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Urban Sprawl Impact on Agricultural Lands in Irbid City, Jordan

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Abstract
Urban sprawl on agricultural lands is considered as one of the major problems that agricultural sector can face, especially in Irbid city. Irbid city, which is located at the north of Jordan, is one of the most important provinces in Jordan for the fertility of its soil. Most of its lands have clay soil which is suitable for cultivation of several crops. Unfortunately, the scenario of urban sprawl is continuing randomly and the percentage of agricultural land continues to decrease. This research article focuses on the agricultural lands of Irbid city and its districts, and how urban constructions will affect their areas based on statistics along the years from 1995 to 2015. In order to provide a solution to agricultural area exhaustion in Irbid governorate, this article suggests allowing adding additional floors to the current allowed floors in order to encourage vertical construction expansion rather than horizontal one.This study presents a simulation study steps to figure out the relationships between the growth of construction areas and the decline of agricultural lands. These relationships can be computed by using statistical techniques of correlation and regression analysis. Based on this analysis and computation, we tested the suggested solution, of adding more floors on the current allowed number of floors, by measuring the appropriate number of allowed floors at the same building that will delay agricultural area blocking for each Irbid district. The simulation results indicate when each district of Irbid city will be blocked before and after using the additional floors, and possible achieved delay for each district is computed. The model indicates that one alternative to reserve the agricultural lands in Irbid city for the coming 40 years is to allow buildings to grow up more than 4 floors. Therefore, this research encourages vertical construction expansion rather than horizontal one, for the coming buildings.
Keywords: Agricultural lands, Construction Area, Distributive Function, Population, Simulation Process, Urban Sprawl.

1. Introduction

There are several definitions for urban sprawl. As in Kahn (2000), Hasse et al. (2003) and Rahimi (2016), urban sprawl is defined as a particular shape of urban growth with low-density, dispersed, auto-dependent, and environmentally and socially impacting characteristics (Kahn, 2000). The outcomes of urban sprawl could be comprised several negative results. Such as increased traffic, which leads to increase the demand for accessibility (Rahimi, 2016; Ewing et al., 2002; Kahn, 2000), fragmentation of lands holdings into smaller one (Demetriou, 2014; Mela, 2014), reduced attractive green lands (Rahimi, 2016; Sullivan and Lovell, 2006), threatening the environment, health, and quality of life (Bhatta, 2010).

In Irbid city, Urban sprawl on agricultural lands is considered as one of the big problems that agricultural sector can face. Irbid city- which is located at the north of Jordan- is one of the most important provinces in Jordan for the fertility of its soil. Most of its lands have clay soil which is suitable for cultivation of several crops. In addition, the rainfall rate in Irbid city is about 400 millimeter per year (Abu-Zreig et al. 2012). Therefore, it had an important contribution in the agricultural production of Jordan. Unfortunately, the scenario of urban sprawl is continuing randomly and the percentage of agricultural land continues to decrease.

As in Riffat et al. (2016), "Random and Massive urban sprawl growth is threatening the sustainability of cities and the quality of city life. Mass urbanization can lead to social instability, undermining the capacity of cities to be environmentally sustainable and economically successful. So, a new form of sustainability is required, including greater incentive to keep energy, reduce consumption and keep the environment while also increasing levels of resident health" (Riffat et al. 2016). In addition, there are needs to update number of buildings regulations to have some constraints on building constructions. This will increase the possibility of control the expansion of urban areas.

Given the importance of urban sprawl problem, there are numbers of studies concerned with simulating this problem using different approaches in order to predict and possibly prevent their impacts in the future. Sharieh et al. (2006) conducted a simulation for Amman city, the capital of Jordan, and its parts and the output results are statistically analyzed. Their simulation identified when each part of Amman will be blocked and how number of allowed floors at the same building will delay green area blocking. Furthermore, there are many simulation studies conducted depending on Cellular Automata structure so as to address urban systems and Land use cover changes (LUCC) (Li et al. 2015; Almeida et al. 2008; Gong et al. 2009; Stevens et al. 2007; Torrens and O'Sullivan 2001; Verburg et al. 2004; Yang et al. 2008). Li and Li (2015) introduced the Monte Carlo approach into Cellular automata and artificial neural networks model to simulate multiple land use changes with a case study in Shenzhen, China. As in Rahimi (2016) a neural network and a geographical information system is used to build a model for Land Transformation of urban land-use change on Tabriz city (Rahimi, 2016). Different researches suggested solutions to urban sprawl problem, one of these solutions is urging vertical instead of horizontal building expansion to postpone the agricultural area blocking as possible (Al Tarawneh, 2014). However, this suggested solution need to be tested to find out its impacts.

This study presents a simulation steps to figure out the relationships between the growth of construction areas and the decline of agricultural lands in Irbid governorate. In addition, it tests and computes the impact of increasing allowed building floors number on the area of agricultural areas, and conduct a comparison between current building state and after using more number of floors.

This study is organized as follows. The upcoming section is Problem formulation which defines the problem and presents the study aims and questions to be answered. The study area section presents some properties of Irbid governorate for which the study focus and the required data collected. Next section is Development of the model which illustrates the relationship between sources of randomness of this study. After that, Model verification and validation section is presented. Results and discussion section presents results founded and discusses them. Finally, the last section presents the conclusion of the study and the future work.

2. Problem formulation

The uncontrolled expansion of urban areas is a problem of interest in this study. There are number of reasons lead to uncontrolled urban sprawl. As in Al Tarawneh (2014) "One of these reasons is the dramatically increasing in population. When the population increases, the demands of lands for housing and human services increase. Thus, the agricultural lands started decreasing day by day, and the rapid cultural transition and population growth have transformed the traditional dependency between people and the environment in Jordan". Other reason is the absence of proper city planning, which leads in randomness of buildings (Al Tarawneh, 2014; Tewfik et al. 2014). This randomness can be seen in building expansion along the way between the center of Irbid and its related districts. Among other reasons is the fragmentation of agricultural land into smaller units (Al Tarawneh, 2014). Therefore, lands become useless for farming. This leads to the reluctance of farmers for agricultural investment and therefore, invests in construction.

Based on this problem, this study aims to:

1) Analyze how the urban construction degraded the area of agricultural lands through 20 years from 1995 to 2015 in Irbid governorate. From this analysis we can predict how urban will expand over 5 years later or more.
2) Identify number of factors that will help in slowing down the process of urban sprawl as possible, and model it to present their successes.
3) Make comparisons between “the urban sprawl with these factors” and “the urban sprawl without these factors”, over these 20 years.

Moreover, this study aims to find answers to the following questions: If the current urban construction growth rates continue as is, at which year the areas of Irbid and its districts will be blocked? How can we degrade the urban construction growth rate? What are the factors help in slowing down the urban construction rate as possible?

We may answer these questions, by measures the urban constructions rate with time unit in Irbid and its districts, in order to calculate the remaining agricultural areas with time unit. Then, we can measure the urban construction rate, with unit of time, of some solutions such as increasing the number of maximum allowed floors in the building. Then, we can conduct a comparison to specify if the suggested solution actually provides any improvements by measuring the amount of delay produced.

3. The study area

This study focuses on Irbid governorate and its districts, and how urban constructions will impact their agricultural areas based on statistics along the years from 1995 to 2015. The total area of Irbid governorate is about 1572 Km^2. Table1 shows the area of each district of Irbid governorate (Department of Agriculture, 2016). Irbid governorate is divided into nine districts: Ramtha, Bani Obaid, Koorah, Agwar Al-shamaliah, Irbid qasabah, Bani kenanah, Taybah, Wassatiyah, and Mazar, as shown in Figure 1. The reason behind the choice of Irbid is because of its fertile lands and increasing urban sprawl upon its agricultural lands significantly in recent years due to increase in number of refugees from neighboring countries of Jordan such as Syria and Iraq.

Table 1. Area for each district of Irbid governorate

District no.	District name	Total area (Dunuam=1000m^2)
1	Irbid Qasabah	235800
2	Ramtha	254557
3	Bani Kenanah	278425
4	Koorah	209518
5	Mazar Shamali	89722
6	Taybeh District	80185
7	Wastiyyah	47600
8	Aghwar Shamaliyah	183763
9	Bani Obeid	188800
	Total Irbid Governorate area	1,572,000

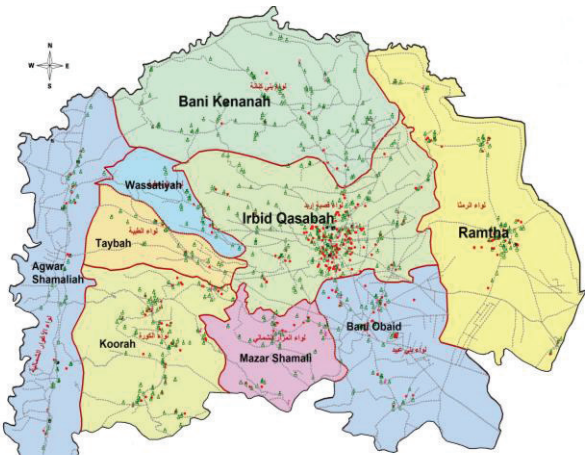

Figure. 1 ***Irbid governorate and its districts.***

Table 2. Population census (in capital) for each Irbid district

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Irbid Govrnorate	996800	1018700	1041300	1064400	1088100	1112300	1137100	1162300	1188100	1770158
1	Irbid Qasabah	403310	41217 0	421320	430670	440250	450040	460090	470260	480710	739212
2	Ramtha	117200	11977 0	122430	125140	127930	130780	133690	136660	139680	238502
3	Koorah	97770	99920	102130	104400	106720	109100	111530	114000	116530	161505
4	Bani Kenanah	82040	83840	85700	87600	89550	91540	93580	95660	97780	131797
5	Aghwar Shamaliyah	91490	93500	95580	97700	99870	102090	104370	106680	109050	122330
6	Bani Obeid	100470	10268 0	104950	107280	109670	112110	114610	117150	119750	204313
7	Mazar Shamali	47420	48460	49540	50640	51770	52920	54100	55300	56530	78427
8	Taybeh	31280	31970	32680	33400	34150	34910	35680	36480	37290	51501
9	Wastiyyah	25820	26390	26970	27570	28190	28810	29450	30110	30780	42571

This study uses the following statistics data:

- Census of population and housing from department of statistics. Table 2 shows census of population for each district of Irbid governorate from 2006 to 2015 (Department of statistics, 2016); and shows the population of Irbid in each year.
- Agricultural areas for each of Irbid governorate's district. Table 3 shows this data from 2006 to 2015.
- Construction areas for Irbid governorate from 2006 to 2015 as shown in Table 4.

4. Development of the model

In this step, the concern is to find out if there exists a relationship between sources of randomness in this study. This can be answered by using techniques of correlation and regression analysis. Correlation is a statistical method used to determine whether a linear relationship between variables exists (Bewick et al. 2003; Bluman, 2011). Regression is a statistical method to describe the nature of the relationship between variables, that is, positive or negative, linear or nonlinear (Bewick et al. 2003; Bluman, 2011). To illustrate how correlation and regression statistical methods are used, take the time in year and the population number for Irbid Qasabah -two variables- as an example in steps. In the first step, draw a scatter plot between these two variables- the time in year and the population number in persons- as shown in Figure 2. This figure suggests a positive relationship, since the number of population increases with time. There is a jump in number of population in the year 2015. This is because of the increase in number of refugees from neighboring countries of Jordan such as Syria and Iraq.

After that, calculate the correlation coefficient, which is a measure to determine the strength of the linear relationship between two variables (Bewick et al. 2003; Bluman, 2011). The one used here is Pearson product moment correlation coefficient r, between the two variables x and y, where S stands for the sum, which has the formula (1) (Bewick et al. 2003; Bluman, 2011).

$$r = S\ (xy)\ /\ \text{sqrt}\left[\ \left(S\ x^2\right) * \left(S\ y^2\right)\ \right] \quad \text{..... (1)}$$

The range of r is between -1 and 1. If r is close to 1, then there exists a strong positive relationship between x and y (Bewick et al. 2003; Bluman, 2011). If r is close to -1, then there exists a strong negative relationship, and if r is close to 0, then there exists no or weak relationship (Bewick et al. 2003; Bluman, 2011).

For Irbid Qasabah, the value of r is equal to 0.736, which indicates that there is a strong positive relationship between the selected years and the population during these years. After that, the regression line equation can be y' = a x +b, where b is the y' intercept and a is the slope of the line. y' will be predicted from the value of x (Bewick et al. 2003; Bluman, 2011). Here the linear regression equation between time in year and the population in Irbid Qasabah is:

$$y' = 333067.758 + 19131.486x$$

Where y' is the population, x is the time in year. Tables 5 through 7 present the summary of equations used in this simulation study.

This study benefited from MegaStat tool available in excel software to make the correlation analysis and to find the required regression equations.

Figure.2, Table 5 and Table 7 show that each district's population data and construction area has a linear relationship with time. In addition, there exists a strong positive correlation coefficient r, because r is close to 1 in all of these cases. On the other hand, Figure.3 and Table 6 show that each district's agricultural area has a negative linear relationship with time. In this case, there exists a strong negative correlation coefficient r.

5. The simulation scenarios

In order to provide a solution to agricultural area exhaustion in Irbid governorate, this study suggests allowing adding additional floors to the current allowed floors. Currently, most of the buildings have number of floors in the range 1 to 4 floors. The most common building type is horizontal. Therefore to reach 6 floors, add 3 floors on the current average floors number, for 8 floors add 5 additional floors and for 10 floors add additional 7 floors, in average. Tables 8a through 8c show the equations used to test the program using three different simulation scenarios which are adding 6, 8 or 10 floors respectively. In addition, the fourth scenario is what we obtained in table 6. Equations in tables 8a through 8c are obtained based on the concept of: By adding number of floors, an amount of agricultural area can be saved. This amount is equal to the additional floors area. This additional floors area is calculated by multiply a specific construction area by number of additional floors. After that, add this result to a specific agricultural area to increase it and then increase the value of agricultural area blocking delay for each district.

Table 3 Agricultural area, in Dunuam, for each district of Irbid governorate

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Irbid Govrnorate	1036865	987474	935027	882036	831389	788433	739755	691800	643729	621483
1	Irbid Qasabah	207431	197022	186135	176013	165062	155461	144945	132278	126711	116541
2	Ramtha	205142	197132	188163	180716	172584	164429	156287	148143	139969	136280
3	Bani Kenanah	137021	132700	129287	125124	121670	119433	114976	112723	107342	105152
4	Koorah District	120620	112380	101153	91934	84784	73453	65216	55984	44754	40721
5	Mazar Shamali	62650	61357	59065	54774	52482	48190	43898	41607	36315	35572
6	Taybeh District	30240	27611	25950	22363	19730	17103	14478	11849	9222	14173
7	Wastiyyah	36090	34639	33189	32736	30285	28832	27381	25930	24478	23484
8	Aghwar Shamaliyah	207431	197022	186135	176013	165062	164429	156287	148143	139969	136280
9	Bani Obeid	30240	27611	25950	22363	19730	17103	16287	15143	14969	13280

Table 4 Construction area, in square meter, for each of Irbid Governorate district

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Irbid Govrnorate	1449675	1490269	1498782	1498921	1619042	1628500	1937115	2497846	2647031	2845495
1	Irbid Qasabah	261913	266427	267369	267384	280736	281782	316073	378376	394952	417004
2	Ramtha	164170	168680	169626	169641	182988	184039	218330	280633	297209	319261
3	Koorah	40268	44778	45727	45739	59086	60137	94428	156731	173307	195359
4	Bani Kenanah	140170	144680	145626	145648	158988	160039	194330	256633	273214	295261
5	Aghwar Shamaliyah	160100	164610	165556	165571	178918	179969	214260	276563	293139	315192
6	Bani Obeid	258070	262580	263526	263541	276888	277939	312230	374533	391109	413161
7	Mazar Shamali	80538	85048	85994	86009	99356	100407	134698	197001	213577	235629
8	Taybeh	87657	92167	93113	93128	106475	107530	141817	204124	220696	242748
9	Wastiyyah	256789	261299	262245	262260	275607	276658	310949	373252	389828	411880

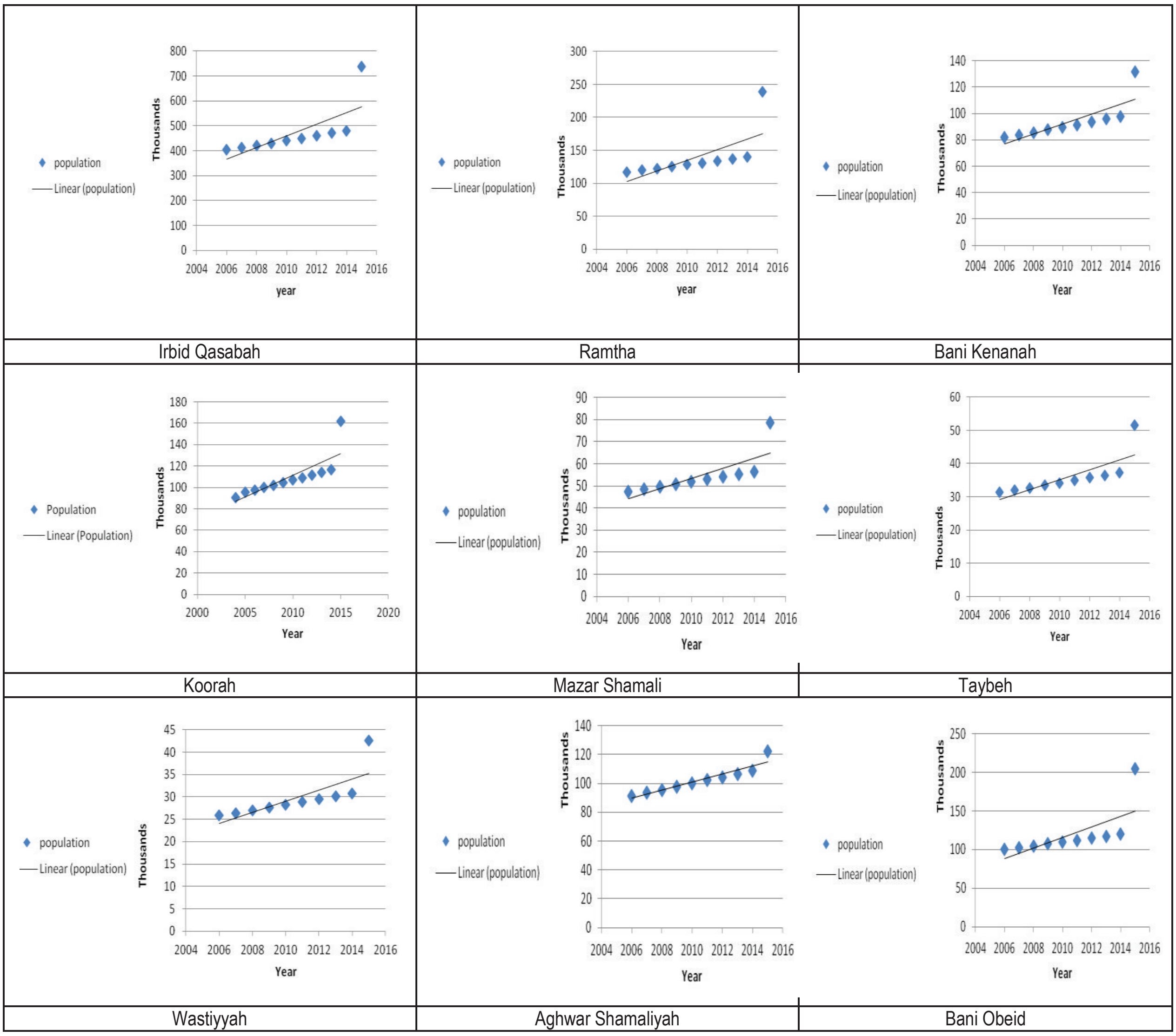

Figure.2 Scatter plot between population and time for each district

Table 5 Regression equations between population number(y'), and time in year (x)

Districts name	Correlation coefficient	Regression line equation
Irbid Qasabah	0.736	$y' = 333067.758 + 19131.486x$
Ramtha	0.724	$y' = 88394.909 + 6970.399x$
Bani Kenanah	0.824	$y' = 70034.227 + 3266.008x$
Koorah District	0.806	$y' = 61322.227 + 6227.619x$
Mazar Shamali	0.801	$y' = 40255.379 + 1959.916x$
Taybeh	0.800	$y' = 26718.985 + 1269.874x$
Wastiyyah	0.822	$y' = 21451.924 + 1116.371x$
Aghwar Shamaliyah	0.958	$y' = 82506.121 + 2663.699x$
Bani Obeid	0.703	$y' = 78332.621 + 13393.675x$

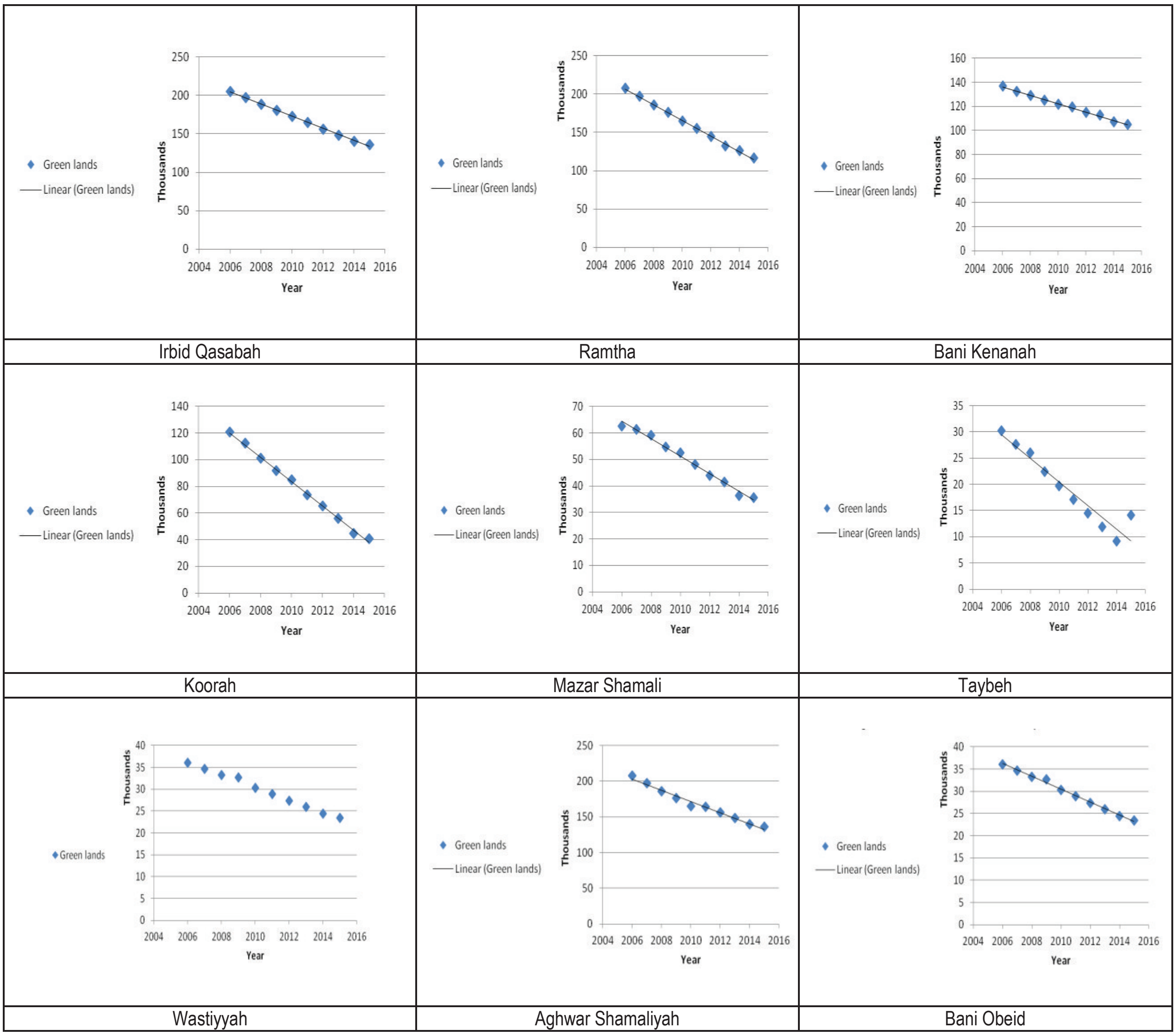

Figure.3 Scatter plot between agricultural area and time for each district

Table 6 Regression equations between agricultural area (y'), and time in year (x)

Districts name	Correlation coefficient	Regression line equation
Irbid Governorate	-0.988	*y'=775925957 – 382925.21 x*
Irbid Qasabah	-0.999	*y'= 15781498520 – 7765373.418 x*
Ramtha	-0.999	*y'= 21598730040 – 10662735.67 x*
Bani Kenanah	-0.998	*y'= 7007443374 – 3.425350 x*
Koorah District	-0.998	*y'= 18284317690 – 9054641.434 x*
Mazar Shamali	-0.994	*y'= 6869630000 - 3391000 x*
Taybeh	-0.851	*y '= 5304850667 – 2626900 x*
Wastiyyah	-0.998	*y'= 2948305667 – 1451600 x*
Aghwar Shamaliyah	-0.991	*y'=15883643.00 - 7815.1580 x*
Bani Obeid	-0.985	*y'=17906783.400 - 8824.1600 x*

Table 7 Regression equations between construction area(y'), and time in year (x)

Districts name	Correlation coefficient	Regression line equation
Irbid Qasabah	0.873	y'=-34673118.2+17401.8x
Ramtha	0.760	y'=-34770861.2+17401x
Bani Kenanah	0.763	y'=-34794861.2+17403 x
Koorah District	0.760	y'= -34894763.2+17402 x
Mazar Shamali	0.870	y'=-34854493.2+17410.9x
Taybeh	0.870	y'=-34847374.2+17414x
Wastiyyah	0.873	y'=-34678242.2+17420.7x
Aghwar Shamaliyah	0.873	y'=-34774931.2+17401x
Bani Obeid	0.872	y'=-34676961.2+17410.8x
Irbid Governorate	0.870	y'=-156856491+78890.17857x

Table 8a Predicted distributed functions for 6 floors

District name	Distributive functions
Irbid Qasabah	y'=15781498520 – 7765373.418 x+3(-346731182+174018x)
Ramtha	y'= 21598730040 – 10662735.67 x+3(-347708612+174010x)
Bani Kenanah	y'= 7007443374 – 3425350 x+3(-347948612+174030 x)
Koorah District	y'= 18284317690 – 9054641.434 x+3(-348947632+174020 x)
Mazar Shamali	y'= 6869630000 – 3391000 x+3(-348544932+174109x)
Taybeh	y '= 5304850667– 2626900 x+3(-348473742+174140x)
Wastiyyah	y'= 2948305667– 1451600x+3(-346782422+174207x)
Aghwar Shamaliyah	y'=15883643-7815.158x+3(-347749312+174010x)
Bani Obeid	y'=17906783.4-8824.16x+3(-346769612+174108x)

Table 8b Predicted distributed functions for 8 floors

District name	Distributive functions
Irbid Qasabah	y'=15781498520 – 7765373.418 x+5(-346731182+174018x)
Ramtha	y'= 21598730040 – 10662735.67 x+5(-347708612+174010x)
Bani Kenanah	y'= 7007443374 – 3425350 x+5(-347948612+174030 x)
Koorah District	y'= 18284317690 – 9054641.434 x+5(-348947632+174020 x)
Mazar Shamali	y'= 6869630000 – 3391000 x+5(-348544932+174109x)
Taybeh	y '= 5304850667– 2626900 x+5(-348473742+174140x)
Wastiyyah	y'= 2948305667– 1451600x+5(-346782422+174207x)
Aghwar Shamaliyah	y'=15883643-7815.158x+5(-347749312+174010x)
Bani Obeid	y'=17906783.4-8824.16x+5(-346769612+174108x)

Table 8c Predicted distributed functions for 10 floors

District name	Distributive functions
Irbid Qasabah	y'=15781498520 – 7765373.418 x+7(-346731182+174018x)
Ramtha	y'= 21598730040 – 10662735.67 x+7(-347708612+174010x)
Bani Kenanah	y'= 7007443374 – 3425350 x+7(-347948612+174030 x)
Koorah District	y'= 18284317690 – 9054641.434 x+7(-348947632+174020 x)
Mazar Shamali	y'= 6869630000 – 3391000 x+7(-348544932+174109x)
Taybeh	y '= 5304850667– 2626900 x+7(-348473742+174140x)
Wastiyyah	y'= 2948305667– 1451600x+7(-346782422+174207x)
Aghwar Shamaliyah	y'=15883643-7815.158x+7(-347749312+174010x)
Bani Obeid	y'=17906783.4-8824.16x+7(-346769612+174108x)

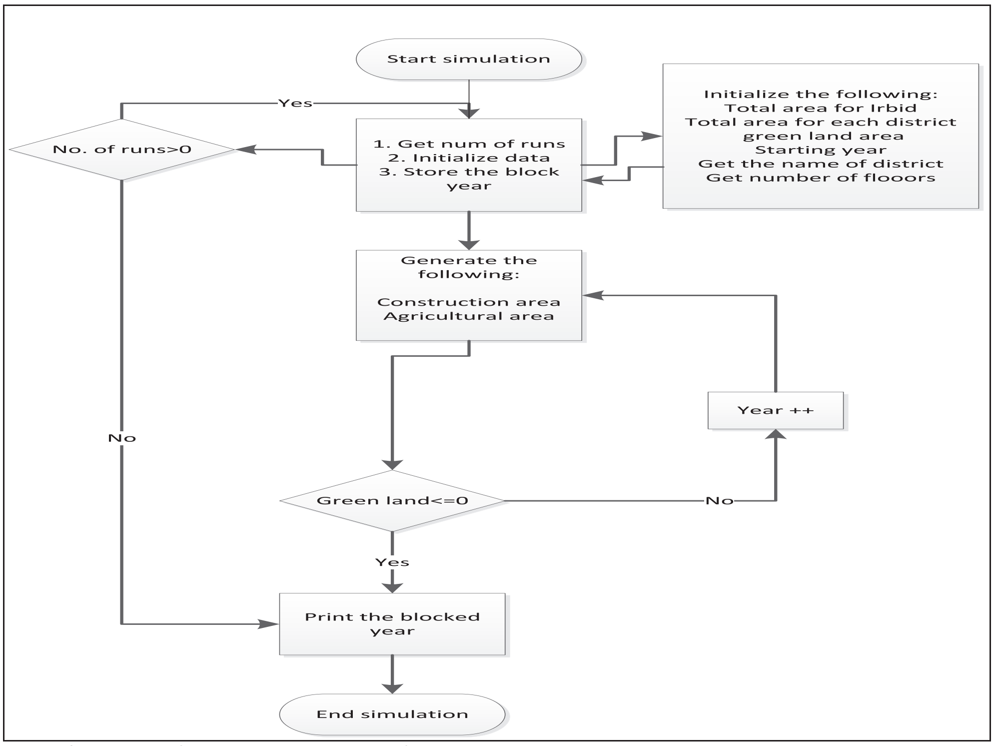

Figure 4 Flow chart for the simulation model of study

The simulation model was implemented using Visual Basic2010 programming language, and using Visual Studio as IDE. Also it benefited from Microsoft Visio 2010 for drawings the required models. Figure 4 shows the flowchart of the simulation to predict the blocked year for each district.

6. Model verification and validation

Verification is concerned with determining if the simulation program is working as intended, and the initial verification efforts included the following (Law et al. 2001):

- The model was programmed and debugged in steps.
- An interactive debugger was used to verify that each program path was correct.
- Model output was checked for reasonableness.
- The values obtained from the previous distributive functions between time and the agricultural lands and construction areas were compared with historical agricultural lands and construction areas respectively for Irbid governorate for year 2015 as shown in the Table 9a and Table 9b.

Table 9a Validation comparison of Agricultural area

Districts name	Historical agricultural lands(2015)in Dunam	Predicate agricultural lands(2015) in Dunam	Difference	Absolute Relative Error
Irbid qasabah	136280	134271	2009	0.014742
Ramtha	116541	113318	3223	0.027656
Bani kenanah	105152	105359	207	0.00197
Koorah	40721	39215	1506	0.036983
Taybah	14173	11647	2526	0.178226
Mazar	35572	35556	16	0.00045
Agwar Alshamaliah	136280	136100	180	0.001321
Bani Obaid	126182	126101	81	0.000642
Wassatiyah	23484	23332	152	0.006472
Irbid governorate	744483	744331	152	0.000204

Errors in tables 9a and 9b indicate the closeness of these values, which indicate that the results of the predicted values are highly acceptable for all districts except for Taybah where the error is 17.8226%. Validation is concerned with determining how closely the simulation model represents the actual system. All distributive functions were tested for correctness by calculating the absolute error between historical data and that obtained from the distributive functions. It is generally hard to validate a simulation model completely, since some parts of the actual system may not currently exist (Law et al. 2001). However, building the simulation model of a similar existing system and comparing model and system outputs will often be the most definitive validation technique available (Law et al. 2001).

Table 9b Validation comparison for construction area

Districts name	Historical construction area(2015)m^2	Predicate construction area(2015) m^2	Differen ce	Absolute Relative error
Irbid qasabah	394952	391508.8	3443.2	0.0088
Ramtha	297209	292153.8	5055.2	0.0173
Bani kenanah	273209	272209	1000	0.0037
Koorah	173307	171307	2000	0.0117
Taybah	220696	241835	21139	0.0874
Mazar	213577	228470	14893	0.0652
Agwar Alshamaliah	293139	288083	5056	0.0176
Bani Obaid	391109	405800	14691	0.0362
Wassatiyah	389828	424468	34640	0.0816
Irbid governorate	2647031	2616039	30992	0.0119

7. Results and discussion

This simulation study presents four different scenarios (system design). The first scenario, used to compute the blocked year of Irbid governorate – when its green land exhausted completely- using the current three average numbers of floors. Second scenario, implemented using 3 additional floors adding on the 3 average numbers of floors, and then computes the blocked year. Third scenario is implemented using 5 additional floors, added to the 3 current averaged floors, and then computes the blocked year. Finally, fourth scenario, is similar to previous one but by adding 7 floors to the current floors. Table 10 represents the blocked year for Irbid governorate and its districts applying these four scenarios.

We can see from Table 10 that each district has different year to be blocked. This is because the construction growth rate and the areas for each district are not the same. Koorah has the fastest growth rate so it is going to be blocked at 2019. In other side, Bani Kenanah has the lowest growth rate and due to its large area it is going to be blocked at 2046 using average of 3 floors. Irbid governorate is going to be blocked at 2046 using first scenario. After applying the second scenario, Irbid governorate will be blocked at 2059. So we can save green lands in Irbid by adding 3 additional floors to the current allowed 3 floors. Irbid Qasabah and due to its location in the centre of Irbid governorate and higher population growth, it will be blocked sooner than Bani Kenanah which is located at the north of Irbid governorate. Also we can see from Table 10 that as we increase the number of allowed floors, we can postpone the blocked year as possible.

Table 10 Blocked year for each Irbid districts and the resulted delay respected to different number of floors

District name	4 floors blocked year	Delay (year)	6 floors blocked year	Delay (year)	8 floors blocked year	Delay (year)	10 floors blocked year	Delay (year)
Irbid qasabah	2032	17	2035	20	2037	22	2039	24
Ramtha	2026	11	2027	12	2028	13	2029	14
Bani kenanah	2046	31	2054	39	2061	46	2071	56
Agwar Alshamaliah	2032	17	2059	44	2086	71	2101	86
Mazar	2026	11	2030	15	2034	19	2038	23
Taybah	2020	5	2023	8	2029	14	2035	20
Wassatiyah	2031	16	2053	38	2091	76	2143	128
Koorah	2019	4	2020	5	2021	6	2022	7
Bani Obaid	2029	14	2035	20	2041	26	2047	32
Irbid governorate	2046	31	2059	44	2086	71	2143	128

8. The simulation program

Figures 5a through 5e show the interfaces used in the simulation program implemented in this study. When the user runs the program, screen like the one in Figure 5a is opened. This interface welcomes the user and asks him/her to press start button in the bottom of the screen.

Figure 5aThe welcomed screen

After that, a screen as shown in Figure 5b will be opened. In this screen, the user can select one of the nine districts of Irbid governorate. Then, the user should also select the number of floors from the drop list as shown in figure 5c and 5d. And then, the user enters the start simulation year and presses the simulation button. A result for simulation is displayed, as the one shown in Figure 5e.

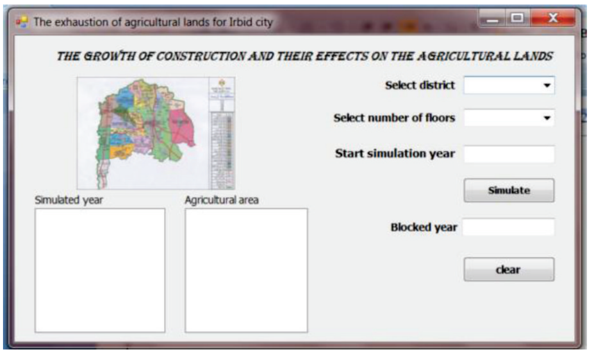

Figure.5b The second screen

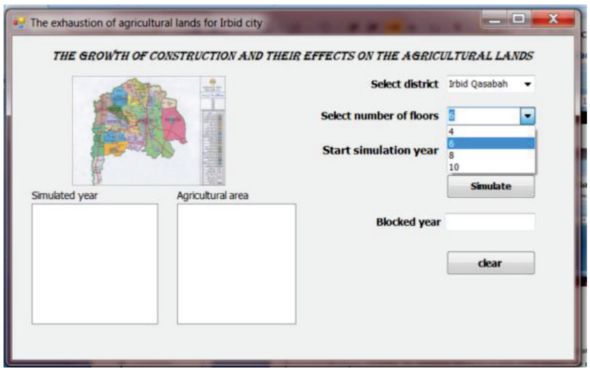

Figure 5d Select number of floors

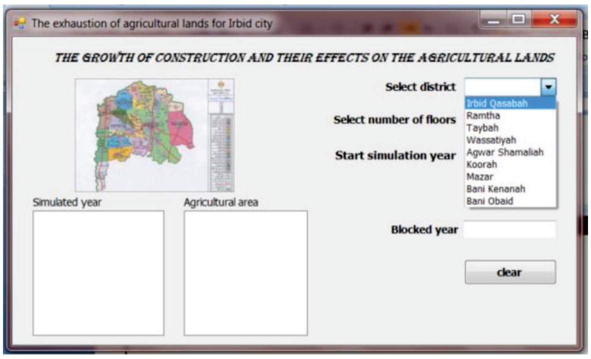

Figure.5c Select the district name

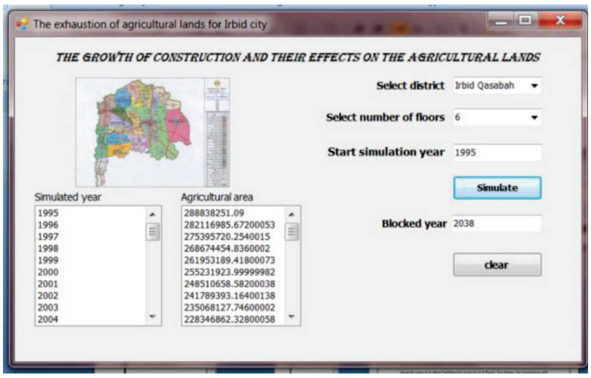

Fig.5e The result from simulation

The results from this simulation, answer the study questions, so we can figure out at which year the areas of Irbid and its district will be blocked. By increasing number of building floors, we can degrade the urban construction growth rate. Encouraging vertical building expansion is one of effective solution helping in decreasing urban construction on agricultural area.

9. Conclusion and future works

A simulation model for urban sprawl on agricultural area for Irbid governorate was developed and tested. The simulation was tested on Irbid and its districts. The results indicate that one alternative to reserve the green lands in Irbid governorate for the coming 40 years is to allow buildings to grow up more than 3 floors. The suggested solution is applicable to the empty existing areas and not on current buildings. The results can be considered for the future expansion of Irbid city and to encourage the urban expansion vertically rather than horizontally. The method is applicable to be used for different cities in the world in general. The results and conclusions can be discussed with architects or urban planners. For future, the simulation will be tested for other cities in Jordan and other cities in the world. Also, when the data becomes available for the new districts of Irbid in later years, the results of the simulation will be presented. We can test other factors that affect the fast growing of construction area such as fragmentation of lands holdings (Demetriou, 2014).

Moreover, we can suggest number of solutions such as: require high taxes on construction license that violate the construction regulations, and utilize the lands which are suitable for agricultural, in urban construction; encourage agricultural projects funding by the government. Also, try to study the impacts of refugees on increasing the rate of urban construction and try to found a solution by customize their construction far away from randomness.

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