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Development of land value algorithm for establishing an effective cadastral system in Erbil City

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Abstract
Land value is one of the economic issues of cadastral systems which is the base of sustainable urban and regional planning. The current paper concerns the estimation of the land values according to many essential factors, which are adopted as ten variables generally. Among these ten parameters, the frontage of the parcel (width), the value of rent, the width of streets, and the level of services represent the most effective parameters that play the main role in process of land price estimation over the Erbil City. The current research introduces the nature of land values and their homogeneous distribution and evaluates the suggested algorithm of land price estimation as one of the efficient factors that affect the national economic situation. The data collection was done for 100 parcels in different locations within the Erbil city boundary, which is being selected to apply the linear multiple regression equation to find the coefficients of the effective factors and to define the correlation between them. The obtained results of the linear multiple regression equation show that the level of existing services and the value of the rent have the maximum effect among these four factors, and they have the maximum correlation with the land price, whereas the road's width has the minimum correlation among them. The worked-out algorithm for land price estimation (which is a vital issue of the modern cadastral systems), is recommended to be applied by the institutions and organizations concerning the land prices and land taxes task.

Keywords: Cadastral system, Parcel, Land value, Multiple regression

1. Introduction

The cadastral issues represent an active field of the economic sector and strategic planning. It is the basis for legal aspects like ownership as well as fiscal aspects like taxation duty of urban territories. The efficient cadastral system provides the necessary data and the required information for land use planning and infrastructure construction. The modern cadastral systems were developed to meet the requirements of the parcel's ownership and mortgage rights and hence the taxation issues. Today a cadaster is also used as a basis for planning assignments like the dedication of land [1]. Land value is one of the three basic components of the cadastral system with land use and land tenure [2].

This research deals with the land as a basic permanent valuable element of the cadastral system and other urban activities. However, in the current research, the parcel is considered to consist of the land and its overland structure, which can be changed according to the reconstruction process or the changing of the land use activity.

2. Material and method

2.1. Case study (Erbil City)

Erbil city is the fourth major city of Iraq after Baghdad, Mosul, and Basra. lies at the longitude 43.9930° E and the latitude 36.1901° N. To define the most vital factors that affect land value, 120 questionnaire forms are prepared and distributed to cover the different zones of Erbil city. One hundred of them are accepted and the other twenty are neglected due to incompletion or inaccurate information [3]. Figure 1 shows the questionnaire distribution areas.

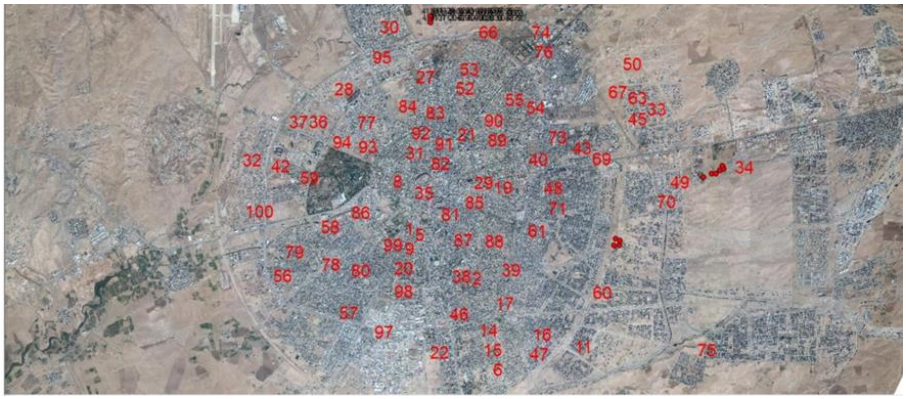

Figure 1. The 100 selected parcel locations for the questionnaire are in Erbil City

Eighty questionaries' forms have been used to establish the required mathematical model and to find the desired coefficients. The questionnaire forms are distributed to the real estate offices and the relevant companies in different zones of Erbil city to cover all the urban territories within the city's administrative boundaries. Twenty of the questionnaires' forms are used for assessing the obtained results, which is done according to ten adopted parameters as follows:

1- Parcel's width. 2- Width of the existing streets. 3- Size of parcel area. 4- Location of the parcel according to the Central Business District (CBD). 5- The value of the rent. 6- Parcel's orientation. 7- Existence of the opposite green area. 8- Parcel's position concerning neighbor parcels (corner). 9- The potential of commercial exploitation. 10- The level of existing services. However, the research's methodology can be summarized in the flowchart below (see Figure 2).

It is worth mentioning that the results of linear multiple regression show that six of the 10 parameters above have a weak correlation with the land price (which is 0.2 - 0.3), therefore they should be regarded as a not significant parameter that can be neglected. Thus, in the next development, just four parameters will be considered as the variables that significantly affect the estimation of the parcel's price (see Equation 1).

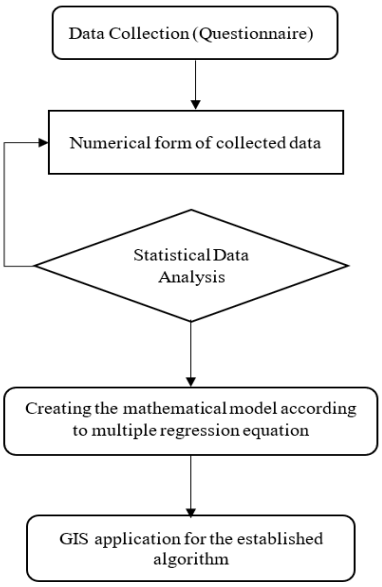

Figure 2. Flow chart of the research methodology

2.2. Linear multiple regression equation

The collected data are converted into a numerical form as a preparation for statistical analysis and then to establish the mathematical model according to the following multiple regression algorithm.

$$\left.\begin{array}{l} P_1 = P_o + B_1 X_1 + B_2 X_2 + B3\ X3 + B4\ X4 \\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots \\ Pn = P_o + B_1 X_1 + B_2 X_2 + B3\ X3 + B4\ X4 \end{array}\right\} \quad \text{---------- (1)}$$

Where:

Pi - is the predicted land price of m2, which represents the dependent variable in the equation.

P_o - is the essential price of m2 (basic price) in the ith zone.

B_1, B_2, B_3, & B_4 - are the coefficients of the four effective parameters (variables) which represent the slope of the regression line.

X_1 - is the parcel's width (frontage of parcel).

X2 - is the width of streets in the ith zone.

X_3 - is the value of rent in the ith zone.

X4 - is the level of services in the ith zone.

n - is the number of the selected parcels in all zones, which represents the number of equations in the mathematical model [5].

The size of the established mathematical model is eighty simultaneous equations, for the four effective parameters. Thus, the mathematical model (system in Equation 1) can be rewritten as follow:

$$\begin{pmatrix} P_1 \\ \vdots \\ \vdots \\ P_{80} \end{pmatrix} = \begin{pmatrix} P_o \\ \vdots \\ \vdots \\ P_o \end{pmatrix} + \begin{pmatrix} X_1 + X_2 + X_3 + X_4 \\ \vdots \\ \vdots \\ X_1 + X_2 + X_3 + X_4 \end{pmatrix} \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{pmatrix} \quad \text{------- (2)}$$

The software called Statistical Package for Social Science (SPSS) version 28 (see figure 3), has been used for the multiple linear regression application and the statistical analysis process, and then for determining the degree of dependency between the variables and the predicted land price [4].

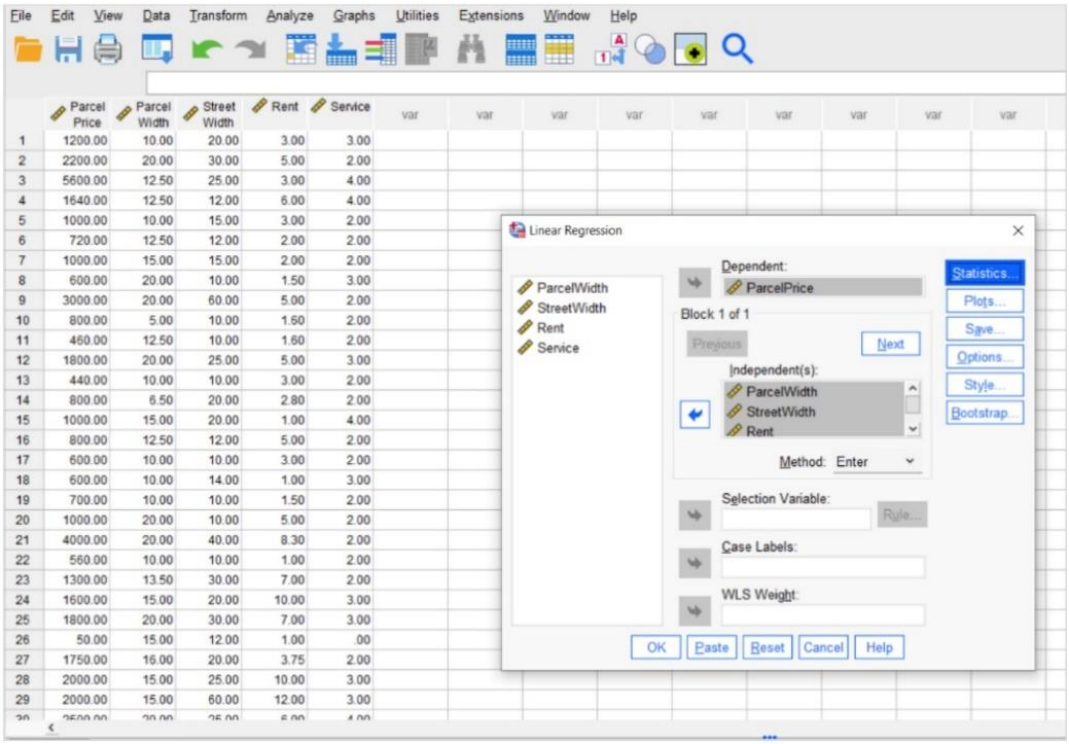

Figure 3. The multiple linear regression using SPSS

The results of the application of the linear multiple regression and the obtained correlations between land price and each one of the four effective parameters are illustrated in tables (1 & 2) below. The data in Table 1 illustrates the obtained coefficients of the four parameters: parcel's frontage (width), street's width, the value of rent, and level of services. Meanwhile, the data in Table 2 show the degrees of dependence between land price and the corresponding four parameters through the obtained values of the Pearson correlation between them [6].

Table 1. Result of the linear multi regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B_i	Std. Error	Beta		
1	P_o (constant)	-1020.621	266.195		-3.834	0.000
2	Parcel Width	48.101	19.135	0.173	2.514	0.014
3	Street Width	24.733	8.067	0.210	3.066	0.003
4	Rent	144.078	19.215	0.546	7.498	0.000
5	Service	264.249	88.030	0.205	3.002	0.004

From the table the B is the constant value in linear regression and Beta is the linear equation with a out constant value in land value must include the B in the equation to achieve the actual land and price as reality , The is to test to find out if small m n is significant with the population mean ? because the computed value is more than the table value which is 2 t test is significant , and the significant level sig. for all independent variables are less than 5% that's mean 95% there is relation between independent and independent variables [7].

Table 2. Correlation between the four independent variables and the land price

	Pearson Correlation from SPSS version 28				
	Parcel Price	Parcel Width	Street Width	Rent	Service
Parcel Price	1	0.504	0.511	0.776	0.535
Parcel Width	0.504	1	0.415	0.352	0.253
Street Width	0.511	0.415	1	0.358	0.166
Rent	0.776	0.352	0.358	1	0.46
Service	0.535	0.253	0.166	0.46	1
Sig. (1-tailed)	.	<.001	<.001	<.001	<.001
N	80	80	80	80	80

Thus, the regression equation after compensation of the values of the coefficients B_1, B_2, B_3, and B_4 becomes as follows:

$$Pi = -1020.621 + 48.101\ X_1 + 24.73\ X_2 + 144.078\ X_3 + 264.249\ X_4 \quad \text{---------- (3)}$$

Then, the price of m2 can be estimated in each zone separately according to the variables, parcel's width, street's width, the value of rent, and the level of existing services as in Eq. 3 above.

Notice, that the rent's value plays the most effective role in process of price estimation since it has a greater correlation with the price, whereas the parcel's frontage (width) has less effect on the predicted price since it has the smallest correlation among all the four parameters [8].

2.3. Evaluation of the obtained algorithm

In the process of evaluation of the obtained land value algorithm, a questionary of 20 selected parcels has been prepared for this purpose. The predicted prices for these 20 parcels are compared with the actual prices obtained by the real estate offices in different zones of the case study. Table 3 shows the results of the evaluation process and the differences between the computed price and the up-to-date actual price of one m2 in different zones over Erbil city territories [9].

These differences (deviations of the price) are used to find the relative price deviation (RPD), which is the (deviation/price) ratio.

$$RPD = \frac{Computed\ Price - Actual\ Price}{Actual\ Price} = \frac{Price\ Deviation}{Actual\ Price} \quad \text{--------- (4)}$$

The obtained results of the evaluation (see table 3) indicate that the price deviations of the tested parcels have a reasonable value with a negative sign in most zones. The analysis of the values of relative price deviation, which does not exceed 0.084 and its average value equal to 0.039, shows the precision of the computed prices and consequently the accuracy of the used algorithm [10].

Table 3. Evaluation of the figured-out algorithm

Parcel No.	Computed Value $	Actual Value $	The Deviation $	RDP	Parcel No.	Computed Value $	Actual Value $	The Deviation $	RPD
1	428.18	450	-21.82	-0.049	11	4837.60	5000	-162.41	-0.032
2	1152.57	1250	-97.43	-0.084	12	2908.98	3000	-91.02	-0.030
3	598.58	600	-1.42	-0.002	13	3917.52	4000	-82.48	-0.021
4	380.07	360	20.07	0.056	14	1156.29	1100	56.29	0.051
5	694.10	700	-5.90	-0.008	15	717.93	700	17.92	0.026
6	648.04	650	-1.96	-0.003	16	1348.02	1350	-1.98	-0.002
7	1420.54	1400	20.54	0.0147	17	1493.69	1500	-6.31	-0.004
8	1443.15	1200	243.15	0.203	18	767.39	750	17.39	0.023
9	936.42	950	-13.58	-0.014	19	284.10	265	19.10	0.072
10	428.18	450	-21.82	-0.050	20	260.05	250	10.05	0.040

The histogram of the obtained regression standard residuals is shown in Figure 4 below.

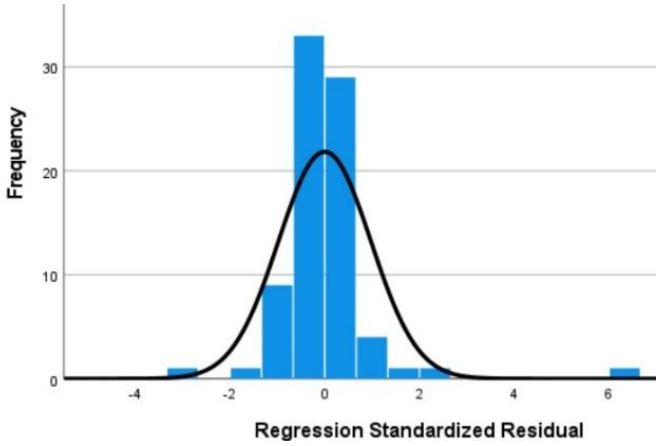

Figure 4. The normal distribution of the regression standard residuals

2.4. Applying the price algorithm using the GIS platform

The platform of Arc GIS version 10.8.1 is used for applying the figured-out algorithm of land price prediction for 23 different shapes parcels, which are selected as samples in the same zone in Erbil city (see Figures 6 and 7). The input data are the four effective variables (rent, services, frontage, & street width) and their coefficients (B_o, B, B_2, B_3, & B_4). [4]

Figure 5. The samples of the parcel in Case Study

The parcel width and street width are uploaded from the digital map (Pimpler, 2017), and the rent with service level is assumed according to governmental regulations in that zone [11]. The linear regression equation (Equation. 3) is applied to calculate the price of one m2 of each sample and then the price of the samples using the predicted price of m^2 multiplied by the area [12]. Furthermore, the taxes of the selected samples are calculated based on governmental tax regulations, which presented the tax's ratio as equal to 0.01 multiplied by the predicted price. The layer of taxes for all samples is illustrated in Figure 8 below [13].

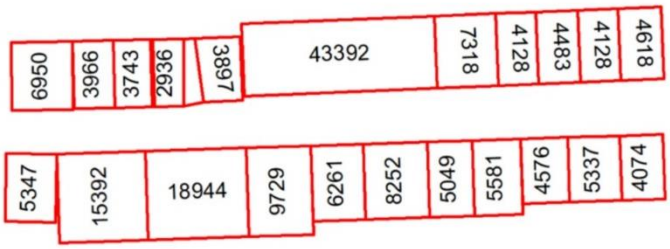

Figure 6. The taxes layer (in US $) for each parcel

The printed cadastral maps are usually at scale 1:1500 or other scale maps as required.

Figure 7. The printed block of parcels with their price

3. Results and discussion

The land value represented by land price can be obtained from following formula:

Land price = -1020.621 + 48.101 Parcel Width + 24.73Street width + 144.078 Rent + 264.249 Service ---------- (4)

Spatially can apply this formula in ArcGis Environment by Field calculator and in property y of attribute table Generating the land price and parcel tax for all parcels in the City of Erbil by in putting the four variables in the formula.

The analysis and results find that the center of the city does not affect forever the land value although it remail as an expensive area, but the other nodes and districts may compete with the center and overcome it the price of land. The assessors and arousers must look at the whole city in terms of price and not on the neighborhoods of the plot to be valued only to obtain a fair, comprehensive, and accurate estimation.

4. Conclusions

1. The predicted land price can be depending on ten parameters in general but, only four of them (Parcel's frontage, Street width, rent value, and level of services) are practically affect the land value since they have a maximum linear correlation with the land price.
2. The other six parameters (parcel orientation, distance from the city canter, closing to a green area, corner, commercial area, and location) have a minimum correlation with land price and therefore they are regarded as not effective variables that can affect the predicted land value.
3. The linear multiple regression equation gives an accurate estimation of the land price if it is applied with the real variables and efficient parameters.
4. The applied linear regression algorithm based on the four effective parameters can be applied in Erbil city territories since it gives fair and accurate predicted prices overall case study area.
5. The evaluation process of the worked-out algorithm shows that the average deviation of the predicted prices is about 3.9%, which can be understood as the average of the algorithm's precision.
6. It is recommended to use the obtained algorithm (Eq. 3) over the Erbil urban territories for estimation of the land price as one of the sources desired for the land exploitation, taxation duties, and other economic activities of the cadastral systems.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Appendix 1. Questionnaire

Figure 10. Questionnaire Form which depended (Source the researchers)

Questionnaire Form

Form No.		**Parcel ID**	

1- Parcel width (Frontage) in m

2- Parcel Area m²

3- Street width Opposite Parcel m

4-Parcel Orientation

N	**E**	**S**	**W**

If parcel orientation between the cardinal directions can tick two boxes for example N and E

5- Is Parcel	**Corner**		**Not Corner**	

6- Is opposite Parcel	**Garden**		**Not Garden**	

7- Rent if the parcel build for each m² US $

8- Parcel commercial Area

1- Residential Area	
2-One Lane Commercial	
3-Two lane Commercial	
4-Two lane Commercial open more than12 hours	

Tick only one of the levels because it's the rank of the commercial area

9- Service

Asphalt Road	
Electricity	
Water & Sewerage System	
Security	

10- Land Price per m² in US $

Appendix 2. Results Tables

Table 4. The parameters arranged depending on the questionnaire form

Parcel No.	Price Per m $ Y	Parcel Width m X_1	Street Width m X_2	Rent per m² $ X_3	Service Level X_4	Location Name
1	1200	10	20	3	3	Zaniary
2	2200	20	30	5	2	Ronaki
3	5600	12.5	25	3	4	DreamCity
4	1640	12.5	12	6	4	DreamCity
5	1000	10	15	3	2	Zaniary
6	720	12.5	12	2	2	Zanko
7	1000	15	15	2	2	Mufty
8	600	20	10	1.5	3	Arab nIeghborhood
9	3000	20	60	5	2	Zaniary on 60
10	800	5	10	1.6	2	Farmanbaran
11	460	12.5	10	1.6	2	Farmanbaran sector 4000
12	1800	20	25	5	3	Arab nIeghborhood
13	440	10	10	3	2	New Hawler
14	800	6.5	20	2.8	2	Mhabad
15	1000	15	20	1	4	Zanko Vilage 100 Houses
16	800	12.5	12	5	2	Sharawany
17	600	10	10	3	2	Badawa
18	600	10	14	1	3	Ganjan city
19	700	10	10	1.5	2	havalan
20	1000	20	10	5	2	Azadi
21	4000	20	40	8.3	2	Shorsh
22	560	10	10	1	2	Rasty
23	1300	13.5	30	7	2	Rasty
24	1600	15	30	10	3	Menaret 30 m
25	1800	20	30	7	3	Arab neighborhood
26	50	15	12	1	0	baglu menara No.9443
27	1750	16	20	3.75	2	bakhtiyari 40 m
28	2000	15	25	10	3	naznaz 284
29	2000	15	60	12	3	60m opposiste setaqan
30	2500	20	25	6	4	Ainkawa
31	650	10	20	5	2	Tairawa 30m
32	800	10	30	1.4	2	Sarbasty
33	550	12	12	1	2	Hawlere new
34	100	10	10	1	0	8 Hasarok
35	2720	15	20	8	4	DreamCity
36	2100	20	15	7	4	DreamCity

Parcel No.	Price Per m $ Y	Parcel Width m X_1	Street Width m X_2	Rent per m² $ X_3	Service Level X_4	Location Name
37	950	14.5	15	2	2	Ronaki
38	1550	10	30	2.5	2	40 Momostayan
39	1900	8	40	8.3	2	40 m Farma Street
40	100	10	10	1	0	8 Hasarok
41	3000	2	4	20	4	Suq Kaisaria
42	7200	25	25	30	3	Vital
43	325	10	15	1.5	2	Awenae Shar
44	600	10	15	2	2	Mufty
45	550	6.25	15	6	3	Sharawani
46	700	10	15	1.5	3	Hawlere new
47	500	8	10	2.5	2	Mentkawa
48	700	10	15	2	2	Sharawani
49	500	10	10	3	2	Havalan
50	500	10	10	1	2	5 Hasarok
51	700	10	15	1.4	2	Hawlere new
52	400	9	10	1.5	2	Zhiyan
53	1200	12.5	15	5	2	Zhiyan
54	675	12.5	15	2	2	Arab district
55	600	10	13	2	2	Khanaqah
56	500	10	12	1.5	2	Lana City
57	600	9	14	2	2	Frmanbaran
58	700	6.5	15	2	3	Hawleri new
59	300	12	12	1	3	Ganjan City
60	800	10	15	2	2	Rasty
61	750	10	12	1.5	3	Italy Village 2
62	600	11	15	2	3	Italy Village 2
63	700	13	15	2	3	Italy Village 2
64	180	10	15	1.5	0	8 Hasarok
65	120	12.5	12	1	0	Sebardan
66	450	10	15	1	2	Lawan
67	500	10	12	2	2	Minara
68	1100	12	15	2	2	Afsaran
69	1500	10	15	3	2	Havalan
70	700	10	12	2	2	Rasty
71	250	12.5	12	0.5	2	Ashti City
72	500	15	12	1	3	Pack Land
73	700	5	20	2	2	Afsaran
74	700	10	12	2	2	Hewa City
75	300	12	12	0.5	2	Zaiton City
76	625	15	15	2	2	Mass City
77	850	11	15	2	2	Hawlerui new
78	500	10	15	2	2	Hewa City
79	500	10	12	1	2	Lawan City

Parcel No.	Price Per m $ Y	Parcel Width m X_1	Street Width m X_2	Rent per m² $ X_3	Service Level X_4	Location Name
80	350	10	12	0.5	2	Ashty City

Table 5. The 20 samples for evaluation process

Parcel No.	Price Per m $ Y	Parcel Width m X_1	Street Width m X_2	Rent per m² $ X_3	Service Level X_4	Location Name
81	450	8	10	2	2	Kani
82	1250	12	15	3	3	Quistan
83	600	10	13	2	2	Raparin
84	360	7	10	2	2	Raparin
85	700	12.5	12	2	2	Kurdistan
86	650	10	15	2	2	Bahare new
87	1400	15	15	3	3	Neshtiman
88	1200	14	18	2	4	English Village
89	950	13	15	3	2	Karezan
90	450	8	10	2	2	Zanayan
91	5000	15	30	25	3	bakhtiari
92	3000	10	20	15	3	bakhtiari
93	4000	10	20	22	3	bakhtiari
94	1100	15	20	3	2	waziran
95	700	10	12	3	2	hakmawa
96	1350	10	20	6	2	Sarbasti
97	1500	12	22	6	2	Sarbasti
98	750	10	14	3	2	Shadi
99	265	8	10	1	2	Shadi
100	250	7.5	10	1	2	Zhiyan

Table 6. Correlation between all Variables depending on SPSS software

Correlation between all Variables												
		Parcel price	Parel width	Parcel area	Street width	Distance CBD	Rent	Orientation	Garden	Corner	Commercial	Service
Parcel price	Pearson Correlation	1	.451**	.452**	.447**	-.372**	.750**	0.216	.396**	0.23	.707**	.439**
	Sig. (2-tailed)		<.001	<.001	0.001	0.007	<.001	0.128	0.004	0.105	<.001	0.001
Parel width	Pearson Correlation	.451**	1	.928**	.356*	-.331*	.281*	0.266	0.166	0.132	0.244	0.083
	Sig. (2-tailed)	<.001		<.001	0.01	0.018	0.046	0.059	0.245	0.357	0.084	0.561
Parcel area	Pearson Correlation	.452**	.928**	1	.470**	-.425**	.346*	0.224	0.092	0.085	.297*	0.1
	Sig. (2-tailed)	<.001	<.001		<.001	0.002	0.013	0.114	0.521	0.555	0.034	0.484
Street width	Pearson Correlation	.447**	.356*	.470**	1	-.376**	.291*	0.09	0.071	0.093	.579**	-0.008
	Sig. (2-tailed)	0.001	0.01	<.001		0.007	0.038	0.53	0.619	0.517	<.001	0.954
Distance CBD	Pearson Correlation	-.372**	-.331*	-.425**	-.376**	1	-.397**	-0.239	0.028	-0.009	-.429**	-.290*
	Sig. (2-tailed)	0.007	0.018	0.002	0.007		0.004	0.091	0.843	0.953	0.002	0.039
Rent	Pearson Correlation	.750**	.281*	.346*	.291*	-.397**	1	0.07	.282*	0.084	.604**	.339*
	Sig. (2-tailed)	<.001	0.046	0.013	0.038	0.004		0.624	0.045	0.556	<.001	0.015
Orientation	Pearson Correlation	0.216	0.266	0.224	0.09	-0.239	0.07	1	.334*	0.153	.286*	0.269
	Sig. (2-tailed)	0.128	0.059	0.114	0.53	0.091	0.624		0.017	0.282	0.042	0.056
Garden	Pearson Correlation	.396**	0.166	0.092	0.071	0.028	.282*	.334*	1	0.028	0.151	0.163

Correlation between all Variables												
		Parcel price	Parel width	Parcel area	Street width	Distance CBD	Rent	Orientation	Garden	Corner	Commercial	Service
	Sig. (2-tailed)	0.004	0.245	0.521	0.619	0.843	0.045	0.017		0.846	0.289	0.254
Corner	Pearson Correlation	0.23	0.132	0.085	0.093	-0.009	0.084	0.153	0.028	1	0.162	0.187
	Sig. (2-tailed)	0.105	0.357	0.555	0.517	0.953	0.556	0.282	0.846		0.255	0.19
Commercial	Pearson Correlation	.707**	0.244	.297*	.579**	-.429**	.604**	.286*	0.151	0.162	1	0.23
	Sig. (2-tailed)	<.001	0.084	0.034	<.001	0.002	<.001	0.042	0.289	0.255		0.105
Service	Pearson Correlation	.439**	0.083	0.1	-0.008	-.290*	.339*	0.269	0.163	0.187	0.23	1
	Sig. (2-tailed)	0.001	0.561	0.484	0.954	0.039	0.015	0.056	0.254	0.19	0.105	
** Correlation is significant at the 0.01 level (2-tailed).												
* Correlation is significant at the 0.05 level (2-tailed).												