
Predicting Land Changes in River Margin and Urban Areas by Remote Sensing and GIS

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Abstract

Today, the rapid growth of the world's urban population, especially in developing countries, has created many problems in various fields. Among these, land-use change is of great importance. Modeling and predicting future land-use changes has become increasingly important for urban and environmental management and other relevant authorities and researchers. The main purpose of this study is to apply cellular automata (CA) Markov models based on spatial information system to simulate and predict land-use change. Landsat satellite imagery was prepared during the three periods of late June 1986, 2001, and 2016. Then land use maps of the study area were obtained by classifying the maps. The model derived from the CA Markov was implemented to predict and process and to analyze land-use changes by 2031. Forecast results showed that from 2016 to 2031, green space, urban residential land use increased and the agricultural and open land use declined. This study will generally show the decline in open land and agriculture and the expansion of residential and urban areas in 2031, which was caused by the loss of agricultural land and vegetation. The region's economy, based on agricultural and livestock production will face the current productivity situation in 2031.

Keywords: Forecasting, Trend, Markov, Modeling, Changes.

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1. Introduction

Land-use change is one of the major challenges in the 21st century. Land-use changes are the result of a complex interaction of physical, biological, economical, and social indicators. In most cases, these factors have a significant impact on erosion processes, increased surface runoff, and changes in biodiversity (Onate and Sendra, 2010).

Sometimes the type and percentage of different uses and coatings is a fundamental need to know and manage an area (Eslami et al., 2014). Urban land use development are often caused by human activities that are one of the most important urban problems in the modern environment due to the lack of principle planning, lack of sustainable development, lack of sustainable management and without regard to environmental constraints. Today, modeling has become the process of urban development with Geographical Information Systems and Open Systems decision support model increasingly in the management of coastal areas are handled and remote sensing satellites common data source for the detection, quantification and mapping patterns of land use change is the same (Alavi Panah et al., 1996). Models of land-use change to analyze the causes and consequences of land-use change and to better understand the performance of systems of land use, land use management and identify zones sensitivity and land cover changes in the future according to different scenarios (Zare and Al-Sheikh, 2012). One of the effective, useful, and applicable information sources in identifying land cover and its variations is the remote sensing data. Extracting information from satellite images by classifying the most commonly used methods (Mirzaizadeh et al., 2015) (and since remote sensing data can be easily entered into a GIS environment, it is widely used in GIS modeling (Azarmehr et al., 2010; Sakieh et al., 2015). To better manage natural and man-made ecosystems and long-term planning, land use/land cover modeling and future changes need to be modeled. Over the past two decades, a wide range of land use/land cover change models has been developed to assist in land management and better understanding, evaluation and assessment of the role of these changes in land system functioning (Mas et al., 2014). The use of models enables the mapping of uncertainties in a suitable format (Amici et al., 2017).

Imani et al. (2017) in their modeling, the process of land cover and land use changes using Markov chain and automated network in Hamadan province, the results showed that land use classes would decrease in the future and become human uses. According to the results, the foothills and rangelands will decline in the coming years. Imani et al. (2017), predicted the urban growth in the Gaza strip using the LCM model and GIS in 2016. It was predicted that by 2023, 212.3 square kilometers would be added to urban areas. (Abuelaish and Olmedo, 2016), they examined the land-use change in Hamadan city using the LCM model (Roshanbakhsh et al., 2017). The results indicated that nearly 800 hectares of agricultural land and vegetation in the area were destroyed between 2002 and 2009. Kusratmoko et al., (2017) investigated the land-use changes in the Komerling watershed using Markov and cellular automated methods. Forecast for land-use change in 2030 showed a decline of 3.37 percent in forest cover, a decline of 2.13 percent in agricultural land and an increase of 5.56 percent in the wasteland.

Wang and Murayama (2017) examined land-use changes in Tianjin City, China using the Markov method and cellular automated and more new researches about this title are (Karimi et al., 2018; El Jazouli et al., 2019; Van et al., 2020). They studied land use during 1995, 2005 and 2015. The results showed that more than 10 percent of agricultural fields had been converted to cities. Finally, land use forecasts were made for 2025 and 2035, and the results indicated a 2 and 3 fold increase in the city's future. CA-Markov shows that agricultural land use has declined over time. Using the CA-Markov and LCM models, it is observed that residential land use along the Zayandehrud route has increased over time. This study predicted the status of five land-use classes, urban areas, agricultural lands, rivers, vegetation, and open land in the study area for 2016 based on land use maps derived from the classification of 1986 and 2001. In the first step, of Markov model, the user map of 1986 as the old map and the user map of 2001 as the new map was introduced and the probability matrix was calculated, the matrix of the transition area for the next 15 years with 15% error. In the literature review, it was found that Markov modeling was not used in the study of river margin areas. Therefore, the study of Zayandehroud using advanced Markov cellular automation in predicting changes using one of the satellite imageries is unique in this research. The assumption in this study is that in recent years agricultural and green land use has been reduced and added to artificial and residential uses. The development has also been steeper near development factors such as roads and water. The purpose of this study is to analyze the land-use changes with new GIS modelling techniques.

2. Methods and Materials

2.1 Study Area

In this study, Saman is considered as the study area. Saman is one of the cities of Charmahal and Bakhtiari province in Iran and the center of Saman city. The city is about 2 kilometers northeast of Shahrekord. Because of its location on the margins of the Zayandehrood River, Saman is a good destination for agriculture, gardening, and tourist attraction. The location of the study area is presented in Figure 1.

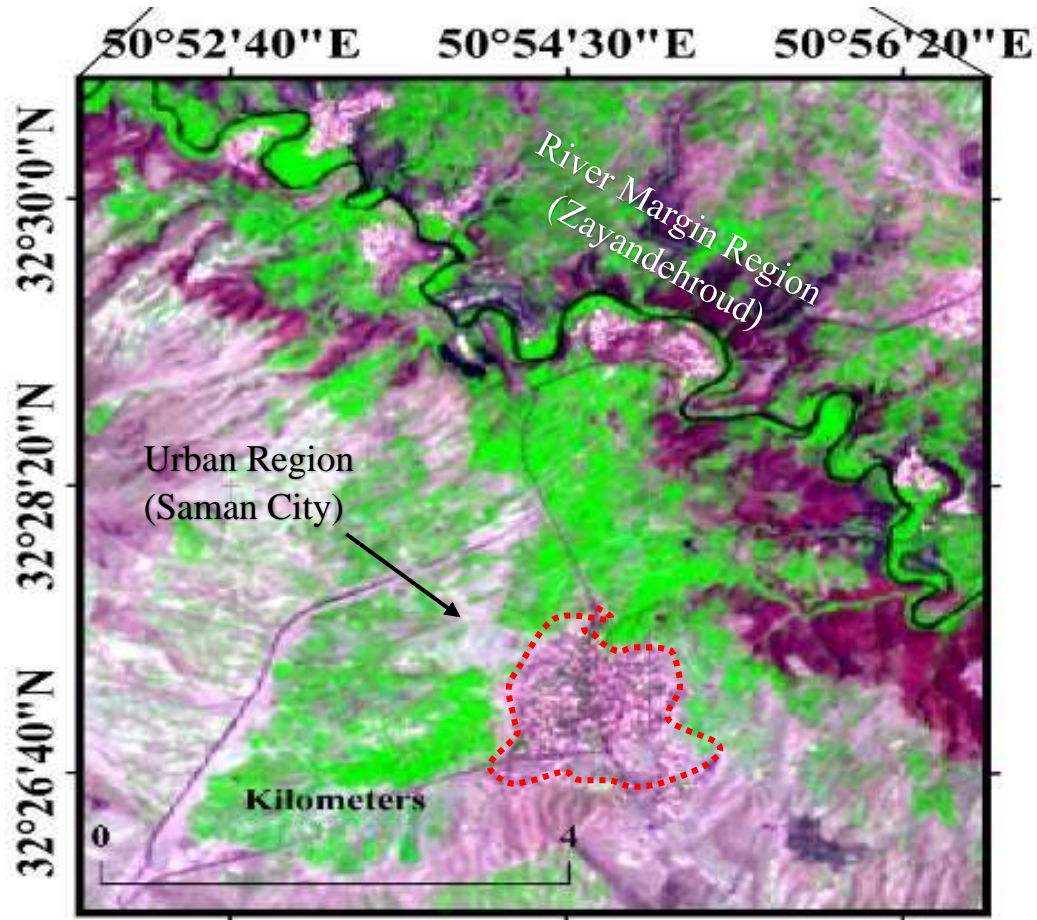


Figure 1. Location of the study area

2.2 Method

A summary of the research process steps is shown in Figure 2.

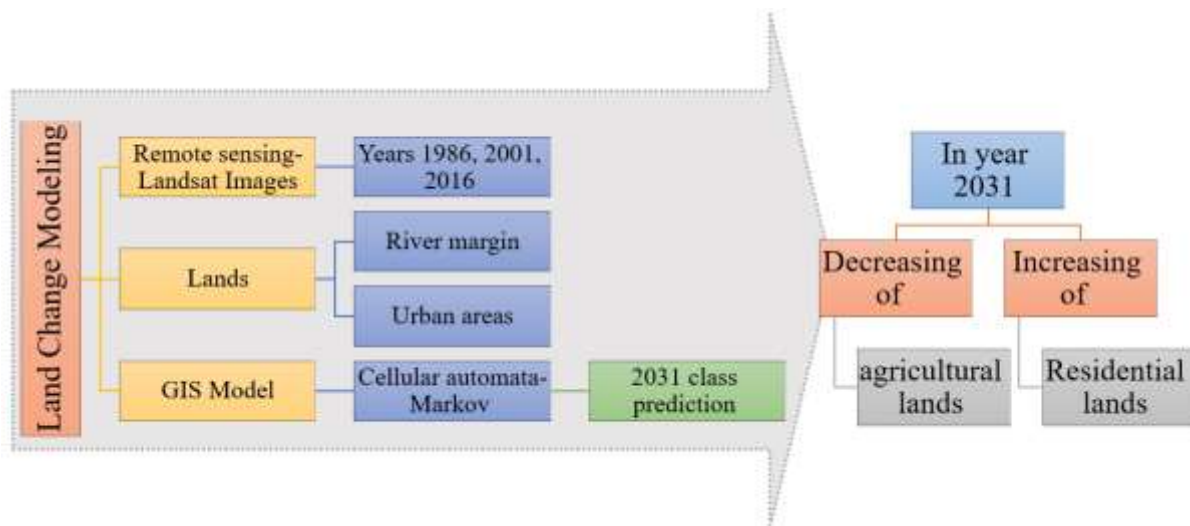


Figure 2. The method investigated in this study

Landsat satellite imagery was prepared during the three periods of late June 1986, 2001 and 2016. Then land use maps of the study area were obtained by classifying the maps (Figure 3). The maximum likelihood classification algorithm supervised by the classification group was used for the classification.

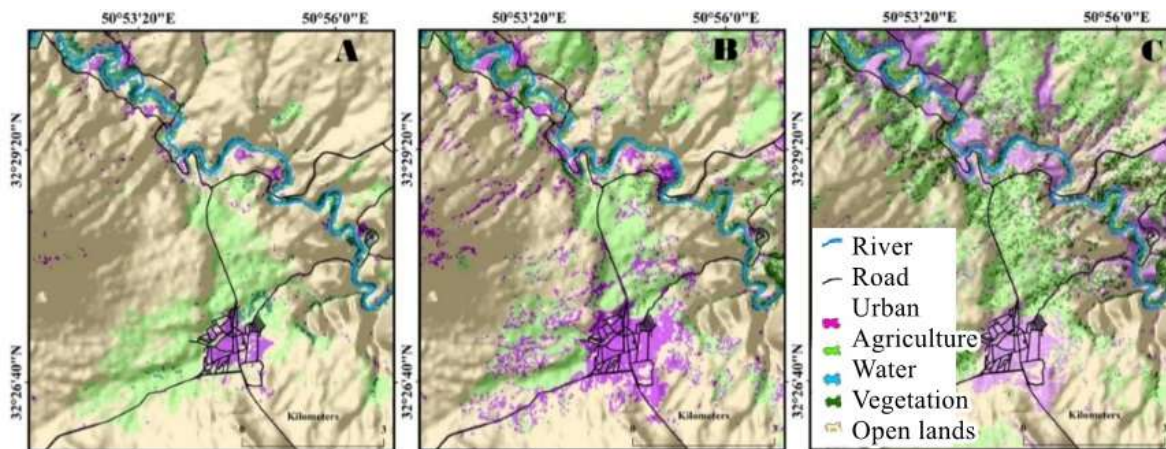


Figure 3. Land use maps of the study area during 1986 (A), 2001 (B) and 2016 (C)

To select the effective parameters on urban land use development and change, a comprehensive study was carried out on the parameters used in previous studies related to urban development issues. Slope direction, river distance, street distance, village distance, sightseeing, and religious distance.

2.3 Modeling with Land Change Modeler (LCM)

Land Change Modeling (LCM) is software for sustainable ecological development designed to understand and identify land cover changes and the environmental and conservation needs resulting from these changes. Modeling the land cover changes using the land change modeler is done in four main stages:

1- Change Analysis and Highlighting: At this stage, the land cover maps of 1986 and 2001 together with

2001 and 2016 have been put together to model the LCM land changes and highlighting and analyzing the changes in them. Finally, land-use change and mapping maps were plotted to reveal the spatial distribution of land use changes over the periods studied. In addition, the spatial trend map of urban land use was obtained at this stage. At the end of this phase, the amount of annual change in each user was also analyzed in terms of percentage increase or decrease.

2- Transfer Potential Modeling: In the second stage of land cover change modeling, the land use transfer potential is modeled according to the variables introduced to the land change modeler. In other words, at this stage, the potential of each pixel of the image to be converted to other uses is examined. At this stage, all types of land-use changes are subdivided and subdivided into potential explanatory variables. Kramer correlation coefficient was used to investigate the relationship between variables used in the model (independent variables) and land-use changes (dependent variable). The numerical Kramer coefficient is between zero and one, in which closer to one, indicating a high degree of correlation between the independent and dependent variables. In this study, to model the potential of land use and land cover transfer, CA-Markov was used.

3-Forecasting and Modeling Changes: At this stage, the Markov Chain model is used and the probability of changing each user to another is calculated. The Markov Chain is a type of stochastic process model that states the likelihood that one situation may change to another. This model has a key descriptive tool and it is the matrix of the probability of transfers.

4-Modeling accuracy assessment: The validity of the modeling was evaluated based on the estimation of the Kappa coefficient between the 2016 land cover map and the land cover maps derived from different sub-models and calibration periods produced for 2016.

3. Results

The Markov chain has three outputs: Transition probability matrix where the probability of changing each class to other existing classes is specified, the transition area matrix representing the number of pixels from each class that is likely to be converted to other classes. The Markov model also shows the position of each user by generating sets of probability images from the transition probability matrix. In the last stage of the modeling using the CA-MARKOV transfer area matrix, a simulated future land use map can be obtained (Equation 1) (Ghorbani Kalkhajeh and Jamali, 2019).

$$\text{K-quantity} = \frac{M(m) - NQML}{PQML - NQML} = \frac{0.5715 - 0.4147}{0.5842 - 0.41} = \frac{0.1568}{0.169} = 0.9251 \quad (1)$$

Considering the overall agreement values (57.15%) for both years it is concluded that there is a relatively good agreement between the two maps and the model has a good ability to predict the classes. Also, given the K-location (41.19%) and K-quantity = 0.9215, one can predict the location model and the number of pixels relatively well.

Table 1. Values of disagreement and disagreement of actual and projected 2016 map

Parameters	Value (%)
General agreement ((M (m))	57.15
Overall disagreement (M (m))	1 42.85
Location Agreement	22.04
Spatial disagreement	31.47
Odds Deal (N (n))	20
Agreement due to quantity (N (m)) - (N (n))	15.11
Quantity Disagreement (P (p)) - (P (m))	11.38

Detection of land-use changes and land cover in 2031 horizon using MARKOV chain model

This study forecasts the status of five land-use classes including urban areas, agricultural lands, rivers, vegetation and open areas in the study area for the year 2031 based on land use maps derived by year classification of 2001 and 2016; Firstly, in the Markov model the 2001 user map is introduced as the old

map and the 2016 user map as the new map and the probability matrix is calculated, the matrix for the next 15 years is calculated with a 15% error was done. Using the ground cover maps obtained for each period, the matrix transforms the status of the ground cover classes between the two periods. From the cover maps of 2001 and 2016, the probability matrix of the transfer (Table 2) was obtained.

Table 2. Percentage transfer matrix for 2001 and 2016 derived from MARKOV

	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	0.4374	0.2291	0.0001	0.0574	0.2760
Class 2	0.0483	0.6143	0.0004	0.2034	0.1336
Class 3	0.1167	0.0427	0.7578	0.0712	0.0116
Class 4	0.0717	0.1687	0.0624	0.6695	0.0278
Class 5	0.1442	0.1465	0.0010	0.0584	0.6499

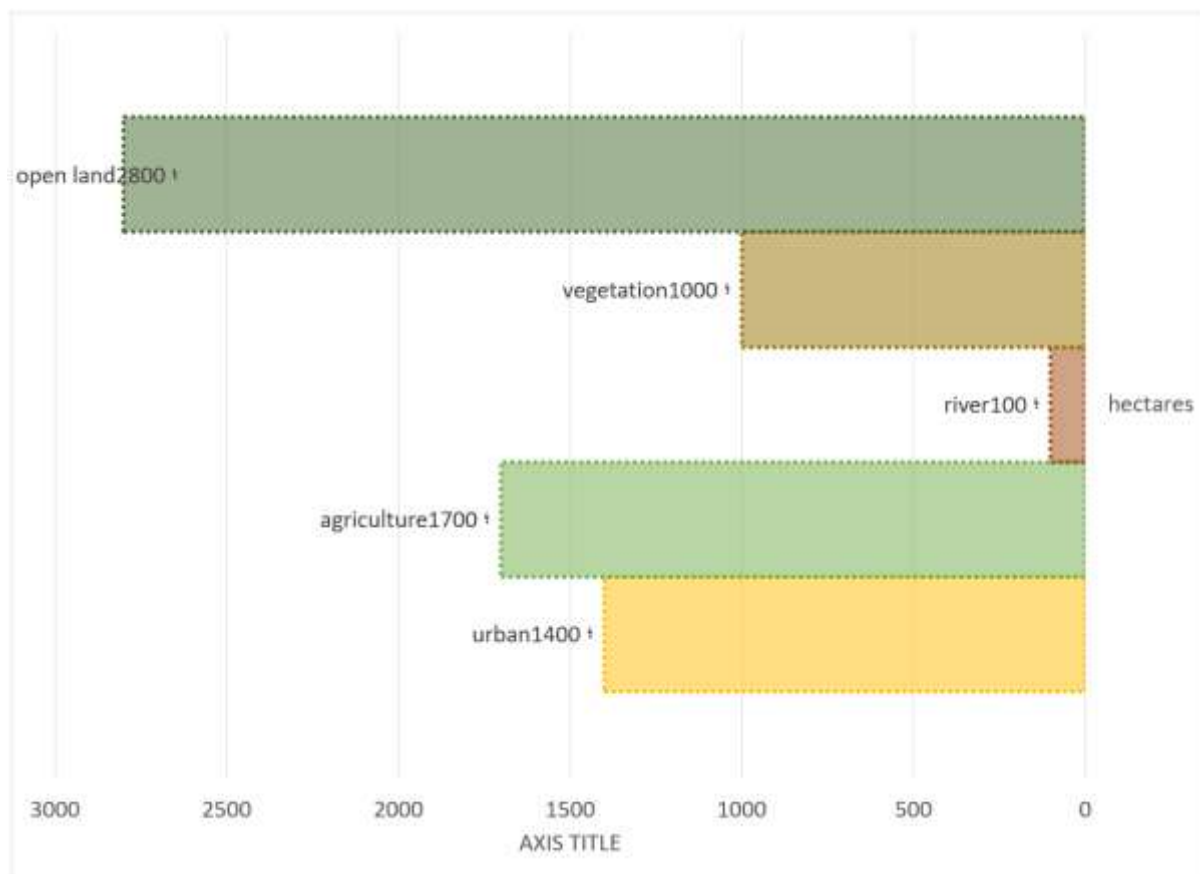


Figure 4. Predicted transition area matrix for 2031 derived from MARKOV

After this step, the CA-MARKOV operator was predicted 2031 (Figure 5) in terms of the 2016 user map as the base map and the introduction of the previously obtained transmission area file.

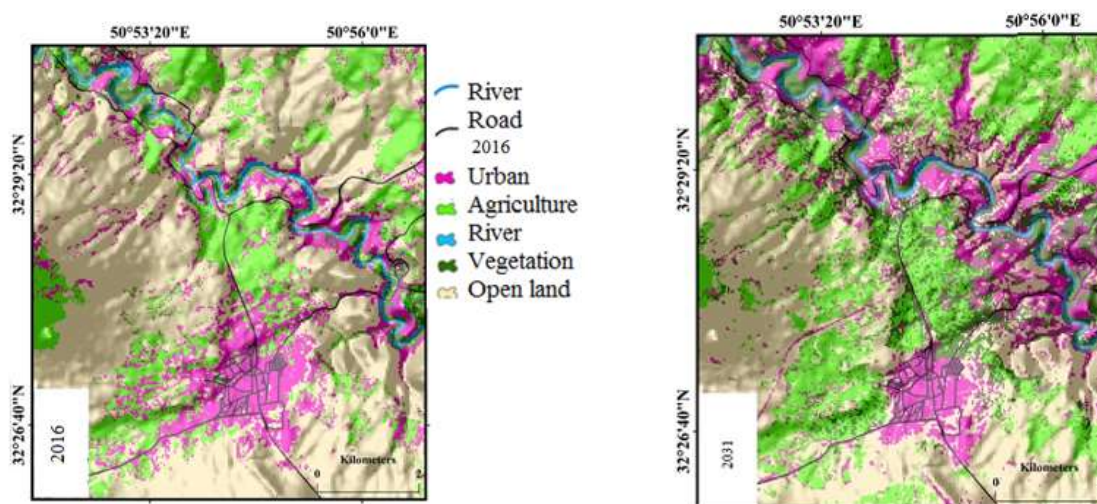


Figure 5. Land Use class forecast for the years 2016 (left), and 2031 (right)

4. Discussion

The results showed that the changes in the land cover of Saman from 1986 to 2016 were very significant. Similar to the results of this study, a study by a team of researchers (Murayama et al., 2012; Leh et al., 2013) studied urban growth in the valley Kathmandu, Nepal, showed that the process of urban development in urban and suburban areas was unprecedented and natural ecosystems in contact with these areas also suffered from stress and strain. In a similar study, Mas et al. (2014) used a land-change modeler to model the degradation and recovery of Mexico's tropical rainforest. They modeled the transmission force with an artificial neural network, and their results indicated damage to forest uses. In a study in northern Iran Goldavi, et al. (2011) used Markov to model user changes in the Gorgan region. For this purpose, using the images of 1988, 1998 and 2007, they investigated the detection of land-use changes and then predicted the changes for 2016 and 2025. Their results are in line with the results of this study and revealed that the region will in the future be associated with urban growth and deforestation. The Kappa criterion also indicated the successful implementation of both models for modeling land-use changes. The results of previous research are as follows.

Wang and Murayama, 2017 conducted a quantitative analysis of the altered structure of the Baimahe Basin from 1996 to 2008 in a study using ArcGIS and Idrisi software and the dynamics of land use and Shannon entropy information. The CA-Markov model was used for prediction in 2020. The results applied to predict land-use patterns showed that the dominant lands in the area are agriculture, forests, and construction land in the Baimahe Basin. From 1996 to 2008, agricultural land and forests in the area declined and other types of land use including construction land increased. The forecast results showed that the changes in land-use patterns will be 20-2020. Finally, it was concluded that conservation measures for agricultural and grain land for green projects to enhance the stability of the land-use system in the Baimahe Basin should be adopted to promote regional sustainable development.

Roy et al., 2015 investigated and predicted a land-use change process using the Markov model and automated cells in Bangladesh. The results showed that from 1989 to 2014, forests decreased by 3062 km². Simulations also indicated that between 1841 and 2041, 1831 sq km of forests and 148 sq km of water resources would decrease (Roy et al., 2015).

Yuan et al., (2015) studied the land cover change in Hangzhou since 1990. The results showed that the pattern of land-use change was very significant. In this study, land use structures were investigated using GIS and IDRISI and CA were used to simulate spatial and temporal variations. The results showed that the constructed land had an increasing trend and the agricultural land had a decreasing trend. Forecasting results

also indicated the decline of forest and agricultural land and the conversion of large areas of land to the city before 2060 (Yuan et al., 2015).

In 2017, Roshanbakhsh and colleagues investigated land-use change in Hamadan city using the LCM model. The results showed that nearly 800 hectares of agricultural land and vegetation of the area has disappeared from 2002 to 2009 (Roshanbakhsh et al., 2017).

Wang and Murayama, 2017 examined land-use changes in Tianjin City, China, using the Markov method and cellular automata. They surveyed land use during 1995, 2005 and 2015. The results showed that more than 10 percent of agricultural fields had been converted to cities. Finally, land-use status was predicted in 2025 and 2035, and the results showed 2 and 3 fold increase in future urban development, which is in line with the results of this study (Wang and Murayama, 2017).

Investigated land-use changes in the Komerling watershed using Markov and cellular automata methods. Forecasts of land-use change in 2030 indicate a decline of forest cover of up to 3.37%, reduction of agricultural land up to 2.13% and an increase of wasteland up to 5.56% (Kusratmoko et al., 2017).

5. Conclusion

Using CA-Markov, it is observed that residential use along the Zayandehrud route has increased over time. The CA model is a good tool for modeling urban user development. According to the above, the CA model is considered a dynamic model; it can be updated and used in urban land-use change modeling in a dynamic and constantly changing environment. It is changing, providing well results, and is considered as a good tool because of the kappa index obtained from CA modeling indicates good modeling accuracy. Predictive results and information and Figures as well as forecasts of changes occurring for different uses over different periods depending on the geographical location and cognition of the study area, as well as field and library studies. Predictive validity is statistically acceptable given the region of interest. The major contribution of this research is to fill the research gap in land-use change studies in Saman, especially the study of land-use changes with different classifications. The use of the CA-Markov model that has been successfully applied is high precision than other models do not employ artificial intelligence methods. This research presents a new method for land use forecasting that leads to more accurate planning for land-use change. Future land-based simulation can help planners and policymakers to understand the environmental impacts and land-use problems associated with the current urban development process. Alternative programs and policies can be created that reduce the negative impacts and control the scale and extent of land development. For example, land-use change may affect the quality of soil, town, and village water. That is why the ability to predict future land use conditions is important. If a suitable future land-use model is available, better future planning can be achieved.

Future studies: Application of socio-economic parameters in urban development modeling and urban land-use change considering population density effects as the main factor of urban development in addition to physical parameters is suggested. CA-based urban development modeling is explored at the local and regional scales, which are suggested in future studies and application of parameters to identify hazardous areas to reduce the damage caused by natural disasters. To analyze the sensitivity of the CA model, changes in other parameters affecting cellular automata such as changes in the transition rules can also be used.

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