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MONITORING LAND COVER/LAND USE CHANGE USING REMOTE SENSING AND GIS TECHNIQUE AT DHULIKHEL AND BANEPA MUNICIPALITY, NEPAL

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ABSTRACT

This study illustrates the land cover/ land use (LULC) (Agriculture, Forest, Built-up, Barren) and its changes using geo-spatial technology like Remote Sensing and GIS. The land cover has been detected for the years 1992, 2002, 2012, and 2020 using freely available Landsat Images. In addition, land cover change analysis within a decade and also overall from 1992 to 2020 has been carried out. The approaches like Maximum Likelihood Classification (MLC) have been applied in ENVI for supervised classification. Observing the statistics generated from this study, over the time frame of 38 years (1992-2020), forest and agricultural land were decreased by 8.27 sq. km (7.57%) and 8.12 sq. km (7.44 %) respectively, whereas built-up and barren areas were increased by 12.39 sq. km (11.3 6%) and 3.99 sq. km (3.66 %) respectively. To prevent the haphazard conversion of agricultural land in other land use, the implementation of the land use policy 2015, which has recently been enacted in Nepal, is important.

Keywords: Land Use, Land Cover, GIS, Remote Sensing, Agriculture.

I. INTRODUCTION

Land Use or Land Cover is two different terminologies that were found to be applied interchangeably in various literature (Lambin et al., 2003; Lira et al., 2012). Land Cover is described as the biophysical pattern in the earth's surface that denotes various cover like vegetation, built-up, water, and other man-made physical features. This term seems to originate originally by referring to the vegetation only but later broadened to include human structures like building, roads etc. While land use refers to the way and intention that the human manipulates the biophysical attributes for meeting their socio-economic demand (Briassoulis, 2019; Rawat & Kumar, 2015). It can be articulated that a land cover is a generalized form of land use. However, land cover and land use change patterns are an outcome of various social, economic, and environmental factors associated with the human and land interaction and use of land resources to fulfill the required necessity. It is pointed out that "land use effects land cover and changes in land cover effects land use"(Rawat et al., 2015).

The detection of land cover/ land use (LCLU) and its change within a certain time series is very essential to obtain sustainable land management which is understood as a process by which sustainability in its use is obtained by its effective utilization. As highlighted by Shrestha et al. (2021), regulatory instruments like land use policies play a vital role in sustainably managing land. The study of land use/ land cover (LCLU) has been carried out from various land management perspectives. In this regard, LULC from forest management (Lira et al., 2012; Schulz et al., 2010), LULC from land fragmentation (Nagendra et al., 2004), LULC from soil erosion (Sharma et al., 2011) has studied the perspective. In this study, besides various land cover like a built-up, barren, forest the change in agricultural land has been discussed more specifically.

Application of Remote Sensing (RS) and Geographical Information System (GIS) technique helps in understanding the spatiotemporal change of land cover and land use. Remote sensing (RS) is the process of data acquisition through airborne or space sensors without having any contact with the object on the earth's surface (Richards, 2013). GIS has been understood from the map view, database view, and spatial analysis view (Chrisman, 1999). This geo-spatial technique allows obtaining the existing land cover/ land use (LULC) in that particular period. This technique is useful in planning the use of land for various purposes like agriculture, industrial, forest, etc. (Selçuk et al., 2003). In addition, the Remote Sensing technique has made it possible to analyze LULC at low cost, fast, and also accuracy obtained to the desirable threshold (Kachhwala, 1985).

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Remote Sensing with an association of GIS provides a suitable platform for data analysis, update, and retrieval (Singh, 1989).

The satellite imaginaries are used for analyzing the land cover and its change. Freely available satellite imaginaries like Landsat 5 –Thematic Mapper (TM), Landsat7 TM, Landsat7 ETM+, Landsat OLI have been used to study land cover and its changes by various studies (Dewan & Yamaguchi, 2009; Wang et al., 2020). Since the early 1970s, Landsat-TM images have been continuously and consistently archiving images of the earth's surface. Moreover, the entire Landsat archive is made freely available which has made the possibility of identifying and also monitoring land cover and land use dynamism (Chander et al., 2009)

This paper attempts to analyses land cover change basically forest, built-up, barren, and agricultural land cover between the years 1992 and 2020 (almost for the three decades) by adopting Landsat images which are freely available. In addition, the paper shed light on the planning instruments to preserve agricultural land.

II. DESCRIPTION OF STUDY AREA

The study areas selected for this study are Banepa and Dhulikhel municipalities which are located in Kavre District, Bagmati Province, Nepal (Figure 1).

Banepa municipality is the historical and religious sites located at 27°38′ N and 85°31′ E. It lies 1500m above sea level. It has an area of about 55 sq. km and consists of 14 wards. According to the Central Bureau of Statistics, Nepal (2011) census, the population of this municipality is identified as 55, 628. Similarly, Dhulikhel municipality is a place that carries the magnificent beauty of nature and is located at 27°37′ N and 85°33′ E. It lies at 1550m above sea level. It has an area of about 55 sq. km and consists of 12 wards. According to the Central Bureau of Statistics (2011), census, the population of this municipality is 32,162 (Ministry of Federal Affairs & General Administration, 2021)(Ministry of Federal Affairs & General Administration, 2021).

The main reason to select these two municipalities as the study area is because they are an important trading center on the commercial route linking Nepal to Tibet for centuries. In addition to this, two major B.P. Highway and Araniko Highway passes through these municipalities which make these strategically important cities. Also, these two municipalities are local and national tourist attraction hubs. Moreover, due to the establishment of the Katmandu University in 1991 and Dhulikhel Hospital in 1996 inside Dhulikhel municipality the built-up expansion is increasing year by year. Besides, due to urban development inside Banepa municipalities, the agricultural land is continuously converting from agricultural land to built-up year by year.

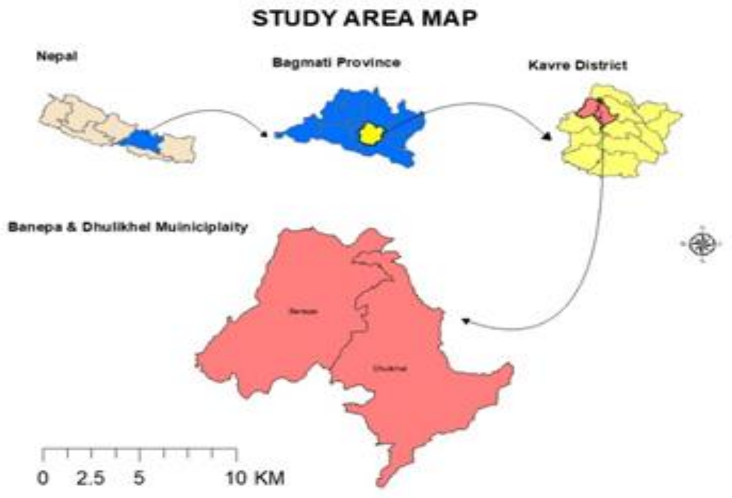

Figure 1: Map Showing Study Area

III. DATA AND METHODOLOGY

In this section, the methods applied for data acquisition, preparation including methods for determining land cover and land cover changes have been described.

Data Acquisition and Preparation

Landsat images of resolution 30m for the years 1992, 2002, 2012 and 2020, with the time interval of decades, were acquired for land cover change analysis. Table 1 shows the details of the acquired images.

The satellite images were obtained from the USGS website. These data sets were imported in ENVI (https://www.l3harrisgeospatial.com/Software-Technology/ENVI), software that supports satellite image processing to analyze multi and hyperspectral data. Then the software has been used for applying image preprocessing for the correction of raw satellite images. A series of sequential operations; radiometric calibration, atmospheric correction, geometric correction, and mask were performed in the image-preprocessing step, for this study. Meanwhile, periodic line dropout for the year 2012 in LandSat-7 ETM+ was removed initially.

Radiometric Calibration tool in ENVI software was used firstly for converting the DN's of acquired satellite imageries into the radiance and secondly, converting those radiance values into Top of Atmosphere (TOA) reflectance using the information available in metafile such as; sun elevation angle. Atmospheric correction was done to reduce or correct errors in the digital numbers of images that occurred due to atmospheric effect. Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) model available in ENVI software was used to perform the atmospheric correction. Since it can reduce the atmospheric effect on the image data effectively. The geometric correction was done to acquired raw image data due to varying topography, instability of the sensor platform, the motion of the scanning system. Thus, images were geometrically corrected using topographic map sheets prepared by the Survey Department, Nepal at the scale of 1:2500 with local horizontal datum (Everest 1830). The image Registration module available in ENVI was used during the geometric correction Finally, the subset of satellite images of respective time series has been performed for extracting the study area by taking georeferenced outline boundaries of Banepa and Dhulikhel municipalities as AOI (Area of Interest). After demarcating AOI, the training samples were extracted to apply as an input for the supervised image classification. Respective land cover maps for each study year were prepared using ArcGIS software. Quality assessment of prepared land cover maps was done based on confusion matrix in ENVI software.

Table 1: Data Specification

Data Type	Acquisition Date	Band	Resolution	Source
LandSat5 TM	29 March 1992	Multispectral	30m	USGS
LandSat7 TM	02 April 2002	Multispectral	30m	
LandSat7 ETM+	12 April 2012	Multispectral	30m	
LandSat8 OLI	4 April 2020	Multispectral	30m	

Land Cover Detection

To perform land cover detection, a supervised classification method with Maximum Likelihood Classification (MLC) was applied in the ENVI software. MLC is considered as one of the most acceptable and used supervised classifications with remotely sensed satellite imagery data. According to, (Caetano, 2009), theoretically this method assigned each respective pixel to particular clusters (class) having a high probability to match with it. In addition to it, probabilities value (statistical distance) of belonging respective pixels to particular classes obeys Gaussian (normal) distribution (Kerle et al., 2004). The advantage of using this method is; it not only uses the centers of the clusters but also other geometric properties (shape, size, orientation) of clusters using mean values and covariance matrix of clusters (Kerle et al., 2004). Meanwhile, this method needs time consuming computation, mostly relies on Gaussian distribution of probabilities (Deilmai et al., 2014). In addition to this, the supervised classification method, Minimum distance is a time-saving method but cannot obtain better accuracy than MLC since, cannot incorporate spectral variation significance (Sahu et al., 2015). Four land cover classes (Agriculture, Forest, Built up, and Barren) were considered in this study based upon the spatial resolution of image data and literature review. Then, using the rule of thumb (Bakker, et al., 2009), 30*n training datasets per class (where n=number of bands) were generated, on respective satellite imageries for the particular time interval in the study area, using the 'ROI' tool in ENVI. Generated training datasets were evaluated and refined successively based upon the spectral reflectance curve since almost most of the accuracy of MLC depends upon the choice of training datasets. For Image classification, the 'Classification Workflow' module was used. Preliminary extracted training datasets were used for training the MLC classifier. Majority/ Minority filter' in post processing module of ENVI software was also used then after image classification, to remove errors, in the form of small groups of pixels from the classification image. Lastly, smooth images for respective time intervals were generated. Accuracy assessments of classified images have been performed to compare the classified pixels with their corresponding location in the real-world ground. To conduct an accuracy assessment, initially adequate ground truth sample points were collected for a particular class, for the respective time interval, using Google Earth imageries. Collected ground truth was further used for testing over the classified image using, 'Confusion Matrix Using Ground Truth Image' in the post-processing module of ENVI. Outputs files as; Confusion Matrix (Error Matrix), overall accuracy, producer accuracy, user accuracy, and kappa coefficient were obtained with other additional information. Obtained kappa value and other statistical parameters for respective time intervals were obtained with a significance value indicating efficiency.

Finally, using proper cartography Landover map for respective time interval were prepared using the ArcGIS software.

Land Cover Change Detection

After detecting land cover by applying the MLC method for the years 1992, 2002, 2012, and 2020, a post-classification detection method was applied. The land cover change between two consecutive years i.e. between 1992-2020, 2002-2012, 2012-2020 has been detected. In addition, the total changes between 1992-2020 were also detected. A pixel-based comparison was used to produce the information on land use change on a pixel basis. This leads to a more efficient interpretation of the changes. During the analysis, the advantage of the ''-from, -to'' principle, which refers to the pixels or percentage or area of change of land cover at time T1 to the same land cover at time T2, has been considered. The comparison of land use changes between various years has been carried out by comparing the classified image using cross-tabulation. A change matrix (Weng, 2001), between 1992-2002, 2002-2012, 2012-2020 was produced using the ENVI software to determine changing percentage of each land cover category to all other classes based upon ''-from, -to'' principle. Thus, quantitative areal data of the overall land use/cover changes as well as gains and losses in each category of land use between 1992-2002, 2002-2012, 2012-2020 were compiled.

IV. RESULT AND ANALYSIS OF LAND COVER/ LAND USE CHANGES

The results obtained through the analysis of multi-temporal satellite imageries were diagrammatically illustrated in Figs. 2–4 and data are registered in Tables 1 and 2. Fig. 2 depicts land use/cover status, Fig. 3 depicts land use/cover change in different land use categories and Fig. 4 illustrates the magnitude of change in different land categories. A brief account of these results is discussed in the following paragraphs.

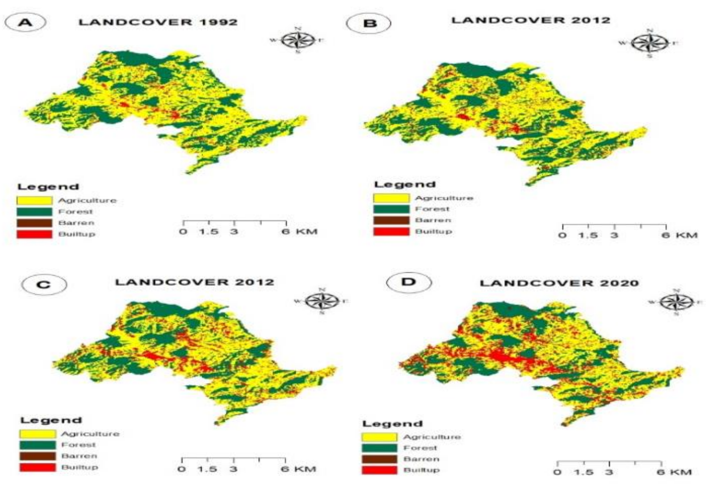

Figure 2: Land Cover in various Time Series

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Table 2: Land Cover in Area (sq. km) & percentage (%)

	1992		2002		2012		2020	
Land Cover	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**
Forest	41.88	38.36	40.68	37.27	37.13	34.02	33.61	30.79
Agriculture	60.89	55.79	59.01	54.06	56.72	51.96	52.77	48.34
Built-up	5.19	4.76	7.12	6.53	11.52	10.55	17.59	16.11
Barren	1.17	1.08	1.68	1.54	3.76	3.45	5.17	4.74

Status of Land Cover

Table 1 and **Error! Reference source not found.** illustrates that 55.79 % of the total land of the study area is covered by agriculture which occupied an area of 60.89 km^2 in the year 1992. Meanwhile, forest occupied 38.38 % of the land covering an area of 41.88 km^2 whereas built-up and barren land occupied 4.75 % and 1.08 % of the land with 5.19 and 1.17 km^2 respectively. Results generated from the classified image of 2002 illustrates that forest land covers nearly 37.27 % with an area of 40.68 km$^{2.}$ Similarly, agricultural land occupied nearly 60% with an area of 54.06 km^2. Furthermore, built up occupied 7.12% and area of 6.53 km^2 of total land surface whereas baren land occupied 1.54% land with 1.68 km^2. In 2012, the regions under agriculture and forest are 34.02 % and 51.96 % with an area of 37.13 and 34.02 km^2 respectively. 10.55 % and 3.45 % with an area of 11.52 and 10.55 km^2 land were occupied by built-up and barren land respectively. In the case of 2020, the built-up occupancy is greater compared to another time interval i.e. 16.11 % with an area of 17.59 km$^{2.}$ Similarly, forest and agriculture land occupied 30.79 % and 48.34 % of the total land with an area of 33.61 and 52.77 km^2 respectively. Meanwhile, barren land had covered 5.176 % of the land with an area of 4.74 km^2.

Land Cover Change

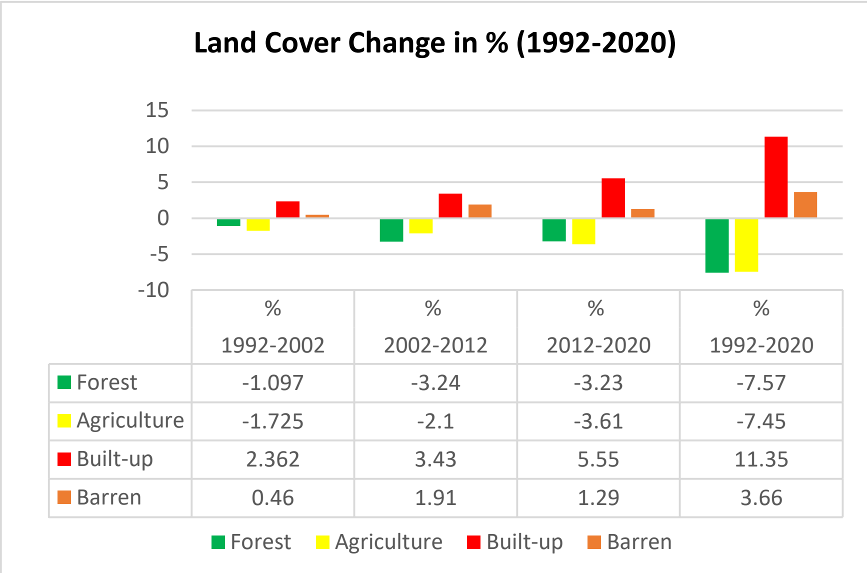
The results obtained from the land cover change analysis using multi-temporal satellite images are illustrated and data registered in Figure 2 and Figure 3, show that both positive and negative land use cover was obtained in the study municipalities.

During 1992-2002, forest and agriculture land cover has been found decreased by 1.097 % and 1.725 % with an area of 1.198 and 1.883 km2 respectively. Similarly, built up and barren have decreased by 2.36 % and 0.5 % covering an area of 2.36 and 0.5 km2 respectively. The percentage of changes between land cover classes during 2002-2012 has been observed in the given Figure 3. The figure illustrates that forest and agriculture have decreased by 3.24 % and 2.1 % with covering an area of 3.54 and 2.29 km2 respectively. On the contrary, built up and barren has increased by 3.43 % and 1.92 % with an area of 3.75 and 2.08 km2 respectively. In addition, during 2012-2020, it has been observed that forest and agriculture have been significantly declined by 3.23 % and 3.61 % with an area of 3.52 and 3.94 km2 respectively. Meanwhile, built-up and barren has inclined by 5.55 % and 1.29 % with an area of 6.06 and 1.41 km2 respectively.

Besides, during 1992-2020, forest and agriculture land has been noticed in decreasing trend by 7.57 % and 8.27 % respectively with an area of 8.27 sq. km and 8.12 sq. km. Meanwhile built up and barren has also been significantly inclining by 11.35 % and 12.39 % respectively covering an area of 12.39 and 2.99 sq km respectively.

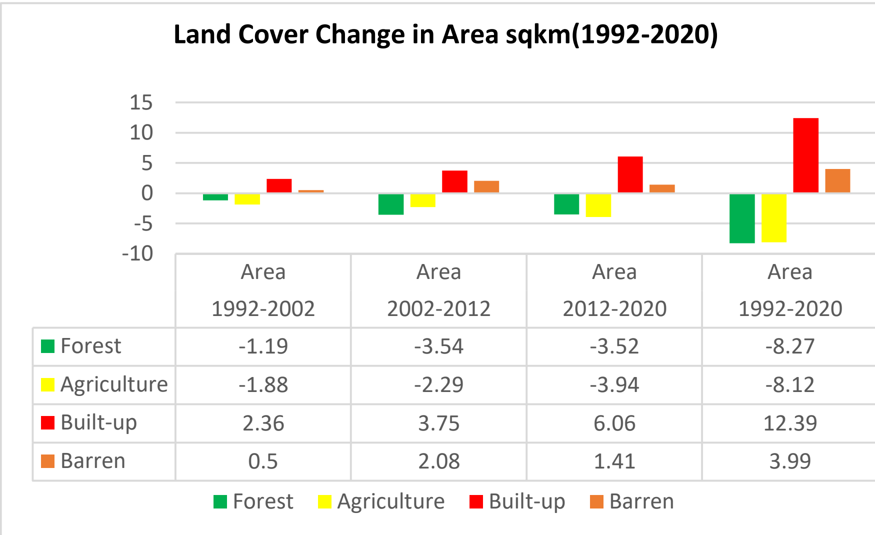
It has been noticed that forest has been continuously declining throughout the time interval 1992-2002. Later, in 2012-2020 it has been observed that the declining rate was less compared to the previous interval i.e., 1992-2002. Meanwhile, agriculture seems continuously decreasing over different time intervals. Whereas built up and barren has been significantly increasing over the various time interval. It has been observed that compared to other land cover magnitude of barren is comparatively low due to the uncertainty during supervised classification because of mixed pixels with built up and also due to availability of limited spatial resolution of image data.

Considering the overall change analysis, it reveals that the agricultural land has been decreasing in the municipalities. The trend of this decreasing pattern needs to be intervened by applying the land use planning instruments. Regulatory instruments like land use zoning can control the haphazard conversion of agricultural land. Recently, to implement the land use policy 2015, the Nepal government has enacted the land use act 2019. The major policy goal of the land use policy is to preserve agricultural land (Shrestha et al., 2021). In addition, the land use zoning prepared for Dhulikhel municipality also reflects about controlling fragmentation of agricultural land to protect agricultural productivity (Nepal, 2019).



	% 1992-2002	% 2002-2012	% 2012-2020	% 1992-2020
Forest	-1.097	-3.24	-3.23	-7.57
Agriculture	-1.725	-2.1	-3.61	-7.45
Built-up	2.362	3.43	5.55	11.35
Barren	0.46	1.91	1.29	3.66

Figure 3: Percentage of Land Cover Changes between each Decades



	Area 1992-2002	Area 2002-2012	Area 2012-2020	Area 1992-2020
Forest	-1.19	-3.54	-3.52	-8.27
Agriculture	-1.88	-2.29	-3.94	-8.12
Built-up	2.36	3.75	6.06	12.39
Barren	0.5	2.08	1.41	3.99

Figure 4: Change in Area within each Decades

V. CONCLUSION

The study conducted in Banepa and Dhulikhel municipalities reveals that the application of RS and GIS with the input of multi-temporal satellite images plays an important role in quantifying spatial and temporal phenomenon of bio physical attributes in the earth's surface. The results of this study reveal that, during the study period (1992-2020), there is the highest percentage increase of built-up land and a small increase of barren land respectively. Besides, there is a gradual decrease in forest and agricultural land over the time frame of 38 years (1992-2020). The decrease in forest area and agriculture area has been noted as 7.57 % (8.27 sq km) and 7.45 % (8.12 sq km) respectively between the years 1992-2020. This result indicates that the municipalities if this trend continues, there will be rapid urban growth with a quick loss of arable land. Hence, to prevent the loss of arable land and for obtaining sustainable land management, land use planning instruments like land zoning and land use planning must be implemented soon.

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VI. REFERENCES

[1] Briassoulis, H. (2019). Analysis of land use change: theoretical and modeling approaches.

[2] Chrisman, N. R. (1999). What does 'GIS'mean? Transactions in GIS, 3(2), 175-186.

[3] Deilmai, B. R., Ahmad, B. B., & Zabihi, H. (2014). Comparison of two classification methods (MLC and SVM) to extract land use and land cover in Johor Malaysia. Paper presented at the IOP conference series: Earth and environmental science.

[4] Dewan, A. M., & Yamaguchi, Y. (2009). Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. Environmental monitoring and assessment, 150(1), 237-249.

[5] Kachhwala, T. (1985). Temporal monitoring of forest land for change detection and forest cover mapping through satellite remote sensing. Paper presented at the Proceedings of the 6th Asian Conf. on Remote Sensing. Hyderabad, 1985.

[6] Kerle, N., Janssen, L. L., & Huurneman, G. C. (2004). Principles of remote sensing. ITC, Educational textbook series, 2, 250.

[7] Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. Annual review of environment and resources, 28(1), 205-241.

[8] Lira, P. K., Tambosi, L. R., Ewers, R. M., & Metzger, J. P. (2012). Land-use and land-cover change in Atlantic Forest landscapes. Forest Ecology and Management, 278, 80-89.

[9] Ministry of Federal Affairs & General Administration. (2021). Retrieved from https://www.sthaniya.gov.np/gis/

[10] Nagendra, H., Munroe, D. K., & Southworth, J. (2004). From pattern to process: landscape fragmentation and the analysis of land use/land cover change: Elsevier.

[11] Nepal, G. o. (2019). Integrated urban development plan of Dhulikhel Municipality: Land Use and Zoning Plan. Dhulikhel.

[12] Rawat, J., & Kumar, M. (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. The Egyptian Journal of Remote Sensing and Space Science, 18(1), 77-84.

[13] Richards, J. A. (Producer). (2013). Springer. Retrieved from https://www.springer.com/

[14] Sahu, S., Prasad, M., Barik, K., & Tripathy, B. (2015). Study on remote sensing data classification using statistical techniques. Universe of Emerging Technologies and Science, 2(5), 1-6.

[15] Schulz, J. J., Cayuela, L., Echeverria, C., Salas, J., & Benayas, J. M. R. (2010). Monitoring land cover change of the dryland forest landscape of Central Chile (1975–2008). Applied Geography, 30(3), 436-447.

[16] Selçuk, R., Nisanci, R., Uzun, B., Yalcin, A., Inan, H., & Yomralioglu, T. (2003). Monitoring land-use changes by GIS and remote sensing techniques: case study of Trabzon. Paper presented at the Proceedings of 2nd FIG Regional Conference, Morocco.

[17] Sharma, A., Tiwari, K. N., & Bhadoria, P. (2011). Effect of land use land cover change on soil erosion potential in an agricultural watershed. Environmental monitoring and assessment, 173(1), 789-801.

[18] Shrestha, R., Nepali, P. B., & Dahal, T. P. (2021). Towards Sustainable Land Management: State-of-the-Art in Land Use Policies of Nepal Examining International Land Use Policies, Changes, and Conflicts (pp. 351-369): IGI Global.

[19] Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. International journal of remote sensing, 10(6), 989-1003.

[20] Wang, S. W., Gebru, B. M., Lamchin, M., Kayastha, R. B., & Lee, W.-K. (2020). Land Use and Land Cover Change Detection and Prediction in the Kathmandu District of Nepal Using Remote Sensing and GIS. Sustainability, 12(9), 3925.

[21] Weng, Q. (2001). A remote sensing? GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. International journal of remote sensing, 22(10), 1999-2014.