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Original Research Article

Assessment of Change in Land Use Land Cover and Effect of it on Soil Loss from Phewa Watershed

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Abstract

Land use land cover change trend in Phewa watershed of Nepal was found very unsymmetric over the past two decades causing tones of soil loss from it. This research focused on providing some valuable insights related to land use land cover change and its effects on soil loss from Phewa watershed using the ArcGIS and RUSLE Model in conjunction with Remote Sensing data for the year 2000, 2005, 2010, 2015, and 2020. This study predicts that the settlement change rate in very intensive compared to other coverages. However, change rate for forest, agriculture, barren, and water was found noticeable. Highest rate of change for settlement land was found 128.40 ha/yr in 2005 to 2010 while for agriculture and forest land it was found 192.92 ha/yr and 181.88 ha/yr respectively in 2000 to 2005. For the barren land and water highest rate of change were 94.12 ha/yr and 12ha/yr respectively. The overall land use change from 2000 to 2020 for built-up area, agricultural land, forest area and bare land were found as 12.30 Km^2 (342.20%), 6.47 Km^2 (13.12%), 2.45 Km^2 (4.27%), and 3.44 Km^2 (39.13%) respectively. This research predicts that the fluctuation of land use change has great effects on the soil loss. The year interval having higher land cover change consisted with higher loss of soil and vice versa. Soil loss rate was found highest in 2010 (16.74 t/ha/yr) followed by its lowest rate in 2015 (11.58 t/ha/yr. Year interval with these two significant soil losses has high rate of LULC change. Additionally, this study forecasted the land use land cover change using MOLUSCE in QGIS for the year 2025 and 2030. Forecasted result showed that settlement area will maintain its coverage as 17.10 Km^2 and 17.19 Km^2 in 2025 and 2030 respectively. In 2025, forest and agriculture will maintain their coverage as 54.99 Km^2 and 42.53 Km^2 respectively followed by their coverage in 2030 as 55.10 Km^2 and 42.39 Km^2 respectively. The barren land will be 4.33 Km^2 in 2025 but 4.25 Km^2 in 2030 while the water coverage for both 2025 and 2030 years will be the same as 3.86 Km^2. The results of this study could be very useful and could serve as a corner stone for the sustainable management of land use land cover and to control the soil erosion from the Phewa watershed.

Keywords: ArcGIS, Land Management, MOLUSCE, QGIS, RUSLE, Soil Erosion.

1. INTRODUCTION

The land use land covers within any watershed boundary usually change over a period due to human and natural activities. Most of the watershed land of Nepal were found to face with rapid change of land use covers. It has significant negative impact on hydrological cycle and ecosystem, and it ultimately reduces the land resources. Wash out of top fertile soil is a major problem caused by land use land cover change. The land use land cover change is considered as crucial driver or key engine to cause soil erosion from the mountainous region of Nepal. Nepal is a country having complex and diverse topography with improper land use land cover management practices (Kabir *et al.*, 2018). Land use land cover (LULC) change is one of the most dominant factors that triggers erosion in a landscape. The land use Change in any watershed land occurs by human or natural activities over the period. It leaches out all the nutrient and organic matters from watershed. Erosion caused by runoff in areas with poor vegetation cover is perhaps the most common process of land degradation because it is irretrievable and is globally widespread causing substantial damage to the landscape (Chadli, 2016). About 45.5% of the land in Nepal suffers from water erosion, mostly through sheet and rill erosion (Pooja *et* *al*., 2019). Variation in topography, slope, land use and land cover patterns, and population pressures across the physiographic regions produces different rate of soil loss in Nepal ranging from zero in the lowland areas to 420 t/ha/yr in the shrub lands (Devraj and Lalit Kumar, 2020).

Soil erosion assessment for watershed is one of the major concerns for this world. To predict soil loss from the watershed, many research studies have been conducted in the world. The exact and proper estimation of soil loss from proposed watershed land means correct measure of risk related to soil erosion problems for that area. Field studies for prediction and assessment of soil erosion are expensive, time consuming and need to be collected over many years. But erosion models can simulate erosion process in the watershed. Soil erosion prediction and assessment has been a challenge to researchers since 1930s' and several models have been developed (Lal, 2001). The Revised Universal Soil Loss Equation (RUSLE) is an empirical model (primarily based on observation and are usually statistically in nature) that is widely used all over the world for the assessment and prediction soil erosion due to water runoff. The universal soil loss equation (USLE) was first developed in the 1960s by Wischmeier and Smith of the United States Department of Agriculture as a field scale model which was later revised in 1997 for better and accurate estimate of the erosion parameters in USLE (Yongsik Kim, 2014). The RUSLE represents how climate, soil, topography, and land use affect rill and inter-rill soil erosion caused by raindrop impacts. The Assessment of soil loss for Dhalai River Basin, Tripura, India has been carried out using the USLE with some modifications and study found that annual soil loss of the study area ranging from 8 to 836 t/ha/yr (Kapil et al., 2012). RUSLE model with addition of GIS has been used to predict soil loss estimation in Kelani River Basin in Srilanka and result said that average annual loss of study area as 10,9 t/ha/yr (Cassim, et al., 2019). The estimation of soil loss using RUSLE with Arc GIS, has been carried out for the Sebou Watershed in Morocco and the predicted result was 78.83 % of the study area has low risk of erosion, 17.36 % medium risk, 3.04 % high risk and 0.77 % a very high risk (Khalid, 2016).

Soil erosion, a complex phenomenon, is assessed using various approaches, among which spatial data combination is commonly used. The Revised Universal Soil Loss Equation (RUSLE) model was used in this approach. In this research RUSLE model was used to measure spatial distribution of soil erosion in Phewa watershed (aka Phewa Lake Watershed). However, it considers only sheet erosion and rill erosion ignoring the gully erosion which has significant impact on soil loss. Despite its limitation, the model combines several parameters (rainfall erosivity factor, soil erodibility factor, slope length factor, cover management factor and support practice factor) to give reasonable estimates of soil erosion. The research may deliver a reference point for the entire Phewa lake watershed and contribute to soil erosion database.

2. MATERIALS AND METHODS

2.1 Study Area

This research was conducted in Phewa lake watershed which is in the south-west corner of the Pokhara valley 28°11′39″ to 28°17′25″ N latitude and 83°47′51″ to 83°59′17″ E Longitude. It is a micro region of the hill of Nepal and lies on a relative subsidence zone between the greater Himalaya and Mahabharat range. This watershed is fully or partially poured on various parts of Pokhara metropolitan city of Kaski district (Sarangkot, Kaskikot, Dhikurpokhari, Bhadaure Tamagi, Chapakot and Pumdi Bhumdi) as shown in Figure 1. Its coverage area is about 123 Km^2.

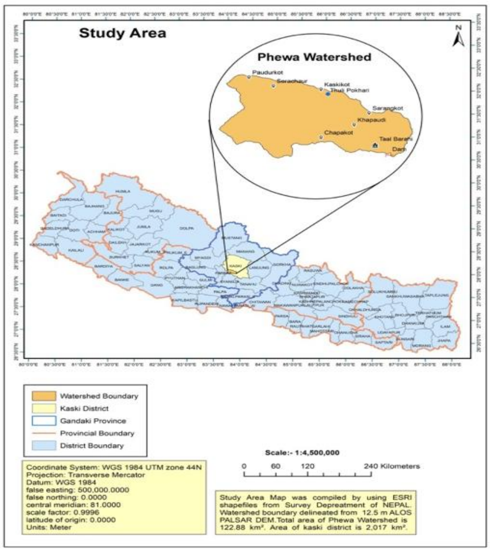

Fig-1: Study Area

2.2 Data Collection

The applied datasets and their relevant sources for this research are shown in Table 1 and the detailed specification about the satellite images i.e., resolution, path and row, band combination and date of procurement are shown in Table 2. All the spatial data sets have been 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.

Table-1: Source of Data

Data Sets	Data Source
Landsat Image	Landsat 4-5 TM and Landsat 8 OLI/TIRS https://earthexplorer.usgs.gov/
DEM	ASTER GDEM https://earthexplorer.usgs.gov/
Digital Soil Map	Digital Soil Map of the world Produced by FAO-UNESCO http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116&currTab=distribution
Rainfall Data	Mean Annual Precipitation Produced by DHM of Nepal

source: http://doi.org/10.3390/geosciences9040147

Table-2: Specification of USGS Landsat Image Data

Year	Satellite	Resolution	Path/Row	Band Combination	Date of Procurement
2000	Landsat 4-5 TM	30	142/040	1,2,3,4,5,6,7	June/July 2000
2005	Landsat 4-5 TM	30	142/040	1,2,3,4,5,6,7	June/July 2005
2010	Landsat 4-5 TM	30	142/040	1,2,3,4,5,6,7	June/July 2010
2015	Landsat 8 OLI/TIRS	30	142/040	1,2,3,4,5,6,7	June/July 2015
2020	Landsat 8 OLI/TIRS	30	142/040	1,2,3,4,5,6,7	June/July 2020

2.3 Methods

This research was basically conducted in two phases. In the first phase of this research, assessment of land use land cover change over the past twenty years and its forecasting for the upcoming years was carried out for Phewa watershed while the second phase of research consisted of estimation of soil erosion using the RUSLE model. The assessment of soil loss due to the LULC change impact was done in this research. The methodological framework used in this study for the LULC change and RUSLE model are shown in Figure 2 and Figure 3.

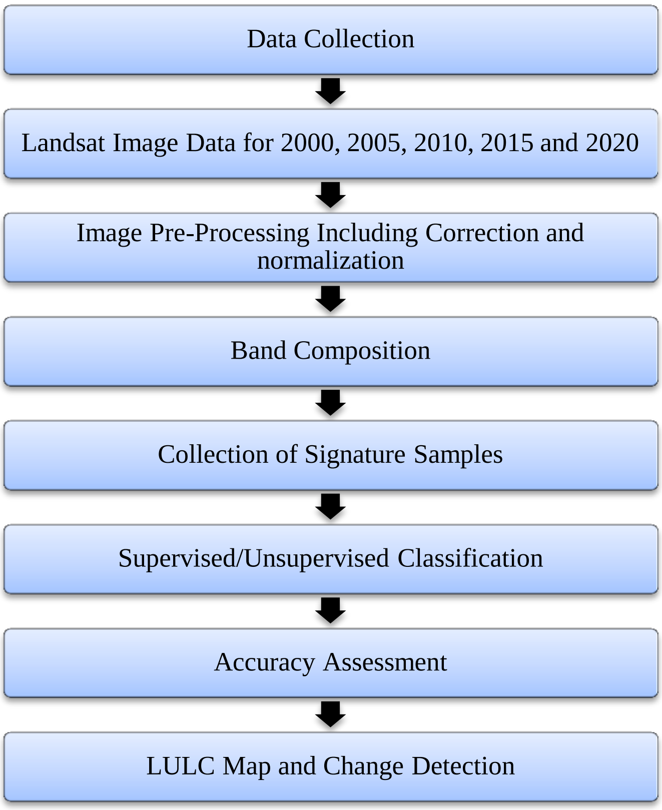

Fig-2: Flow Chart for LULC Classification

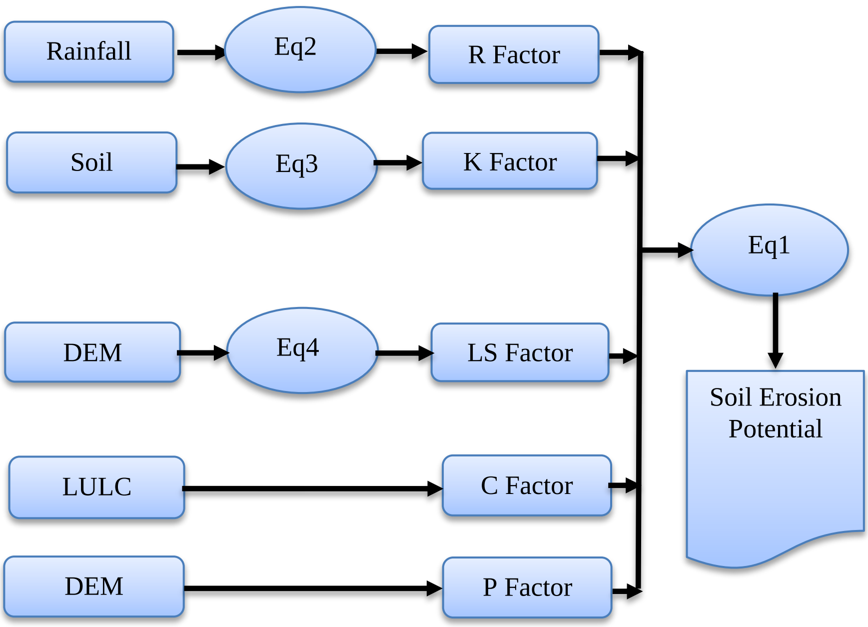

Fig-3: Flow Chart for RUSLE Model

2.3.1 Methodology to Assess LULC Change in Phewa Watershed

(a) LULC classification from 2000 to 2020

The boundary of Phewa lake watershed was fixed by watershed delineation by following the series of steps as DEM acquisition, fill, flow direction and flow accumulation. After fixing the boundary line of watershed land use land cover classification was carried out by overlaying the satellite image within this boundary. Various signature samples (training samples) were taken for classification of each land use type with the combination of various band compositions such as 4-3-2 for natural color, 7-6-4 for urban area, 5-4-3 for vegetation, 6-5-2 for agriculture and 5-6-4 for land or water. Supervised/unsupervised classification was done on this research as per requirement to produce LULC map.

(b) Accuracy Assessment for LULC Classification

To make the result better reliable it is very important to carry out accuracy assessment once the land use classification completed. In this research the classified Landsat images were compared with the ground truth image data taken from the google earth. During the accuracy assessment various sample points were chosen from each land use type and then those points were compared with the ground truth with the help of google earth image. Table 3 shows a sample process adopted for assessing the accuracy and Figure 4 stands to show how the signature samples were chosen from the produced LULC map to verify it with the real google earth image.

Table-3: Accuracy Assessment for 2015

Object ID	Forest	Agriculture	Urban	Barren	Water	Row sum
Forest	54	5	1	0	0	60
Agriculture	4	46	3	4	2	59
Urban	0	2	22	2	0	26
Barren	0	2	2	29	0	33
Water	0	0	0	0	21	21
Col Sum	58	55	28	35	23	

Total sum of row sum was 199 and total sum of column sum was 199 and total sum of diagonal value was 172. So, the accuracy was equal to 172/199*100 = 86.43% in 2015. It was found that the accuracy of classified images dated 2000, 2005, 2010, 2015 and 2020 were 89.14%, 89.72%, 86.97%, 86.43% and 89.10% respectively. The overall accuracy for all maps was found more than 85%.

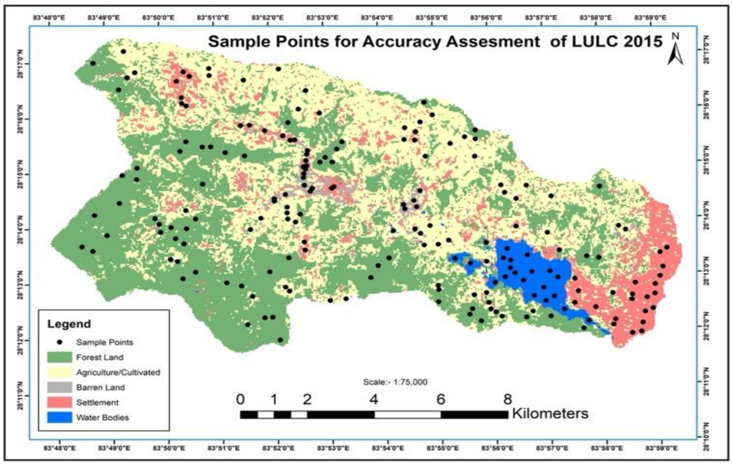

Fig-4: Sample Point Selection for Accuracy Assessment

(c) Forecasting of LULC Change for 2025 and 2030

The LULC map developed for the year 2020 was used as reference to forecast the LULC area for 2025 and 2030. The Euclidean Distance tool of QGIS was used to prepare the distance from road and distance from stream in the raster format. The LULC forecasting software named as "MOLUSCE" was installed with the help of QGIS plugins. In the platform of MOLUSCE raster map of 2010 was used as initial input and 2015 map as final input along with spatial variables such as 'DEM of watershed' and 'Distance from Road' to check the geometry. To evaluate the area change 'Pearson's Correlation' was used which gave the 'Class Statistics' and 'Transition Matrix'. The class statistics shows initial and final LULC area, and the transition matrix shows proportion of pixel change from one land use cover to another. The 'Create Changes Map' produced the map of change classes. In 'Transition Potential Modeling' of MOLUSCE an artificial neural network method was used to model the LULC transition potential as shown in Figure 5.

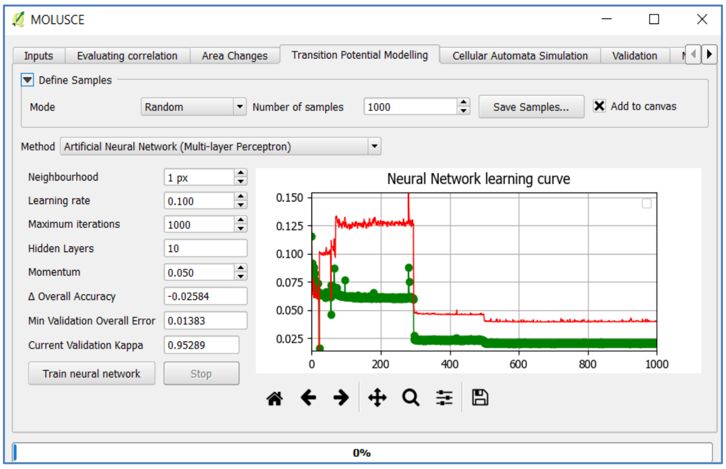

Fig-5: Neural Network Learning Curve

The option tool named as Cellular Automata Simulation of MOLUSCE was run to simulate the land use land cover map. Simulated result of LULC map was validated using the validation tab of MOLUSCE as shown in Figure 6. After the Model validation the LULC forecasting for 2025 and 2030 were assessed.

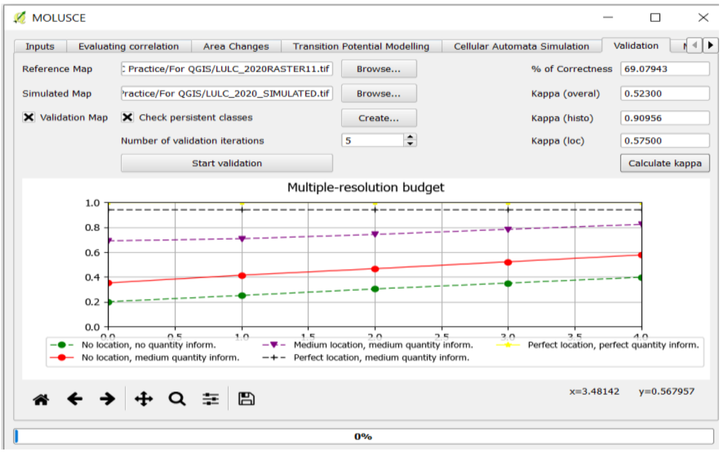

Fig-6: Validation of LULC Result

2.3.2 Methodology to Assess Soil Loss from the Phewa Watershed

(I) RUSLE Parameters Computation

(a) Rainfall Erosivity Factor (R)

Rainfall erosivity factor (R), describes the erosivity of rainfall at any 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. Mean annual rainfall data of stations (Lumle, Pokhara airport, and Pumdibhumdi) were taken from DHM, Pokhara. The R factor was estimated by equation 2.

$R = 38.5 + 0.35r$ ……………………. (Eq.2)

Where, R is rainfall erosivity factor (MJ mm/ha/h/yr.) and r is Mean annual rainfall of target area (mm) and it can be provided by DHM of Nepal.

(b) 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 map of the study area was extracted from the Digital Soil Map of the World (DSMW) generated by FAO. Calculation for K factor value was carried out using following formulae (Puja *et al.* 2019).

$K = Fcsand * Fsi\text{-}cl * Forgc * Fhisand * 0.1317$ .....(Eq.3)

Where,

$Fcsand = [0.2 + 0.3 \exp(-0.0256\ SAN\ (1 – SIL / 100)]$

$Fsi\text{-}cl = [SIL / (SIL + CLA)]^{0.3}$

$Forgc = 1- [0.25\ ORG / (ORG + \exp(3.72 – 2.95\ ORG)]$

$Fhisand = 1- [0.7\ (1- SAN /100) / \{(1 – SAN / 100) + \exp(- 5.51 + 22.9\ (1 – SAN / 100)\}$

Where, Fcsand = It provides a low soil erodibility factor for soil with coarse sand and a high value for soil with little sand content, Fsi-cl = It provides a low soil erodibility factor with high clay to silt ration, Forgc = It is the factor that reduces soil erodibility for soil with high organic content and Fhisand = It is the factor that

reduces soil erodibility for soil with extremely high sand content.
Where, SAN, SIL and CLA represent % sand, silt, and clay respectively; ORG is the organic carbon content.

(c) Slope Length Factor (LS)

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 research, 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 for the study area using equation 4 in raster calculator in ArcGIS (Yongsik, 2014).

LS Factor = [Power {("Flow Accumulation" * (Cell Resolution / 22.1, 0.4)} * Power {(Sin ("Slope of degree" * 0.01745) / 0.09, 1.4)} * 1.4]…………(Eq.4)

(d) Cover Management Factor (C)

The cover management factor (C) is used to reflect the effect of cropping and other management practices on 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. Table 4 represent the various land use type and their relevant cover management factor.

Table-4: Cover Management Factor (C)

Land Use	C Factor
Forest	0.03
Shrubland	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

Source: http://doi.org/10.3390/geosciences90401

(e) 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. In Nepal farming practices in sloppy agricultural land occur through the construction of terraces that closely resembles the contour farmland, which is a mean of conservation farming. Thus, we considered the contour farmland as an agricultural support practice. To find Support Practice factor for the study area, DEM data was extracted from ASTER GDEM produced by NASA. Boundary map of study area was then extracted by mask from this DEM data. The raster slope map then produced and reclassified in five slope categories in ArcGIS. The generated raster map was converted into polygon to add the contour range for respective slope in polygon map. After that the conversion for polygon to raster has been carried out to get P factor map. The Table 5 is a standard contouring value depending on the slope of real ground.

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

Source: http://doi.org/10.3390/geosciences9040147

(II) Simulation of Soil Loss by RUSLE Model

Once the RUSLE parameters such as rainfall erosivity factor (R), soil erodibility factor (K), slope length factor (LS), cover management factor (C), and practice factor (P) were assigned, their factor maps were produced in the ArcGIS. The RUSLE model was then made to run in the ArcGIS which multiplied the factor maps to produce the soil loss due to rill and sheet erosion from the Phewa watershed. It didn't consider gulley erosion during soil loss modeling. The RUSLE model used in this research to estimate the quantity of soil loss from the Phewa watershed has the unique mathematical expression which has been given below.

[A] = [R] x [K] x [LS] x [C] x [P]……………. (Eq.1)

Where, A stands for soil loss (t/ha/yr), R is rainfall erosivity factor(mm/ha/yr), K represents soil erodibility factor (t/mm), LS stands here for slope length factor (dimensionless), C indicates cover management factor (dimensionless), and P stands for support practice factor (dimensionless).

3. RESULT AND DISCUSSION

3.1 LULC Change in Phewa Watershed

The trend analysis for LULC change represents the direction of land class change based on their respective initial years as a reference (Appiah *et al.*, 2015). The Figure 7 is a land use map from 2000 to 2020 which shows a single view for all the land use maps considered in this study. The result showed that the settlement land is one whose value never seen to decrease since 2000 to 2020. The highest increment of settlement area occurred in between 2005 to 2010 with the value of 6.42 Km^2 (106.72%) and lowest change occurred in between 2010 to 2015 with the value of 1.36 Km^2 (0.11%). This means there is very high risk of unplanned urban development. The agricultural land was found to increase by 9.65 Km^2 (19.57%) in between 2000 to 2005 but after that it was found to decrease continuously, and the highest decrement of agriculture land was appeared in the year interval of

2015 and 2020 indicating decreased value of 7.36 Km^2 (14.66%). The forest land was found to decrease by 9.09 Km^2 (15.89%) in the first five years interval i.e., 200 to 2005. The remaining each five years interval, its coverage value was found to increase slightly however its coverage area was found to reduce at the end. The bigger increased value of forest land was found in the interval of 2015 to 2020 by 2.94 Km^2 (5.67%). Barren land was found to decrease in the first decade i.e., 2000 to 2010 but its value was found to increase in between 2010 to 2020 however its value was found to decrease ultimately. The Waterland was found to decrease for the years intervals of 2000 to 2005, 2005 to 2010, and 2015 to 2020 but its coverage value was found to increase in the years intervals of 2010 to 2015. At the end of day its coverage area was found neither increased nor decreased.

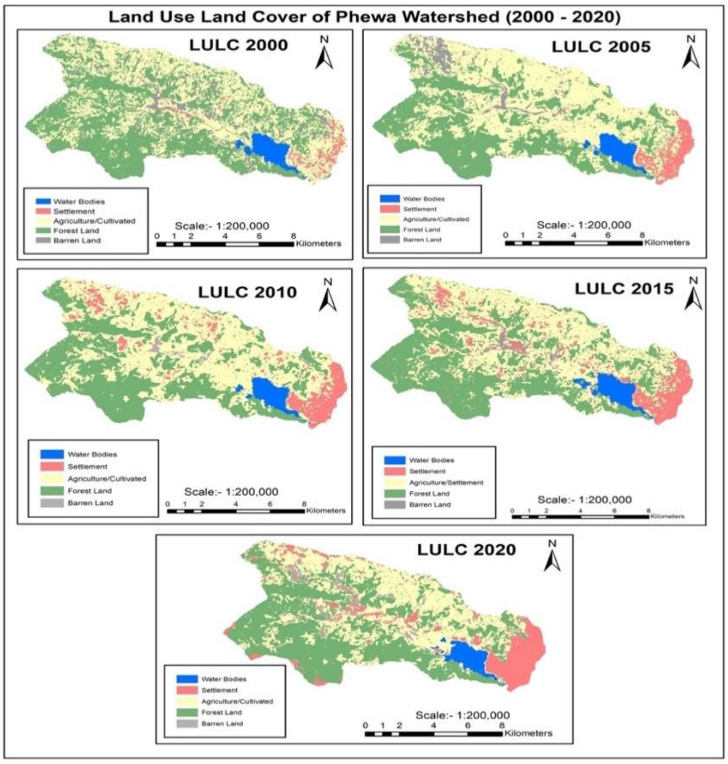

Fig-7: LULC Map of Phewa Watershed from 2000 to 2020

Table-6: Land Use Land Cover Area in Phewa Watershed

Land Use Land Cover	2000		2005		2010		2015		2020	
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%
Agriculture	49.30	40.11	58.95	47.95	55.65	45.29	50.19	40.85	42.83	34.86
Bare Land	8.79	7.15	5.92	4.82	1.22	0.99	2.63	2.14	5.35	4.35
Forest	57.23	46.56	48.14	39.16	49.77	40.50	51.85	42.20	54.79	44.59
Urban	3.60	2.92	6.02	4.89	12.44	10.12	13.80	11.23	15.90	12.94
Water	4.00	3.25	3.90	3.17	3.80	3.10	4.40	3.58	4.00	3.25

The settlement land is one whose value was never seen to decrease over the study period. Its coverage was found to increase in geometrical order in first three five-year intervals and its value was not stopped to increase afterward too as shown in Figure 8. Cultivated land was found to increase in first five intervals and then its coverage maintained falling rate till the end of 2020. Forest land decreased more at first interval, but its value increased continuously up to 2020 however did not coverup the lost value at initial. Waterbodies were seen very small amount of change over the period but at the end change was nothing for it which is very amazing thing. Barren land was also found to decrease over the period as shown.

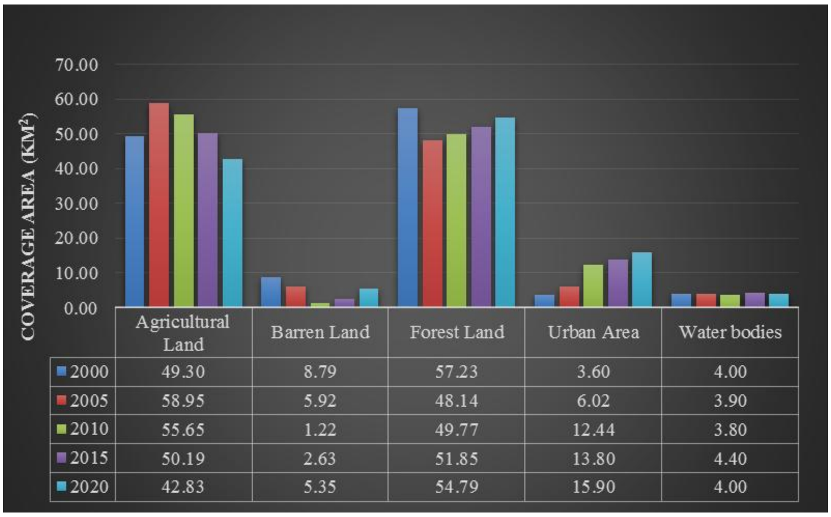

Fig-8: Land Use Land Cover Area in Phewa Watershed

3.2 Forecasted LULC Change in Phewa Watershed

MOLUSCE was used to forecast the LULC area of Phewa lake watershed for 2025 and 2030. Model validation was done keeping the LULC map of 2020 as reference for the accuracy of result. After the model validation it was made to run in the QGIS platform to simulate the future land use land cover value for Phewa lake watershed. It forecasted the land use land cover map for upcoming years 2025 and 2030 as shown in Figure 9 and Figure 10. The land use land cover area of Phewa watershed for the predicted years were shown in Table 7.

Table-7: Forecasted Land Use Land Cover Area in Phewa Watershed

Land Use Land Cover	2025		2030	
	Area (Km^2)	%	Area (Km^2)	%
Agriculture	42.53	34.64	42.39	34.52
Bare Land	4.33	3.52	4.25	3.46
Forest	54.99	44.78	55.10	44.86
Urban	17.10	13.91	17.19	14.00
Water	3.86	3.15	3.86	3.15

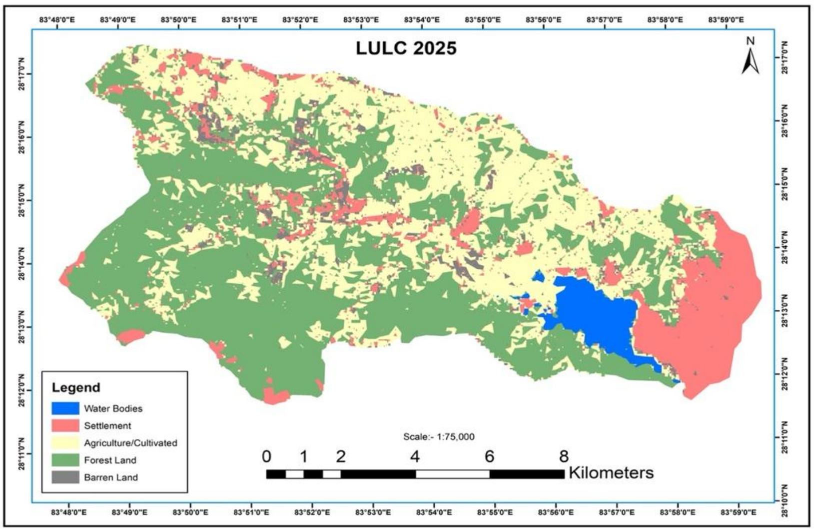

Fig-9: Forecasted LULC Map for 2025

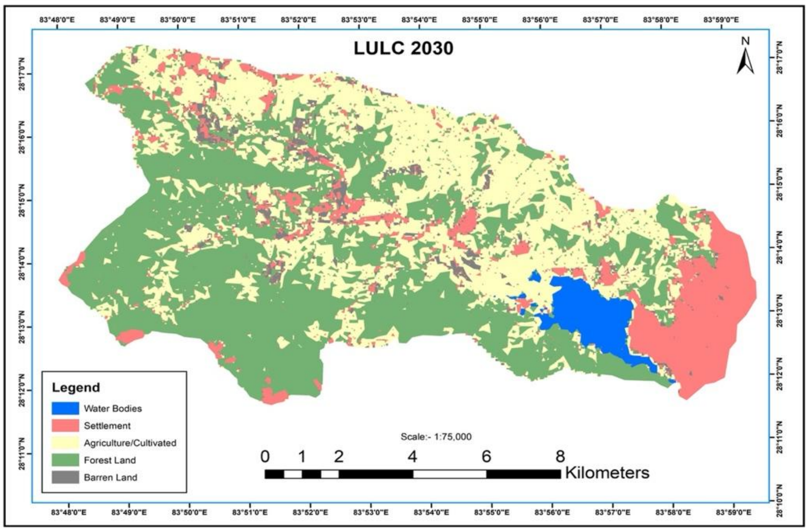

Fig-10: Forecasted LULC Map for 2030

3.3 RUSLE Factor Maps

The result obtained from this research showed that the soil erodibility factor (k) values ranged from 0.0165 to 0.0252 while slope length factor (LS) values ranged 0 to 25.55. The cover management factor (C) was found to range between 0 to 0.45 and the support practice factor (P) was found to range from 0.55 to 1. The rainfall erosivity factor (R) was found to range from 165 to 200.

Table 8 shows calculated value of K factor using the digital soil map of the world. Only two soil unit symbol were found for study area named as BD and I. The soil properties obtained from this unit symbol were used to fond K factor. The equations described in methodology were used to find it.

Table-8: Calculated Value of K- Factor

Soil unit symbol	Sand % Topsoil	Silt % Topsoil	Clay % Topsoil	OC % Topsoil	Fcsand	Fcl_si	Forgc	Fhisand	K Factor
BD	32.7	30.3	37.1	3.28	0.711	0.787	0.750	0.300	0.017
I	58.9	16.2	24.9	0.97	0.912	0.756	0.927	0.300	0.025

Figure 11 is a K factor map obtained from the research for Phewa watershed. The digital soil map of the world gave the percentage soil parameters contained in the watershed land such as clay, silt, sand, and organic matter content. Using the Equation 3, soil erodibility factor was calculated and then value for K factor was found as 0.0165 which is shown in eastern part of map by brown color. The K value for western part of watershed land was found as 0.0252 which is shown in Figure 11 with dark green color. These two values of K assured that this watershed region has consisted of soil type as clay, clay loam, loam, sandy clay loam, silty clay.

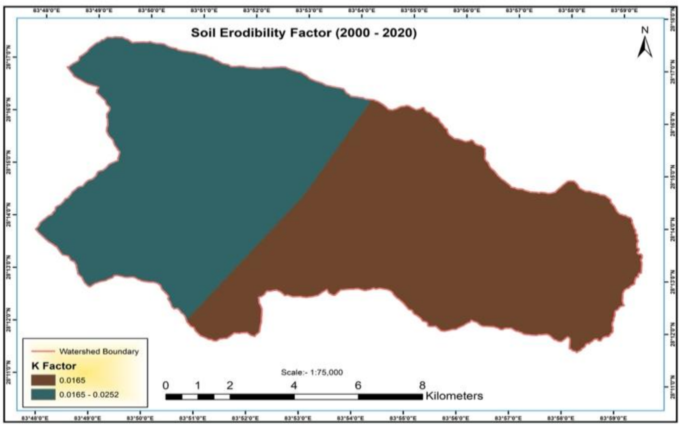

Fig-11: K-Factor Map

Figure 12 is an output gained from ArcGIS processing using the DEM data in raster calculation by following the Equation 4. If slope length factor is high that means steepness of ground is high where chance of soil loss per unit area will be more. In case of my research the LS factor was found not much that more. The range of it was 0 to 25.55 as shown in Figure 12. The full blue portion in the figure indicates here land coverage with minimum LS factor (0 to 5.11) for this watershed. The highest LS factor containing area was not clearly visible in the map due to small catchment area however these areas were laid on the ridge of watershed.

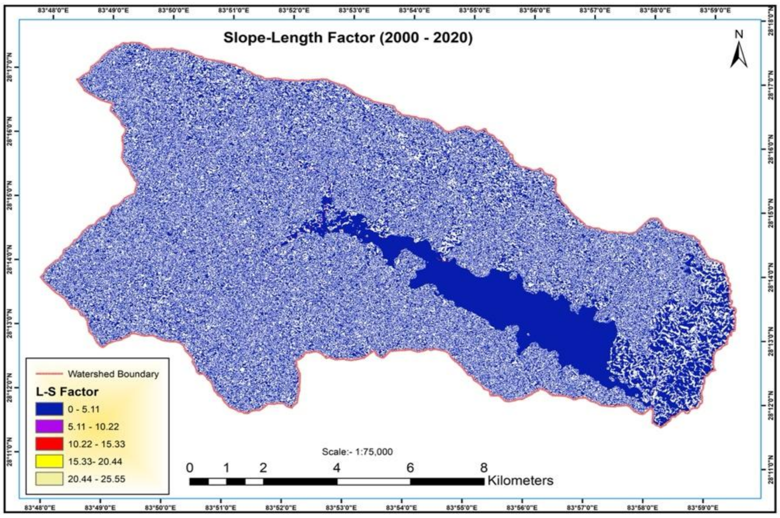

Fig-12: LS - Factor Map

Figure 13 is a C factor map found from this research. After the LULC map development for all considered years, C factor values for all years were assigned using the produced map in ArcGIS platform. C-factor values of respective land use cover such as forest, agriculture, water, bare land, built up area were made to input in ArcGIS. In the map 0 value represent the water bodies and settlement area. The C values containing 0.03 represent here forest land and 0.21 represent agricultural land. The coverage consisting of C value as 0.45 indicates the bare land.

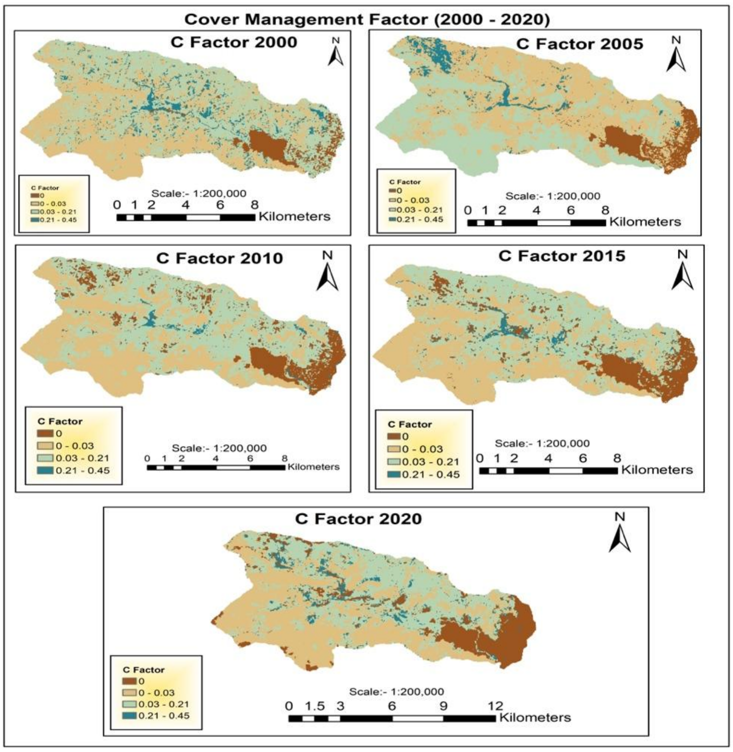

Fig-13: C - Factor Map

The Figure 14 is a P factor map gained from the research by processing DEM data in the platform of ArcGIS giving the slope range and respective P values for each slope range. The P value always ranges from 0.55 to 1. The P value is 1 for the slope percent more than 26.8 and 0.55 for the slope percent ranges from 0 to 7 percent. The water and settlement area usually consisted of mild or less slope value so the dark brown portion in the map given below was found to consist of P value minimum ranging from 0.55 to 0.66. But yellow portion of this watershed mostly represent the more slopy area of watershed due to which P value is 1 for it.

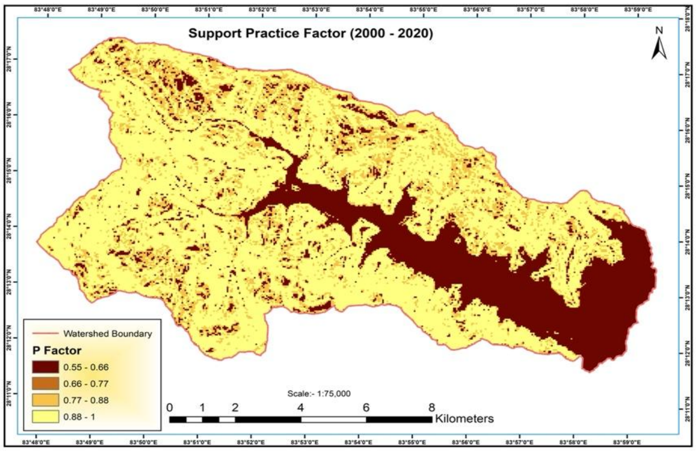

Fig-14: P-Factor Map

Figure 15 is a rainfall erosivity factor (R) map produced from the research using the annual mean rainfall data provided by DHM in the equation 2. The R factor values for all year found to range from 165 to 220 mm/ha/yr. The highest R factor containing region in the map has been shown by dark green color with value of 200 to 220 mm/ha/yr. The lowest one is presented by mild pink color with value of 165 to 176 mm/ha/yr.

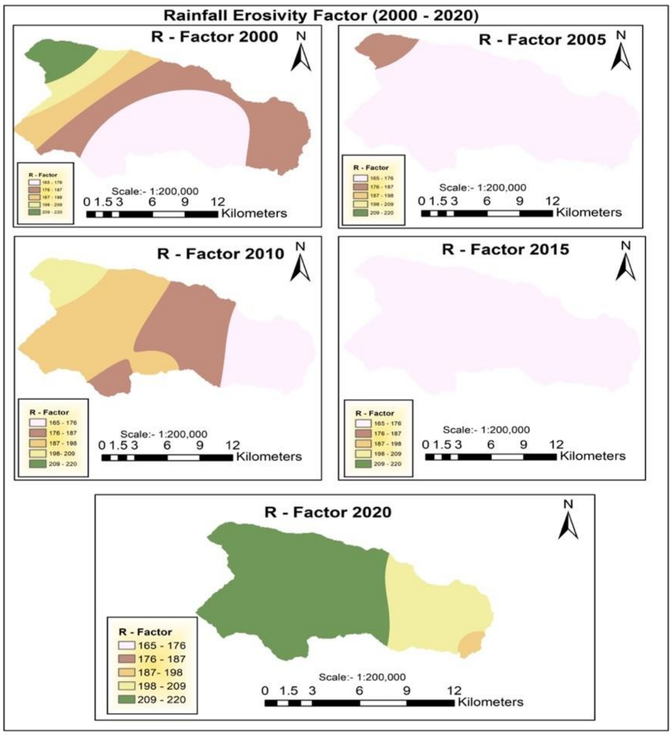

Fig-15: R - Factor Map

3.4 Effects of LULC Change on Soil Loss from Phewa Watershed

Among the various effects of land use land cover change soil loss is one of them and is considered as major problems which can totally scoured out the fertile soil from the watershed land causing noticeable decrease in the agricultural productivities. This research assessed the soil loss from Phewa watershed due to the change of land use coverages within it. The research found that the land use land cover changes have significant effect on soil loss from the watershed. The change pattern of LULC in each five years intervals are presented in Table 9 and Figure 16. Its effects on soil loss from the Phewa lake watershed has been shown in Figure 17. As the LULC changes for each five years interval were found in a very fluctuated quantity so the soil loss was also found to vary in each year of interval. This means the LULC change has direct effect on the soil loss. The years interval having highest diminishing of forest, agriculture, and water bodies with increased area of barren land and settlement area were faced with large value of soil loss. It indicates that the shifting of greenery land into barren and settlement area has more effect on soil loss in any watershed land because greenery land consists of more vegetative cover protection to save the soil loss as compared to naked or barren land. Research predicted there was alternative rise and fall in soil loss due to the unsymmetric change in land use land cover. The trend of soil loss values in each five years interval were shown in Figure 17.

Table 9: LULC Change in Each Five Years Interval

LULC Change	2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020
	Area (Km^2)	Area (Km^2)	Area (Km^2)	Area (Km^2)
Agriculture	9.65	-3.30	-5.46	-7.36
Bare Land	-2.86	-4.71	1.41	2.72
Forest	-9.09	1.63	2.08	2.94
Urban	2.42	6.42	1.36	2.10
Water	-0.10	-0.09	0.60	-0.41

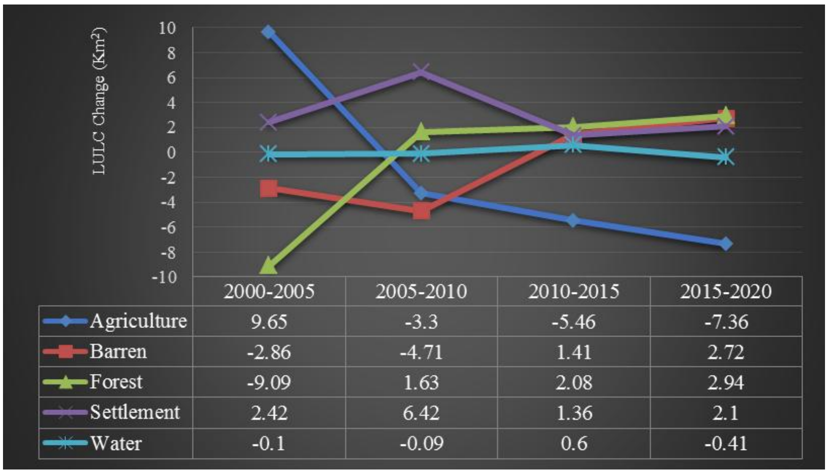

Fig-16: Variation of LULC Change in Phewa Watershed

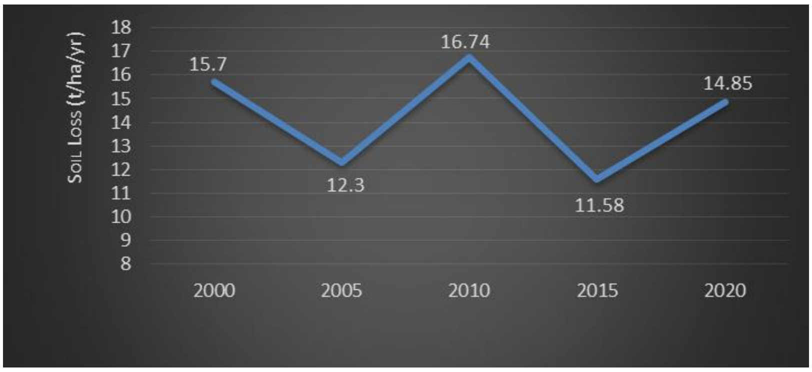

Fig-17: Soil Loss Trend from 2000 to 2020

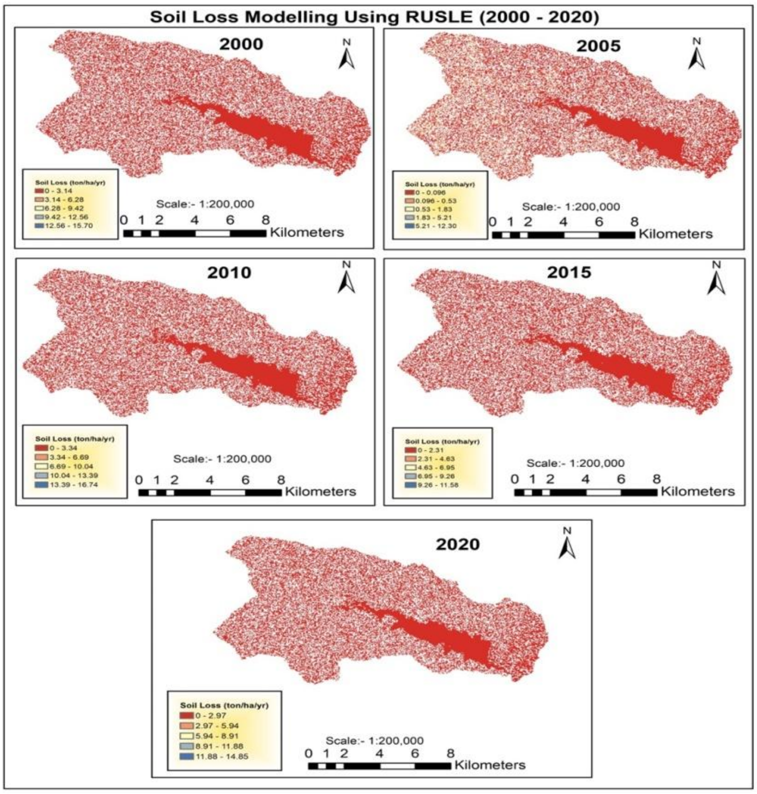

Fig-18: Soil Loss Map from of Phewa Watershed (2000 to 2020)

The potential soil erosion map developed by this study using the RUSLE tool in ArcGIS has been shown in Figure 18. This map was produced through RUSLE model in the platform of ArcGIS. Each soil loss map in the Figure 18 stands to indicate soil loss happened in the years 2000, 2005, 2010, 2015 and 2020. Alternate rise and fall in the soil loss occurred in the maps while moving from 2000 to 2020. In the maps, the solid red color represents the area of less quantity of soil loss zone while the dark blue color represents high soil loss rate zone. Mostly waterbodies lie in the solid red zone from where soil loss rate was found to range 0 to 3.14 t/ha/yr and the dark blue color represent here mostly the bare land from where soil loss rate was found to range from 3.14 t/ha/yr to 15.70 t/h/yr in 2015. But in the case of 2005, 2010, 2015 and 2020 the lowest and highest soil loss ranges were found as 0-0.096 t/ha/yr and 0.096-12.30 t/ha/yr, 0-3.34 t/ha/yr and 3.34-16.74 t/ha/yr, 0-2.3 t/ha/yr and 2.31-11.58 t/ha/yr, 0-2.97 t/ha/yr and 2.97-14.85 t/ha/yr respectively.

4. CONCLUSION

Soil erosion is a global issue with its major effects on agricultural lands. Assessment of land use land cover change and its impact on soil loss is very essential for the watershed land of Nepal. Every year tones of soil are migrating from ridge zone to valley zone by washing the productive layer of land from top surface. It has great impact on agricultural productivity. The immature and unplanned land use activities of locality have great tendency to bring unusual change in the land use land cover area enhancing towards soil erosion from the watershed land like Phewa watershed.

This study was conducted using ArcGIS, Remote sensing, and RUSLE tool for the prediction of land use land change and its effects on soil loss from 2000 to 2020 keeping five years of interval for the Phewa watershed. Additionally, MOLUSCE and QGIS tool were also used in this research for the prediction of LULC area. In this study settlement area was found to be increased by rapid rate of change. Its value was found to change with 12.3 Km^2 (342.20%) from 2000 to 2020. It means there is higher chances of formation of concrete jungle by reducing the greenery land in the watershed. The diminishing value of forest, agriculture, and bare land were found as 2.45 Km^2 (4.27%), 6.47 Km^2 (13.12%) and 3.44 Km^2 (39.13%).

Research conducted to predict the LULC change for Phewa watershed produced the LULC maps for past two decades and based on this result of LULC map, forecasting of LULC map for 2025 and 2030 was carried out. The forecasted result for LULC change showed that settlement area will maintain its coverage as 17.10 Km^2 and 17.19 Km^2 in 2025 and 2030 respectively. In 2025, forest land and agricultural land will maintain their coverage as 54.99 Km^2 and 42.53 Km^2 respectively followed small variation in 2030 maintaining their coverage as 55.10 Km^2 and 42.39 Km^2 respectively. The barren land will be 4.33 Km^2 in 2025 but 4.25 Km^2 in 2030 while the water coverage for both 2025 and 2030 years will be the same as 3.86 Km^2. The forecasted result indicates that the shifting of greenery land into settlement area will not stop till the end of 2030. This means settlement area will be shifted into agriculture and other land use sectors causing great loss of productive lands as well as water lands. The soil loss from watershed was found highest in the year 2010 (16.74 t/ha/yr) and lowest was found in the year 2015 (11.58 t/ha/yr).

Due to the land use land coverage change the soil loss were found as 15.70 t/ha/yr, 12.3 t/ha/yr and 14.85 t/ha/yr in the years 2000, 2005, and 2020 respectively. This loss of soil has great negative effects on the greenery land within this watershed. The fluctuation of land use land cover change seems directly proportional with the soil loss from the Phewa watershed. The findings from this study could be used for the effective management of land use land cover and soil loss from Phewa watershed. This study considered only five categories of land use type but the consideration of a greater number of categories following the soil loss from each land use type would be better to understand the erosion prone zones of Phewa watershed land.

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