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RESEARCH ARTICLE

Accuracy Assessment of Duhok City Land use Official Maps

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ABSTRACT

In this study, the geometric accuracy of four different maps for three sectors of Duhok city was assessed. The maps were produced in different periods and different techniques. One set of maps was paper plotted maps, which had to be geo-referenced. The other three maps were digitally plotted with reference to the global coordinate system UTM/WGS-84/Zone 38 N projection. A total of 51 points were identified on one reference map, which is the master plan of Duhok city prepared by the general directorate of urban planning/Kurdistan region/Iraq with the collaboration of the German company Ingenieurburo Vossing Company. The reference map, which is the master plan of Duhok governorate, is an official map that is certified and checked by the ministry of planning of the Kurdistan region to have a positional accuracy of ± 1.5 cm. These points were searched for and identified on the other three maps. Discrepancies in Easting and Northings of these points were calculated, which resulted in the mean discrepancy of 2.29 m with a maximum value of 8.5 m in one event. The maximum standard deviation in dE and dN was 3.8 m. These values are reasonably accepted, considering that the maps were prepared using different techniques and a variable accuracy standard.

Keywords: Assess geometric accuracy; Discrepancy; Geo-referencing; Land use maps

INTRODUCTION

The aim of this study is to assess the geometric accuracy and quality of the available land-use maps of Duhok city.

In land-use mapping, especially cadastral mapping, large errors cannot be tolerated. Errors here mean financial issues, specifically in expensive commercial districts. The most important expected error sources are: (1) Survey control errors such as traverse closures, differential global positioning system net accuracy and correction, (2) detail surveying errors, (3) plotting errors, and (4) plotting scale.

Old paper cadastral maps were produced using large to medium scales ranging between 1/500 and 1/10000. In contrast, modern digital maps can be produced in any required scale without having a specified limit.

Many authors and organizations tackled the accuracy subject of cadastral maps, (Siriba, 2009, presented an approach to estimate the positional accuracy of a cadastral dataset derived from uncontrolled and un-rectified aerial photography. The survey department of Jamaica, 2000, published the procedures and standards for digital cadastral surveying in Jamaica. In which, the details are listed about responsibilities of the surveyor, instrumentation which are mainly GPS and total stations with their calibration, procedures, and specifications for fieldwork, office work, and information about the main GPS control points as a national calibration network.

Hashim et al., 2016, gave the details of how the Department of Surveying and Mapping of Malaysia modernized and reformed its cadastral legacy datasets by generating an accurate digital-based representation of cadastral parcels. These legacy databases usually are derived from paper parcel maps known as a certified plan. The cadastral modernization will result in the new cadastral database on a global digital map no longer being based on single and static parcel paper maps.

On the other hand, Mustafa et al., 2012, used remote sensing images from different satellite datasets and GIS tools for checking and assessing land-use change in Duhok city, Kurdistan region-Iraq. The results of their study indicated that Duhok city have changed considerably and increased up to 20% from 1989 to 2012. Furthermore, Mohammed, 2013, used the same technique in such work to show the effect of remote sensing imagery and GIS tools in the mapping of land use and land cover in Duhok city from specific periods of time those being 1998, 2007, and 2011.

For the purpose of this study, three different maps and one orthophoto were used. One map was held as a reference for the purpose of comparing the other three maps. These maps were prepared in different periods and used different techniques. Old maps were prepared using the plane table detail survey method and traverse survey with a direct plotting in the field. The other maps were produced using photogrammetric techniques producing vector digital maps. Three sectors of Duhok city were selected. The four maps are available for these sectors. Clear features identified in all of these maps were marked, and their coordinates were measured. The aim is to find the discrepancies among these available maps as well as to find out if these discrepancies are systematic and can be treated using common shift or rotation using different methods. For comparison purposes of old and new maps, it also displayed the growth of the city in the past few decades.

RESOURCES

For the purpose of this study, the following resources were utilized:

Master Plan, Duhok City

The design plan of Duhok city is an official map that is certified and checked by the ministry of planning of the Kurdistan region to have a positional accuracy of ±1.5 cm. The Master Plan Duhok 2032/ land-use plane, Figure 1 was prepared by the general directorate of urban planning/ Kurdistan region/Iraq with the collaboration of the German company called IngenieurburoVossingCompany. The map dated to August 3, 2016 and has a scale of 1/6000 (although in digital maps, the scale is not limited). The map is a UTM geo-referenced vector map. The Zoomed in view of a sector of the map is shown in Figure 2. The preparation of this map is mainly built on details.

This map (the land-use plan) will be used throughout this work as a reference map to check the accuracy of the other maps utilized in this study.

Old Paper Maps

There are three old paper maps for the three sectors of the city those being: Down Malta, Barushky, and Shakhky area, Figure 3. The maps are differently dated with a scale of 1/1000 written on the title block. They survey was completed using plane table traversing and plane table detail survey using the telescopic alidade instrument.

Figure 4 shows a zoomed in view of part of Down Malta sector. As shown above, the map was drawn on transparent trace paper and drawing ink.

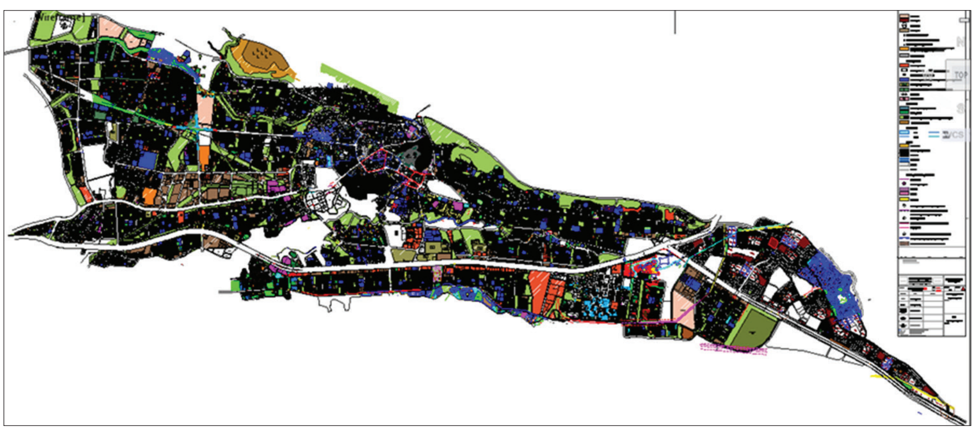

Figure 1: The land-use master plan of Duhok city

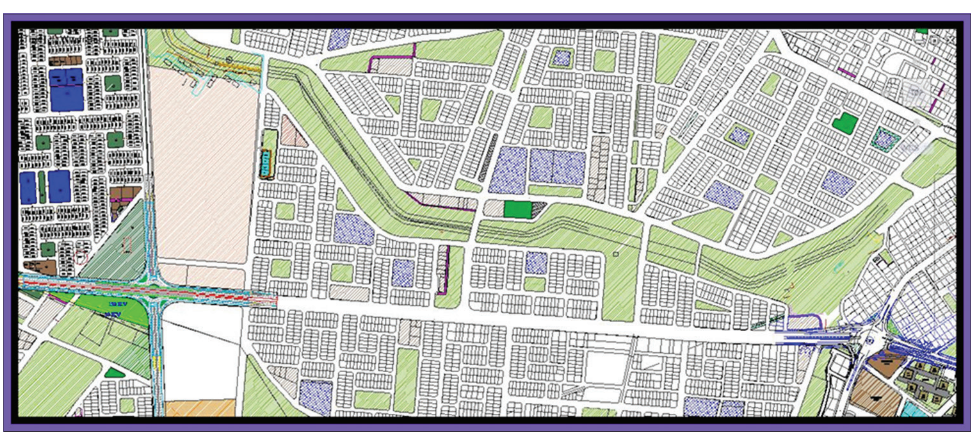

Figure 2: Zoomed in view of the land-use plan/master plan of Duhok city

Figure 3: Paper old maps of Down Malta, Barushky, and Shakhky

Figure 4: Zoomed in view on part of Down Malta, old map

The maps were scanned and geo-referenced based on common control points with the land-use plan. Nine control points were used for Down Malta map, six points for Barushky, and five points for Shakhky sectors. For geo-referencing, the Global Mapper software was used. Then, the three maps were put in the UTM coordinate system. The range of accuracy of the geo-referencing procedure is shown in Table 1.

Table 1: Standard deviation of geo-referencing accuracy

Sectors	Number of GCPs for Geo-referencing	Number of GCPs for Checking	Geo-referencing accuracy	
			Std. E (m)	Std. N (m)
Down malta	9	5	1.652	0.907
Barushky	6	5	1.035	2.303
Shakhky	5	5	1.016	1.118

Aerial Survey Map

Aerial survey map was produced by the Vossing German Company in 2011 and digitized by the directorate of municipality of Duhok city Figure 5.

The map is geo-referenced to UTM projection. It is a topographic vector map based on extensive aerial survey which shows contour lines, roads, and building details. Figure 6 enlarged view to a part of this map.

Orthophoto Map

The orthophoto map was produced by the Vossing German Company, Figure 7 dated to the year 2011. The image is a mosaic of rectified aerial photos. Rectification makes the photos vertical with the correct scale and orientation. The orthophoto is a geo-referenced digital image.

METHODOLOGY AND MEASUREMENTS

The AutoCAD Civil 3D 2019 software was used as a measuring and recording tool. The Master Plan Duhok map was loaded, and the other maps were superimposed on that map each in its turn. This was accomplished for the three chosen locations in the city mentioned above. These sectors appear on the four available maps, all of which are geo-referenced to UTM projection.

Clear points such as building corners or street intersections were chosen and identified on each of the four maps. The selected points were given a serial number related to the sector and the map. Once the point was identified and marked on the map, its coordinate was stored and listed in AutoCAD civil 3D of the three sectors, as shown in Figure 8.

The measured coordinates were exported to an excel datasheet. Table 2 shows part of the datasheet, which is a sample of the measure coordinates on the three maps for one sector. The points are listed according to their serial number in the group, Northing and Easting of the points, elevations which are assigned to zero, and the point's descriptions which are related to the sector and the map type.

A total of 182 coordinates value were recorded, with 51 points used as a reference and the other 131 points were used as checkpoints. Some points could not be identified on all the four maps; therefore, the number of the selected points dropped down.

The discrepancies described as a length equals $\sqrt{((\Delta E)^2 + (\Delta N)^2)}$ are tabulated in Table 2, column 11. The discrepancies direction, which is expressed as azimuths, is calculated as = ATAN ($\Delta E/\Delta N$) and adjusted to the right

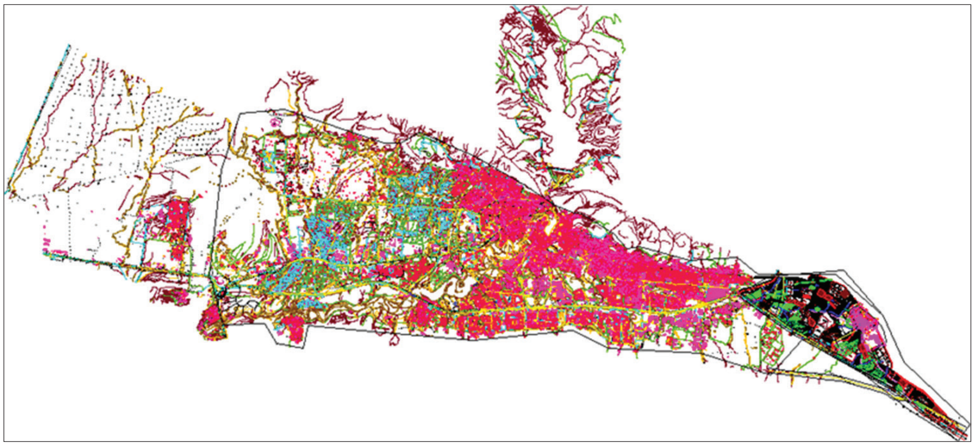

Figure 5: Aerial survey map

Figure 6: A zoomed in view to a part of the aerial survey map

Figure 7: A sample of a zoomed in view to a part of the orthopho of Barashoky overlain the selected points

quadrant by adding or subtracting 180° or subtracting from 360°.

A (3σ) rejection limit was used to sieve large discrepancies in easting and northing. Few points were dropped from the list, and calculations were carried out again.

DISCUSSION OF THE RESULTS

The Master Plan Duhok 2032 is used as a reference for comparison. The coordinates of each point on the other map is subtracted from its corresponding reference coordinate. Table 3 shows a sample of the data and results for Barushky sector.

Figure 8: Samples of zoomed in views to a part of all the selected maps of Barashoky, Downmalta, and Shakhky overlain the selected points

Table 2: Part of the coordinate list for all measured points

Down Malta design map points					Down Malta old map points					Down Malta sky map points				
1	4080160.202	315473.748	0.000	DM1	1	4080161.737	315469.583	0.000	A1	1				SM1
2	4080172.322	315632.781	0.000	DM2	2	4080176.483	315627.651	0.000	A2	2	4080170.329	315630.311	0.000	SM2
3	4080219.121	315763.970	0.000	DM3	3	4080218.414	315765.560	0.000	A3	3				SM3
4	4080206.377	315321.030	0.000	DM4	4	4080206.840	315323.294	0.000	A4	4	4080205.883	315320.953	0.000	SM4
5	4080263.023	315801.567	0.000	DM5	5	4080265.044	315800.135	0.000	A5	5	4080817.896	315982.146	0.000	SM5
6	4080365.043	315615.320	0.000	DM6	6	4080364.155	315614.389	0.000	A6	6				SM6
7	4080487.895	315537.806	0.000	DM7	7	4080488.448	315535.211	0.000	A7	7	4080487.330	315537.867	0.000	SM7
8	4080387.307	315864.849	0.000	DM8	8	4080389.366	315864.493	0.000	A8	8				SM8
9	4080517.082	315704.901	0.000	DM9	9	4080515.424	315704.542	0.000	A9	9	4080516.035	315705.961	0.000	SM9
10	4080551.525	315598.496	0.000	DM10	10	4080549.264	315591.571	0.000	A10	10				SM10
11	4080671.665	315766.598	0.000	DM11	11	4080669.263	315768.280	0.000	A11	11	4080672.494	315765.151	0.000	SM11
12	4080699.125	315862.863	0.000	DM12	12	4080698.376	315861.652	0.000	A12	12	4080699.175	315862.959	0.000	SM12
13	4080673.959	315990.390	0.000	DM13	13	4080675.965	315990.281	0.000	A13	13	4080674.272	315990.654	0.000	SM13
14	4080800.133	315884.521	0.000	DM14	14	4080797.601	315885.839	0.000	A14	14	4080801.039	315885.032	0.000	SM14
15	4080817.921	315982.290	0.000	DM15	15	4080816.037	315981.442	0.000	A15	15				SM15
Barushky design map points					**Barushky old map points**					**Barushky sky map points**				
1	4080567.710	323751.091	0.000	DB1	1	4080570.986	323747.655	0.000	B1	1	4080569.694	323751.596		SM1
2	4080782.856	323739.147	0.000	DB2	2	4080776.196	323735.235	0.000	B2	2	4080776.129	323737.530	0.000	SM2
3	4080594.237	323495.125	0.000	DB3	3	4080589.052	323493.305	0.000	B3	3	4080594.101	323495.280		SM3
4	4080738.987	323573.817	0.000	DB4	4	4080729.887	323572.173	0.000	B4	4	4080728.682	323575.039	0.000	SM4
5	4080779.734	323593.648	0.000	DB5	5	4080787.851	323597.390	0.000	B5	5	4080790.168	323600.648	0.000	SM5
6	4080768.243	323461.794	0.000	DB6	6	4080765.298	323458.343	0.000	B6	6	4080767.721	323462.008		SM6
7	4080789.360	323464.082	0.000	DB7	7	4080786.205	323460.796	0.000	B7	7	4080788.659	323464.064	0.000	SM7
8	4080521.739	323286.439	0.000	DB8	8	4080514.945	323286.830	0.000	B8	8	4080517.635	323289.151		SM8
9	4080574.475	323245.951	0.000	DB9	9	4080572.594	323237.610	0.000	B9	9	4080573.343	323245.994	0.000	SM9
10	4080619.645	323269.658	0.000	DB10	10	4080617.832	323262.916	0.000	B10	10	4080619.179	323269.821		SM10
11	4080654.449	323121.263	0.000	DB11	11	4080653.255	323114.238	0.000	B11	11	4080653.428	323121.554	0.000	SM11
12	4080707.612	323165.265	0.000	DB12	12	4080709.654	323159.174	0.000	B12	12	4080707.103	323165.490	0.000	SM12

In this table, the coordinates of the old map points are subtracted from the reference points coordinates. The results are as follows:

a. The differences in northing and easting in meters are tabulated in columns 9 and 10, respectively. The mean value of the discrepancies in easting and northing is given at the end of each column. Furthermore, the corresponding standard deviations are given.
b. These discrepancies in azimuths are tabulated in column 12. At the end of column 12, the mean discrepancy azimuth from the reference map is 170.569°.

Table 4 shows an abstract of discrepancy means and standard deviations of all maps with reference to the base map; "The Master Plan Duhok."

The mean differences in northings and eastings appear small as the sum of positive and negative large values accumulate to small values. The average of the resultant discrepancies, $\sqrt{((\Delta E)^2 + (\Delta N)^2)}$ of all the 131 points = 2.29 m.

The maximum resultant of discrepancy reached 8.5 m in one event in all of the 131 measured points. This value (8.5 m) does not represent the whole differences obtained. Figure 9 shows the resultant discrepancies as a length and direction drawn for the old Duhok maps with reference to the Master Plan of Duhok for all three sectors. The lengths of the discrepancies were exaggerated by multiplying with a factor of 10.

Figure 9 shows the almost systematic nature of the directions of the discrepancies. For Barushky sector, 16

Table 3: A sample of the data and results for Barushky sector

Barushky design map points					Barushky old map points					ΔN	ΔE	Length	Azimuth
1	4080567.710	323751.091	0.000	DB1	1	4080570.986	323747.655	0.000	B1	3.276	−3.436	4.747	133° 38’ 4”
2	4080782.856	323739.147	0.000	DB2	2	4080776.196	323735.235	0.000	B2	−6.661	−3.913	7.725	210° 25’ 47”
3	4080594.237	323495.125	0.000	DB3	3	4080589.052	323493.305	0.000	B3	−5.185	−1.821	5.495	199° 20’ 57”
4	4080738.987	323573.817	0.000	DB4	4	4080729.887	323572.173	0.000	B4	−9.100	−1.644	9.247	190° 14’ 24”
5	4080779.734	323593.648	0.000	DB5	5	4080787.851	323597.390	0.000	B5	8.117	3.742	8.938	24° 45’ 5”
6	4080768.243	323461.794	0.000	DB6	6	4080765.298	323458.343	0.000	B6	−2.945	−3.452	4.538	229° 31’ 28”
7	4080789.360	323464.082	0.000	DB7	7	4080786.205	323460.796	0.000	B7	−3.156	−3.286	4.556	226° 9’ 38”
8	4080521.739	323286.439	0.000	DB8	8	4080514.945	323286.830	0.000	B8	−6.793	0.392	6.805	176° 42’ 0”
9	4080574.475	323245.951	0.000	DB9	9	4080572.594	323237.610	0.000	B9	−1.881	−8.341	8.551	257° 17’ 30”
10	4080619.645	323269.658	0.000	DB10	10	4080617.832	323262.916	0.000	B10	−1.813	−6.742	6.982	254° 57’ 1”
11	4080654.449	323121.263	0.000	DB11	11	4080653.255	323114.238	0.000	B11	−1.194	−7.025	7.126	260° 21’ 2”
12	4080707.612	323165.265	0.000	DB12	12	4080709.654	323159.174	0.000	B12	2.042	−6.091	6.424	251° 28’ 13”
13	4080870.891	323185.681	0.000	DB13	13	4080870.262	323184.380	0.000	B13	−0.629	−1.301	1.444	244° 12’ 11”
14	4080906.894	323215.250	0.000	DB14	14	4080906.670	323212.517	0.000	B14	−0.224	−2.732	2.742	265° 18’ 56”
15	4080733.751	323183.802	0.000	DB15	15	4080735.221	323180.203	0.000	B15	1.469	−3.598	3.887	112° 12’ 50”
16	4080630.089	322950.300	0.000	DB16	16	4080625.382	322946.913	0.000	B16	−4.707	−3.388	5.799	215° 44’ 42”
17	4080684.501	322979.635	0.000	DB17	17	4080682.624	322973.370	0.000	B17	−1.877	−6.265	6.540	253° 19’ 16”
18	4080790.427	322807.597	0.000	DB18	18	4080787.080	322804.623	0.000	B18	−3.347	−2.973	4.477	221° 36’ 46”
19	4080980.489	322807.955	0.000	DB19	19	4080982.937	322812.483	0.000	B19	2.448	4.528	5.147	61° 36’ 12”
20	4081121.255	322734.167	0.000	DB20	20	4081126.118	322736.229	0.000	B20	4.863	2.062	5.282	22° 58’ 42”
21	4081161.666	322764.398	0.000	DB21	21	4081166.746	322767.875	0.000	B21	5.080	3.477	6.156	34° 23’ 22”
22	4081139.130	322686.975	0.000	DB22	22	4081142.975	322688.233	0.000	B22	3.844	1.258	4.045	18° 7’ 9”
23	4080437.929	323829.243	0.000	DB23	23	4080436.494	323824.981	0.000	B23	−1.435	−4.262	4.497	251° 23’ 10”
24	4080614.355	323855.126	0.000	DB24	24	4080616.847	323853.372	0.000	B24	2.492	−1.754	3.047	144° 51’ 57”
25	4080408.400	323996.962	0.000	DB25	25	4080415.017	323997.381	0.000	B25	6.617	0.419	6.630	3° 37’ 30”
									Mean	-0.428	-2.246	Mean	170.569
									SD	4.427	3.388		

Table 4: Abstract of the mean discrepancies and standard deviations in N and E

Sector	Type of map					
	Old map		Aerial survey map		Orthophoto map	
Down Malta	N=15		N=10		N=10	
	ΔN=-0.019	ΔE=-1.147	ΔN=--0.250	ΔE=--0.250	ΔN=--0.255	ΔE=--0.029
	σN=2.035	σE=2.533	σN=0.981	σE=1.144	σN=0.474	σE=1.526
Barushky	N=25		N=25		N=23	
	ΔN=--0.422	ΔE=-2.532	ΔN=-0.097	ΔE=-0.232	ΔN=--0.161	ΔE=-0.303
	σN=3.756	σE=3.289	σN=2.158	σE=0.841	σN=1.694	σE=0.781
Shakhky	N=11		N=6		N=6	
	ΔN=-0.079	ΔE=--0.898	ΔN=--0.872	ΔE=-0.341	ΔN=--1.076	ΔE=--0.807
	σN=1.239	σE=1.628	σN=0.952	σE=1.273	σN=0.733	σE=1.498

All units are in meter

out of the 25 discrepancy values are pointing south to south-west. The mean value for all points was 170° 35'.

Old Duhok maps were only chosen as a sample of the discrepancy values to be shown in Figure 9, as these values are the largest to be drawn compared with other maps.

CONCLUSION AND RECOMMENDATION

The Quality of Maps

The quality of the maps varies between poor for old paper plotted maps to fair for the newly made digital maps, Figure 10. All maps are suffering lack of parcels numbers. In aerial survey maps, parcels were drawn by tracing over the aerial photos of the area.

Recommendations

Most districts of Duhok city are newly built except the old City Centre since the majority of land used within the city is for housing. Most private houses, which usually have standard dimensions of 10 × 20 m, were built during the last two decades. The parcels sub-divisions are so organized that it is worth to establish well designed cadastral maps that show parcel numbers, segments lengths, and bearings with reference points as this is the case in all modern cadastral

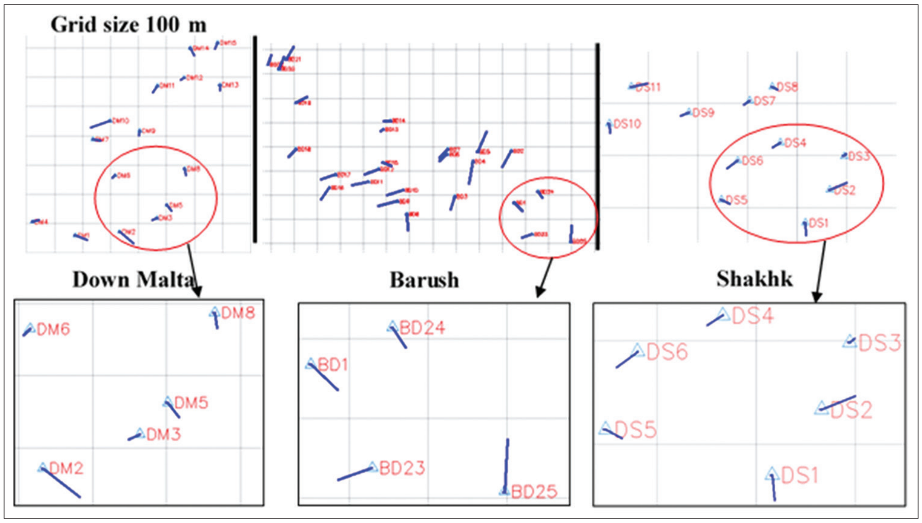

Figure 9: AutoCAD presentation of discrepancy values and directions. (Discrepancy length is enlarged by a factor of 10)

The Master Plan Duhok 2032	
Old Duhok city paper maps	
Aerial Survey map	

Figure 10: Samples of the available maps for the study

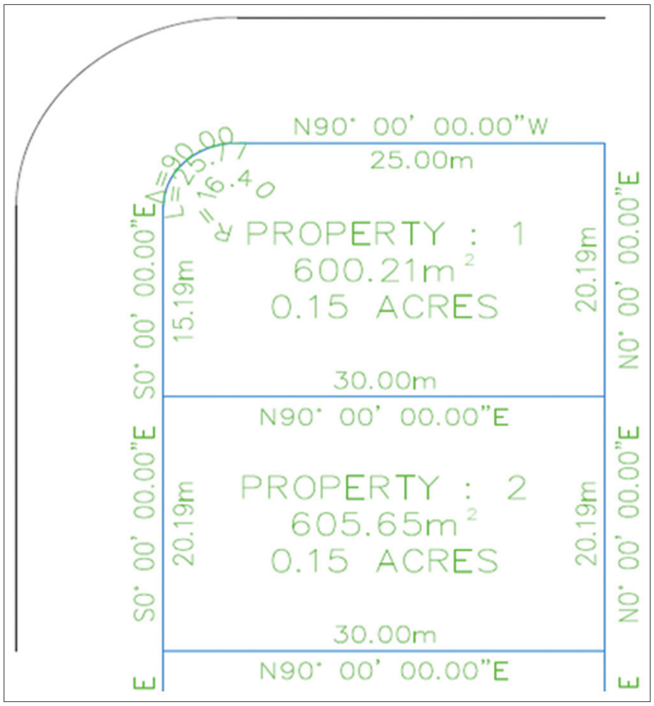

Figure 11: Sample of property map divisions using the AutoCAD software

maps around the world. The AutoCAD software can change any land subdivision into parcels, as shown in Figure 11.

The old Duhok maps drawn on trace papers will soon lose its value; thus, it is prominent that these maps are restored, archived, and changed into vector maps as they contain a lot of important information regarding properties and land use. Standards and specifications for cadastral surveying and mapping must be prepared regarding the recent developments in measurements and plotting.

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