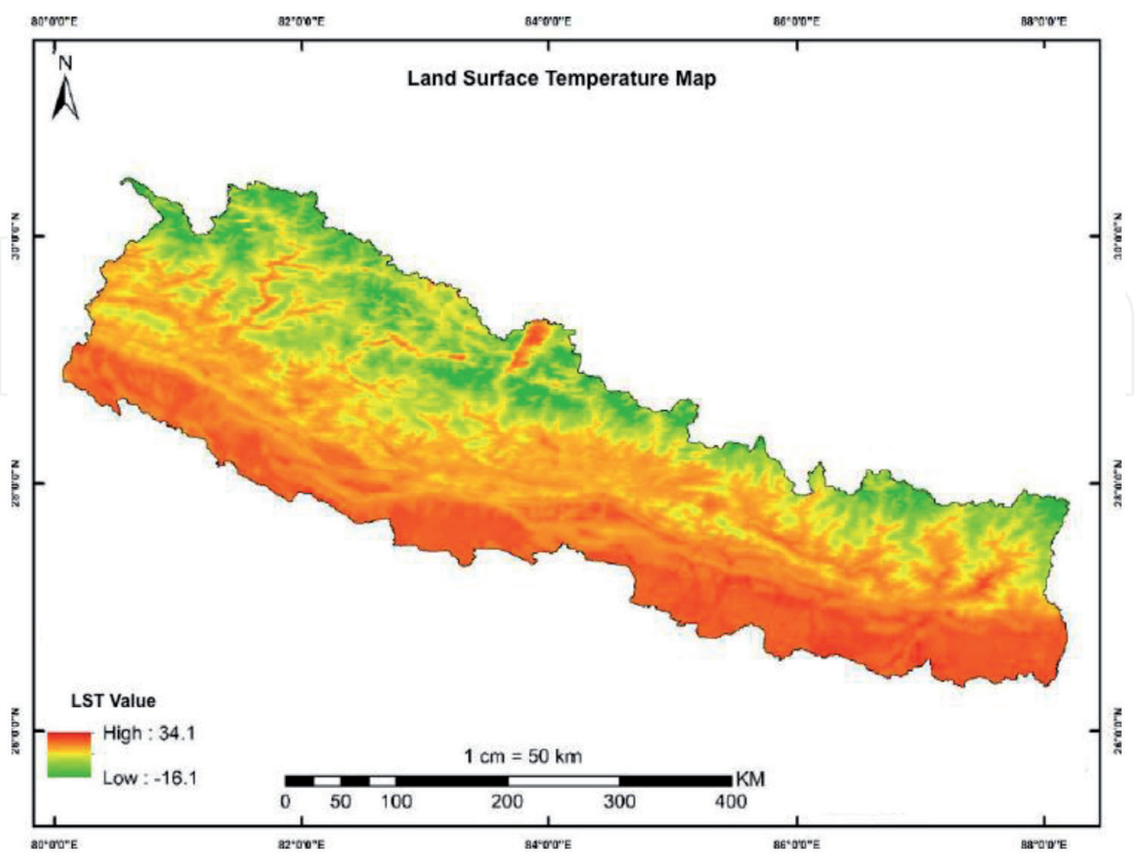


**Figure 1.**
*Map of land surface temperature (LST) of Nepal.*

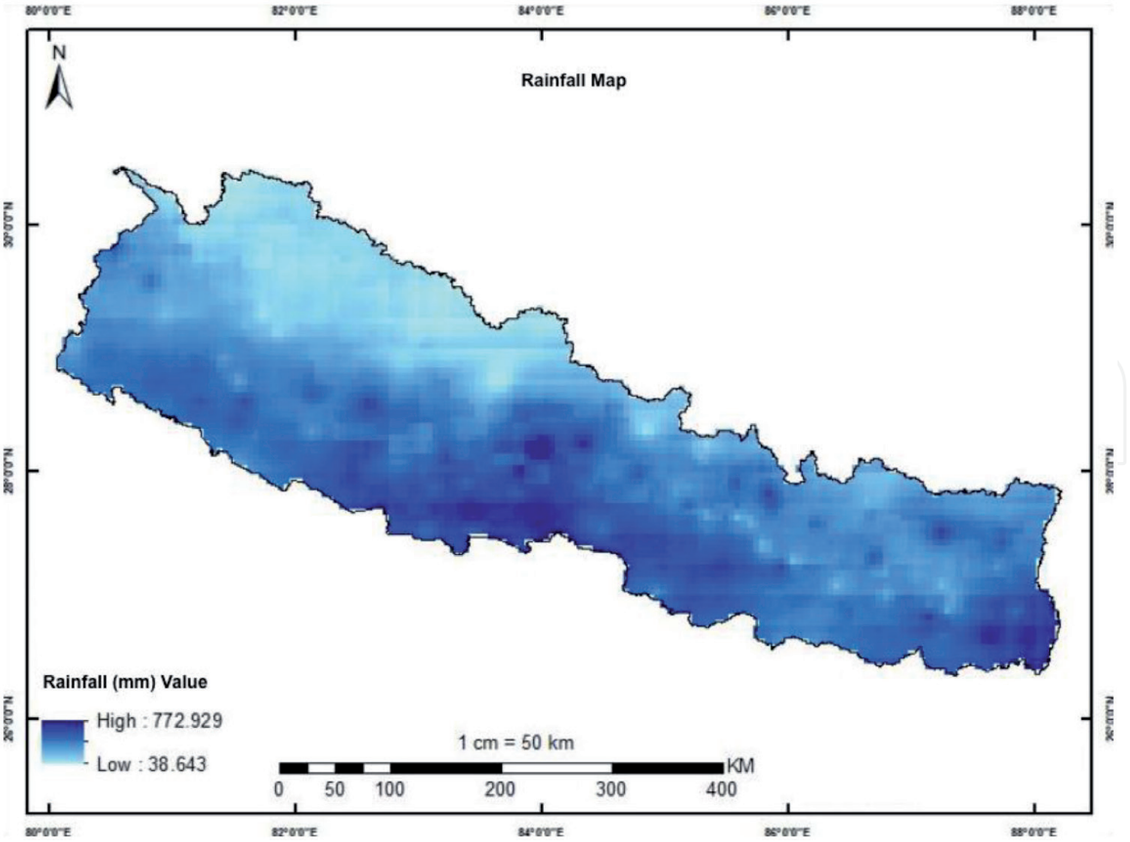


**Figure 2.**
*Map of rainfall of Nepal.*

Monthly Rainfall data apply from Climate Hazard's center InfraRed Precipitation with Station data (CHIRPS). The rainfall extremes are increasing, and the temperature rises in urban areas [54, 55]. There is a significant rise in temperature during summer and lower temperature in winter seasons (**Figure 2**).

The earth science data type for MODIS NDVI is MOD13A2, of a sixteen-day compositing period. It provides Vegetation Index (VI) values at a per-pixel basis at 1 kilometer (km) spatial resolution. The product of 2020 for the entire Nepal. NDVI values also changed significantly in the Kathmandu Valley's central core and outlying areas. The magnitude of change was high in the surrounding areas compared to the valley's core. It shows vegetation decreased significantly over the past two decades and newly developed urban areas (**Figure 3**).

The map global land cover at the 500-meter spatial resolution at annual time step for different land cover legends, from supervised classifications on that map of Spectro-temporal features derived from data from the MODIS. Final land use and land cover map of Nepal prepared (**Figure 4**).

In the year 1993, the growth rise at 2.77 percent and fall at −0.04 percent in 2014. From 2015, there is a gradual growth of population with 0.41 percent that plummeted around four times in 2020. The population growth rate touched 2 percent (**Figure 5**) and remains steady for approximately three decades between 1970 and 1998.

The pie chart shows Land Use Land Cover Change (LULCC) results for 2000 and 2019 (**Figure 6**). In 2000, forest area, agriculture, and built-up area presided land-use types, with 34%, 30%, and 10%, respectively. In contrast, in the year 2019, built-up area, barren area, and commercial area increases, with 16% followed by 9% and 5%, respectively. Landsat seven and eight satellite images acquired with no cloud option on one day: 1 January 2000 and 30 December 2020. LULC pie chart

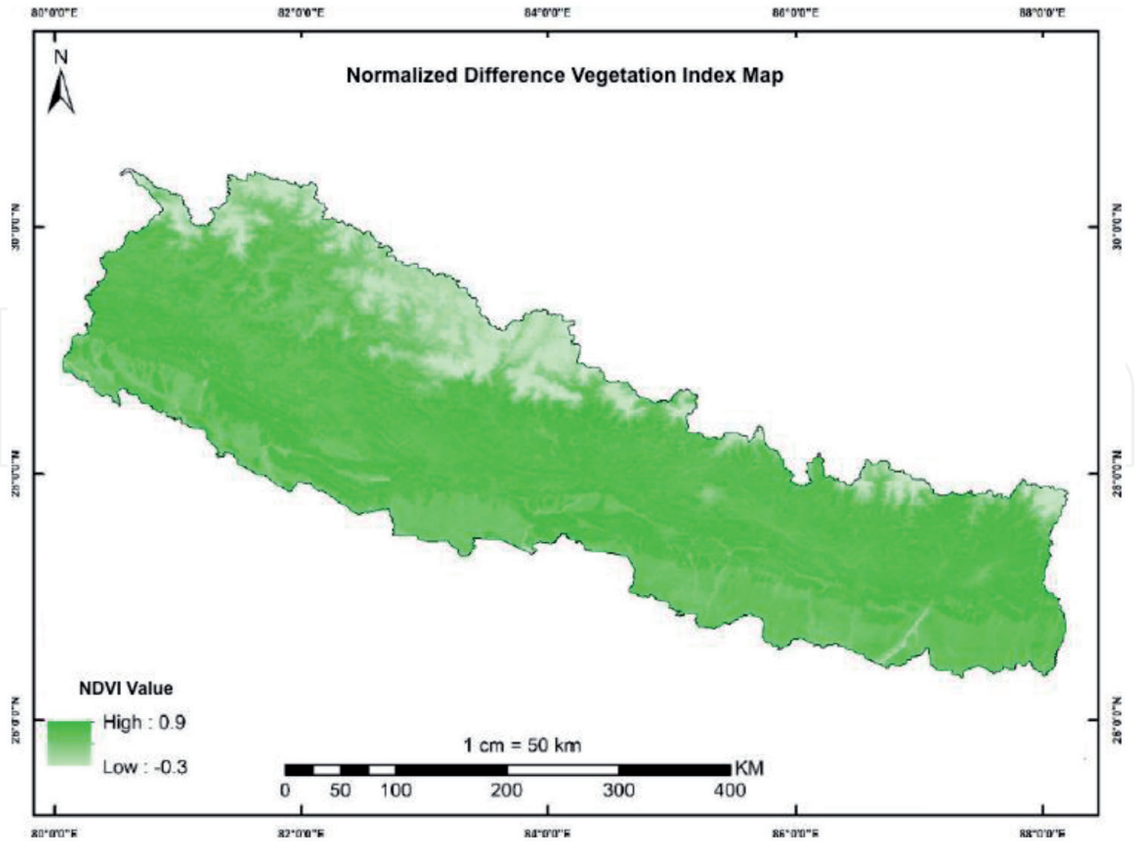


**Figure 3.**
*Map of normalized difference vegetation index (NDVI) of Nepal.*

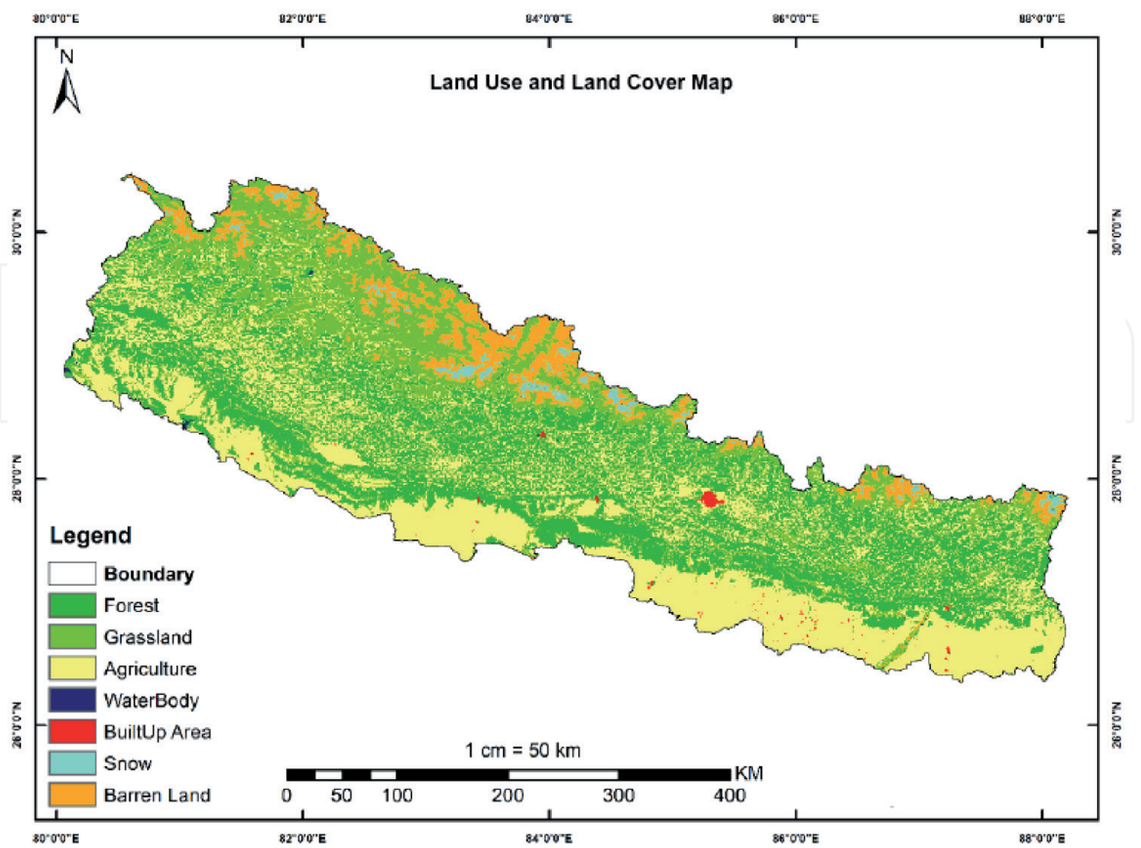


**Figure 4.**
*Map of land use and land cover of Nepal.*

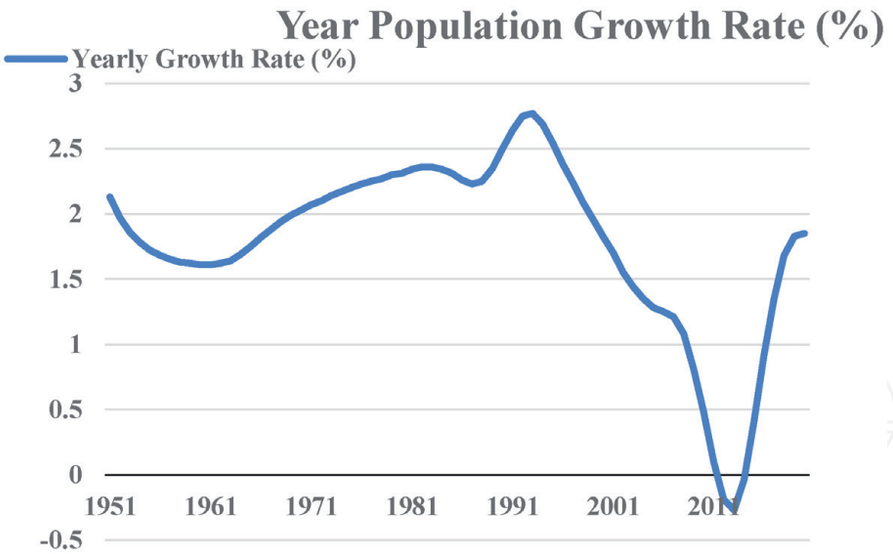


**Figure 5.**
*Line graph of yearly population growth rate (source: Worldometers, 1950 and 2020).*

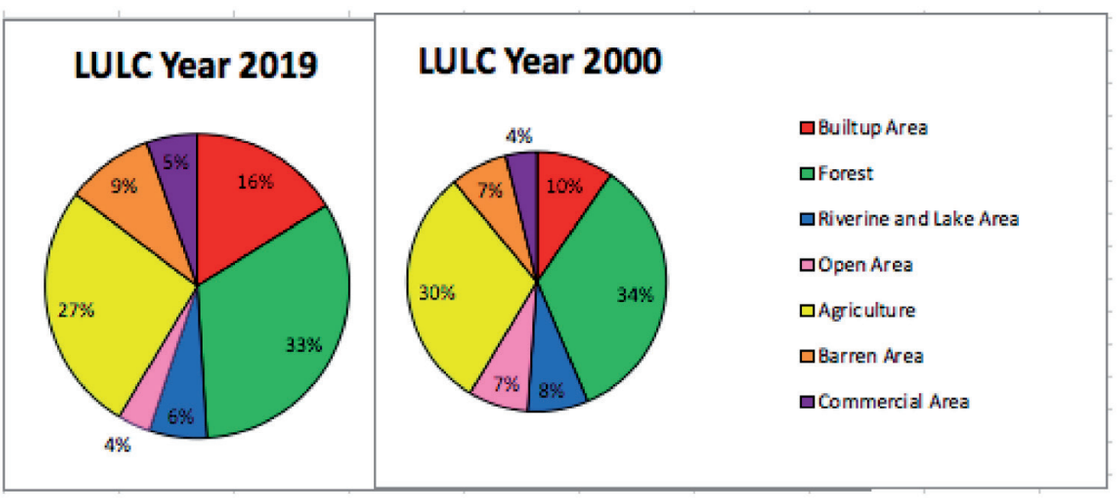


**Figure 6.**
*Pie chart of land use land cover change of 2000 and 2019.*

uses the data extracted from maximum likelihood supervised classification in ArcGIS 10.5. Land use and land cover seven types validate by ground truth samples from Google Earth. The overall accuracy for 2000 and 2019 around 70.93%, and the Kappa coefficients 0.7093.

## 5. Discussion

The relationship shows that both influence each other. It finds land-use change with an increase in significant built-up areas and a gradual decrease in a forest, agriculture, and open areas. It has an unprecedented rate of land use changes over three decades. LST estimates the surface temperature that increases with hot summer and cold winter [56]. MODIS is ideal for monitoring large-scale regional changes in land use and climate change. It can apply at the global or regional scale with a wide spectral range, high temporal resolution, low cost, and real-time [57]. Land Cover implies the physical or natural state of the Earths' surface. Land cover maps represent spatial information on different types (classes) of physical coverage of the Earth's surface, such as forests, grasslands, croplands [58]. It represents how much of a region is

covered by mentioned land cover types. Climate change is a change in temperature and rainfall over three decades and focuses on human influences like land use. One factor of land use and climate change is the human population [1, 3]. Increasing population and urbanization had impacted rapid change in land and climate. According to the research results, Nepal is vulnerable to both changes due to rapid population growth, rainfall and temperature change, land covers, and land-use change [59, 60]. Both changes are comparatively more significant than in other world countries. Climate and land-use change impacts are similar to countries like India, Ethiopia, Bangladesh, Europe, and Africa [61]. Meanwhile, past and present comprehensive LUCC research in Nepal requires driving factors and future prediction.

## 6. Conclusion

The study shows that most studies examine global and regional impacts of land use on climate change. However, several studies take on every scale, such as global, regional, and local, to better understand this complex phenomenon. These studies suggested that proper research and its implementation are needed from every stakeholder to address this situation. The potential for land-related responses and the relative emphasis on adaptation and mitigation is context-specific, including the adaptive capacities of communities and regions. Changes in land conditions, either from land use or climate change, affect global and regional climate. Simple models based on climate change impacts on land use and vice versa will help give initial estimates of their relationship and effects on each other.

## Author details

Pawan Thapa
Department of Geomatics Engineering, Kathmandu University, Nepal

*Address all correspondence to: pawan.thapa@ku.edu.np

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