

# Understanding the relationship between population and land use change in Chure (Siwalik) Region of Western Nepal

Kedar Dahal

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## Author Affiliation:

Associate Professor, Central Department of Geography, Tribhuvan University, Kirtipur, Kathmandu, NEPAL

## Corresponding author:

Kedar Dahal, Ph.D  
Email: kedar.geog@gmail.com

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## ABSTRACT

The Chure region has distinct geographical and biophysical characteristics and lies within the foothills of the Himalayan range. It the youngest mountain chain within the world and suffers from mass erosion, landslides, and alternative environmental issues, that create the region susceptible to degradation of the watershed, lowering of the underground water, and disturbing the ecological niche in and around the region makes more sensitive and fragile. The main purpose of this study is, therefore, to analyses land-use and land-cover change and trace out the relationship between population growth and the local resources in the Chure region during the period 1978-2018 by using maps and images, field observations, and community interactions. Forest is the dominant land-use category. However, over the last three decades, there has been a tremendous change in land use and land cover in the study area. The conversion of dense forest into bushes-shrubs and cultivation has resulted in degraded land in the region. Illegal timber collection, open and uncontrolled grazing, extraction of riverbed deposits, rural road construction, forest fire are major causes of land-use/land-cover change in the study area. Population growth and infrastructure development are also a cause of decreasing forest area in the study area. This analysis shows that the increasing population in the Chure region of western Nepal has not sufficiently affected the local environment (particularly forest coverage and cultivation area).

**Keywords:** chure region, land-use, forestland, cultivation land, population growth

## 1. INTRODUCTION

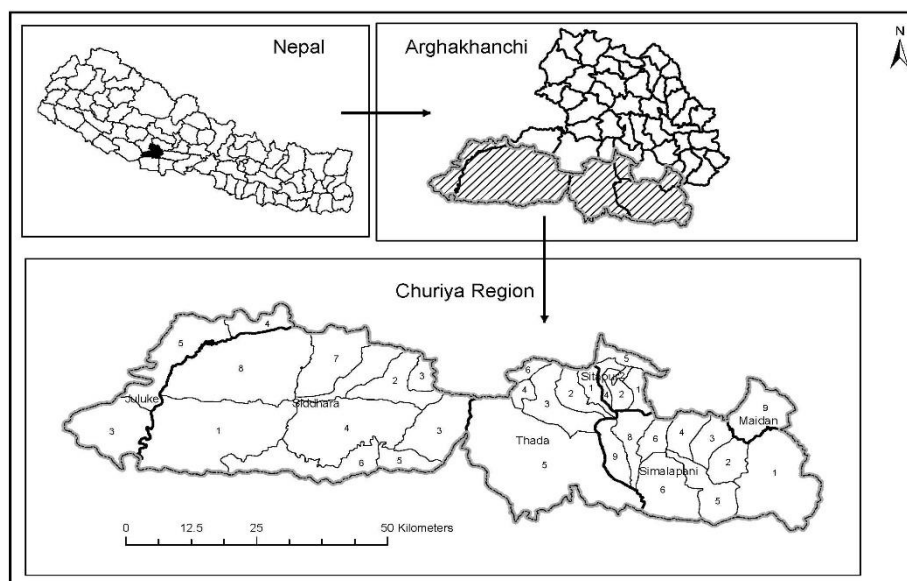
The Chure also called 'Siwalik' is defined as the comparatively low hill terrain stretching from east to west, on the southern flank of the Himalayan range of Nepal. It lies in between the main boundary thrust (MBT) at the southern boundary of the Mahabharat Range (mountain range) and the main frontal thrust (MFT) at the northern boundary of the Tarai (Gangetic plain). The range consists of rock types such as sandstone, mudstone, conglomerate, and some quantities of shale, marl, and clay-stone (GoN, 2015). The region is the youngest in the history of Himalayan evolution is more susceptible to landslides together with flash

floods, debris flows, and inundation compared to other regions. The range consists of hills, steep land slopes, gorges, large spans of temporary streams, and altitude ranges from 120 meters to 1972 meters (GoN, 2015).

Land-use in the Chure range is more dynamic and changing in nature. Forest, shrub, and grassland cover a high proportion of land in Chure that follows agriculture and settlements. In recent years, an excessive excavation of riverbed deposits in and around Chure has brought significant changes in land-use and land-cover patterns. Rampant deforestation has been observed in many areas. There are rapid social and demographic changes due to its locational proximity to municipalities such as Butwal, Shivaraj, Sitganga, etc. Therefore, the main factors that caused land-cover changes from forest to non-forest seem to be driven by urbanization and migration, forest encroachment, illegal logging, grazing, and forest fire (K.C, 2019; Bhattarai, 2008; Suzi, et.al, 2003).

The evidence shows that as household size increases, the demand for new agricultural land outside the forest area grows, causing an increase in deforestation (PAI, 2011). However, people depend on forests to varying degrees based on a number of factors including proximity. The level of dependencies is even greater among some who live in or close to the dense forests (PAI, 2011). A study in the Dang district of Nepal revealed that deforestation occurs because of the effects of different accelerating or decelerating driving forces (Pfaff, 1999; Rudel, 1989 cited in Bhattarai, 2008). Roads and human (re-) settlements, infrastructure development are considered as an accelerating factor (Bhattarai, 2008). However, natural causes, technology advancement (Dull, 2007), and other anthropogenic factors are equally responsible for decreasing the forest area. Encroachment and expansion of settlements have been observed mostly in the lowland, gentle slope, and valleys, whereas it is less noticeable in other areas including ones with higher elevation and steep terrain. People with farms and livestock depend upon forest products for their livelihood. Here, the main objective of the study is to analyze the changes in land use and land cover over the decades in the Chure range, western Nepal.

The study area bounded by the stream the Banganga River in the east and the Rapti River. The study covers the southern belt of Arghakhanchi district, accounts 55,754.91 hectares, which is about 46.74 percent of the district area (DFO, 2011) (Table 1 and Figure 1).



**Figure 1: Location of the Study area (western Chure region)**

**Table 1: Silent Features of the study area (the Chure Region)**

Area	55754.91 Hectare
Geology	Tertiary sandstone, siltstone, shale, conglomerates
Distribution	Southern belt of Arghakhanchi district mostly covered the area of Jaluken, Siddhara, Thada and Simalpani; and partially covered the area of Jukena, Sitapur, Subarnakhal, Patauti, Pokharathok and Maidan.
Elevation	Highest 1493 meter. (Siddhara); and lowest 205 meter. (Simalpani)
Climate	Sub-tropical (with warm temperate in the higher hill spurs)

Vegetation	Saal ( <i>Shorea robusta</i> ), mixed hard wood and pine forest
Rocks and Soil	Quaternary deposits comprising mostly of alluvial and co-alluvial deposits. Sandstone, conglomerates, quartzite, shale, and micaceous sand stone. Drained brown soil, brown soil and red soil are also noticed
Major Settlements	Pawara, Bikramsota, Batheni, Bhangala, Simalpani, Gandhi, Jhirra, Amarain, Thada Daha, Chakala, Tikari, Dhungesera, Siddhara, Lamatal, Ratmata, Jaluke, Tallo Lape
Major River/Streams	Banganga, Bhangala, Kondre, Gudrung, Sit Khola, Sisne, Ransing, Kusum, Ranle, Dhau Khola, Madhur Khola and Rapti River

Source: Ghimire 2006, GoN 2008, Dahal and Pokhrel 2011, Field study 2018

## 2. MATERIALS AND METHODS

The present study is conducted by reviewing the literature, field observation/transect-walk, interaction with the local people, stakeholders, and concerned agencies at the district and local levels. The relevant documents were collected from the Division Forest Office, the District Coordination Committee, and the Sitganga municipality of the Arghakhanchi district. All collected documents have been reviewed, recorded, and cited in the appropriate sections. Land system map (LRMP), Topographical map (topo-sheet)/ geological, and satellite images are used to analyze the time-series data regarding land use and land cover. Interaction with forest officers at the Dohote Range post office had conducted. Landsat Thematic Mapper (TM) at a resolution of 30 meters used for land-use classification/cover classification. The satellite data covering the study area were obtained from the USGS Global Visual Viewer (Source: <http://glovis.usgs.gov>). The data were selected based on the availability of cloud-free satellite scenes during the study period.

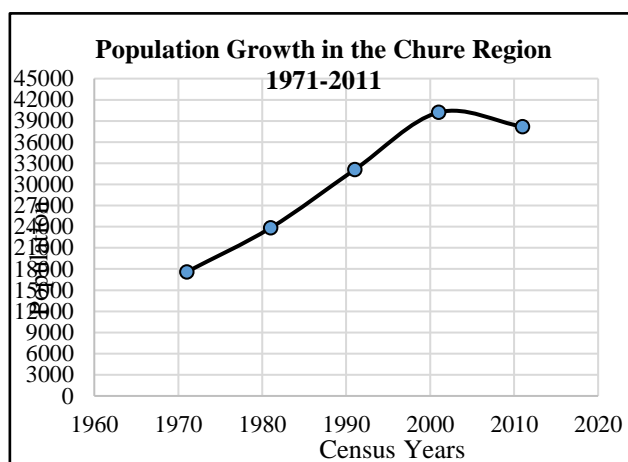
## 3. RESULTS AND DISCUSSION

### Population Growth and Projection

It had been reported that more than 17 percent of dwelling units of Arghakhanchi district were living in the Chure region in 2011(CBS, 2012). Similarly, there were 19.3 percent, 17 percent, 15 percent, and 11 percent population of the total district population recorded in the Chure region in the year 2011, 2001, 1991, and 1971 respectively. Population and households in the Chure region of the study area are given in Table 2 and Figure 2. During the population censuses 1952/54 and 1961, most of the area of the present Chure region was under the Khanchi. The total area under the Khanchi was estimated at 5949.6 square KM, in which 32,757 and 35,826 population was recorded in 1952/54 and 1961 respectively.

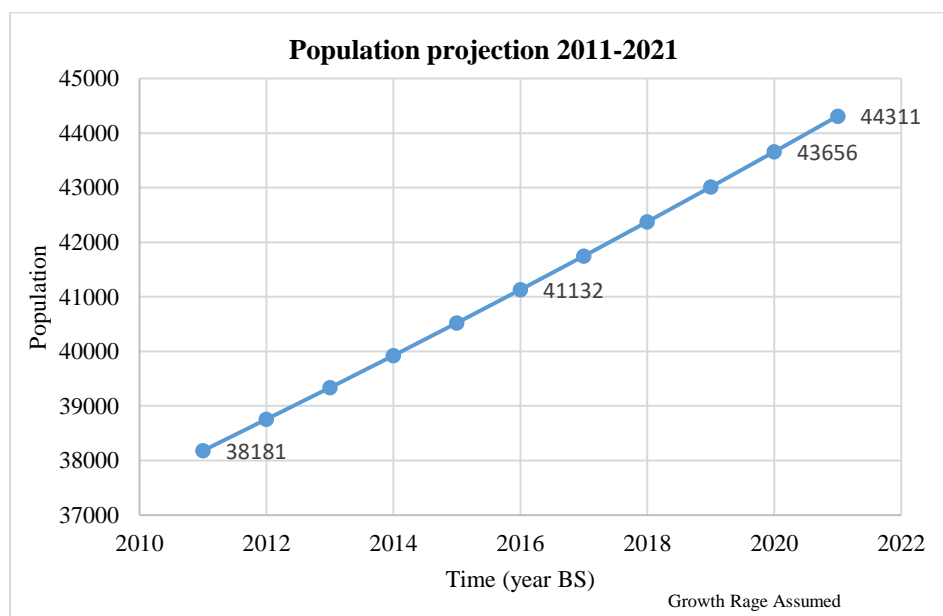
Table 2: Population in the Chure Region of Arghakhanchi District			
Census Year	HH	Population	Average Growth Rate
2011	8104	38181	-0.51
2001	7093	40201	2.28
1991	5694	32078	3.01
1981	3822	23836	3.09
1971	NA	17582	-

As per the population census, 2001 and 2011, the annual population growth rate of Arghakhanchi district was 1.06, while looking at the study area (Chure region), it is estimated that the growth rate was below the district level. On the other hand, most of the study area currently is in the Sitganga municipality, where the population growth rate in the same period was negative e.g.-0.5 percent between 2001-2011, while it was 2.28 percent in the period 1991-2001. It is very difficult to say why the population growth rate has fluctuated in varying census periods, but there has been an intervention programme to discourage migration and settlement in the Chure region in the framework of the national and local government (e.g. President Chure-Terai Madhesh Conservation Development Board 2015, and associated plans and programmes).



**Figure 2: Population Growth in Chure Region**  
Sources: CBS 2011, 2001 1991, 1981, 1971 Kathmandu.

After few years, especially after 2016, most of the area of the Chure region falls under the Sitganga municipality; and field survey, interaction with the local community and the municipal authority revealed that the present rate of population growth will not be constant in the future in the region. There is increasing ridge to valley migration and from the rural to market/urban area migration. Thada, Pokharadanda, Pawara-Bikramsota, Karechuli, Mandre, Deuraligaun, Dhungre, Tikari, Rangsing, Dhi, Lahabeni are major settlement. Thada is the major market of the municipality and the second-largest market center in the district; it was also the district headquarters in the past. The municipality has a direct link with the district headquarter Sandhikharha and other urban centers developed along the east-west highway and easy access to the Indian markets and other hill districts, municipalities, and rural municipalities. Therefore, there is an increasing population in the municipality. Due to the worldwide Corona pandemic, the youth population expected to return to their homeland. In the current road connectivity, increasing urban services and facilities, increasing trade and local business are expected to attract people, goods, and services to the municipality in the coming years. In this context, the population growth rate in the study area will be high, and it is shall be 1.5 percent in the coming years in the study area; and expected that the population in the Chure region shall be 44,311 in 2021 (Figure 3).



**Figure 3: Population projection in the study area 2011-2021**

### Land-Use and Land-Cover Change

Land-use of the Chure region reveals that there has been a drastic change in land-use pattern and has brought many changes in the local environment, different dimensions of natural resource use, and socio-economic transformation over the decades. Forest and

cultivation are the dominant land-use category in the study area. However, in recent years degraded land has been increased significantly in the Chure region (Table 3).

Table 3: Land use and Land Cover Change in the Study area 1978-2018 (in percent)					
SN	Land use categories	1978	1995	2010	2018
1	Cultivated Land	16.16	15.92	19.31	10.74
2	Forest (including bush/shrub land)	81.42	82.18	71.73	87.66
3	Grazing Land	1.71	0.07	-	0.08
4	Sand and Gravels	0.56	1.49	-	0.75
5	Degraded Land	0.15	0.34	8.96	0.78
Total		100.00	100.00	100.00	100.00

Sources: LRMP 1978; Topo-sheet 1995; Landsat Satellite Imagery 2010; DUDBC, 2018 (modified)

Land-use of the Chure experienced considerable changes during the period 1978 to 2018. It has observed that two different stages of change in the period 1978-2018 (Figure 4). First is the stagnation stage, where both cultivated and forest-covered areas have only changed a little bit (or not significantly changed) in the period 1978-1995. The second is the changing stage. This stage shall be categorically divided into two sub-stages; first; accelerating rate of cultivation and deceleration in forest covers in the period 1995-2010; and second, the acceleration rate of forest cover and decelerating in cultivated land in the period 2010-2018.

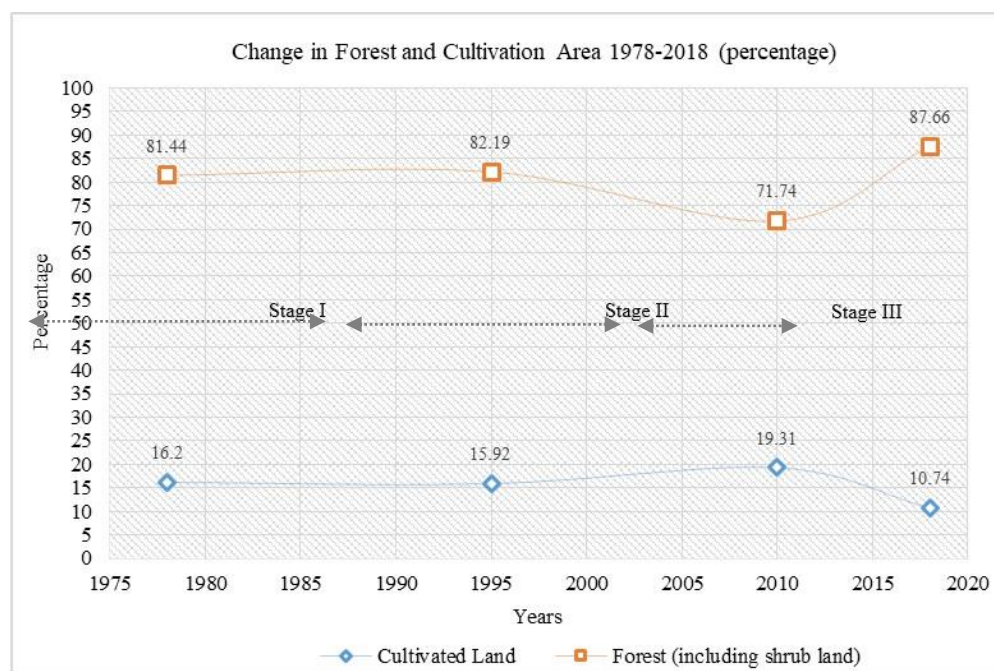


Figure 4: Major Land Use and Land Cover Changes (1978-2018)

Sources: LRMP 1978, Toposheet 1995, Landsat Satellite Imagery 2010, DUDBC, 2018 (modified)

If we look at the historical images and maps of the study area, it is found that there have been considerably changed in land-use/land-cover patterns in the period between 1978- 2010. It has also observed from Table 4 that cultivated land has increased by 3.15 percent, whereas forest area decreased by 9.69 percent. Badlands (cliff, cutting, landslides, eroded land, etc) increased significantly (e.g. 8.81percent) over the last three decades (1978-2010).

Table 4: Land use and Land Cover Change in Chure Region

S N	Land use categories	1978		1995		2010		Change 1978-2010	
		Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent
1	Cultivation	9008.99	16.16	8878.79	15.92	10763.97	19.31	+ 1754.98	+ 3.15

2	Forest (including shrub & bushes)	45394.05	81.42	45821.49	82.18	39994.28	71.73	- 5399.77	- 9.69
3	Grazing	954.51	1.71	37.52	0.07	-	-	-	-
4	Sand and Gravels	312.41	0.56	829.71	1.49	-	-	-	-
5	Badland/ Degraded Land	84.95	0.15	187.40	0.34	4996.66	8.96	+ 4911.71	+ 8.81
<b>Total</b>		<b>55754.91</b>	<b>100.00</b>	<b>55754.91</b>	<b>100.00</b>	<b>55754.91</b>	<b>100.00</b>	-	-

Sources: LRMP 1978; Topo-sheet 1995; Landsat Satellite Imagery 2010

It is evident that the change has largely brought through the land degradation by landslides, soil erosion, and bad extension by the extraction of sand, stone, and gravels (Dahal and Pokhrel, 2011). Population dynamics, method of cultivation, construction of rural roads, and encroachment of forest for farmland, settlement, and illegal trade of forest products reported by local people for rapid change of land-use in the Chure region. Such changes have found mostly in and around Thada, Pokharadanda, Pawara-Bikramsota, Karechuli, Mandre, Deuraligaun, Dhungre, Tikari, Rangsing, Dhi, Lahabeni villages. Land-use change in the Chure region in the period 1995-2010 has also presented in Figures 5, 6, and 7.

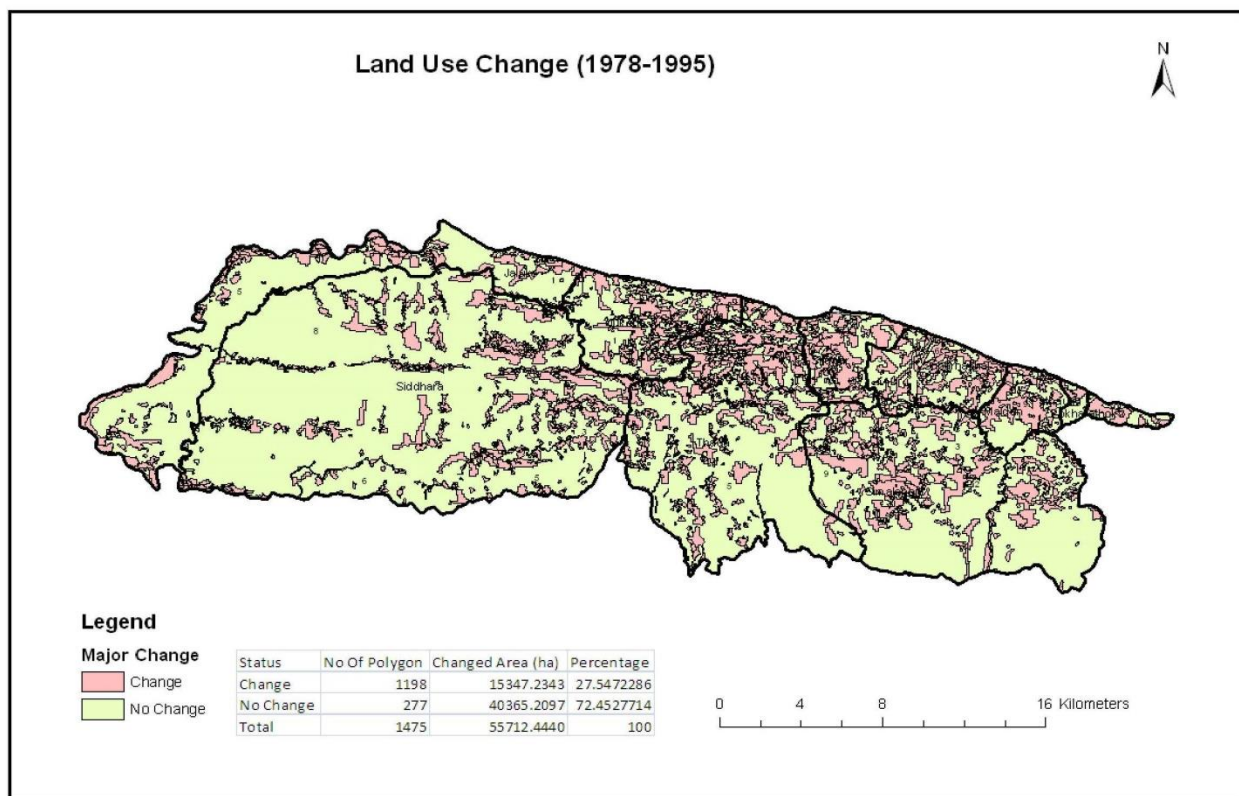


Figure 5: Land Use and Land Cover Changes (1978-1995)

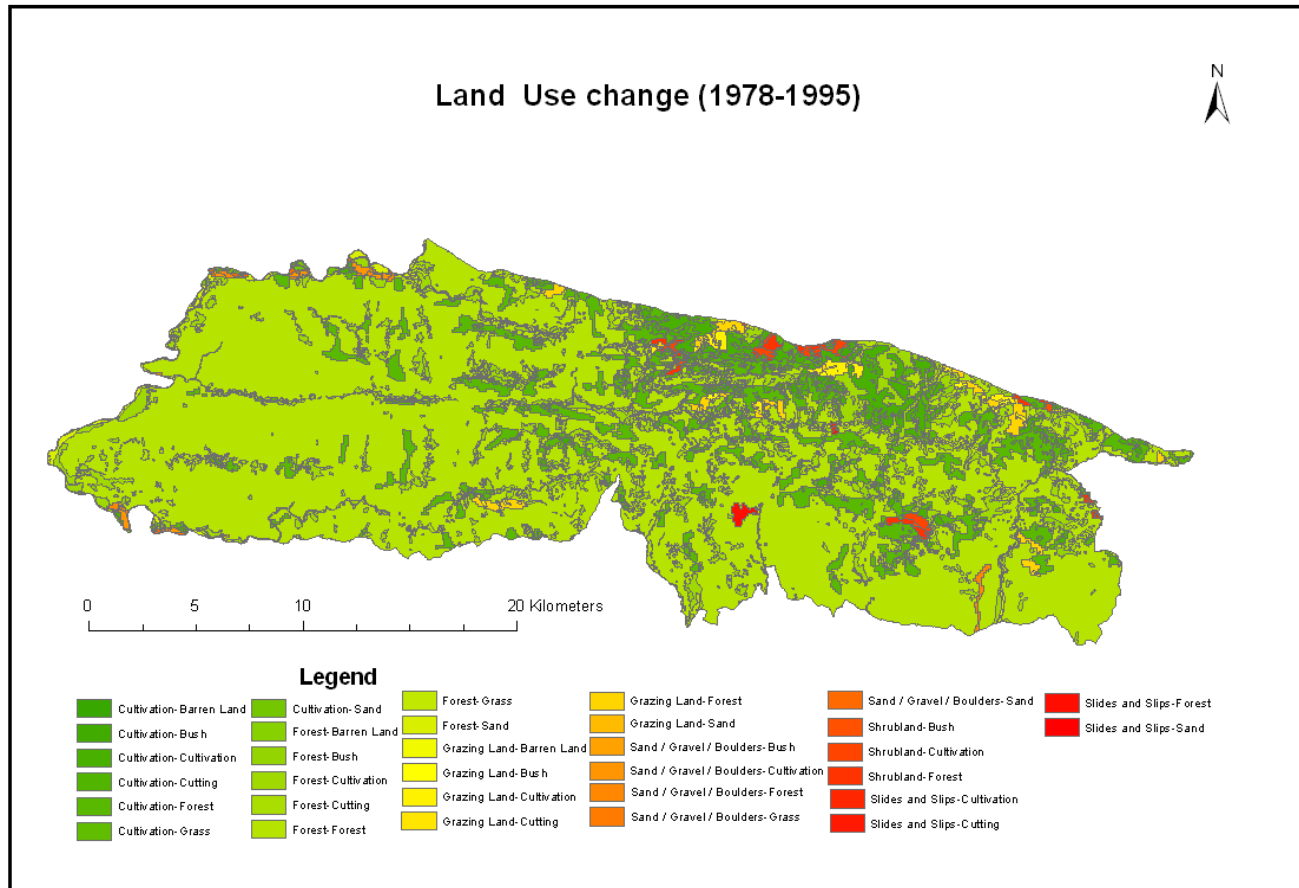


Figure 6: Conservation of Land Use and Land Cover (1978-1995)

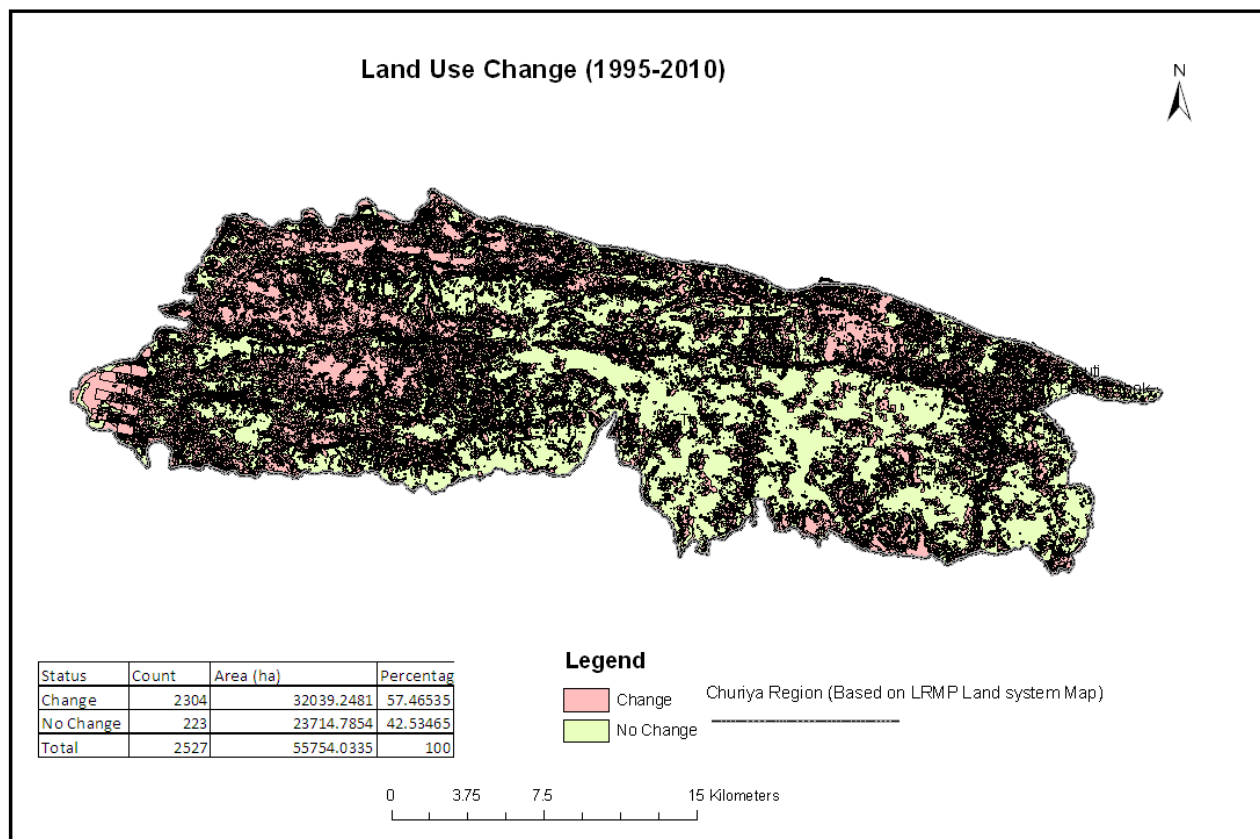
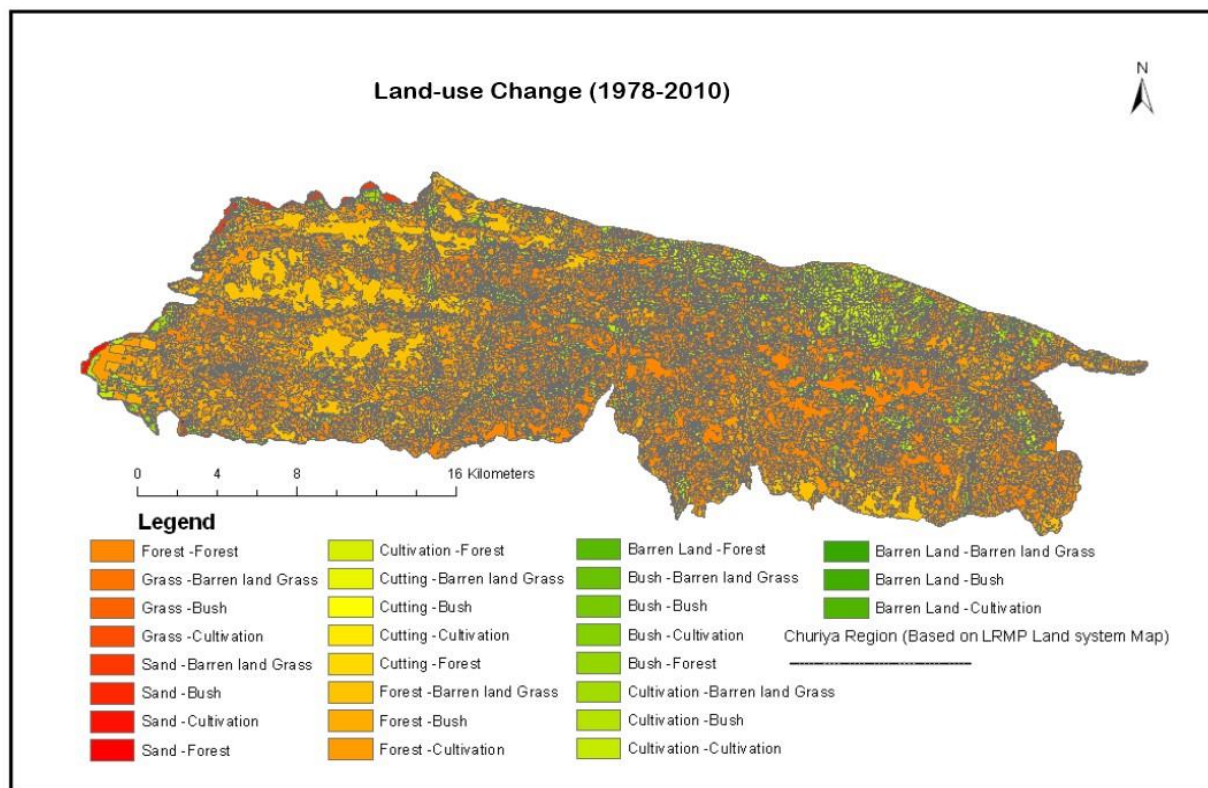


Figure 7: Land Use and Land Cover Change (1995-2010)

The overall change in land-use and land-cover in the period 1978-2010 has been presented in figure 8



**Figure 8: Conservation of Land Use and Land Cover (1978-2010)**

### Processes of Land-use/land-cover Change

The ongoing situation of the area indicates a variety of complex problems. The majority of the problems of the Chure range can be categorized as institutional, natural, or anthropogenic. With regard to the institutional aspect, there are no specific local policies and strategies for the Chure conservation and management. Land-use, settlement inventory, agriculture improvement, and sustainable livelihood development. The last six decades witnessed a shift in the paradigm of forest management with these objectives: restoration of nature-balance, economic mobilization, scientific management, and the promotion of public cooperation at the national level; however, in the Chure region massive deforestation, human encroachment, and illegal timber exports have existed (Dahal and Pokhrel, 2011; DFO, 2011). The stakeholder said that the institutional inadequacies to execute these policies are the main reason for the illegal encroachment on forest land and illegal harvesting of resources, and has resulted in the decline of forested areas in the Chure region. Local people argued that ever-increasing natural disasters such as landslides, riverside cutting, and loss of the topsoil as well as personal property are the main ill effects of rapid deforestation in the Chure region. Furthermore, flash floods, landslide and debris flow, and forest fires are yearly natural catastrophes in the study area.

Soil erosion, landslides, and increasing human encroachment (settlements, roads, and shifting cultivation) are the core issues in the region. In addition, forest fire (particularly at the lower belt of Chure region and in the government forest area, overgrazing and timber smuggling; and extraction of river bed deposits (especially from the small rivers and streams of the Chure region) are other burning issues of the Chure conservation. Over the last three decades, there has been a tremendous change in land use and land cover in the Chure region. Conservation of forest to cultivation has been the main pathway of land-use and land-cover change in the region. A study carried out in 2001 shows that the agricultural land increased by 85 percent from 1954 to 1990 whereas the forestland decreased by 13.25 percent in the Banganga River basin area (Ghimire, 2006). This massive alteration in cultivated land and forest coverage reflects adverse impacts on the hydrological and environmental processes in the basin (Gautam, Gautam, and Paudel, 2007). Likewise, timber smuggling and forest fire reported in southern parts of the study area particularly the Siddhara and Simalpani area; therefore, needs special attention and programme intervention immediately for the conservation of a biophysical environment of Chure.

Forest degradation and agricultural intervention pose the greatest threats to the environment of the Chure region. The erosion hazards are particularly very high in the Chure compared to other mountain areas of the country. Small human intervention causes greater environmental risk. Therefore, it has felt the need for policy/programme intervention for the sustainability of the environment of the Chure landscape and long-term national-level programme strategy for the entire Chure region.

The most critical problem, however, is human encroachment. The poor socio-economic status of the people who reside in Chure region and the lack of economic opportunity has driven most of the economically marginalized population to use forest resources to an excessive degree in order to sustain their livelihoods and to achieve a supplementary income. Natural resource degradation by over-harvesting of forest resources and human encroachment for crop cultivation and land for settlement in the inner and dense forest areas not only accelerated the rate of deforestation but also increased the fragility of the area. Extension of the human settlement towards the Chure forest and the practice of conversion of forest land into farmland was reported as the primary cause of plant and animal species habitat loss as well as causing the loss of many important wild crops and aromatic and medicinal plant species. As the illegal population grew in Thada, Dhohote, Toribari, Pawara, Bikramsota, Batheni, Gagrekhol, Bhangala, Mauwabari, Gainde Khair-Bhatti, Pattharkot, Wel, Sukwel and other different parts of Siddara, Simalpani, and Jaluke area are the most vulnerable for forest encroachment and illegal timber export in the area. This trend continued after the establishment of the multiparty democracy system in the country. The study area has also been subjected to tremendous human-related pressure on forests from other neighboring villages of Arghakhanchi and Kapilvastu districts.

### Land Degradation Processes

It was estimated that more than one-third portion of the Chure region is highly susceptible and more than 40 percent of its region is fairly susceptible to landslides mostly due to natural processes (GoN, 2015). Torrent (topsoil erosion, gully erosion), badlands (barren lands) and slope failure (i.e. landslides or mass wasting/mass movement) is the main form of land degradation. Both natural, as well as human processes, are responsible for the development of poor land development in the Chure region in the study area. Landslides and surface erosion largely observed in/around the rivers or streams of the study area. Debris flow/slides, streamside slides/cutting, mudflow recorded as major geomorphic processes. Such cases are mostly observed in the Mundrebas, Bhalu Khola, Bikramsota, Tikari, Bhangala, Maharain, Kaseri, Jhamtepata, Juwakot, Kamen area. The main factor causing flash floods, landslides and riverside cutting is the areas' permeable structure, weak geology and high risk of natural disaster.

Human intervention in the Chure region in the study area also caused landslides, erosion, flooding, and inundation. The previous study shows that 21.66 percent of houses constructed in the Chure region are highly susceptible area, and 60.39 percent constructed in the fairly susceptible areas in terms of landslides; whereas 10.57 percent houses constructed in high and about 50 percent is constructed in a fairly susceptible area in terms of flood and inundation (GON, 2015). If we look at the national level scenario, nearly one-third of the houses constructed in the highly susceptible area in terms of landslide, flood, and inundation. In addition, the rate of erosion expected to be very high in the Chure region. Previous studies show that the rate of erosion averages from 2.11 cm to 4.23 per year (Gurung and Khanal 1986-88). However, it depends on the intensity of precipitation and vegetative cover, slope, and aspect. Generally, the rate of erosion expected to be higher in the western and southern parts than in the eastern and northern sides of the Chure region (Khanal, 1989-92). These all might be causative factors to deplete local resources. The Expansion of agriculture activities through the practice of slash and burn farming (shifting cultivation), cultivation on steep slopes, construction of roads and other infrastructure, timber smuggling, and overgrazing in the national forest have also caused deforestation and which ultimately has responsibility for the land degradation in the Chure region. Such practices were observed at Batheni-Toribari, Bikramsota, Ranikuwa, Pawara, and Dohate, Jaluke. The expansion cultivation of land on steep slopes and in flood-prone areas clearly indicates environmental degradation and livelihood vulnerability.

### Population Growth, Forest and Agriculture Land use

The relationship between the population and available resources has described by various authors. There are two different schools of thought on the subject that can be termed classical (Malthusian) and neo-classical (Stiles, 1997). Both models are not mutually exclusive. The classical model reveals that population growth leads to an excess of the carrying capacity of the resources. This condition expressed as an equation,  $I = PAT$  (Erlach and Erlach 1990, Vogel 1991); where  $I$ =Environmental impact,  $P$ =Population,  $A$ =Affluence as defined by per-capita consumption, and  $T$ =deleterious technology. The neo-classical model illustrates the two more components. Market force ( $M$ ) and innovation of technology ( $T$ ). Population growth primarily helps economic development through stimulating the market economy and innovation of new technology, which in fact turns to the overexploitation of resources. Taking into consideration the above discussion, there are complex relationships between resources, e.g. forest, agriculture (cultivated land), and (infrastructure) development in the Chure region. The study area is rich in forest resources, as

more than 80 percent of the land has been covered by forest with dominated Saal (*Shorea robusta*), Khair (*Acacia catechu*), Saa (*Terminalia alata*) and Sisau (*Dalbergia sissoo*). On the other hand, the municipality has focused to develop infrastructure, particularly road networks and bridges, small irrigation canals, and other socio-economic infrastructure (DUDBC, 2018). Agricultural land has expanded through cleared forests and bushes. The local government has encouraged commercial agriculture. Illegal lumbering and starting a forest fire during the dry season (April-May), illegal extraction of riverbed deposits e.g. sand, gravel, stones from Banganga, Bhangala, and other rivers/stream in the region are responsible to deplete resources. About 71 percent of the area of the Chure is occupied by forest in the region, including bushes and shrubs; of which about 27 percent are already given to the local community (DFO, 2011). The remaining forests are either in the process of being given to the community or under government forest or private control.

The Pearson's correlation coefficient (Healey, 1999) has been applied to understand the degree of association between population growth and forest cover in the Chure region. It is found that there is a very weak positive correlation between them ( $r=0.042$ ) (data calculation from Tables 3&4). While looking at the relationship between the forest coverage and the cultivation area, the correlation of coefficient ( $r=-0.0034$ ) (data calculation from Tables 3&4) indicates a very weak negative relationship. The analysis shows that an increasing population in the Chure region of western Nepal has not sufficiently affected the local environment (particularly forest coverage and cultivation area) more as observed.

#### 4. CONCLUSION

The Chure conservation issue has been emerged in Nepal in the Forth Five-year plan (1970-1975), then several strategies and policies enacted and promulgated for the conservation plan of Chure region. However, until now, the policies focused on afforestation and construction of physical infrastructure in watershed conservation. The policies, rules, and regulations that were enacted in the past were poorly addressed in the Chure landscape degradation and conservation. Increasing population pressures in the region could make it difficult to implement conservation plans and policies properly. Increasing human intervention in the region, expanding cultivated land and grazing land through deforestation, and other natural calamities have collectively contributed to change the land-use and land-cover pattern in the Chure region. Among the others, forest to cultivation, forest to bushes/grassland, and bush to cultivation have been reported as the main changes. Among the others Siddhara, Jukena, Jaluke, Simalpani, and Thada, Suvernakhil areas have the highest changes in land-use and land-cover in the period 1978-2018. Although, it has a very weak negative correlation between population growth and decreasing forest coverage. The study also shows that it is not necessary to increase cultivation land by decreasing forest coverage. Natural calamities e.g. landslide, flooding, and other anthropogenic factors, e.g. human behaviour, are equally responsible to decrease forest coverage in the Chure region.

#### Conflict of interest

The authors declare that they have no conflict of interest.

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There are no funding sources for this paper.

#### Data and materials availability

All data associated with this study are present in the paper.

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