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Assessment of Land Use Land Cover Change Impact on Soil Loss from Phewa Lake Watershed, Pokhara, Nepal

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Abstract
The land use and land covers (water bodies, forest land, agricultural land, vegetation, built up are, bare land etc) within any watershed boundary of Nepal is getting change over a time due to human or natural activities.It has significant impacts on soil erosion and is considered as a crucial driver (or key engine) for causing the soil loss in the mountainous region of Nepal.With an objectives of providing some valuable insights related to land use change pattern of Phewa Lake watershed and its impact on soil loss, this study was conducted using the 'ArcGIS10.3.1' and 'RUSLE tool' along with Remote Sensing. The output content of this study is very useful and can serve as the corner stones for the sustainable management of Land use land cover and soil erosion for Phewa watershed. Study showed that within a decade (2007 to 2017) there is rapid growth in built up area by 7.2Km^2 and remarkable decrease in agricultural land by 6.1Km^2. Water bodies and forest land were found to decrease mildly by 0.43Km^2 and 1.09Km^2 respectively. Bare land was found to increase by 0.42Km^2. The soil loss from Phewa watershed due to LULC change impact was found 29.3t/ha/yr and 25.4t/ha/yr for the years 2007 and 2017 respectively.

Keywords
Land Use Land Cover, Phewa Lake Watershed, Remote Sensing, RUSLE

1. Introduction

Land use land cover change is considered as one of the most dominant factors to create erosion in a landscape. Natural as well as human induced LULC has a significant impact on land degradation like soil erosion, soil acidification, leaching of nutrient, and organic matter depletion [1]. Increased consciousness of these impacts enhanced their estimating, forecasting and modeling at the global, regional or watershed scales[2]. Soil erosion is a detachment and removal of soil particles from its existing surface under the action of water and wind forces. About 45.5% of the land in Nepal suffers from water erosion, mostly through sheet and rill erosion[3]. Soil erosion and sediment deposition at lowland is one of the major environmental issues of this planet. Nepal is a country having complex and diverse topography with improper LULC management practices [4]. Soil loss in Nepal ranges from zero in the lowland areas to 420t/ha/yr in the shrub lands[5].Heavy rainfall events with high-speed winds and hailstorms during the pre-monsoon make soil erosion more problematic in rain fed agriculture in Nepal. It is essential to examine how soil erosion has changed through the years so that proper soil and water conservation measures can be adopted concentrating more on affected areas.

Our study area was Phewa Lake Watershed Figure 1. Geographically it lies in the coordinates of N28°11.39′ to N28°17.25′ and E83°47.51′ to E83°59.17′. It is located in the west part of Pokhara Metropolitan City, covering about 121.6Km^2 area with the elevation from the sea level between 793m and 2508.81m. Arround 5.75Km^2 area of Phewa Lake Watershed realm lies in Pokhara city [6]. It always faces with highest amount of annual rainfall in Nepal ranging 4.5 to 5m [7].

Unplanned LULC activities, Rill or sheet or gully erosion, lake area encroachment, haphazard infrastructure construction (roads and hotel) etc. are the main issues of study area. So the main motto of this study is to assess the impacts of LULC change on soil loss from the Phewa Lake Watershed using the RUSLE model in the platform of GIS. Study might be fruitful to proper management of LULC and soil loss. Instead of direct field observation only impirical

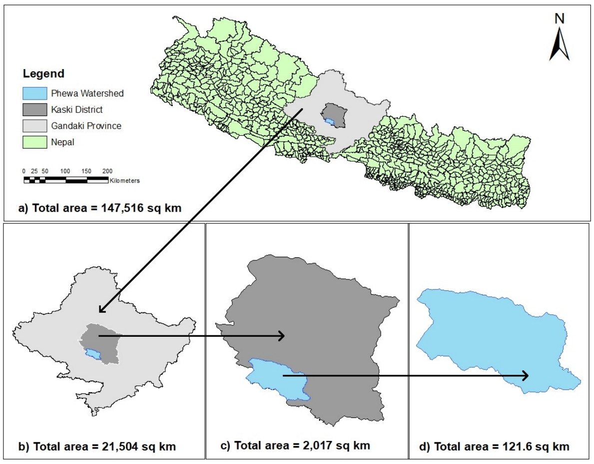

Figure 1: Study Area

modeling process was carried out with statistical data. The modeling tool (RUSLE) analysed soil erosion considering rill and sheet erosion only it ignoring gully erosion which has significant role in erosion of the watershed land. This is the main limitation of this study.

2. Material and Methodology

2.1 Data Acquisition

The data required for study and their sources were shown in Table 1. Spatial data sets were assigned in a projected coordinate system of WGS1984 UTM Zone44N. Because of their geographic coordinate system in WGS 1984 projection and datum, all maps were kept in this state. The specification for satellite

Table 1: Source of Data

Data Sets	Data Source
LULC Image Data	Landsat 7 ETM+ and Landsat 8 OLI/TIRS
DEM	ASTER GDEM
Digital Soil Map	Digital Soil Map of the world Produced by FAO-UNESCO
Rainfall Data	Mean Annual Precipitation Produced by DHM of Nepal

image such as resolution, path/row, band combination are shown in Table 2. Figure 2 is a methodological

Table 2: Specification of USGS Landsat Image Data

Year	Satellite	Resolution	Path/Row	Band Combination	Date of procurement
2007	Landsat 7 ETM+	30	142/040	1,2,3,4,5,6,7	19-Dec-07
2017	Landsat 8 OLI/TIRS	30	142/040	1,2,3,4,5,6(VCID-1),7	22-Dec-17

diagram for the land use land cover classification. Figure 3 is a methodological diagram for soil loss calculation using RUSLE.

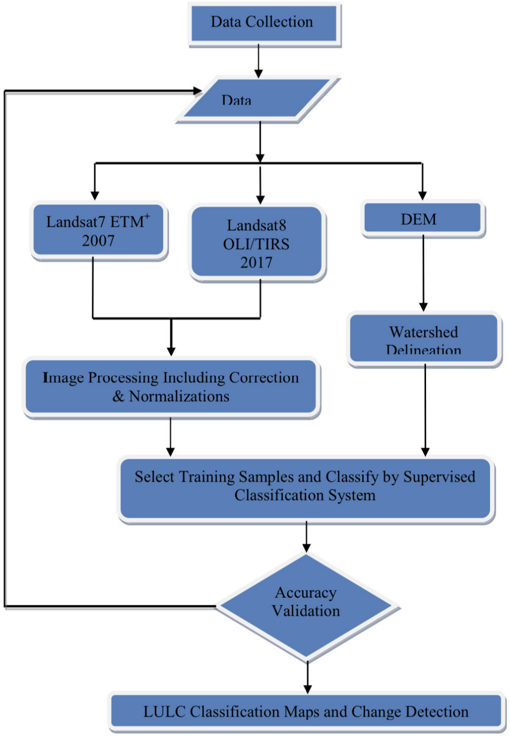

Figure 2: Flow Chart for LULC Classification

2.2 LULC Classification

Watershed delineation for the proposed area is very essential during classification of land use type for study area, that's why following steps were adopted to delineate the Phewa watershed.

2.2.1 Watershed Delineation

Acquired DEM data of study area was processed on the platform of ArcGis to produce the Watershed as shown in Figure 4.The lowest and highest elevation of Phewa Watershed was found as 656m and 2483m respectively.

2.2.2 LULC Mapping

Input data Landsat 7 ETM+ (2007) and Landsat 8 OLI/TIRS (2017) were used in ArcGIS 10.3.1 with a combination of 7 bands. Five land use type (forest, waterbodies, urban land, bare land, agriculture, vegetation) were used to classify the LULC. Interactive supervised classification was run to find classified land use type which gave the classified land use map within the watershed boundary along with its occupied area as shown in Figure 5.

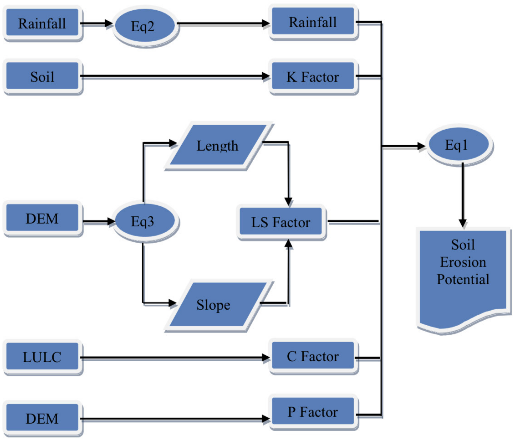

Figure 3: Flow Chart for RUSLE

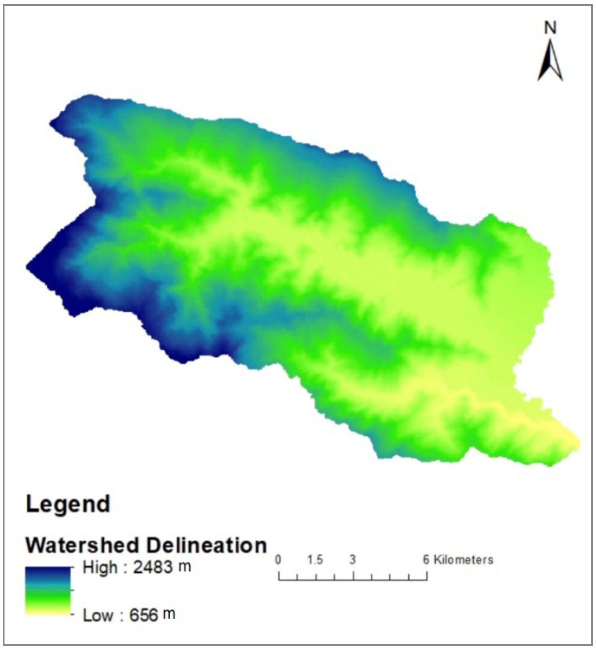

Figure 4: DEM of Phewa Lake Watershed

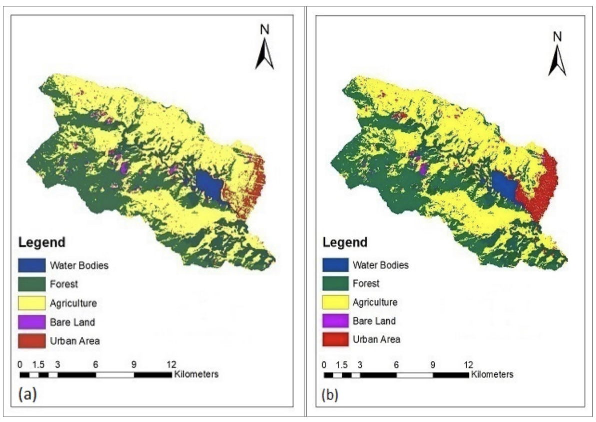

Figure 5: LULC Map of Phewa Watershed; a) 2007 b) 2017

2.3 Assessment of Soil Loss Using RUSLE Model

Revised Universal Soil Loss Equation was used to calculate the quantity of soil loss from Phewa Lake watershed.The RUSLE equation that was used for soil loss calculation is;

$$[A] = [R]x[K]x[LS]x[C]x[P] \tag{1}$$

where, A = Soil loss (t/ha/yr), R = Rainfall erosivity factor (MJ mm/ha/h/yr), K = Soil erodibility factor (t h /MJ/mm), LS = Slope length and slope steepness factor (dimensionless), C = Land management factor (dimensionless), and P = Conservation practice factor (dimensionless)[8]. The RUSLE factors were found in ArcGIS platform using the GIS data.

2.3.1 Rainfall Erosivity Factor(R)

Rainfall erosivity factor (R) describes the erosivity of rainfall at particular location based on the rainfall amount and intensity, and reflect the effect of rainfall intensity for erosion of soil. It is highly affected by storm intensity, duration, and potential. The R factor was estimated using following equation in this project.

$$R = 38.5 + 0.35r \tag{2}$$

where, R = rainfall erosivity factor (MJ mm/ha/h/yr) and r = annual rainfall of target area (mm) The mean annual rainfall (r) for target area was taken from Department of Hydrology and Meteorology, Nepal. For the year 2007 it was found 4699.5mm and for the year 2017 it was found as 4055.24mm.

2.3.2 Soil Erodibility Factor (K)

The K factor represents the soil susceptibility to erode itself under the action of rainfall and runoff water. The soil textural maps of the study area was extracted from the Digital Soil Map of the World (DSMW) and using this soil map soil erodibility factor was found by developing K-factor map in ArcGis. Based on the soil texture the value of k factor was assigned as below. The Figure 6 shows the K factor map and Table 3 shows soil type associated with K value. The value of soil erodibility factor in green portion is 0.035 that means it represents Clay, clay loam, loam, sandy clay loam, silty clay soil on that zone. Similarly, blue portion has K value as 0.007 and this value is associated with sand and loamy soil. The red portion has K value as 0.018 which indicates sandy loam soil in that area. Table 3 shows the K factor value and corresponding meaning for it which help to find out the soil texture of coverage.

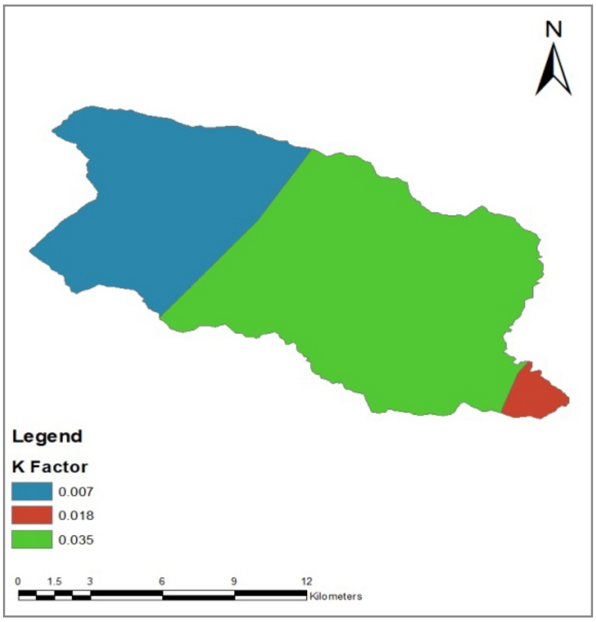

Figure 6: K-Factor Map

Table 3: Soil Erodibility Factor (K)

Soil Texture	K factor
Clay, clay loam, loam, sandy clay loam, silty clay	0.035
Loamy sand, sand	0.007
Sandy loam	0.018
Silty clay loam, silty loam	0.045

2.3.3 Slope Length (LS) Factor

The L and S factors represent the effect of slope length (L) and slope steepness (S) on the erosion of the area. The slope length factor (L) is the ratio of soil loss from a slope length relative to the standard plot length 22.1m. In this project, the DEM data of study area was acquired and then delineation of watershed for proposed in the ArcGIS and then raster data for LS factor was acquired in raster calculation in ArcGis. The Figure 7 represents the slope length factor map of study area.It shows that the minimum slope length value of slope length for the study area is 0 and high value is 37.2.

2.3.4 Cover Management Factor (C)

The cover management factor (C) is used to reflect the effect of cropping and other management practices on

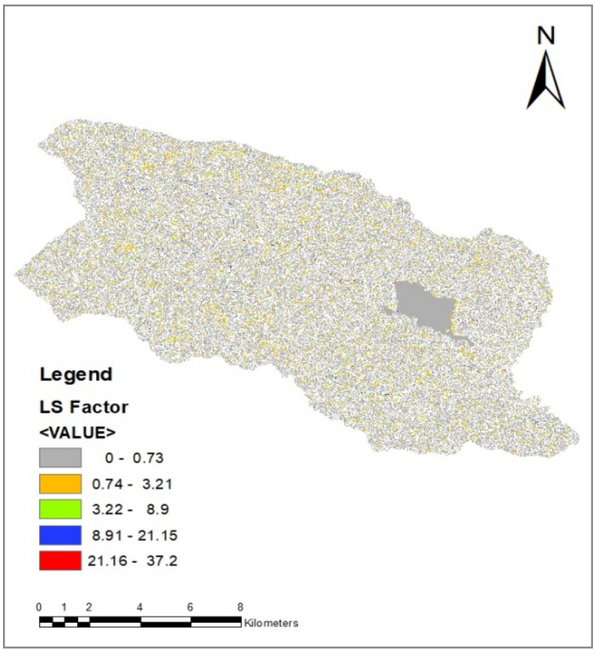

Figure 7: LS Factor Map

erosion rates. The C value ranges from 0 to 1, where higher values indicate no cover effect and soil loss comparable to that from a tilled base fallow, while lower value of C means very strong cover effect resulting in no erosion. During this project, I have prepared C-factor map (raster map) using Landsat image data with five types of land. This raster map was then converted into polygon and the attributes with same land use were merged in Arc-GIS. For each land use type, C value was assigned through reference. The Figure 8 indicates the cover management factor for the years 2007 and 2017 respectively. The Table 4 shows land use type corresponding to C factor. The both map consist of gray, yellow, blue and red areas having C factor values as 0, 0.03, 0.21 and 0.45. The area having C factor as 0 represent built up and waterbodies, similarly 0.03 as forest and shrub land, 0.21 as agricultural land and 0.45 as barren land. Table 4 shows the C factor value and corresponding meaning for it which help to find out the land use type of coverage areas.

2.3.5 Support Practice Factor (P)

The support practice factor (P) indicates the rate of soil loss according to the various cultivated lands. There are contours, cropping, and terrace as its method and it is important factor that can control the erosion. The P value ranges from 0 to 1, where 0 represents a very good anthropic erosion resistance facility and the value 1 indicates a non-anthropic resistance erosion facility.

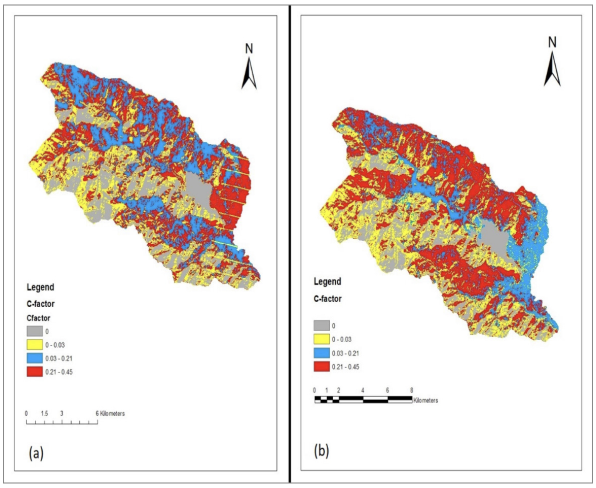

Figure 8: C Factor Map; a) 2007 b) 2017

Table 4: Cover Management Factor (C)

Land Use	C Factor
Forest	0.03
Shrub land	0.03
Grassland	0.01
Agricultural Land	0.21
Barren Land	0.45
Water Body	0.00
Snow Glacier	0.00
Built-Up	0.00

Figure 9 is generated map for support practice factor in ArcGis.

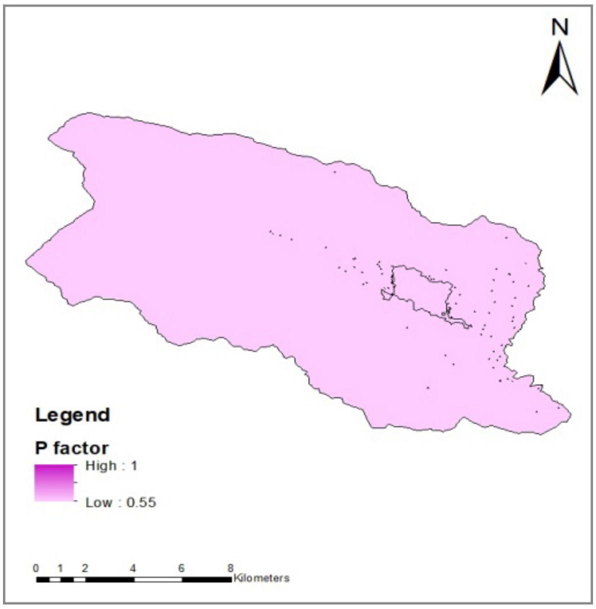

Figure 9: P-Factor Map

3. Result and Discussion

Table 5: Support Practice Factor (P)

Slope	Contouring (P)
0 - 7	0.55
7 - 11.3	0.6
11.3 - 17.6	0.8
17.6 - 26.8	0.95
>26.8	1

3.1 Analysis of Land Use Land Cover

Figure 10 and Figure 11 are LULC map produced for study area which includes only the five categories of land coverage such as forest, agriculture, built up area, water bodies and bare land.Table 6 shows the occupied area of land coverage produced by the study in 2007 and 2017.It was found that the study area is highly covered with forest land and agricultural land in both years. The built up area seems small in 2007 but took rapid growth in 2017.Bare land and water bodies within the boundary seem small change over a decade.

3.1.1 Analysis of LULC 2007

The output result of LULC classification from the Figure 10 and Figure 11 showed that the agricultural and forest land dominated the landscape, with 56.34Km2 (46.33%) and 50.21 Km2 (41.3%), respectively. The forest cover was found more in dense in southern west part while agricultural cover was found more in both southern and eastern north part of watershed. The third largest land use type is composed of built-up area at 5.5Km^2 (4.52%) which is mostly located towards eastern part of the watershed. The northern east part of this watershed is in growing rate of urban development. There is little cover of land by water bodies and bare land in this area as 3.96Km^2 (3.25%) and 5.59 Km2 (4.6%) respectively. The higher coverage of agriculture and forest but the lower coverage by water bodies and bare land, indicates that there is less risk fragile ecological divergence within the region. There is less potential of occurrence of drought and shortage of water.

3.1.2 Analysis of LULC 2017

Compared to 2007 results, findings from the 2010 shows a significant increase in the cover of built-up area followed by a slight increase in bare land cover. The rest of the land classes decreased significantly with forest, agricultural land, water bodies as shown in (Figure 10 and Figure 11). Despite these decrease, agricultural and forest land maintained their dominance with coverage of 50.24Km^2 (41.31%) and

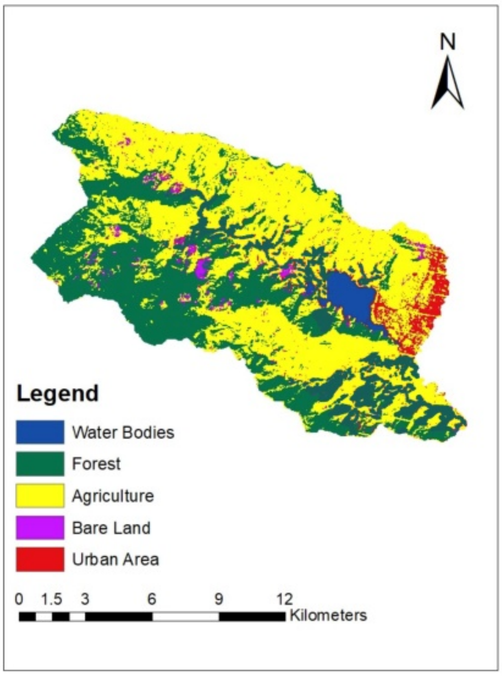

Figure 10: LULC Map of Phewa Watershed 2007

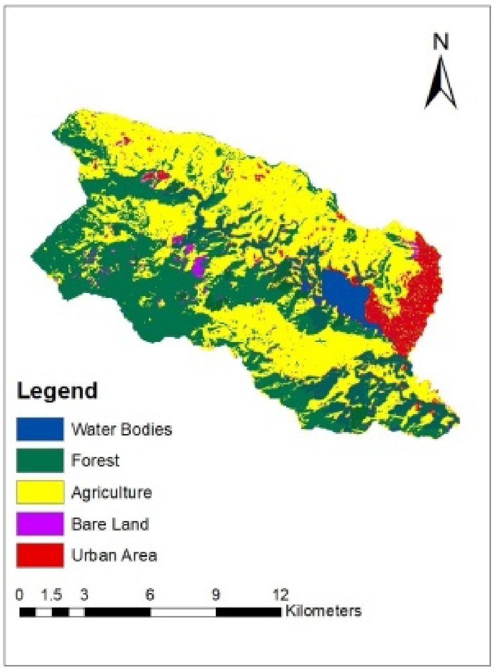

Figure 11: LULC Map of Phewa Watershed 2017

49.12Km^2 (40.40%), respectively. However, the built area expanded into the agricultural and forest land with 12.70Km^2 representing over 10.44% of the total watershed land. This represent an increase of almost 7.2Km^2 (130.91%) increase since 2007 and has sustainable management consequences including degradation of land and ecosystem services. A slight increase in bare land is probably due to haphazard construction of earthen roads and building infrastructures.

3.1.3 Analysis of LULC Trend from 2007 to 2017

The trend analysis for LULC change represents the direction of land class change based on their respective initial years as a reference[9].Table 6 show that both agriculture and forest coverage decreased by 6.1Km^2 (10.82%) and 1.09Km^2 (2.17%), respectively. These decreases signal a warning for degrading ecosystem services and increase in food insecurity that could be triggered by unsustainable utilization of forest resources and land conversion to urban and settlement centers and impacts of climate change. Decrease in water bodies poses an imminent water crisis for the already water scare city especially under global warming scenarios. Urban area has expanded by 130.91% from 2007 to 2017, representing a significant increase in built up area by 7.2Km^2. This rapid increase in built up land tells that there is high risk of land encroachment and vulnerability of poor infrastructure development in the area. Rapid urbanization is mainly responsible for the conversion of agricultural and forest land into built up areas.

Table 6: LULC Area Calculation for 2007 and 2017

Land Cover Types	2007		2017		2017 to 2017	
	Area (Km^2)	Percent	Area Km^2	Percent	Change Area (Km^2)	Percentile Change
Forest	50.21	41.3	49.12	40.4	-1.09	-2.17
Urban Area	5.5	4.52	12.7	10.44	7.2	130.91
Agriculture Land	56.34	46.33	50.24	41.31	-6.1	-10.82
Bare Land	5.59	4.6	6.01	4.94	0.42	7.51
Water Bodies	3.96	3.25	3.53	2.91	-0.43	-10.86

3.1.4 Analysis of LULC Through Charts

The LULC change study of Phewa Lake watershed for a decade (2007 to 2017) gave a clear comparative vision for land use type within study area. The Figure 12 clearly figured out about percentage land use land cover area of Phewa Watershed for the year 2007 and 2017. Forest land, urban area, agricultural land, bare land and water bodies were found 41%, 5%, 46%, 5% and 3% 2007 respectively and same values were found as 40%, 11%, 41%, 5% and 3% respectively in the year 2017 respectively. The drastic variations were found in urban area and agricultural land but other land use type were found in small change in land use area. The Figure 13 is a compare

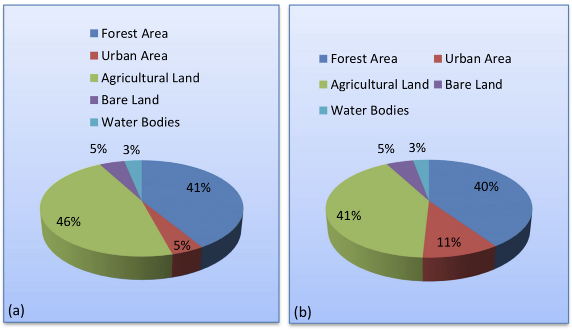

Figure 12: Percentage LULC; a) 2007 b) 2017

of land use type of study area in between 2007 and 2017 in Km^2.It can be observed from the chart that there is a little bit change in coverage area for forest, waterbodies and bare land but a huge variation in urban and agricultural land from 2007 to 2017.Urban area seems rapid growth while agricultural land is in rapid decreasing rate

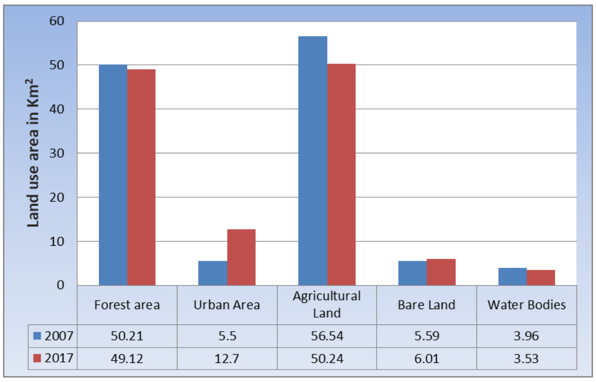

Figure 13: LULC Compare for 2007 and 2017

3.2 Soil Loss Calculation Using RUSLE Model

The LULC change has great impacts on soil loss. In this study we calculated the quantity of soil loss for the year 2007 and 2017 as below; Average soil loss from Phewa Lake watershed;

$$[A] = [R]x[K]x[LS]x[C]x[P] \qquad (3)$$

Where, A = Soil loss (t/ha/yr), R = Rainfall erosivity factor (MJ mm/ha/h/yr), K = Soil erodibility factor (t h /MJ/mm), LS = Slope length and slope steepness factor (dimensionless), C = Land management factor (dimensionless), and P = Conservation practice factor (dimensionless).

The soil loss from Phewa Lake Watershed for the year 2007 was found 29.3t/ha/yr.The soil loss from Phewa Lake Watershed for the year 2017 was found 25.4t/ha/yr

3.2.1 Analysis of Soil for 2007 and 2017

The soil loss from any landscape depends on soil erodibility, rainfall erosivity, cover management, slope length and support practice factors. Higher the all those factors, higher will be the loss of soil from the area. This study showed that soil loss in 2017 was less compared to 2007. Phewa lake watershed is not much suffered from the erosion over a time. It may be due to less occurrence of rainfall and increased vegetation within the watershed over a time. The study predicted that soil loss from Phewa watershed for the years 2007 was 29.3t/ha/yr and for 2017 it was 25.4t/ha/yr in. The scenario showed that soil loss trend is in decreasing trend if we consider only the start (2007) and end (2017) year of a decade without considering intermediate years.

3.3 Major Findings

Predicting of LULC change in Phewa watershed and soil loss within watershed due to its impact were the major findings of this study. The study found that forest, agriculture, water bodies were in decreasing order with passes of time and urban area and bare land were in increasing rate. The result showed that only urban and agricultural land were in high fluctuation of increasing and decreasing rate respectively. However, other land use type were in slow speed of change from 2007 to 2017. The soil loss from the study area was found more in 2007 as compare to 2017. The average decadal rate of soil loss from Phewa Lake watershed (without considering the intermediate years between 2007 to 2017) was found in decreasing rate of 0.39t/ha/yr. Table 7 is a percentile change value of land use type from 2007 to 2017. Forest, agricultural land and water bodies appear as in decreased value but urban and bare lands seem increase over a period of decade. The Table 8 is a soil loss value for the year

Table 7: LULC Change of Phewa Watershed

Land Use Type	Change in Land Use Coverage Area from 2007 to 2017	
	Change Area (Km^2)	Percentile Change
Forest	-1.09	-2.17
Urban Area	7.20	130.91
Agriculture Land	-6.10	-10.82
Bare Land	0.42	7.51
Water Bodies	-0.43	-10.86

2007 and 2017. The soil loss table shows that loss of soil is greater in 2007 as compared to 2017. In this study, the soil loss values for the years in between 2007 and 2017 were not considered for the average value of soil loss. Soil loss of 2007 and 2017 were considered as representative of all the ten years value due to which soil loss rate was obtained as negative rate here however it will be in positive if we use all the ten years soil loss value for the calculation of average loss.

Table 8: Soil Loss from Phewa Watershed

Year	Soil Loss Rate (t/ha/yr)	Difference (t/ha/yr)	Average Soil Loss Rate (t/ha/yr)
2007	29.3	-3.9	-0.39
2017	25.4		

3.4 Comparision of Result

After extracting and analyzing the values of LULC change and soil loss from Phewa lake watershed, a comparison was made with the result of obtained by previous researcher. The LULC values for Forest, waterbodies, built up land/urban area and agricultural land were found 46.36%, 3.21%, 4.43%, 46% respectively for 2007 and the same values for the 2017 were 37.73%, 3.22%, 7.83%, 42.75% respectively (Subedi, 2018). The soil loss values from Phewa lake watershed due to the impacts of LULC change was found as 28.5 t/ha/yr and 39.07t/ha/yr in 2005 and 2015 respectively[10]. The result obtained in this study was found near about the result in other literatures. So the result of this project can be considered as acceptable. Table 9 is a compare table

Table 9: LULC Comparision with Literature

Year	Forest (km2)	Water Bodies (km2)	Built up Area (km2)	Agricultural Land (km2)	Bare Land (km2)	Grass and Bush Land (km2)	References
2007	53.77	3.9	5.39	56	-	2.65	Subedi 2018
	50.21	3.96	5.5	56.34	5.59	-	This Study
2017	45.9	3.92	9.53	52	-	10.31	Subedi 2018
	49.12	3.53	12.7	50.24	6.01	-	This Study

for land use cover predicted in this study with the other literature, for the confidence of correctness and validation. The coverage values predicted in this study didn't match exactly with the literature value but seems nearly about it. In the compared literature there is no consideration of bare land but it was considered in this study. This study considered grass and bush in the forest sector but in literature it was taken as separate from forest land. This considerations made fluctuations in the coverage area however predicted results of this research are in the track of literature values. Figure 14 and Figure 15 shows the LULC

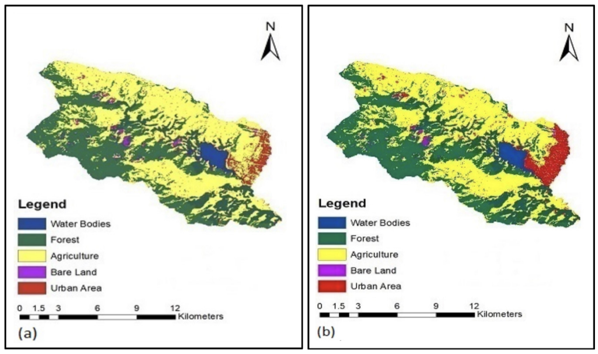

Figure 14: LULC Map From This Study; a) 2007 b) 2017

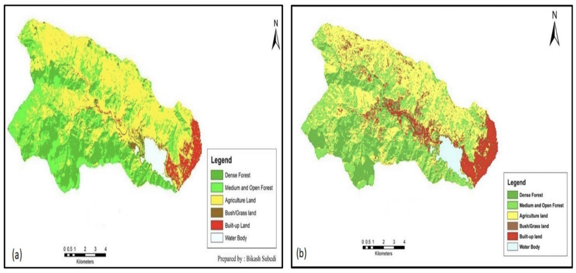

Figure 15: LULC Map From Study of Subedi(2018); a) 2007 b) 2017

map of Phewa watershed developed by this study and Bikash Subedi(2018) for the same study year. LULC result of this study seems near to Subedi (2018) therefore, the result produced on this study can be considered as valid result.Table 10 shows the soil loss value of this study and value in the study of [10].The soil loss value for the year 2007 seems nearly equal for both study but in the 2017 value predicted in this study seems far differ than that of compared literature. It is because difference in average value consideration. In this study, the average soil loss value for 2017 is only the value of 2017 but in the literature this value is taken as average of each year from 2007 to 2017 which made the deviation of soil loss value of this study from literature.

4. Conclusion and Recommendation

4.1 Conclusion

Soil erosion is a global issue with its major impacts being on agricultural lands. The observation in the Phewa Lake watershed exhibits the magnitude and

Table 10: Soil Loss Comparision with Literature

Year	Soil Loss (t/ha/yr)	References	
2007	29.3	Regmi and Saha	2015
	28.5	This study	
2017	39.07	Regmi and Saha	2015
	25.4	This study	

extent of threats and challenges that unplanned urbanization trends occurring at high rate and also rapid diminishing of greenery land calling a high risk of natural disasters in the future. The importance of the study is to predict soil loss from Phewa Lake watershed which can be used for the conservation and management planning processes, at the policy level, by land use planners and policy makers. This study has been conducted using GIS, Remote sensing and RUSLE tool for the prediction of land use change and its impact on soil loss over a decade (2007 to 2017) where the output is based on the RUSLE model in ArcGis. The five factors that influence the soil erosion are soil erodibility, rainfall erosivity, cover management, slope length and support practices.According to this study, within a decade (2007 to 2017) there is rapid growth in built up area by $7.2Km^2$ and remarkable decrease in agricultural land by $6.1Km^2$. The soil loss from Phewa watershed due to LULC change impact was found 29.3t/ha/yr and 25.4t/ha/yr for the years 2007 and 2017 respectively. The quantitative evidence from this study indicates that the Phewa Lake watershed has undergone significant land use land cover changes since 2007. Agricultural and forest lands followed by built up area dominated the coverage of study area during the period from 2007 to 2017. However, rapid increase in urbanization remains a key driver of land use land cover changes and is taking over agricultural and forest lands. There is also overwhelming reduction of water bodies and increase of bare lands which calls for urgent adaptation and mitigation plans. The mean potential soil erosion from Phewa watershed was found more in 2007 compared to 2017. In countries like Nepal, which lacks continuous and long term monitoring of erosion hazards, RUSLE erosion modeling to develop a soil loss could be a good option.

4.2 Recommendation

The beauty of Phewa Lake Watershed is getting diminished over a time so it is required to conserve its present beauty by the effort of local level government and villagers. Provincial and Local Level government should prepare and implement the plan and policy as per Land Use Policy 2015". Specially Pokhara Metropolitan should implement the land use policy strictly on this watershed land so as to preserve the present land use of Phewa watershed in long lasting. Local level government should carry out frequent awareness program regarding to impacts caused by bad land use practices using the internet medium, radio program, street program,local magazines, school or college program etc. The haphazard construction of earthen route network should be prohibited within watershed boundary. The agricultural activity and irrigation system in the steep slope should be restricted as far as possible. The main priority should be given in eco-based and biodegradable construction rather than fragile and non-eco-friendly construction activities.

This study didn't consider intermediate years in between 2007 and 2017 during LULC analyzing so the consideration of each year in future study can predict the more better scenario of LULC activities trend within this watershed. Also to find more accurate average soil loss from the study area over a decade, there must be consider each years soil loss in future study rather than consideration of only start and end year of a decade.

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