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Land Change Prediction using Markov Change Multi-Layer Perceptron in Navi Mumbai, Maharashtra, India

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Abstract*: Long-term evaluation of land change and future prediction change is extremely important for planning and land use management. This research conducted for the analyze future prediction change in the study area Navi Mumbai. For this prediction analysis used satellite images year from 1998, 2008 and 2018 are taken. Thus, the change detection obtained from land use and land cover assist in most favourable solutions for the choice, planning, implementation, and observance of development schemes. To meet the increasing demands of human need, land management is required. In this work for upcoming predict year, Markov change model is used for simulating 2028 year. It will give vital and useful information on future development and planning. And also, is easy for continuing to monitor land change for the large area due to natural human activities and the effect of natural resources.

***Index Terms*: Land use and Land cover change, Change detection, Spatial modelling, Markov Multi-Layer Perceptron**

I. INTRODUCTION

Land cover change is suffering from many factors linked to the spatial-temporal thing, for example, proximity, environmental condition, and socio-economical conditions. The most important fears of the world, now current situation change in the environment that are caused by human manipulation leading to local and global climate change due to deforestation, expanding farmland, and urban area (Balak et al.,1993, J.S. Rawat et al. 2013). Land use/Land cover (LULC) modelling is detailing the fast development in the area and transformation in the environment due to human interference. It is one of the most critical points leading to global warming. Sometimes human interference activity resulted in development causes. Many lands use study on environment uses spatial and temporal social approach to use widely investigate. Subsequently, land use by human and change land type is the main fact of environment changes (Basommi et al., 2016).

Throughout the last few decades, some studies searching for the most effective means of predicting land cover change. Land change modelling is calculating by three different sorts of the model such as the empirical/statistical model, dynamic model, and model that is hybrid. A hybrid model is known as better modelling than other modelling as it combines dynamic model and empirical/statistical model (Dawn C. Parker, et al. 2003).

High urban intensity is found in area different near to facilities like public transportation and good infrastructure. Development in any area is depending on connectivity and location near road (De Chiara 2001). Finding LU/LC cover changing from the past to the upcoming can be a vital step towards identifying probable effects. The models for analyzing and simulating the LU/LC offer an appropriate tool for distinguishing the special pattern and dynamics of land use/cover (Gong et al., 2015, Jiang et al., 2015).

Markov chain method is developed for the time-based Multi-Objective land distribution, multi-criteria analysis and cellular automata (CA) is used particularly for probable land use source. focus of results on the main three the primary was formed through involved variation inside the land cover categories, the second was conducted utilizing just two land cover maps for the standardization of method, and therefore the third was created supporting the idea that temporal multi-objective land allocation (Araya et al., 2010, H.A. Bharath, et al. 2017).

Primarily, the lowest common multiple is on the idea of CA-Markov that assesses land use/cover alterations between two spells, measures the changes, and depicts the results with completely different charts and maps. Afterwards, sustained related change possible maps it formulates future Land Use and Land cover maps (Roy et al., 2015, Thomas Houet, et al. 2007, M. E. Mirici et al., 2017).

Therefore, this paper aims to analyze the last land use changes in the area, as well as simulate the changes in the future years using integrated Markov Multi-Layer Perceptron model.

II. STUDY AREA

Navi Mumbai is located in India, Maharashtra state, Asia continent. Latitude coordinate is 19.077065° N, and longitude is 72.998993° E and elevation is 14 meters above sea level. Temperature changes from 22°C to 36°C. Winter time is going in between 17°C to 20°C and summer range up to 36°C to 41°C. The total area of Navi Mumbai is 344 km^2 and this area is divided into 14 nodes is divided into different sectors. Location of the study area is shown in figure 1 and Figure 2.

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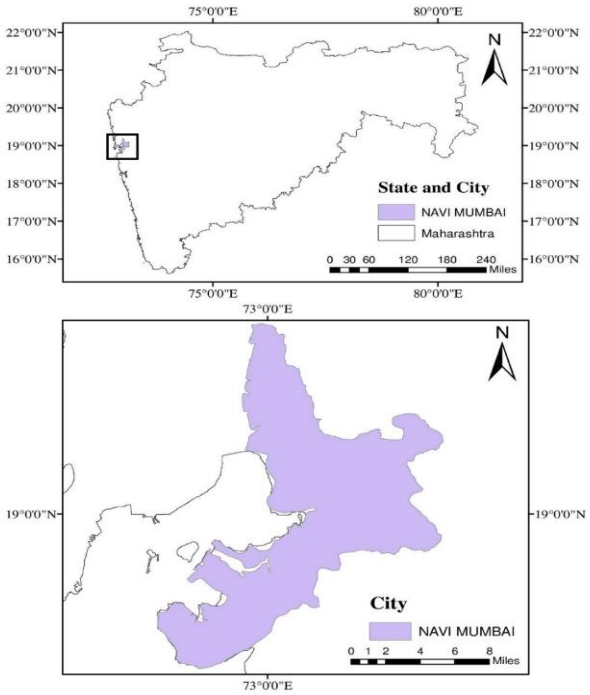

Figure 1. Location of Study Area

Figure 2. Location Map (Source: Google Earth with Shape File)

Satellite images are taken from the United States Geological Survey (USGS). Land change analysis used Landsat data land sat-5 and Landsat-8 Satellite data obtained from this site Earth Explorer. This study also uses other data such as slope map, digital elevation and road maps. For the process of groundwater potential zone analysis required an extra file rainfall map and soil map. List of datasets used in the study is given in Table 1.

Table 1. List of Datasets

Datasets	Date	Source	Path and Row	Resolution
Land Sat Image 1998	15-03-98	United States Geological Survey (USGS)	Path:148 Row:47	Raster (30 meters)
Land Sat Image 2008	27-04-08			
Land Sat Image 2018	22-03-18			
Digital elevation	17-10-11	ASTER GLOBAL DEM	Coordinates 18.5, 72.5 18.5, 73.5 19.5, 72.5 19.5, 73.5	Raster (30 meter)
Road network map	2018	Open street maps	UTM zone 43	Vector

III. METHODOLOGY

Methodology for future land change prediction and groundwater potential zone analysis is shown in Figure 3. Data used for analysis is given in Table 1. In this research satellite images of Navi Mumbai area with the same resolution for the years of 1998, 2008 and 2018 are selected.

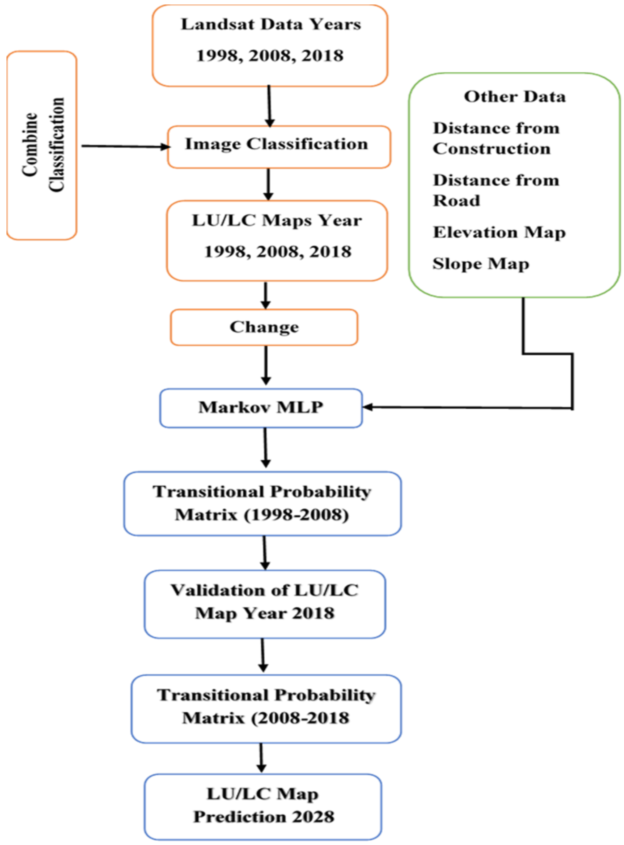

Figure 3. Methodology Markov MLP

IV. DATA PREPARATION

Data set and the land sat images are prepared to run the Markov model. This data is obtained from the United States Geological Survey website. Road layer data is processed in ArcGIS and data is extracted for the required area. All processed data is georeferenced in UTM zone 43 (WGS 84).

Image classification

For image classification, satellite images are downloaded for the year of 1998, 2008 and 2018. In the classification process, for image enhancement and geometric correction, ERDAS software is used.

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With the help of ERDAS software, image enhancement is done by using 3*3 filter in order to get a better view for further process.

Images analysis is done in five different categories such as forest land, agricultural land, constructed area, water body and open land. These classified images are shown in Figure 4. Accuracy assessment for ground truthing is done by using ERDAS Imagine software. The data of constructed area distance map, elevation map and distance from the road is used to run the model. The final output of this model gives the data regarding the prediction of land use and land cover change. These predicted images were also used for ground water potential zone analysis of Navi Mumbai area.

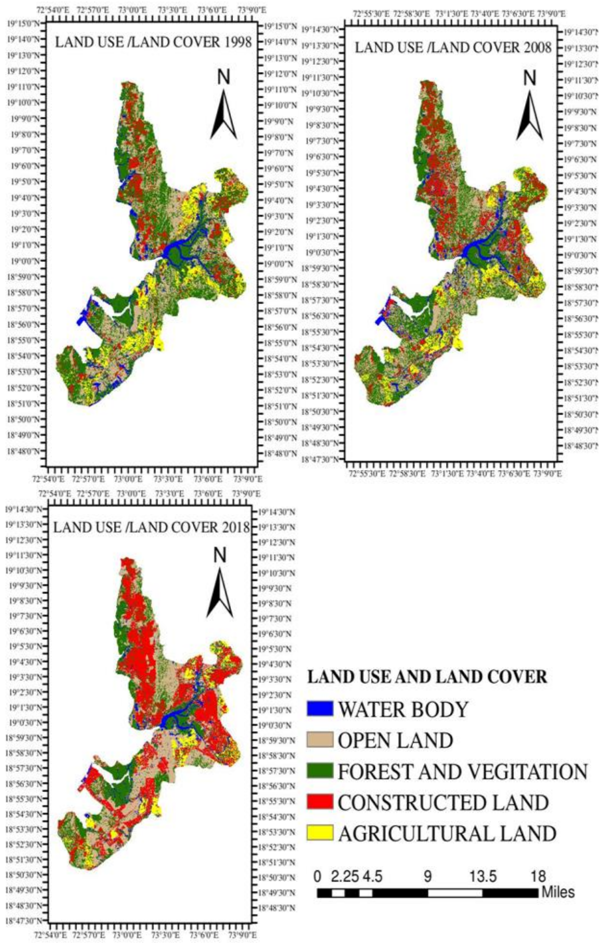

Figure: 4 LU/LC Images 1998-2018

Construction of Distance Map

Distance map is created in ArcGIS software by separating first constructed area by using the Con tool. By using separate constructed area. Euclidean Distance is used for creating a distance map as shown in Figure 5.

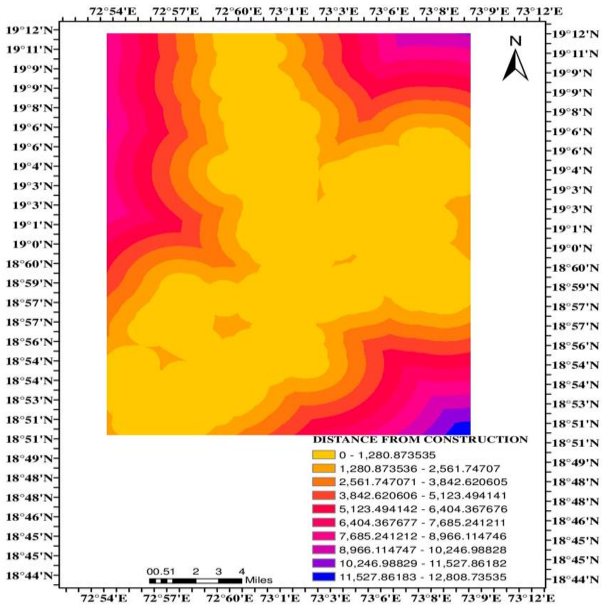

Figure: 5 Distance from construction

Road Layer Map

Road layer map is obtained from open street map. This data is incorporated in QGIS software to convert it into road line and shape file format. Further, this shapefile map is added in ArcGIS software reprojection system and then required data is extracted as per shapefile. Required road layer data is extracted from the several data of road map and as shown in Figure 6.

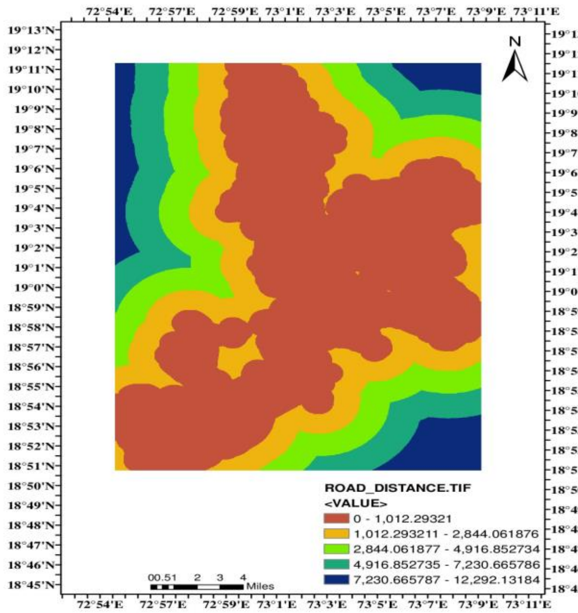

Figure: 6 Road Distance Map

Digital Elevation Model Map

Digital elevation data is downloaded from the USGS website. To cover the whole study area of Navi Mumbai, four slides are used. These four slides are merged into a single slide by using the mosaic tool of ArcGIS software. Required data is extracted by using the mask tool.

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In order to maintain the same cell size, changes are done in the environmental setting process as per any land use image. Digital elevation model map for Navi Mumbai area is shown in Figure 7.

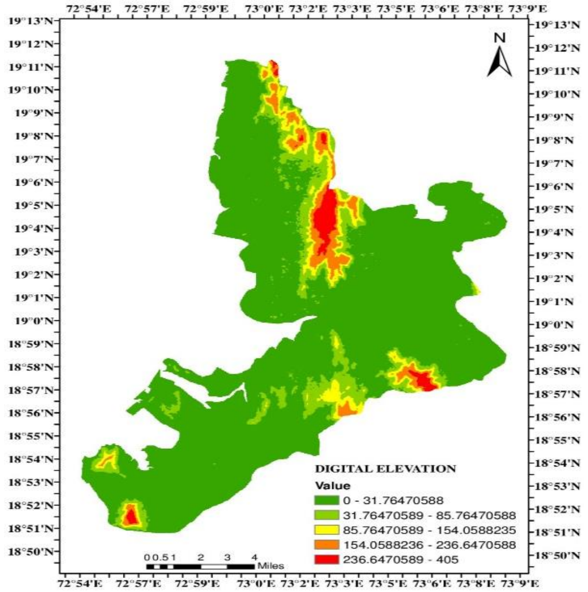

Figure: 7 Digital Elevation Model Map of Navi Mumbai

Slope Map

Slope map of Navi Mumbai area is created with the help of digital elevation map in ArcGIS software by using spatial analysis tool. The cell size is the same for all the process maps. Slope map is shown in Figure 8.

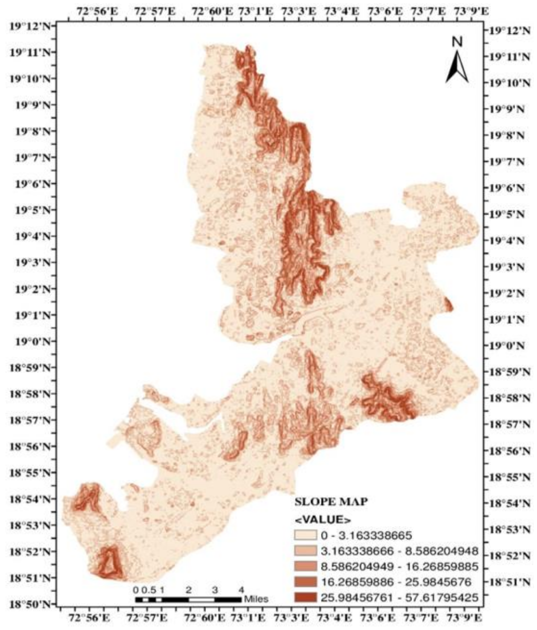

Figure: 8 Slope Map of Navi Mumbai

V. CRITERIA DEVELOPMENT

Criteria is created as it is basis measure and evaluation decision making in CA-Markov method. Criteria consist of two types: Constraints and Factors constrain and factor mention in table 2.

Constraints

Constraints are used to limit the alternatives under consideration. Basically, it identifies the areas in a course which can be used for change from other classes to this class, while the areas that simply cannot be changed. It shows that the value in the field included in the consideration is 1 and the field value considered is zero which are not include in consideration. Constrain images created using reclass module in this study constrain are mentioned in (Table2). Digital elevation model images obtained from NASA was convert in triangulated irregular network image and then slope map is established in ArcGIS software. For the urban area slope, more than 13^{o} is very difficult for building construction so the slope is considered having as a constraint.

Factors

Factors are generally continuous images (measured in a consistent scale) defining the suitability area when it comes to alternatives of the change. To put it simply, these are generally images with a way of measuring the change suitability by a continuous scale (e.g. 0 to 255).

Table 2. Classes Constraint and Factors

Class	Constraints	Factors
Water	Non-Water class	No factor
Open land	Urban, Water	Open Land, Agricultural land, Vegetation
Forest	Urban, Water	Vegetation, Agricultural land, Open Land
Construction	Water, Slope	Urban, Agricultural land, Vegetation, Open land
Agricultural land	Urban, Water	Agricultural land, forest, open land

VI. MARKO CHANGE MULTI-LAYER PERCEPTRON (MC- MLP)

For running Marko MLP model, Terr Set software is used. And also, all tiff format files are converted into a suitable format using Terr Set. For the prediction process, the following steps are followed which are Tera Set land change modeller, transition potentials, change prediction.

Land Change Modeler

Land change modeller provides information regarding session parameters of road layer, elevation, land use and land change images of two different dates. Further maps are changed from one to other class. In this section, suitable trend images are created as per the prediction map.

Transition Potentials

In this part of the model, transition sub-model status is selected. The input of selected classes (forest, open land and agricultural land) is given to model to obtained target class (constructed area). Important parameters for the transition of sub-model structure are selected and transition sub-model is run.

Change Predication

Marko MLP method is the last stage to check model prediction. It will give the prediction for land change for the date which we will add in the model. We can also check the accuracy of prediction with the help of this model.

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Validation

Model validation

To ensure that the model is reliable to predict the LLCC for a particular project year, it is necessary to verify it using the existing datasets. Therefore, the used Marco MLP models have been certified using two maps: the first is the real land use and the cover of the land of 2018, and the second map is an estimated (simulat) 2018 map.

The latter was simulated by using the model and the same procedure that was implemented in predicting 2028 land use and land cover map, but, in this case, the 1998 and 2008 maps were used for simulating 2018 maps. The validate module in Tera set was used for validating the model identify the accuracy of the model. Result of the validation module is shown in Table 3.

Table 3. Comparison of actual and predicted the year 2018

Class	Actual Area (Km^2) 2018	Predicted Area (Km^2) 2018
Waterbody	17.1	23.5134
Open Land	105.68	89.3745
Forest Area	96.29	131.5341
Constructed Area	103.74	78.4296
Agricultural Land	21.93	21.0177

VII. RESULT AND DISCUSSION

Land Cover Change Analysis

The classification of land use and land cover images classification into five different class water body, open land, forest land and constructed land. In this classification starting year from 1998, 2008, and 2018 data used for analysis. Over the 20-year change in Navi Mumbai area change detection shown in figure 4. All change in the study area is showing in Table 5 and Table 6.

Table 5. Change detection Matrix 1998 – 2008

Change Detection Matrix 1998 – 2008							
Sr. No	Class	Waterbody	open land	Forest Area	Constructed Area	Agriculture Land	Total 2008
1	Waterbody	15.89	2.90	6.37	0.65	0.65	26.46
2	Open Land	2.52	46.97	41.94	4.93	6.40	102.76
3	forest	7.27	35.32	113.56	11.71	10.40	178.26
4	Constructed Area	0.66	13.31	16.19	14.02	3.69	47.87
5	Agriculture Land	0.41	1.27	11.27	1.36	19.10	33.41
Total 1998		26.75	99.77	189.34	32.67	40.23	388.75

Table 6. Change Detection Matrix 2008- 2018

Change Detection Matrix 2008 – 2018							
Sr. No	Class	Waterbody	open land	Forest Area	Constructed Area	Agriculture Land	Total 2018
1	Water	11.15	1.66	3.357	0.228	0.696	17.10
2	Open land	4.23	48.06	41.52	6.051	5.802	105.68
3	Forest	3.24	17.59	67.96	3.457	4.015	96.29
4	Constructed Area	4.56	23.36	34.58	36.15	5.069	103.74
5	Agriculture Land	0.51	1.15	6.926	1.265	12.06	21.93
Total 2008		23.71	91.85	154.3	47.16	27.65	344.74

Transition probabilities matrix

In this transition probability matrix, the change in a class from one to other class is explained. This matrix could be the result of a cross combination of the two images because of the proportional change in one class with another class.

From the actual record of the Transition matrix, information regarding the number of pixels or cells varies from one class to another class for the next occasion is obtained. This matrix is prepared by multiplication of each and every column using the transition probability matrix because of a large number of cells from land used in later images. When it comes to forecasting land use and land cover is carried out for 2028 using short and long-time trajectory respectively 1998-2008 and 2008-2018.

In this trajectory are considered to evaluate change measurement of temporal trajectory in modelling conceivable land use and land cover future status. Land use/land cover images and transition matrix are used from 1998 to 2008 for prediction of the year 2028 land change model. All the details of the transition matrix are given in Table 6 and 7. In Figure 9 shows prediction map of the year 2028 and Figure 10 mention change from 2008 to 2028 in class.

Table 7. Transition Probabilities Matrix 2008- 2018

Transition probabilities matrix 2008 – 2018						
Sr. No	Class	Waterbody	open land	Forest Area	Constructed Area	Agriculture Land
1	Waterbody	0.5795	0.1039	0.2714	0.0282	0.0169
2	Open Land	0.0295	0.4659	0.3493	0.1425	0.0128
3	Forest Area	0.0379	0.2248	0.5845	0.0976	0.0553
4	Constructed Area	0.0201	0.1510	0.3566	0.4379	0.0345
5	Agriculture Land	0.0176	0.1695	0.2554	0.0935	0.4639

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Table 8. Transition Probabilities Matrix 2018 – 2028

Transition probabilities matrix 2018 – 2028						
Sr. No	Class	Waterbody	open land	Forest Area	Constructed Area	Agriculture Land
1	Waterbody	0.4750	0.1759	0.1386	0.1951	0.0154
2	Open Land	0.0183	0.5213	0.1951	0.2540	0.0114
3	Forest Area	0.0219	0.2689	0.4425	0.2246	0.0421
4	Constructed Area	0.0048	0.1226	0.0737	0.7771	0.0217
5	Agriculture Land	0.0246	0.2138	0.1371	0.1739	0.4506

Table 9. Change Detection 1998– 2028

Change Detection 1998 – 2028					
Sr. no	Year	1998 (Km^2)	2008 (Km^2)	2018 (Km^2)	2028 (Km^2)
1	Waterbody	23.07	23.71	17.1	17.1216
2	Open Land	91.41	91.85	105.68	78.4017
3	Forest Area	163.25	154.36	96.29	74.7441
4	Constructed Area	32.1	47.16	103.74	155.7405
5	Agricultural Land	34.91	27.65	21.93	17.8614

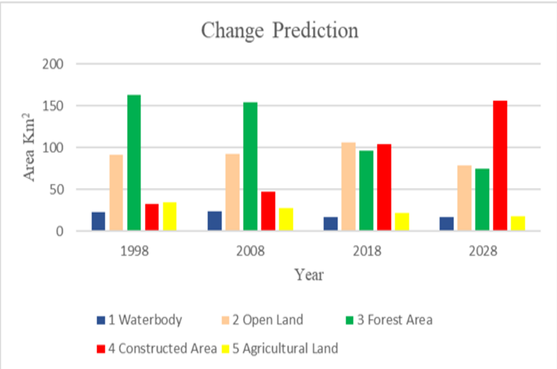

Figure: 9 Change prediction 1998-2028

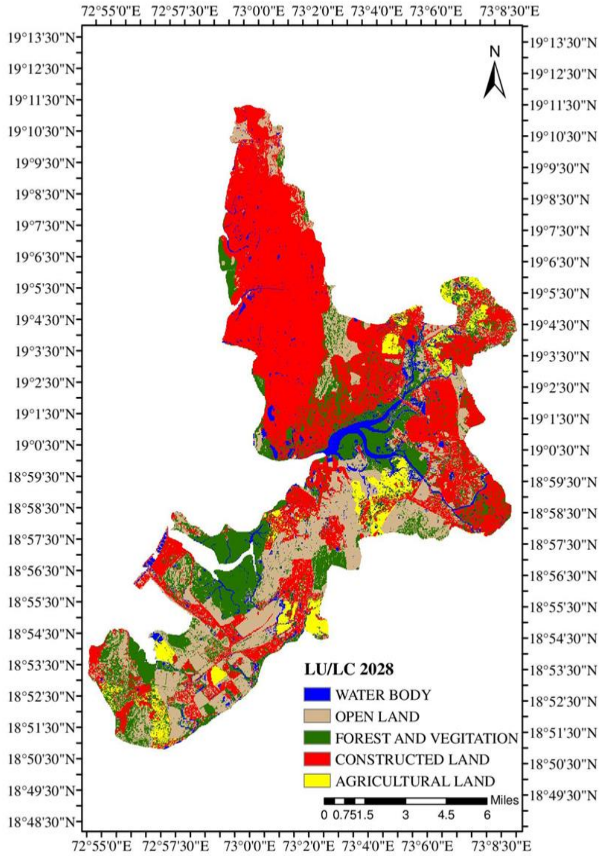

Figure: 10 Change prediction 2028

VIII. CONCLUSION

Increased population similarly increase food, land surface and other resource demand but from last decade constructed area is increased in Navi Mumbai. Since water and soil policy is complete change. Analysing LULC provide valuable data for planner regarding planning and manage natural resource. In this research using Markov MLP model predict real trend change land in Navi Mumbai.

Using this model and assuming the scenario of continuing the existing process, the long-term land use was predicted for 2028. The overall accuracy associated with the model was greater than 82.23%. From 2018 to 2028 constructed area is increased by a possible 52 km2 area. Due to this increased possible construction area reduce in forest area is 21.55 km2 and agricultural land is reduced by 4.07 km2 respectively. This suggests that Markov MLP model can be used to analyse and predict the long-term spatiotemporal dynamics associated with the land use development in the study area. The model is based upon real trends of changes in Navi Mumbai City.

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