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Depopulation and Rural Land Abandonment in the Hills of Nepal

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Abstract: Decreasing population leads to changes in local patterns of land uses due to abandonment of agriculture land which increase in fallow lands and wild vegetation. In recent decades hill areas of Nepal has lost greater proportion of population resulting labour deficit on hill agriculture. The study area of this paper is Andhikhola watershed of Syangja, western hill of Nepal which district has population change rate nearly negative one during last two censuses. Population census, Landsat image and topographic maps are data sources. DEM was generated from contour of topographic map. Altitude, slope gradient and slope aspect were derived from DEM. Land use data was derived from Landsat image. Intersection of land use maps with maps of altitude and slope gradient and slope aspect maps. These intersected maps generate landuse change data by different wards, altitudinal range, slope gradient and slope aspect categories. Tables, maps and different statistical tests have been used to identify the relation between population and landuse change. In general decreasing population has greater impact on decreasing cultivated land but local variability of population change on cultivated land is not regular pattern. Regular relation of population change and cultivated land is much better determined by slope gradient than altitude and slope aspect. The greater regularities of spatial pattern of cultivated land and vegetated area indicate the conversion of cultivated land into vegetated area.

***Key word** : Chi-square test, Cultivated land abandonment, Depopulation, Vegetated area, Rank correction.*

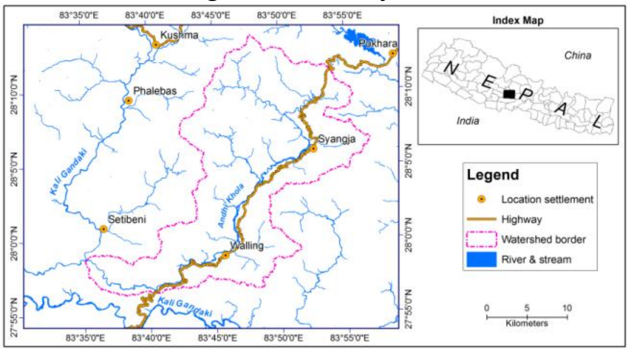
Introduction

Depopulation leads to changes in local patterns of land uses due to agriculture contraction, increase in fallow lands and wild vegetation with far reaching ecological consequences [1] and food deficit. Re-growth of natural forest is the result of a decline in traditional agricultural practices that can be observed worldwide [2]. Land abandonment and forest re-growth are related to positive consequences such as soil stabilization, carbon sequestration and temporary increase in biodiversity but equally irreversible loss of traditional cultivation forms, long term loss of species rich habitats and the higher probability of wild fires are negative consequences. In the past, expansion of agriculture land even in steep mountain slope because of rapid population growth was considered one of the main causes of growing environmental degradation and poverty in the Nepal Himalaya [3] but in last two decades heavy outmigration of population from rural hill and mountain areas has resulted growing land conversion and abandonment. It is not only because of the depopulation, Nepalese agriculture system of these areas have reduced scope for enhancement of productivity of traditional agriculture due to fragile mountain environment, reduced economies of scale because of the highly fragmented and diversified biophysical condition, and resistance to adopting modern, market oriented farming practices by mountain people are other reasons for growing trend of land abandonment [4, 5 and 6]. Outmigration of hill farmers of mountain and hill of Nepal to urban centre, plain area and foreign countries is highly increasing during last two decades which has created heavy labour shortage in Nepalese hill agriculture as a result cultivated land is shrinking because of land abandonment in the rural hill areas of Nepal. Conversion of cultivated land into grassland, shrubs and forest (vegetative) area is increasing day by day [7]. Depopulation in the agriculture area, shrinking of cultivated land and landuse change is a greater issue for food security, employment and environmental perspectives as well but very few attentions have been taken on dynamic situation of Nepal. The changing pattern of population and landuse are very complex due to diverse topographical features in the hill of Nepal. It requires in depth analysis of the relationship between population change, landuse and shrinking of cultivated land under certain physical constraint.

The Study Area

The study area is Andhi Khola watershed area of Syangja district, Western Hill of Nepal. The geographical extension of the study area is 27˚56'20" to 28˚13'46" north latitude and 83˚35'07" to 83˚57'00" east meridians of longitude.

Figure 1: The study area



This watershed area covers 480.9 square kilometer which has altitudinal range of minimum 520 meter to highest 2468 meter within nearly 35 kilometer aerial distance. Steep hill slopes with streams and streamlet between the hill flanks to the both sides of the upper parts of the watershed area and lower altitudinal area have mostly deposited flat fertile land along the main stream and branches of it. Due to the monsoon region winter is cold and dry and summer is wet and hot. Climatic data of 2012 shows that annual rainfall is 3200 mm. Eighty percent of total annual rainfall is contributed by summer monsoon and remaining 20 percent by winter. Temperature ranges from 5˚C to 32˚C. Winter is cold and summer is warm. This area is not exception of intensive subsistence farming than the most of the hill areas of Nepal. Some commercial farming and business activities is also another occupation along the highway and accessible areas. Additionally, foreign remittance is a being another major income sources during recent past. This area is crossed by highway from southwest to northeast which connects this area from other parts of Nepal. Many branch roads have connected to other parts of the study area. Many urban and suburban centres along the highway and accessible areas have been developed. Most of them are locating in lower parts of the watershed. During last two decades heavy out migration of rural hill to urban area, tarai area and foreign countries in Nepal and this area is not an exception. There is continuous decreasing in sex ratio in the district indicates the increasing male migration from the study area and population change rate during 2001 to 2011 census in the district is -0.93 in which national rate is 1.35. It indicates high rate of outmigration of population during this period.

Methods and Materials

Population data of the smallest administrative unit (ward) is available in population census has been used. Population change in percentage of each ward was calculated of two censuses 2001 and 2011. Land use maps of 30 meter spatial resolution were derived from Landsat7 and Landsat8 images for 1999 and 2014 respectively. Images were classified by supervised classification method using maximum likelihood and probability method using Erdas Imagine 9.1. Landuse were categorized into forest, shrubs, grassland, cultivated land, sandy area and water body. Over all accuracy of classification was 85% in 1999 and 95% in 2014. Ten meters Digital Elevation Model (DEM) was developed by nearest neighbour method on the basis of 20 meter contour interval of topographic map using ArcGIS10.1. Altitude, slope gradient and slope aspect maps were developed on the basis of DEM. All classified image were converted to vector file in ArcGIS 10.1. Landuse change of total watershed area, ward level, different elevation zones, different slope gradient zones, slope aspects data were derived intersecting different GIS layers.

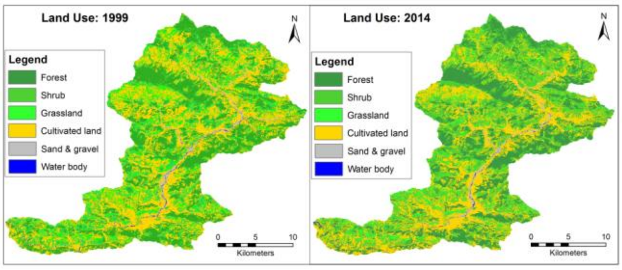
Numerical data of landuse change and population change in whole watershed area and each corresponding polygon level were derived for meaningful result. Percentage change in population, cultivated land, vegetative areas (forest, shrubs and grassland) were calculated in different slope gradient, slope aspect, altitudes and different wards.

For detail analysis of changing situation of population and land use, and their local level relationship different statistical test have been applied. Due to the problems of normality of land use data, this paper has used nonparametric statistical tools like Spearman's rank correlation and Pearson's Chi-Square test. Rank correlation has been used on percentage change of cultivated land, vegetated area and population at different land altitude, slope gradient and slope aspects. Similarly, Chi-Square test has been applied on the frequency distribution of wards in different hierarchical category of the percentage change of population, cultivated land and vegetated area.

Land use change and transformation

Conversion of cultivated land into vegetated area is clearly visible on the figure 2 land use map of 1999 and 2014. Land use maps of 1999 and 2014 below show higher greenery has increased in the most of the areas. However, higher proportion of greenery is in the north and eastern parts.

Figure 2: Land use pattern in 1999 and 2014.



Cultivated land is decreasing during 1999 to 2014 (see table 1). In 1999 there was 18987 hectares of cultivated land and it decreased to 15325 hectares in 2014. Study area has lost 3662 hectares (19.29%) of cultivated land during this period. Similarly, vegetated area has increased 13.15% (3705 hectares) from 28177 hectares to 31883 hectares in 1999 and 2014 respectively.

Table 1: Land use change in the study area during 1999 to 2014.

Landuse	Area in 1999 (hect.)	Area in 2014 (hect.)	Area change (hect.)	Chang e %
Cultivated Land	18987.20	15325.34	3661.86	-19.29
Vegetated area	28177.90	31882.02	3705.12	13.15
Sand & Gravel	757.66	792.33	34.67	4.58
Water body	191.20	113.26	-77.94	-40.76

Most of the cultivated land was transformed to vegetated area due to higher proportion of abandonment of cultivated land due to labour shortage. Some vegetated area has been converted to cultivated land which is mostly in lowland areas. Total conversion of cultivated land to vegetated area is 39.43 percent in which most of them is into shrubs. Higher proportion of sand and gravel converted to cultivated land because of the maintenance of former cultivated land damaged by heavy flood damage occurrence in 1996. However, it does not play significant increase in total area of cultivated land because of smaller area of sand and gravel in compare to cultivated and vegetated area.

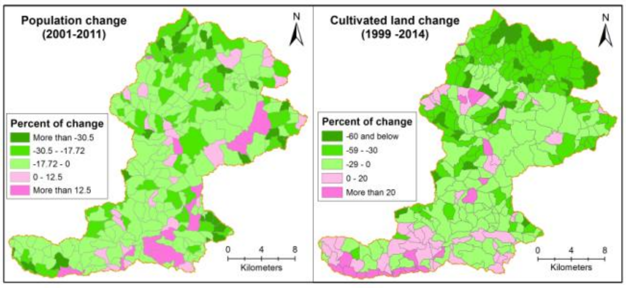
Table 2: Percentage of landuse transformation from 1999 to 2014.

Landuse	Cultivated Land	Vegetated area	Sand/ Gravel	Water body
Cultivated Land	58.49	39.43	1.90	0.18
Vegetated area	13.31	86.40	0.28	0.02
Sand & Gravel	48.45	6.40	41.11	4.04
Water body	54.05	1.10	22.38	22.47

Population and cultivated land change

Ward level population increase is mostly along the river basin and Siddhrtha highway. It is because of the location of urban area. Decreasing pattern of population is higher with the increasing altitude and remoteness from the road access and increasing altitude (see fig. 3). Changing situation of cultivated land is also similar in general. Higher proportion of decreasing cultivated land is much higher at northern part with higher proportion of population decrease. Southern part has extension of cultivated land even at the wards of decreasing population. Increasing population in wards along the Sidhartha highway has not quietly correlated with increasing cultivated land. Many wards with increasing population have deceasing cultivated land but in the southern part many wards have increasing cultivated land at the wards of decreasing population. In some wards of western part of middle region have increasing cultivated land at decreasing population because of the less steep slope than other hilly parts and south facing sunny slope which is more suitable area for cultivation. The correlation coefficient is 0.328 at 99% confidence level.

Figure 3: Percentage of population and land use change.



Higher proportion of population has been decreased with increasing altitude accordingly decreasing rate of population density is also similar but density of population has decreasing more in 1300 to 1700 altitudinal range. Total population change percentage is - 9.04 and average population density change is -17.98 in the watershed area. Both population density and population change is very low at low altitudinal zones in compare to higher altitudinal zones.

Table 3: Percent change by altitude (1999 to 2014).

Altitude (Metre)	Population change (2001-2011)	Cultivated land (1999-2014)	Vegetated area (1999 to 2014)
520 to 900	-4.82	1.18	-1.02
900 to 1300	-8.17	-8.75	8.82
1300 to 1700	-12.83	-15.18	15.25
1700 to 2500	-15.07	-2.29	2.29
Average	-9.04	-7.61	7.70

The decreasing proportion of cultivated land is not quite similar with the changing proportion of population at different altitudinal zones. However, the rate of change is similar up to 1700 metre. Lower proportion of cultivated land has decreased at 1700 to 2500 metre altitude. Vegetated area has also similar situation. Changing pattern of cultivated land and vegetated area have inverse relation because of the conversion of cultivated land into vegetated area. The highest percentage change in population, cultivated land and vegetated area is in 10˚ to 25˚ slope gradient. The proportion of change in population, cultivated land and vegetated area are quite similar to all other slope gradient. Changing proportion of cultivated land and vegetated area is quite inverses. It is because of the conversion of cultivated land into vegetated area. It indicates that population change has direct impact on landuse change in all slope gradient.

Table 4: Percent change by slope gradient (1999 to 2014).

Slope gradient (Degree)	Population change (2001-2011)	Cultivated land (1999-2014)	Vegetated area (1999-2014)
0 to 10	-7.22	-6.65	8.06
10 to 25	-10.29	-13.52	13.34
25 to 40	-9.39	-5.96	5.77
40 to 82	-8.08	-2.47	2.38
Average	-9.04	-7.61	7.70

The highest percentage change in population, cultivated land and vegetated area is in the east and south facing slope. Lowest is in the plain area. Higher slope gradient western face slope becomes shadow most of the time so this area gets very little sunshine. So, cultivated land in this area has decreased at the highest proportion. However, changing pattern of population, cultivated land and vegetated area is not correlated because of the complex topographical situation and base of the data extraction. Ward level population data is the major problems of exact location of the settlement at different slope aspect because single ward has different slope aspects.

Table 5: Percent change by slope aspect (1999 to 2014).

Slope Aspect	Population change (2001-2011)	Cultivated land (1999-2014)	Vegetated area (1999-2014)
East	-10.35	-7.46	3.47
South	-10.29	-8.47	7.35
North	-8.08	-4.13	4.24
West	-7.68	-11.90	7.99
Plain	-6.11	0.77	12.02
Average	-9.04	-7.61	7.70

From the field observation it was found that north and west facing slope have higher proportion of decrease in cultivated land. From the field observation it was estimated that north facing slope has also higher proportion of decreasing cultivated land converting to vegetated area but this estimation is quite contrast with extracted value from image analysis. This contrast is because of the ward level population change because a single ward has different slope aspects but population change became similar in a single ward. Another cause of weak relation of slope aspect and landuse change is because of the different altitude and slope gradient into a single slope aspect. It has already been indicated that altitude and slope gradient have very close relationship with population and landuse change.

Local variability

Percentage change of population during population census 2001and 2014, and percentage of landuse change during 1999 to 2014 in each wards by altitude, slope gradient and slope aspects were calculated. Researcher has two apparently related sets of numerical information (population and cultivated land, and cultivated land and vegetated land) in which one item from each set forms a pair and each of the pairs refers to a particular place or a particular event in time. Spearman's rank correlation is nonparametric statistical test which is used on the ordinal data and as well as where data is available on the interval and ratio scale but deviate from normality and transformations also do not prove to be effective [8 and 9]. Therefore, Spearman's rank correlation was used to identify the relationship of change between population and cultivated land because these data are not normal and could not be satisfactorily normalized by data transformation. Same method was used for identification of relationship of change between percentage change of cultivated land and vegetated area.

Table 6: Spearman's rank correlation coefficients in wards by altitude.

Altitude	Observed frequency	Population /cultivated land (sig.)	Cultivated land/vegetated area (0.01sig.)
520-900	152	0.142 (0.18)	-0.752
900-1300	283	0.243 (0.01)	-0.811
1300-1700	213	0.156 (0.05)	-0.369
1700-2500	69	0.179 (0.14)	-0.678

Table 6 shows that the relationship between population and cultivated land change have weak positive relationship in each altitude ranges. However, the relationship of changes between population and cultivated land at the altitude range of 900 to 1300 and 1300 to 1700 meter is significant but below and above of this altitude ranges some relationship may be just by chance because of low confidence limit. The relation between the changes of cultivated land and vegetated area is highly negative in each altitudinal ranges but correlation coefficient value is low in 1300 to 1700 meter altitude. However, all of these negative relationships are highly significant. It confirms that the cultivated land has been converted to vegetated area in each altitudinal zones.

Table 7: Spearman's rank correlation coefficient (at 0.01 significant level) in wards by slope gradient.

Slope	Observed frequency	Population/ cultivated land	Cultivation/ vegetated area
0- 10	314	0.236	-0.577
10-25	314	0.279	-0.78
25- 40	314	0.314	-0.836
40- 82	310	0.25	-0.891

Table 7 shows that the relationships between population and cultivated land changes have weak positive relationship in each ranges of slope gradient. However, relationships of these changes are significant at 0.01. So, it confirms that there is relationship at different slop gradient is real even though it is weak. The relation is very high between cultivated land and vegetated area. The inverse relation between cultivated land and vegetated area shows the negative value of correlation coefficient. There is lowest value at 0 to 10 slope gradient. However, all relationships are significant at 0.01. So, it can be concluded that the conversion of cultivated land is into vegetated area in each slope gradient in the study area.

Table 8: Spearman's rank correlation coefficients in wards by slope aspect.

Slope aspect	Observed frequency (n)	Population /cultivated land	Cultivation /vegetated area
Plain	308	0.121*	-0.382**
West	312	0.225**	-0.731**
East	314	0.259**	-0.773**
North	311	0.248**	-0.837**
South	312	0.195**	-0.751**

* indicates 0.05 significance level and ** indicates 0.01 significance level.

Table 8 shows that the relationship between population and cultivated land change have weak positive relationship in each range of slope aspects. However, relationships of these changes are significant at 0.01. So, it confirms that there is relationship at different slop aspect is real even though it is weak. The coefficient value of relation between cultivated land and vegetated are is very high except plain area and all are highly significant at 0.01. The inverse relation between cultivated land and vegetated area shows the negative value of correlation coefficient. From this table it can be concluded that hierarchical changes of cultivated land is due to the population change although there are also other factors which determines landuse change. Secondly, higher proportion of cultivated land is being converted into vegetated area in all slop aspect. However, in plain area cultivated land has been converted to other landuse category also.

The chi-square test is a powerful statistical tool widely applicable for geographical data analysis because these data are mostly nominal and are based on some sort of frequency grouping. This test is the most important of all distribution free tests and enables us to compare the frequency distributions rather than mean values (Pal 1982). Frequency count of wards by altitude, slope gradient and slope aspects according to the above defined percentage category of population and land use changes were prepared. Those six frequency tables were used to identify whether the category of percentage change of population and land use are similar to altitude, slope gradient and slope aspects. Karl Pearson's coefficients of correlation were used for these frequency tables. The table 8 shows the Chi-Square value and their level of significance.

Table 8: Pearson's Chi-Square test and level of significance.

Variables	Observed Frequency (ward "n")	Pearson's Chi-Square	Level of Significance
Population & altitude	717	9.736	0.639
Population & slope	1252	0.008	1.00
Population & slope aspect	1557	0.075	1.00
Cultivated land & altitude	717	318.90	0.001
Cultivated land & slope	1252	80.292	0.001
Cultivated & land slope aspect	1557	77.696	0.001

Each of the Chi-Square value of percentage of population change at different altitude, slope gradient and slope aspect is not significant. It does not represents the relationship of population change proportion according to different altitude, slope aspect and slope gradient. From the frequency table it is clear that there is similar proportion of each frequency in each category of altitudes, slope gradients and slope aspects. So, no clear variations of the proportion of frequency are seen for each percentage category of population change. In case of land use change proportion category, each of the chi-square value is significant at 99 percent confidence level. It concludes that there is highly correlation of land use change percentage category with altitude, slope gradient and slope aspects.

Frequency table shows that higher altitude region have higher proportion of land use change rather than lower altitude region. In case of slope gradient, higher proportion of land use change is at greater slope steepness rather than flatter areas. There is regular decrease in land use change proportion with deceasing slope steepness. North and west face slope have a greater proportion of land use change and south facing slope has the least followed by east. It is because of the south and east facing slopes are sunny slope in the study area. North and west facing slope are shadowy slope. Plain areas have also higher proportion of land use change than in the east and south. It is because of the higher land use change at higher altitude with lower slope gradient and converting cultivated land into sandy at river bank. These situations have already been approved by above defined significant chi-square values.

Conclusion

Depopulation due to the outmigration of population from the hill rural areas of Nepal is very high during last two decades. As a result, changes in local patterns of land uses due to agriculture contraction, increase in fallow lands and wild vegetation are the general situation. Loss of higher proportion of population form the study area has greater impact on decreasing of cultivated land because of converting cultivated land into shrubs and grassland. Generally, spatial pattern of population and vegetated area change is similar with altitudinal variation and slope gradient. Higher altitude regions have greater proportion of population decrease rather than lower altitudinal regions and it has a greater impact on decreasing cultivated land and increasing vegetated area up to 1700 meter but decreased change proportion of cultivated is at higher altitude which is not quite correlated with population change. Slope gradient has greater impact on decreasing cultivated land and increasing vegetated area. Impact of slope aspect does not indicate the particular relationship of population change with land use change.

Correlation test has proved that local level variability of decreasing population has the impact on middle altitude region ranges from 900 to 1700 meter but irregular situation does exist below 900 and above 1700 meter altitudinal areas. Impact of population change has greater on cultivated land in all slope gradient and different slope aspects. However, local level impact of population change on cultivated land seems weak. It is because of the other factors also plays significant role on land use change. Higher negative correlation value of local level relationship of cultivated land and vegetated area conforms that most of the cultivated land has been converted to vegetated area in each altitude, slope gradient and slope aspects. Frequency distribution of categories of percentage change on population, cultivated land and vegetated area indicates that there is not any particular regularity on the spatial relationship between population changes with cultivated land in altitude, slope gradient and slope aspects. There are higher regularities between cultivated and vegetated area changes. So, this research concludes that population distribution is based on ward boundary in which higher ranges of geographical diversity does exist but impact of altitude, slope gradient and slope aspect limits only on its local situation.

Finally, general situation of population change has greater impact on land use change but there is greater variability on strength of it. Regular situation on the proportion change relation is at middle altitude and all slope gradients and aspects. Relation between cultivated land and vegetated area confirm the conversion of cultivated land into vegetated area in each locality.

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