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

Sandip P. Patil, Manisha B. Jamgade

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 km² 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.
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.

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

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     | Raster (30 meters) |
| Land Sat Image 2008 | 27-04-08 | Path:148                        | Path:148     | Raster     |
| Land Sat Image 2018 | 22-03-18 | Path:47                         | Row:47       | Raster     |
geometric correction, ERDAS software is used. With the help of ERDAS software, image enhancement is done by using 3x3 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. 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.

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° 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 Modeller
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.
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 (Km²) 2018 | Predicted Area (Km²) 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

| Sr. No. | Class       | Waterbody | Open Land | Forest | Constructed | Agricultural |
|---------|-------------|-----------|-----------|--------|-------------|--------------|
| 1       | Waterbody   | 15.80     | 2.90      | 6.37   | 0.65        | 0.65         |
| 2       | Open Land   | 2.52      | 46.97     | 41.94  | 4.93        | 6.40         |
| 3       | Forest      | 7.27      | 35.52     | 113.56 | 11.71       | 10.40        |
| 4       | Constructed | 0.66      | 13.31     | 16.19  | 14.02       | 3.69         |
| 5       | Agricultural| 0.41      | 1.27      | 11.17  | 1.16        | 19.10        |
Table 8. Transition Probabilities Matrix 2018 – 2028

| Sr. No | Class        | Waterbody | Open Land | Forest Area | Constructed Area | Agriculture Land |
|--------|--------------|-----------|-----------|-------------|------------------|------------------|
| 1      | Waterbody    | 0.475     | 0.175     | 0.138       | 0.195            | 0.015            |
| 2      | Open Land    | 0.018     | 0.521     | 0.195       | 0.254            | 0.011            |
| 3      | Forest Area  | 0.021     | 0.268     | 0.442       | 0.224            | 0.042            |
| 4      | Constructed Area | 0.004  | 0.122     | 0.073       | 0.777            | 0.021            |
| 5      | Agriculture Land | 0.024  | 0.213     | 0.137       | 0.173            | 0.450            |

Table 9. Change Detection 1998–2028

| Sr. no | Year | 1998 (Km²) | 2008 (Km²) | 2018 (Km²) | 2028 (Km²) |
|--------|------|------------|------------|------------|------------|
| 1      | Waterbody     | 23.07      | 23.71      | 17.1       | 17.126     |
| 2      | Open Land     | 91.41      | 91.85      | 105.68     | 78.401     |
| 3      | Forest Area   | 161.25     | 154.36     | 96.29      | 74.3441    |
| 4      | Constructed Area | 32.1  | 47.16      | 103.74     | 155.7405   |
| 5      | Agriculture Land | 34.91  | 27.65      | 21.93      | 17.8614    |

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.

REFERENCES

1. Al-Sharif A. A.A and Pradhan B (2014) “Monitoring and predicting land use change in Tripoli Metropolitan City using an integrated Markov chain and cellular automata model in GIS”. Arabian Journal of Geosciences 7 4291-4301.
2. Araya, Y.H.; Cabrall, P., (2010), Analysis and modeling of urban land cover change in Setúbal and Sesimbra, Portugal. Remote Sens. 2(6): 1549-1563.

3. Balak, R., Kolarkar, A.S., 1993. Remote sensing application in monitoring land use changes in arid Rajasthan. Int. J. Remote Sens. 14 (17), 3191–3200.

4. Bacani VM, Sakamoto AY, Quénon H, Vannier C, Corgnec S. 2016, “Markov chains–cellular automata modeling and multicriteria analysis of land cover change in the Lower Nhecolândia subregion of the Brazilian Pantanal wetland”. J. Appl. Remote Sens. 10(1), 016004-20

5. Dawn C. Parker, Steven M. Manson, Marco A. Janssen . Matthew J. Hoffmann, Peter Deadman (2008) “Multi-Agent Systems for the Simulation of Land-Use and Land-Cover Change： A Review” Annals of the Association of American Geographers, 93:2, pp. 314-337.

6. De Chiara J (2001) Time-saver standards for building types. McGraw-Hill Professional Publishing, New York.

7. Guan D, Li H, Inohae T, Su W, Nagai T, Hokao K (2011) “Modeling urban land use change by the integration of cellular automaton and markov model Ecological Modelling” pp. 222 3761-3772.

8. H.A. Bharath, M.C. Chandan, S. Vinay, T.V. Ramachandra 2017 “Modelling urban dynamics in rapidly urbanising Indian cities”, The Egyptian Journal of Remote Sensing and Space Sciences.

9. Fuglsang M, Münier B, Sten Hansen H 2013 “Modelling land-use effects of future urbanization using cellular automata: An Eastern Danish case Environmental Modelling & Software” 50 1-11.

10. J.S. Rawat, Vivekanand Biswas, Manish Kumar, (2013) “Changes in land use/cover using geospatial techniques: A case study of Ramnagar town area, district Nainital, Uttarakhand, India” The Egyptian Journal of Remote Sensing and Space Sciences, 16, pp. 111–117.

11. M. E. Mirici, S. Berberoglu, A. Akin, O. Satir, (2017) “Land use/cover change modelling in mediterranean rural landscape using MLP-MC” Applied Ecology and Environmental Research 16(1), pp. 467-486.

12. Roy, S.; Farzana, K.; Papia, M.; Hasan, M. 2015 “Monitoring and prediction of land use/land cover change using the integration of Markov chain model and cellular automation in the Southeastern Tertiary Hilly Area of Bangladesh”. Int. J. Sci. Basic Appl. Res., 24, 125–148.

13. S. J. Hadi, H. Z. M. Shafri, and M. D. Mahir, “Factors Affecting the Eco-Environment Identification Through Change Detection Analysisbhy Using Remote Sensing and GIS: A Case Study of Tikrit, Iraq,” Arab. J. Sci. Eng., vol. 39, no. 1, pp. 395–405, 2013.

14. Senanayake, I.P., Dissanayake, D.M.D.O.K., Puswevala, U.G.A., (2012) Analysis of the abundance of abandoned tanks in Hambantota District, Sri Lanka using GIS techniques. The Egyptian Journal of Remote Sensing and Space Science 15 (2),143e150.

15. Thomas Houet, Laurence Hubert-Moy, (2007) “Modeling and projecting land-use and land-cover changes with Cellular Automaton in considering landscape trajectories” European Association of Remote Sensing Laboratories, pp.63-76.

16. Varun Narayan Mishra, Praveen Kumar Rai 2015 “A remote sensing aided multi-layer perceptron-Markov chain analysis for land use and land cover change prediction in Patna district (Bihar), India” Arabian Journal of Geosciences pp. 9:249.

17. Von Neumann J and Burks A W 1966 “Theory of Self-reproducing Automata” (Urban:University of Illinois Press)

AUTHORS PROFILE

First Author Sandip P. Patil, M. E Research Scholar, Pillai HOC College of Engineering and Technology, Pillai HOC College of Engineering and Technology, Rasayan, Raigad, Maharashtra, India, B.E. in civil engineering from Pune University in 2015.

sandippatil25311@gmail.com

Second Author Manisha B. Jamgade, Assistant Professor, Pillai HOC College of Engineering and Technology, Ph.D. (Pursuing): Pillai HOC College of Engineering and Technology, Rasayan, University of Mumbai, M.Tech. 2001 Visvesvaraya National Institute of Technology (V NIT), Nagpur University, B.E. 1999 K.D.K College of Engineering, Nagpur University.

manisha21jamgade@gmail.com

Published By: Blue Eyes Intelligence Engineering & Sciences Publication

Retrieval Number IJITEE-18532.0881019
DOI: 10.35940/ijitee.I8532.0881019