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Monitoring and Prediction Functional Change of Land Uses Toward Urban Sustainability

Naseer Abdul Razak Hasach Albasri[1], Hawraa Sabri Shakir[2], Sara Mahmood Al-Jawari[1*]

[1] Urban Planning Department, Faculty of Physical Planning, University of Kufa, Najaf 54001, Iraq
[2] Department of Geography, University of Karbala, Karbala, 56001, Iraq

Corresponding Author Email: Sarahm.hpetr@uokufa.edu.iq

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ABSTRACT

Urban land uses are in a dynamic state that varies over time, the city of Karbala in Iraq has experienced functional changes over the past 100 years, as the city is characterized by the presence of significant tourist and socio-economic activity represented by religious tourism, and it occur due to various reasons such as urbanization. The purpose of this study is to apply a Markov model to analyze and predict the behavior of transforming the use of land in Karbala city over time. This can include the conversion of agricultural land, or other areas into residential, commercial, industrial land uses. The process of urbanization is typically driven by population growth, economic development, based on a set of probabilities and transitions between different states. They can help decision-makers understand the likely outcomes of different scenarios for the future. The research question is in which direction of the functional during the next 50 years in the case study? What are the values of the prediction of functional changes for future? The research Hypothesis: Urban functions are changed in different areas; agricultural land uses have decreased and land use functions have changed in an unplanned direction in the next 50 years. The study discovered that almost one-third of the agricultural land in Karbala has reduced. Additionally, there has been a 10% alteration in the usage of residential land in slums and other sectors. However, there has been a positive growth in transport, cemeteries, trade, industry, and services, with different degrees of progress.

1. INTRODUCTION

The Markov model is a method of analyzing the current behavior of a specific variable, to predict the state of the phenomenon in the future [1]. This model was discovered by Andrey Andreyevich Markov, a Russian mathematician.

Markov chains are one of the "dynamic programming" and "Probability Models" in Operations Research. The Markov model is interested in the decision-making process, it deals with the probability of a specific event in the future [2]. Markov models are commonly used in planning to model and analyze systems. These models allow planners to analyze the behavior of a system over time, based on the probabilities of different events occurring. Planning using Markov models involves analyzing the transition matrix to determine the long-term behavior of the system.

There are other definitions of this pattern, which is a random process that speculates on the future without needing to know the past [3].

Markov models are commonly used to study how land use in urban areas changes over time. It is a statistical tool that predicts the probability of a future state based on the current state and the probabilities of transition between different states, there are two different forms of Markov chains:

"Discrete-time Markov chains" and "continuous-time Markov chains". This indicates that there are two cases: one in which the changes are limited to certain states, and the other in which the changes are ongoing. For this, on discrete-time Markov chains, we shall concentrate [4]. Markov operations depend on imposing the stability of the possibilities of transformation of the state from one period of time to another period and the existence of equal periods, the transformation between them and the number of transformation cases can be limited, which is known as "a finite Markov chain" [4]. The logical steps of applying mathematics should be portrayed as in the ensuing math calculations [3].

$$S(t+1) = Bij \times S(t) \quad (1)$$

where, $S(t+1)$=status of the phenomenon at t or $t+1$; Bij=a state's "transition probability matrix," which is shown below:

$$\begin{bmatrix} B_{11} & B_{12} & \dots & B_{1n} \\ B_{21} & B_{22} & \dots & B_{2n} \\ B_{n1} & B_{n2} & \dots & B_{nn} \end{bmatrix}$$

$$\left(0 < 1 \; and \leq B_{ij} \sum_{j=1}^{N} B_{ij} = 1, (i,j = 1,2,\dots\dots,n)\right)$$

or

$$\begin{array}{c|cccccc} & 0 & 1 & 2 & 3 & 4 & 5 \\ 0 & B_{00} & B_{01} & B_{02} & B_{03} & B_{04} & B_{05} \\ 1 & B_{10} & B_{11} & B_{12} & B_{13} & B_{14} & B_{15} \\ 2 & B_{20} & B_{21} & B_{22} & B_{23} & B_{24} & B_{25} \\ 3 & B_{30} & B_{31} & B_{32} & B_{33} & B_{34} & B_{35} \\ 4 & B_{40} & B_{41} & B_{42} & B_{43} & B_{44} & B_{45} \\ 5 & B_{50} & B_{51} & B_{52} & B_{43} & B_{54} & B_{55} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{array} \quad (2)$$

According to the following equation, the outcome of the forecast is dependent on the phenomenon's existing circumstances, i.e., the current change in the research area's urban land use functions [3].

$$S(t, t+1) = \int (S(t), N) \tag{3}$$

Probability assumptions in statistics are based on the assumption that all probability values between zero and one, when multiplied multiple times or multiplied by themselves, will either lead to stability or be based on a specific value. This is a feature of problem-able values. For instance, when it rains, what is the weather forecast for the next two months? There should be ways to indicate this by weather variations over the past period and probabilities to determine if it is raining or sunny. The anticipated value, whether or not it will rain after this time (For instance, two months), demonstrates weather stability and reveals weather tendency, i.e., no matter if it's sunny or raining. The stabilization of the possibility of the likelihood of Markov adjustments represented by Markov chains is what is referred to as the steady state of Markov chains.

To understand the logical steps of applying Markov, see Figure 1.

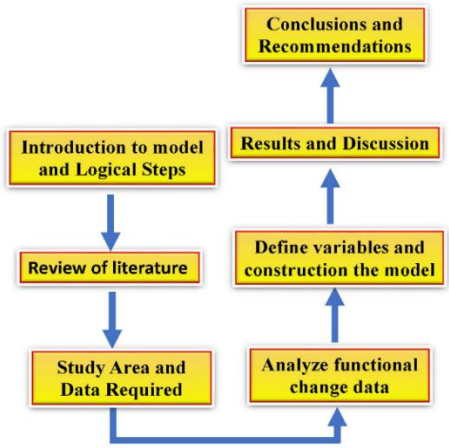

Figure 1. A flowchart of the research methodology

The article will use information provided by the local urban management in Karbala and satellite imagery processed by GIS software to determine the extent of changes in urban land use. The Markov chain method will then be used to forecast future changes in the city's spatial functions over the next 50 years.

2. LITERATURE REVIEW

Kesaulija et al. [5] used satellite image data to determine changes in land cover, then predicted land cover in the next decade. Factors influencing land cover transformation were also determined in this study, The Markov prediction chain was adopted for studying the shift of land use functions in "Paupa Barat, Sorong Regency in Indonesia". In this study, remote sensing was used to produce maps of land cover using the multi-temporal data from Landsat. The data showed that the forest area and the transformation of settlement and shrub areas dominated land cover changes from "2003-2017". In Sorong, a prediction of land cover changes from "2017-2025" could be done by using a "Markov Chain" and "Cellular Automata integration".

In the study of Baqa et al. [6], Using Google Earth the author classified the Land Use and Land Cover ("LULC") in Karachi city every ten years from 1990 to 2020 using "Satellite imagery" and "a random forest algorithm." To analyze changes in the urban landscape, the six urban classes were divided into major urban centers, secondary urban cores, dispersed settlements, suburban fringes, non-urban areas, and urban open spaces. Other LULC sites for 2030 were calculated using a CA Markov model. The findings revealed that the populous area had grown most unexpectedly. According to an analysis of changes in the urban landscape, the main urban core emerged from the central districts, specifically the central, southern, and eastern districts, and a new secondary urban core appeared in Malir in 2020. The overall urban settlement area could grow from "584.78" km^2 in 2020 to "652.59" km^2 in 2030, according to the CA Markov model. For studying urban sprawl in a city that is experiencing rapid growth, the integrated method—which combines GIS, RS, and an urban sprawl matrix—has proven to be particularly effective.

Albasri et al. [3] This study examined the magnitude of anticipated changes for the year 2025 while examining trends in urban land use function patterns in Al-Najaf, Iraq, between the years "2005-2015". The rising spatial functional change in land use patterns for the study period is based on economic and social reasons, according to the research hypothesis. This study is motivated by the accurate forecast of the scale of spatial change as a guide for city management in creating potential remedies to cope with the impact of this change, as well as the requirement to comprehend its sources and potential rising trends. The Markov chain model was used in this work to forecast how land use will change spatially over the next 10 years. According to the study's findings, the study region will see rapid functional changes over the next ten years; it won't continue in the same form, direction, or pattern. Future adjustments to "other land use functions" in the city as well as the land use of the Industrial function will occur quickly and dramatically. Future shifts from domestic to industrial duties will happen quickly and dramatically, as with the other activities, in the following period.

Ghalehteimouri et al. [7] examined recorded and current data on anticipated changes in "LULC" in one of the regions of Iran to explore Land Use & Land Cover, or "LULC", which had a lot of trouble getting access to crucial natural resources. Based on current data that has concentrated on "Cellular Automata," Markov has to emulate each "LULC." According to LULC map data for the Kurdistan region and western county of Azerbaijan from 1989 to 2019, as well as a future study that used a Markov model to predict land changes until 2049, the "LULC" class for mountains and willows is continuing to deteriorate in comparison to other classes. Additionally, "LULC" classes in terms of time and location should be expanded to include precipitation amounts and water resources for past and future years.

This study used a prediction model "Cellular Automata (CA)-Markov chain" to simulate and predict future "LULC" trends based on past changes of "LULC" [8]. This study also used "IDRISI" software and GIS to determine the land use area changes and spatial distribution of "LULC", then the transformation of forest area in other "LULCs" was calculated to obtain the deforestation area up to "1980-2018". Then, using the "Transition Potential Matrices" for data from "1999-

2018", the CA Markov chain was performed to show the distribution of "LULCs" in 2018. The future transformed "LULCs" in the period "2018-2037" and "2037-2056" was predicted using the "CA-Markov chain model". The results showed that during the study period, the forest area decreased and the agricultural area increased between "2018 and 2037".

The literature review highlights several gaps in current research, including the need to understand patterns of spatial changes in cities for effective planning and sustainability. The Markov chain method is crucial for predicting future changes and creating a guide for policymakers. Previous studies have relied solely on satellite imagery, whereas this study utilizes data from multiple sources, including field surveys and statistical operations. Additionally, this study has developed a dynamic transitional matrix model that can predict various spatial systems, whereas previous studies only predicted one case using algorithms. This approach has not been used in other Iraqi cities, making this study unique. Furthermore, this study focuses on predicting functional urban changes, which goes beyond the scope of previous research that only analyzed land cover, forest area, and green cover.

3. METHODOLOGY

3.1 Study area and data required for analysis

Karbala is a city located in central Iraq, about 100 kilometers southwest of Baghdad. It is one of the holiest cities for Shia Muslims and is home to the shrine of Imam Hussein, the grandson of Prophet Muhammad, who was martyred in Karbala in 680 CE. Millions of pilgrims visit Karbala every year during the annual Shia Muslim commemoration of Ashura, which marks the martyrdom of Imam Hussein. The city has a rich history.

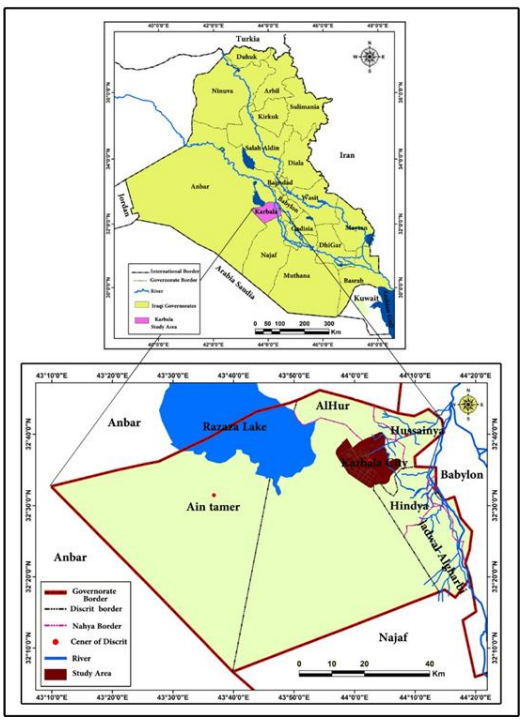

Figure 2. The location of the study area for Karbala Governorate and for Iraq
Source: Using the ARC GIS 10.8 software

The Iraqi city of Karbala, which is located within the location coordinates (latitude: 32°36′57″ N Longitude: 44°01′29″ E Elevation above sea level: 32 m, see Figure 2. It was distinguished by an important position that made its importance, because of its land originated and formed the oldest human civilizations Which supplied the world with various sciences, which were an extension of the civilization of Babylon, and thus increased its importance and became populated with residents and housing units, especially for Muslims.

3.2 The functional change of urban land uses passed through two important stages

First: the stage growth and expansion for the period (1972/1922):

This stage is one of the important urban stages that the study area went through during its history, the city expanded from the year (1870 AD), And depending on A group of factors these data growth population Whether this data (natural or human) and extended towards the south After it collapsed and demolished its wall on the side of the Bab al-Najaf district, it led to the construction of the new locality, which was known as al-Abbasiya, which extended and expanded and was divided into two localities with (Al-Abbasiya, its western and eastern branches), So he lost this expansion and development came in response to the growth of the number of population and their development, Including (City planning), In addition to the city's inadequacy of the functional and service requirements and conditions for them, the expansion was represented by the development of a new locality through the sorting and division of lands and the provision of services.

Table 1. The change in the land uses from 1922-1972 (H.C)

Land Use	Area	%	Changes	%
Residential	523.3	23.3	414.3	22.9
Religious	3.0	0.1	2.3	0.1
Commercial	26.1	1.2	8.6	0.5
Public Health	4.9	0.2	4.8	0.3
Education	48.6	2.2	47.7	2.6
Open Space	5.9	0.3	5.9	0.3
Transportation	99.7	4.4	99.7	5.5
Administrative	1.5	0.1	265.7	14.7
Cemeteries	97.9	4.4	84.2	4.7
Agricultural lands	1439.3	64.0	877.7	48.5
Total	2250.2	100.0	1810.8	100.0

Source: Karbala Department of Municipality/ Department of City Planning/ data of secretarial maps. Unpublished data, 2021.
Karbala Department of Physical Planning. Karbala city master plans. Unpublished data, 2021

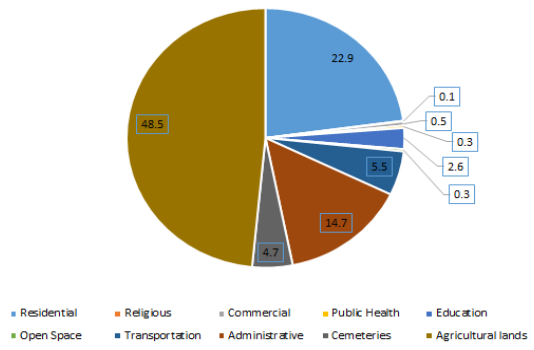

Figure 3. The change in land uses from 1922-1972
Source: Table 1

It is also clear that the city always seeks to provide several necessary facilities for its residents to ensure the social life of the recipient, as it appears at the beginning of this stage that there were no clear effects on the construction and engineering of the city, which made urban and architectural planning limited to the presence of administrative and military buildings. In the year (1922 AD) the city of Karbala began the twenties of the last century to take a privileged position, due to the political position of Karbala as well as its religious location. Ali (peace be upon him), which works to connect the north of the city with its south, and also Imam Ali al-Akbar Street (peace be upon him), which connects the two shrines, which was built using an iron. As for the year (1948 AD), Al-Muheet Street was opened in the shrine of Imam Abi Abdullah (peace be upon him), which is considered a method of isolating the honorable shrine from the urban fabric, and (Bab Al-Qibla) Street came in the year (1949 AD) whose purpose was to confirm the Western style, while in the year (1950 AD) The Iraqi government began to deal with foreign companies in development projects and the construction of cities. Table 1 and Figure 3 show details of the areas of land use during this stage.

During this stage, the local administration, in cooperation with the Greek company Doxiadis (Greek Docksides Company) in Iraq, specifically in the forties of the last century, by building and constructing some residential neighborhoods represented by (Al-Iskan neighborhood), which was established during the time of Abdul Karim Qasim Which is 6.2 km away from the old city center and has a population of (8850 people), which was intended for state employees and in terms of its location, it is located to the southwest of the central commercial area. As for the year (1958 AD), the government worked to implement (Al-Hussein neighborhood), in addition to other neighborhoods Such as (Al-Hurr, Al-Naqeeb, Al-Baladiya, Al-Muallimeen) respectively for each of them. Else for the city, which was a compliment and modification of the plan of the Doxiadis Company with the addition of other new areas, it established neighborhoods, including (Al-Islah Al-Zaraiyyah, Al-Abbas, Al-Ulama, Al-Ansar) (Figure 4), and other residential neighborhoods, and at present, the number of neighborhoods in the city is (65 residential neighborhoods). In addition, the city at this stage lacks a basic plan that regulates the uses of some uses administration in addition to some other uses, including commercial use, which is relatively superior to the previous stage.

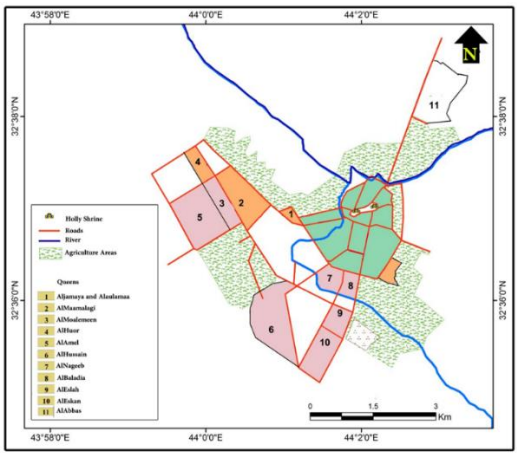

Figure 4. The first phase of the growth and expansion of the study area
Source: Using the ARC GIS 10.8 software

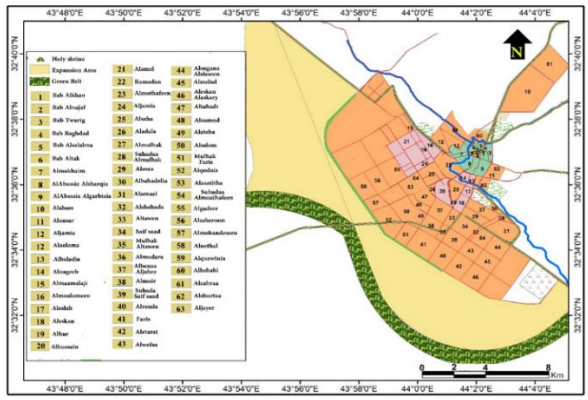

Figure 5. The second phase of the growth and expansion of the study area
Source: Using the ARC GIS 10.8 software

Second: the stage of maturation and completion (the contemporary stage) (1972-2022M)

At this stage, the city was distinguished by features and characteristics that exceeded the previous urban stages, represented by an urban and population structure, as well as urban integration, through which it was crystallized. The most developed urban functions and religious services formed a significant part of the urban land uses, and it seems clear that the composition of the population in the city was constantly increasing, as the estimates indicated the current population with a population increase of about (1,550,552 people). As they are distributed over three residential sectors, namely (the old city, al-Haidariyya, and al-Jazeera) with (65) residential neighborhoods (Figure 5). In this phase has become a crucial period in the city's development due to its integration into the urban structure. As a result, the study area has entered a new phase of growth and development, marked by a significant increase in population due to migration for work and settlement. Additionally, there has been a considerable expansion in residential and commercial areas, driven by the city's economic growth and development focused on tourism and commercial activities, which are directly linked to its religious function. Despite its vast size and diverse population, the city remains a focal point for religious rituals, attracting visitors from various regions of the country and beyond.

This is in addition to increasing the areas allocated for religious uses. Table 2 and Figure 6 show details of land use during this stage.

Table 2. The change in the land uses from 1972-2022 (HC)

Land Use	Area	%	% Changes	
Residential	6330	66.2	3926	59.5
Religious	44.43	0.5	39.3	0.6
Commercial	121.53	1.3	123.4	1.9
Public Health	92.5	1.0	86.7	1.3
Education	245.6	2.6	214.6	3.3
Open Space	131.39	1.4	126.7	1.9
Transportation	952	10.0	878.9	13.3
Administrative	42.3	0.4	39.6	0.6
Cemeteries	336.76	3.5	263.3	4.0
Agricultural lands	756.23	7.9	370	5.6
Industrial	221.6	2.3	237.6	3.6
Other	287.6	3.0	292.3	4.4
Total	9561.94	100	6598.4	100

Source: Karbala Department of Municipality/ Department of City Planning/ data of secretarial maps. Unpublished data, 2021.
Karbala Department of Physical Planning. Karbala city master plans. Unpublished data, 2021 [9, 10].

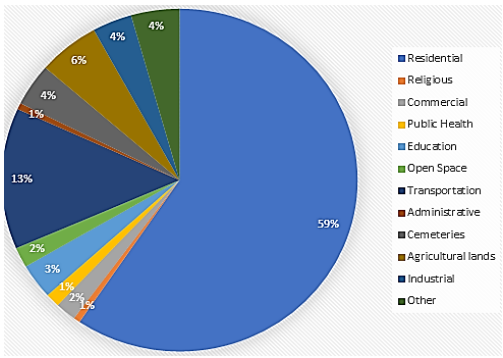

Figure 6. The change in the land uses from 1972-2022
Source: Table 2

It is clear that some land uses are still growing despite the spatial expansion that occurred in the city in recent times, thus making most of them dominate and strongly over the rest of the other types of uses, and this stems from the expansion of urbanization, while we see some land uses have diminished as a result of their competition with urban land use else.

The reasons are due to Population growth, Economic development, Technological advancements, Environmental factors and Government policies such as zoning regulations, land use planning, and urban renewal policies.

4. ANALYSIS OF THE RELATIONSHIP OF FUNCTIONAL CHANGE BASED ON AREA OF LAND USES

A linear regression model was used and a program was used SPSS to diagnose the relationship between the functional change of land uses depending on the land use area variable for the two phases, the results were as shown below:

It is clear from the above analysis that the functional change of land uses in Karbala has changed during the two mentioned phases according to the area of use and with a correlation coefficient R greater than (90%) and the coefficient of determination (Coefficient of Determination), R^2 (R squared) greater than (90%) and significant statistical significance according to the result of (Fisher Test) and the level of significance (Sig. < 0.05).

It is clear from the above statistical results that the functional change of land uses is directly proportional to the area of use, the greater the area, the greater the possibility of functional change and vice versa, assuming the stability of the rest of the factors (Figure 7).

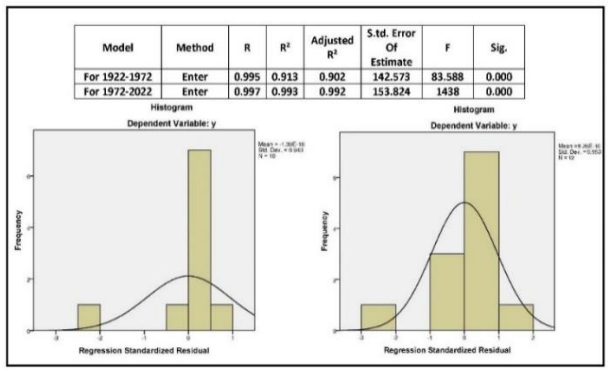

Figure 7. Relationship between the functional change of land use depending on the land use area variable for the two phases
Source: The Authors by using SPSS

5. A SPATIAL CHANGE ANALYSIS OF SLUMS WITHIN URBAN LAND USES

In the following steps, the Markov model will be applied for the purpose of prediction. Through the rates of functional change for the different uses of land in the city during 1972-2022, as shown in Table 3.

From Table 4, the transitional matrix (Markov Transition Probability Matrix) was derived, which is a diagonal matrix, which will be relied upon to carry out round states, up to the (absorbing states) state. As in Tables 5-8.

In order to make future predictions of the impending values of change over the next 50 years, it is important to note that we have reached the state of stability or saturation (also known as the "absorbing states"), which is the state that assumes the stability of the values of change in the transition matrix.

Table 3. Functional change data in Karbala for 1972-2022 (HC)

Landuse	Area (HC)	Reside-Ntial	Religious	Comme-Rcial	Public Health	Education	Open Space
Residential	6330	-	14,424	45,676	31,252	79,332	**45,676**
Religious	44.43	3.05235	-	0.09747	0.06669	0.16929	**0.09747**
Commercial	121.53	1.11265	0.01122	-	0.02431	0.06171	**0.03553**
Public Health	92.5	3,451	0.0348	0.1102	-	0.1914	**0.1102**
Education	245.6	18,445	0.186	0.589	0.403	-	**0.589**
Open Space	131.39	2.79055	0.02814	0.08911	0.06097	0.15477	-
transportation	952	43.4945	0.4386	1.3889	0.9503	2.4123	**1.3889**
Administrative	42.3	1.6065	0.0162	0.0513	0.0351	0.0891	**0.0513**
Cemeteries	336.76	43.4945	0.4386	1.3889	0.9503	2.4123	**1.3889**
Agricultural-lands	756.23	229.80685	2.31738	7.33837	5.02099	12.74559	**7.33837**
Industrial	221.6	9.52	0.096	0.304	0.208	0.528	**0.304**
Other	287.6	2.7965	0.0282	0.0893	0.0611	0.1551	**0.0893**

Landuse	Trans-Portation	Administrative	Cemeteries	Agricultural Lands	Industrial	Other
Residential	319,732	14,424	96.16	134,624	86,544	105,776
Religious	0.68229	0.03078	0.2052	0.28728	0.18468	0.22572
Commercial	0.24871	0.01122	0.0748	0.10472	0.06732	0.08228
Public Health	0.7714	0.0348	0.232	0.3248	0.2088	0.2552
Education	4,123	0.186	1.24	1,736	1,116	1,364

Open Space	0.62377	0.02814	0.1876	0.26264	0.16884	0.20636
transportation	-	0.4386	2,924	4.0936	2.6316	3.2164
Administrative	0.3591	-	0.108	0.1512	0.0972	0.1188
Cemeteries	9.7223	0.4386	-	4.0936	2.6316	3.2164
Agricultural-lands	51.36859	2.31738	15.4492	-	13.90428	16.99412
Industrial	2,128	0.096	0.64	0.896	-	0.704
Other	0.6251	0.0282	0.188	0.2632	0.1692	-

Table 4. Markov transition probability matrix

	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	**0.595005**	0.006	0.019	0.013	0.033	0.019	0.132998	0.006	0.04	0.055999	0.036	0.043999	**1**
2	0.590636	**0.013291**	0.018861	0.012905	0.032758	0.018861	0.132024	0.005956	0.039707	0.055589	0.035736	0.043677	**1**
3	0.585652	0.005906	**0.034412**	0.012796	0.032482	0.018702	0.130911	0.005906	0.039372	0.05512	0.035434	0.043309	**1**
4	0.601387	0.006064	0.019204	**0.002405**	0.033354	0.019204	0.134428	0.006064	0.040429	0.056601	0.036386	0.044472	**1**
5	0.5864	0.005913	0.018725	0.012812	**0.046976**	0.018725	0.131078	0.005913	0.039422	0.055191	0.03548	0.043364	**1**
6	0.601314	0.006064	0.019202	0.013138	0.03335	**0.00859**	0.134411	0.006064	0.040424	0.056594	0.036382	0.044467	**1**
7	0.59589	0.006009	0.019028	0.013019	0.033049	0.019028	**0.131703**	0.006009	0.04006	0.056084	0.036054	0.044066	**1**
8	0.595144	0.006001	0.019005	0.013003	0.033008	0.019005	0.133032	**0.005759**	0.04001	0.056014	0.036009	0.044011	**1**
9	0.593566	0.005986	0.018954	0.012969	0.03292	0.018954	0.13268	0.005986	**0.042313**	0.055865	0.035913	0.043894	**1**
10	0.595788	0.006008	0.019025	0.013017	0.033044	0.019025	0.133176	0.006008	0.040053	**0.054749**	0.036048	0.044058	**1**
11	0.595144	0.006001	0.019005	0.013003	0.033008	0.019005	0.133032	0.006001	0.04001	0.056014	**0.035766**	0.044011	**1**
12	0.599038	0.006041	0.019129	0.013088	0.033224	0.019129	0.133903	0.006041	0.040271	0.05638	0.036244	**0.037512**	**1**

Source: The Authors by using SPSS

Table 5. Functional change matrix for first round

6330	**44.43**	**121.53**	**92.5**	**245.6**	**131.39**	**952**	**4 2 .3**	**336.76**	**756. 23**	**221.6**	**287.6**
					×						
0.0439	0.0359	0.0559	0.0399	0.0059	0.1329	0.0189	0.0329	0.0129	0.0189	0.0059	0.595
99462	9956	99315	99511	99927	98374	99768	99597	99841	99768	99927	4952
0.0436	0.0357	0.0555	0.0397	0.0059	0.132	0.0188	0.0327	0.0129	0.0188	0.0132	0.5906
77255	35936	89234	6596	55989	2443	60633	57 94 1	4644	60633	91101	35609
0.0433	0.0354	0.0551	0.0393	0.0059	0.1309	0.0187	0.0324	0.0127	0.0344	0.0059	0.5856
8745	34427	20221	71586	5738	10524	1503	81559	95765	11851	5738	52343
0.0444	0. 0 363	0.0566	0.0404	0.006	0.1344	0. 0192	0.0333	0.0024	0.019 2	0.006	0.6013
7232	86443	1134	29381	64407	27693	3956	5424	5012	3956	64407	8705
0.043 3	0. 0354	0. 055 1	0.039 4	0.0059	0.131	0.0187	0.04 6 9	00.12 8	0.0187	0.0059	0.5864
64048	79676	90606	21862	13279	77 6 9	25384	76494	12105	25384	1327 9	193
0.0444	0.0363	0.0565	0.0404	0.006	0.1344	0.0085	0.0333	0.0131	0.0192	0.006	0.6013
6692	82026	94262	24473	63671	11372	89802	5019	37954	1625	63671	14035
0.044	0.036	0.056	0.04	0.006	0.1317	0.019	0.033	0.013	0.019	0.006	0.5958
6582	53853	83772	59837	8976	3038	28422	49365	19447	28422	8976	90072
0.044	0.036	0.056	0.04	0.0057	0.133	0.019	0.033	0.013	0.019	0.006	0.5951
10669	8729	13579	9699	58972	3225	4607	8002	3152	4607	1455	44277
0.0438	0. 0 359	0.0558	0.0423	0.0059	0.1326	0.0189	0.0329	0.0129	0.0189	0.0059	0.5935
93974	13252	65058	13288	85542	79513	542 16	204 8 1	68674	54216	85542	66243
0.044	0.036	0.0547	0.04	0.006	0.1331	0.019	0.033	0.013	0.019	0.006	0.5957
583	477	49203	53	795	76225	25 17 5	43725	17225	25175	795	88373
0.04 4 0	0. 0 3 57	0.056	0.04	0.006	0. 1330	0. 0 19 0	0.033	0.013	0.019 0	0.006	0.5951
10669	66246	13579	9699	1455	3225	4607	8002	3152	4607	1455	44277
0.0375	0.036 2	0.0563	0.0402	0.006	0.1339	0.0191	0.0332	0.013	0.0191	0.006	0.599
11849	44324	80059	71471	40721	264	28949	23963	88228	28949	40721	38128
					=						
418.8	**344.2**	**534.5**	**383.3**	**57.4**	**1270.3**	**180.3**	**319.1**	**123.3**	**183.6**	**57.7**	**5689.5**

Table 6. Functional change matrix for second round

5689.5	**57.7**	**183.6**	**123.3**	**319.1**	**180.3**	**1270.3**	**57.4**	**383.3**	**534.5**	**34 4 .2**	**418.8**
					×						
0.0439	0.0359	0.0559	0.0399	0.0059	0.1329	0.0189	0.0329	0.0129	0.0189	0.0059	0.595
99462	9956	99315	99511	99927	98374	99768	99597	99841	99768	99927	4952
0.0436	0.0357	0.0555	0.0397	0.0059	0.132	0.0188	0.0327	0.0129	0.0188	0.0132	0.5906
77255	35936	89234	6596	55989	2443	60633	57 94 1	4644	60633	91101	35609
0.0433	0.0354	0.0551	0.0393	0.0059	0.1309	0.0187	0.0324	0.0127	0.0344	0.0059	0.5856
8745	34427	20221	71586	5738	10524	1503	81559	95765	11851	5738	52343
0.0444	0. 0 363	0.0566	0.0404	0.006	0.1344	0. 0192	0.0333	0.0024	0.019 2	0.006	0.6013
7232	86443	1134	29381	64407	27693	3956	5424	5012	3956	64407	8705
0.043 3	0. 03 54	0. 055 1	0.039 4	0.0059	0.131	0.0187	0.04 6 9	00.12 8	0.0187	0.005 9	0.5864
64048	79676	90606	21862	13279	77 6 9	25384	76494	12105	25384	1327 9	193
0.0444	0.0363	0.0565	0.0404	0.006	0.1344	0.0085	0.0333	0.0131	0.0192	0.006	0.6013
6692	82026	94262	24473	63671	11372	89802	5019	37954	1625	63671	14035

0.044	0.036	0.056	0.04	0.006	0.1317	0.019	0.033	0.013	0.019	0.006	0.5958
6582	53853	83772	59837	8976	3038	28422	49365	19447	28422	8976	90072
0.044	0.036	0.056	0.04	0.0057	0.133	0.019	0.033	0.013	0.019	0.006	0.5951
10669	8729	13579	9699	58972	3225	4607	8002	3152	4607	1455	44277
0.0438	0. 0 359	0.0558	0.0423	0.0059	0.1326	0.0189	0.0329	0.012 9	0.0189	0.0059	0.5935
93974	13252	65058	13288	85542	79513	542 16	204 8 1	68674	54216	85542	66243
0.044	0.036	0.0547	0.04	0.006	0.1331	0.019	0.033	0.013	0.019	0.006	0.5957
583	477	49203	53	795	76225	25 17 5	43725	17225	25175	795	88373
0.04 4 0	0. 0 3 57	0.056	0.04	0.006	0. 1 3 3 0	0. 0 19 0	0.033	0.013	0.019 0	0.006	0.5951
10669	66246	13579	9699	1455	3225	4607	8002	3152	4607	1455	44277
0.0375	0.036 2	0.0563	0.0402	0.006	0.1339	0.0191	0.0332	0.013	0.0191	0.006	0.599
11849	44324	80059	71471	40721	264	28949	23963	88228	28949	40721	38128
					=						
417.9	**344.1**	**534.8**	**383.4**	**57 .4**	**1269.8**	**179.8**	**320.2**	**123**	**184. 6**	**57.8**	**5689.4**

Table 7. Functional change matrix for third round

5690.3	**57.8**	**184.6**	**123**	**320.2**	**179.8**	**1270**	**57.4**	**383.5**	**534.8**	**344.2**	**418**
					×						
0.0439	0.0359	0.0559	0.0399	0.0059	0.1329	0.0189	0.0329	0.0129	0.0189	0.0059	0.595
99462	9956	99315	99511	99927	98374	99768	99597	99841	99768	99927	4952
0.0436	0.0357	0.0555	0.0397	0.0059	0.132	0.0188	0.0327	0.0129	0.0188	0.0132	0.5906
77255	35936	89234	6596	55989	2443	60633	57 94 1	4644	60633	91101	35609
0.0433	0.0354	0.0551	0.0393	0.0059	0.1309	0.0187	0.0324	0.0127	0.0344	0.0059	0.5856
8745	34427	20221	71586	5738	10524	1503	81559	95765	11851	5738	52343
0.0444	0. 0 363	0.0566	0.0404	0.006	0.1344	0. 0192	0.0333	0.0024	0.019 2	0.006	0.6013
7232	86443	1134	29381	64407	27693	3956	5424	5012	3956	64407	8705
0.043 3	0. 03 54	0. 0551	0.039 4	0.0059	0.131	0.0187	0.04 6 9	00.12 8	0.0187	0.005 9	0.5864
64048	79676	90606	21862	13279	77 6 9	25384	76494	12105	25384	1327 9	193
0.0444	0.0363	0.0565	0.0404	0.006	0.1344	0.0085	0.0333	0.0131	0.0192	0.006	0.6013
6692	82026	94262	24473	63671	11372	89802	5019	37954	1625	63671	14035
0.044	0.036	0.056	0.04	0.006	0.1317	0.019	0.033	0.013	0.019	0.006	0.5958
6582	53853	83772	59837	8976	3038	28422	49365	19447	28422	8976	90072
0.044	0.036	0.056	0.04	0.0057	0.133	0.019	0.033	0.013	0.019	0.006	0.5951
10669	8729	13579	9699	58972	3225	4607	8002	3152	4607	1455	44277
0.0438	0. 0 359	0.0558	0.0423	0.0059	0.1326	0.0189	0.0329	0.012 9	0.0189	0.0059	0.5935
93974	13252	65058	13288	85542	79513	542 16	204 8 1	68674	54216	85542	66243
0.044	0.036	0.0547	0.04	0.006	0.1331	0.019	0.033	0.013	0.019	0.006	0.5957
583	477	49203	53	795	76225	25175	43725	17225	25175	795	88373
0.0440	0. 0357	0.056	0.04	0.006	0.1330	0. 0190	0.033	0.013	0.0190	0.006	0.5951
10669	66246	13579	9699	1455	3225	4607	8002	3152	4607	1455	44277
0.0375	0.0362	0.0563	0.0402	0.006	0.1339	0.0191	0.0332	0.013	0.0191	0.006	0.599
11849	44324	80059	71471	40721	264	28949	23963	88228	28949	40721	38128
					=						
418	**344.2**	**534.8**	**383.5**	**57.4**	**1270**	**179.8**	**320.2**	**123**	**184.6**	**57.8**	**5690.3**

Table 8. Functional change matrix for final round (Absorbing states)

5690.3	**57.8**	**184.6**	**123**	**320.2**	**179.8**	**1270**	**57.4**	**383.5**	**534.8**	**344.2**	**418**
					×						
0.0439	0.0359	0.0559	0.0399	0.0059	0.1329	0.0189	0.0329	0.0129	0.0189	0.0059	0.595
99462	9956	99315	99511	99927	98374	99768	99597	99841	99768	99927	4952
0.0436	0.0357	0.0555	0.0397	0.0059	0.132	0.0188	0.0327	0.0129	0.0188	0.0132	0.5906
77255	35936	89234	6596	55989	2443	60633	57941	4644	60633	91101	35609
0.0433	0.0354	0.0551	0.0393	0.0059	0.1309	0.0187	0.0324	0.0127	0.0344	0.0059	0.5856
8745	34427	20221	71586	5738	10524	1503	81559	95765	11851	5738	52343
0.0444	0.0363	0.0566	0.0404	0.006	0.1344	0. 0192	0.0333	0.0024	0.019 2	0.006	0.6013
7232	86443	1134	29381	64407	27693	3956	5424	5012	3956	64407	8705
0.043 3	0. 03 54	0. 055 1	0.039 4	0.0059	0.131	0.0187	0.04 6 9	00.12 8	0.0187	0.005 9	0.5864
64048	79676	90606	21862	13279	7769	25384	76494	12105	25384	1327 9	193
0.0444	0.0363	0.0565	0.0404	0.006	0.1344	0.0085	0.0333	0.0131	0.0192	0.006	0.6013
6692	82026	94262	24473	63671	11372	89802	5019	37954	1625	63671	14035
0.044	0.036	0.056	0.04	0.006	0.1317	0.019	0.033	0.013	0.019	0.006	0.5958
6582	53853	83772	59837	8976	3038	28422	49365	19447	28422	8976	90072
0.044	0.036	0.056	0.04	0.0057	0.133	0.019	0.033	0.013	0.019	0.006	0.5951
10669	8729	13579	9699	58972	3225	4607	8002	3152	4607	1455	44277
0.0438	0. 0 359	0.0558	0.0423	0.0059	0.1326	0.0189	0.0329	0.0129	0.0189	0.0059	0.5935
93974	13252	65058	13288	85542	79513	542 16	204 8 1	68674	54216	85542	66243
0.044	0.036	0.0547	0.04	0.006	0.1331	0.019	0.033	0.013	0.019	0.006	0.5957
583	477	49203	53	795	76225	25 175	43725	17225	25175	795	88373

0.0440	0.0357	0.056	0.04	0.006	0.1330	0.0190	0.033	0.013	0.019 0	0.006	0.5951
10669	66246	13579	9699	1455	3225	4607	8002	3152	4607	1455	44277
0.0375	0.036 2	0.0563	0.0402	0.006	0.1339	0.0191	0.0332	0.013	0.0191	0.006	0.599
11849	44324	80059	71471	40721	264	28949	23963	88228	28949	40721	38128
					=						
418	**344.2**	**534.8**	**383.5**	**57.4**	**1270**	**179.8**	**320.2**	**123**	**184.6**	**57.8**	**5690.3**

Source: The Authors by using SPSS

6. RESULTS AND DISCUSSION

In the future, there will be changes in urban land use functions that will result in a decrease of approximately 122.6 hectares of agricultural and green lands, which is equivalent to 35% of the current agricultural land area. On the other hand, there will be an increase of 640 hectares of residential slums, which is equivalent to 10% of the current residential area, and this will have a negative impact on the urban environment. Commercial functions will decrease by 52% of the current area, which is 63.07 hectares, while industrial functions will increase by 55%, which is 122.6 hectares. Religious and administrative functions will each increase by 13.37 hectares, and cemetery areas will increase by more than 46 hectares from the current area. Transportation functions will see a change of 33% of the current area, which is estimated at 318 hectares. However, there will be a positive increase in areas allocated for education, healthcare, and other functions.

Using the predictive Markov model in the study, it was determined that the rate of change over the next 50 years will not follow the same pattern or direction due to various developmental factors and their variables that were considered in the final matrix for prediction.

7. CONCLUSIONS

The Markov chains model is one of the most important models that are commonly used for the prediction of spatial phenomena. Changes in the functions of urban land use over the past period (the past 50 years) were relied upon to extract the prediction transition matrix. The city of Karbala witnessed functional changes in urban land uses during the period The reasons are due to the importance of the city being an important religious tourism center at the regional and international levels, as well as population growth, immigration, and rapid urbanization.

That some urban land uses are still growing and changing, and there are some land uses that have declined as a result of their competition with other urban land use, and the strength of spatial competition affected that change rapidly and remarkably outside the standards of local urban planning.

The functional change of land uses was significantly associated with the areas of urban events and activities, and this was shown through the results of applying the linear regression model using the program (SPSS). It was clear from the statistical results that the functional change of land uses is directly proportional to the area of use, the greater the area, the greater the possibility of functional change and vice versa, assuming the stability of the rest of the factors been extracted (Markov Transition Probability Matrix) Which is (a diagonal matrix) And it was relied upon to do the math rounds (Round States) It took four rounds to get there (Absorbing states) It is the case that assumes the stability of the values of change in the transition matrix for future prediction. We found a decline in agricultural and green lands estimated at more than a third (agricultural lands) current. And that the city will suffer from an increase in residential slums, which will negatively affect the overall urban environment. Commercial functions will change during the coming period by more than half of the current space allocated for commercial use, as well as for industrial functions in a similar way. Transport functions will change to occupy more than a third of the space currently allocated for functions Transport. And it will increase religious functions, administrative functions, cemetery areas, administrative, educational and health functions significantly increased, as shown by the results of the study.

The findings of this study can be used as a basis for an urban observatory, which is crucial for the development of future urban policies that address changes in spatial functions and control of factors that affect these changes. These results will inform the development of housing policies, urban plans, regional development plans, urban land management policies, and spatial organization. The transition matrix is advantageous because it can be used for future predictions if different data is entered for a different time period.

1. The research recommends adopting (Markov Transition Probability Matrix) extracted to diagnose future functional change when studying urban functions independently.
2. Activating the urban observatory to control the change in land use functions and enabling local administrations to monitor changes and address them immediately to prevent their aggravation.
3. Building digital databases for urban land use in the city to facilitate electronic transactions and electronic management of urban functions data.
4. The possibility of simulating the results extracted in this research on other cities, since the approach is useful for city planners and urban administrations.
5. Reconsidering the current master plan for the city by drawing up a long-term development plan that takes into account the development of effective solutions to the effects of unplanned change in urban functions.

8. FUTURE PROPOSED STUDIES

Using of a Markov model to analyze the functional change in Karbala city.

Prediction of the impact of urbanization on agriculture land in sub-urban areas by using Markov model.

Analysis of urban transformation in Karbala: using Markov model.

The prediction of the decline in agricultural areas in the sub urban of the city of Karbala.

REFERENCES

[1] Azizi Ghalati, S., Rangzan, K., Sadidy, J., Heydarian, P., Taghizadeh, A. (2016). Predicting locational trend of land use changes using CA-Markov model (Case study:

Kohmare Sorkhi, Fars province). Journal of RS and GIS for Natural Resources, 7(1): 59-71.
[2] Karimi, H., Jafarnezhad, J., Khaledi, J., Ahmadi, P. (2018). Monitoring and prediction of land use/land cover changes using CA-Markov model: A case study of Ravansar County in Iran. Arabian Journal of Geosciences, 11: 1-9. https://doi.org/10.1007/s12517-018-3940-5
[3] Albasri, N.A.H., Al-Jawari, S.M., Al-Mosherefawi, O.J. (2022). Prediction of urban spatial changes pattern using markov chain. Civil Engineering Journal, 8(4): 710-722. https://doi.org/10.28991/CEJ-2022-08-04-07
[4] Konstantopoulos, T. (2009). Introductory lecture notes on markov chains and random walks. Department of Mathematics, Uppsala University, 200(9). http://www2.math.uu.se/~takis%20/L/McRw/mcrw.pdf.
[5] Kesaulija, F.F., Aipassa, M.I., Sumaryono, M., Suhardiman, A. (2021). Modeling land cover change using markov chain-cellular automata in sorong, west Papua province. In Joint Symposium on Tropical Studies (JSTS-19), pp. 157-162. https://doi.org/10.2991/absr.k.210408.026
[6] Baqa, M.F., Chen, F., Lu, L., et al. (2021). Monitoring and modeling the patterns and trends of urban growth using urban sprawl matrix and CA-Markov model: A case study of Karachi, Pakistan. Land, 10(7): 700. https://doi.org/10.3390/land10070700
[7] Ghalehteimouri, K.J., Shamsoddini, A., Mousavi, M.N., Ros, F.B.C., Khedmatzadeh, A. (2022). Predicting spatial and decadal of land use and land cover change using integrated cellular automata Markov chain model based scenarios (2019–2049) Zarriné-Rūd River Basin in Iran. Environmental Challenges, 6: 100399. https://doi.org/10.1016/j.envc.2021.100399
[8] Gemmechis, W.A. (2022). Land use land cover dynamics using CA-Markov chain a case of belete gera forest priority area south western ethiopia. https://doi.org/10.21203/rs.3.rs-1805209/v1
[9] Karbala Department of Municipality. (2021). Department of city planning/ data of secretarial maps.
[10] Karbala Department of Physical Planning. (2021). Karbala city master plans.