A Study On The Determination Of The Maximum Error In Digitizing Cadastral Map Sheets

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Key words: Digital Cadastre, Cadastral Map, Digitizing, Transformation, Maximum Error

SUMMARY

In the last 15-20 years when technology has entered into our lives, as in the other areas of engineering, it has become a necessity to utilize the conveniences and facilities provided by technology also in the area of cartography. Cadastral map sheets which were produced in earlier times need to be digitized in order to be used in the present day digital cadastre and the GIS(Geographic Information System) environment. However, the fact that the error limits which have been defined by the present regulations for digitizing old cadastral map sheets are low makes it difficult to use those map sheets. For this purpose, a regulation draft has been prepared in order to increase the usability of old cadastral map sheets in Turkey.
In the present study, 4 cadastral map sheets of Konya/Turkey at a scale of 1/1000 were digitized and compared with land values and the coordinate differences were calculated. These coordinate differences were compared with the point position error limit values which were provided in the present regulation, in the regulation draft and which were obtained from the results of the implementation.
It was observed that 48 % of the points in the old cadastral map sheets could be accepted when the error limits(maximum error) defined in the present regulation are taken into consideration, 55 % of the points could be accepted when the error limits defined in the regulation draft are taken into consideration, and 59 % of the points could be accepted according to the error limits obtained as the result of the study implemented. According to these results, it can be seen that error limit values need to be increased. The area values of the map sheets which are composed of the points exceeding the error limit value should be recalculated according to the cadastre law.

Kadastro Paftalarının Sayısallaştırılmasında Hata Sınırının Belirlenmesi Üzerine Bir Çalışma

Anahtar Kelimeler: Sayısal kadastro, Kadastro haritası, Sayısallaştırma, Dönüşüm, Hata sınırı

ÖZET

Teknolojinin yaşantımıza yaygın ve hızlı bir şekilde girdiği son 15-20 yıl içinde diğer kurumlarda olduğu gibi, haritacılık alanında da teknolojinin getirdiği kolaylıklardan yararlanmak zorunluluk haline gelmiştir. Eski teknolojiye göre üretilen kadastro paftalarının CBS içerisinde kullanılabilmesi için sayısallaştırması gerekmektedir. Ancak, eski kadastro

paftalarının sayısallaştırılmasında yönetmeliklerde verilen hata sınırlarının düşük olması bu paftaların CBS'de kullanılabilirliliğini güçleştirmektedir.

Bu çalışmada, Konya/Türkiye 20-J-2, 20-K-1, 20-K-2, 20-K-4 çizgisel paftaları olmak üzere 4 adet 1/1000 ölçekli kadastral paftaların sayısallaştırılması yapılarak arazi değerleriyle karşılaştırılmış ve koordinat farkları alınmıştır. Bu farklar mevcut yönetmeliğe, yönetmelik taslağına ve uygulama sonuçlarından elde edilen nokta konum hata sınırı değerleriyle karşılaştırılmıştır.

Yönetmelikte verilen hata sınırları esas alındığında, eski kadastro paftalarındaki parsellerin %48'inin kabul edilebileceği, yönetmelik taslağına göre hata sınırları esas alındığında parsellerin %55'inin kabul edilebileceği ve yapılan araştırma sonuçlarına göre elde edilen hata sınırına göre de parsellerin %59'unun kabul edilebileceği görülmüştür. Hata sınırı değerini geçen parsellerin yüzölçüm düzeltmelerinin kadastro kanununa göre yeniden hesaplanması gerektiği görülmüştür.

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1. INTRODUCTION

All modern cadastral map sheets generated and cadastral applications in Turkey that were intended to meet the needs have been implemented during the Republican period, especially in the last 20-25 years. Initial Works generally concentrated in cities and map sheets with scales of 1/5000, 1/1000, 1/2000 and 1/500 were generated. Moreover, current maps with a scale of 1/1000 which are intended to prepare and implement the developmental plans within municipal borders were produced.

Almost all of the maps produced by the abovementioned institutions for various purposes, especially those produced before 1985-1990, are graphic maps. In the last ten years, photogram metric maps with a scale of 1/5000 have begun to be made by The General Directorate of Title Deeds and Cadastre in rural areas. During the last 16 years, on the other hand, beginning in 1990, digital maps have been produced in accordance with the Regulations for the Production of Large-Scale Maps (RPLSM).

It became a necessity to digitalize graphic map sheets in order to meet the needs regarding real estates, implement application procedures, eliminating border conflicts and form bases for the projects that some institutions prepared or perhaps most importantly for the Geographical Information Systems (GIS). Transfer of map sheets onto computer environment brings benefits of time, economy and use.

However, while these map sheets are being transferred onto computer environment, analysis of positional sensitivities of map sheet data is being discussed today and efforts are being made to adapt them to regulations.

2. DIGITALIZATION

Digitalization methods can be called with different names depending on the source of data used, techniques and tools and instruments. For example, the procedure for the digitalization of the existing graphic bases (maps, plans and images) is usually defined with the term “cartographic digitalization”. On the other hand, in photogrammetry, there are also works conducted with photographic devices in the generation of digital maps and formation of digital land models.

Positional data in the computer environment are defined in the vector (point) or raster (scanning) mode. In the vector mode, the point is defined with coordinate pair, a series of graphic coordinates. The area, on the other hand, is composed of lines (graphs). The basic definition in the raster mode is usually a unit square area (pixel). Point object is determined

with a single unit square area. Area and graphic objects are defined according to a certain order and there is no need for a coordinate to define this unit square area. Definition is a total of the unit square areas of the same type. Methods of transformation from graphic bases into digital data are can be grouped under three headings on the basis of the equipment used (Ulugtekin, 1993).

- Automatic digitalization
- Semi-automatic digitalization
- Manual digitalization.

Sources of error in a digitalization procedure can be listed as follows.

- Map drawing errors
- Map evaluation errors
- Operator's errors in manual digitalization
- Errors of tools.

The transformations used in digitalization procedures can be listed as follows.

- Helmert (similarity) transformation
- Affin transformation
- Projective transformation
- Ortagonal transformation
- Helble transformation.

The study conducted by Ceylan, Mutluoglu and Gunaslan (2005) cover 341 parcels and a total of 962 parcel corners in 5 map sheets of scale 1/1000 within the borders of the village of Selahattin in the district of Selcuklu in the province of Konya. The total area is 30 ha. The parcel corner points of these map sheets were digitalized. The areas of the 341 parcels in the area of study were calculated in three different ways with coordinates obtained from the land, scanner and digitalizer. According to these calculations, 96 % (341-15= 326 parcels), of the area values obtained as a result of digitalization were within the limits. Furthermore, the areas of the 341 parcels in question were calculated using SOKIA Placom-KP-90N digital planimeter. A comparison revealed that 78 % (341-71= 271) of the differences in area were within the error margins (A. Ceylan, Mutluoglu and Gunaslan, 2005).

In the study which Yurt (2001) conducted, four map sheets belonging to the district of Karatay, Konya of scale 1/1000 which were drawn on an astrolon base and had dense residential area were digitalized in order to digitalize the graphic map sheets with an eye to establishing a land information system. The map sheets were digitalized with 491, 2289, 3079 and 1611 points respectively. All of the digitalized points had coordinates calculated via geodesic methods. Machine coordinates obtained as a result of digitalization were converted into balanced land coordinates through affin and projective transformation methods. Positional errors appear to be around 60 cm. Since positional errors were around 60 cm, it was concluded that the errors made during the drawing did not stay below the limit of 0.2* md. Indeed, when the frequency distribution was examined, it was seen that the differences in x and y values reached 90 to 100 cm in certain points. This means that those points were not drawn in the correct position of 28.2 cm. According to the frequency distributions in the

transformations made as a result of digitalization, the values found at the end of the projective transformation appeared to be closest to the true value of the point (K. Yurt, 2001).

3. MATERIAL AND METHOD

The area where the study was conducted comprised of 150, 587, 851 and 88 points respectively in 4 map sheets of scale 1/1000, namely the graphic map sheets of 20-J-2, 20-K-1, 20-K-2, 20-K-4, within the borders of the districts of Selcuklu and Meram in the province of Konya. The abovementioned map sheets were generated by the Directorate of Cadastre of Selcuklu and Meram. The map sheets were drawn on a blueprint base.

In the process of the digitalization of the images obtained through scanners, the map sheets were scanned in a resolution of 600 dpi with a cylinder type Canon colortrack smartlf scanner of size A0 and stored as an image file in jpg format. Digitalization was performed with the NetCAD 2.9 software. The rasters that were scanned were converted using affin transformation loaded in the software and 4 grid points were used for each map sheets. Transformation reports are given in Table 1.

Table 1. Transformation reports

Map Sheet No.	Error ratio of 1. Point	Error ratio of 2. Point	Error ratio of 3. Point	Error ratio of 4. Point	Needed turning angle	Total of error ratio
20-J-2	0.512	0.512	0.511	0.511	-359.8588	0.0724
20-K-1	0.102	0.102	0.102	0.102	-359.9387	0.0144
20-K-2	0.661	0.662	0.663	0.661	-359.9228	0.0937
20-K-4	0.305	0.304	0.304	0.305	-359.8775	0.0425

During the evaluation, the coordinates obtained through each of the methods were compared with the true coordinates calculated with geodesic methods and (Vx) and (Vy) coordinate differences were calculated. The differences between the coordinates obtained as a result of digitalization and the original field coordinates were calculated from the correlations;
Vx:Xs-Xa
Vy:Ys-Ya

Here,
Xs and Ys indicate coordinate values obtained as a result of digitalization,
Xa and Ya indicate coordinate values obtained in the field through geodesic methods,
Vx and Vy indicate the differences between coordinate values obtained as a result of the digitalization of any point in the field and the field coordinate values.

4. APPLICATION

The differences between the coordinates that were obtained as a result of the digitalization of map sheets 20-J-2, 20-K-4, 20-K-1, and 20-K-2 and the field coordinates were investigated at the distributional level of ±10 dm in the directions of X, Y and X-Y.

The Distribution of map sheet 20-J-2 in the direction of X,Y;
In the 20-J-2 map sheet, investigations were made in a total of 150 points in the direction of X and no blunders were detected while investigations were made in 150 points in the direction of Y, 6 blunders were not included in the investigations and their distributions were given in Figures 1, 2 and 3.

Değerler(dm)	Frekans	Yüzdesi
-10	0	0,00
-9	0	0,00
-8	0	0,00
-7	0	0,00
-6	0	0,00
-5	1	0,67
-4	16	10,67
-3	19	12,67
-2	20	13,33
-1	12	8,00
0	7	4,67
1	17	11,33
2	9	6,00
3	15	10,00
4	20	13,33
5	13	8,67
6	1	0,67
7	0	0,00
8	0	0,00
9	0	0,00
10	0	0,00
Toplam	150	100,00

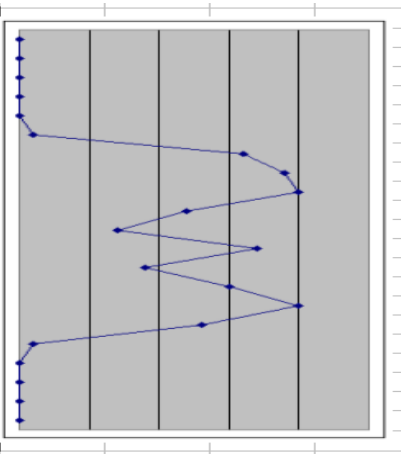

Figure 1. The Distribution of ferquency 20-J-2 in the direction of X

Değerler(dm	Frekans	Yüzdesi
-10	3	2,08
-9	2	1,39
-8	0	0,00
-7	0	0,00
-6	0	0,00
-5	0	0,00
-4	3	2,08
-3	12	8,33
-2	13	9,03
-1	16	11,11
0	17	11,81
1	24	16,67
2	30	20,83
3	15	10,42
4	0	0,00
5	1	0,69
6	1	0,69
7	3	2,08
8	1	0,69
9	0	0,00
10	3	2,08
Toplam	144	100,00

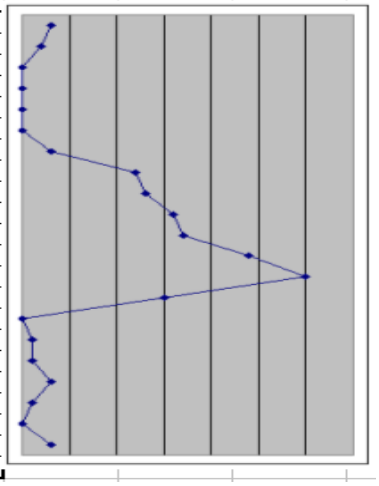

Figure 2. The Distribution of ferquency 20-J-2 in the direction of Y

Değerler(dm	Frekans	Yüzdesi
-10	3	1,02
-9	2	0,68
-8	0	0,00
-7	0	0,00
-6	0	0,00
-5	1	0,34
-4	19	6,46
-3	31	10,54
-2	33	11,22
-1	28	9,52
0	24	8,16
1	41	13,95
2	39	13,27
3	30	10,20
4	20	6,80
5	14	4,76
6	2	0,68
7	3	1,02
8	1	0,34
9	0	0,00
10	3	1,02
Toplam	294	100,00

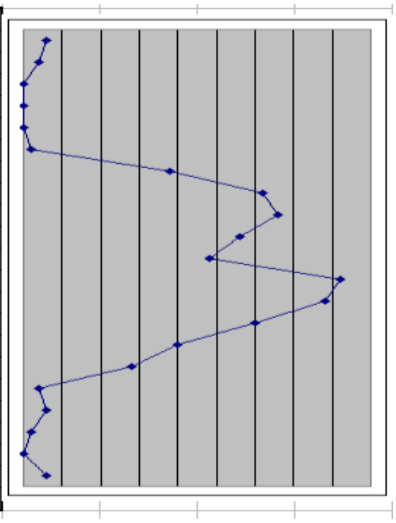

Figure 3. The Distribution of ferquency 20-J-2 in the direction of X,Y

The Distribution of map sheet 20-K-4 in the direction of X,Y;

In the 20-K-4 map sheet, investigations were made in 578 points in the direction of X, 2 blunders were not included in the investigations while 587 points were investigated in the direction of Y and 9 blunders were not included in the investigations.

The Distribution of map sheet 20-K-1 in the direction of X,Y;

In the 20-K-1 map sheet, investigations were made in 851 points in the direction of X, 7 blunders were not included in the investigations while 851 points were investigated in the direction of Y and 18 blunders were not included in the investigations.

The Distribution of map sheet 20-K-2 in the direction of X,Y;

In the 20-K-2 map sheet, investigations were made in a total of 88 points in the direction of X and no blunders were detected while investigations were made in 88 points in the direction of Y, 1 blunders were not included in the investigations.

4.1. Positional error according to the Regulations for the Preparation of Large-Scale Maps (RPLSM):

According to the Regulations for the Preparation of Large-Scale Maps, average errors in the directions of X and Y are indicated with (mx), (my) and root mean square error (m).

$$m_{y=\pm}\sqrt{\frac{[V_y V_y]}{n}}, \quad m_{x=\pm}\sqrt{\frac{[V_x V_x]}{n}}, \quad m_{=\pm}\sqrt{\frac{[V_y V_y + V_x V_x]}{2n}}$$

Again, when a graphic reading of the existing regulations is rendered on a map sheet, the average theoretical error of the value to be obtained is equal to the value given by the equation Ms:(0.2 mm)*(md). Here,

md: is the scale of the map sheet

The positional error of point belonging to any value read on a map of scale 1/1000 is equal to mp:± 28.2 (Yildiz et al., 1993).

4.2. Positional Error of Point According to the Draft Regulations

The formulas below are used in the digitalization made according to the values obtained by reading the map sheets (Dogan, 2005).

- ♦measurement error = m_O
- ♦drawing error = $m_T = 0.0002m.x\ M$
- ♦digitization error = $m_S = 0.0002m.x\ M$

Mp: positional error of the digitalized point
M: Denominator of the Map sheet Scale
a) Classic Map Sheet:

$$m_P = (m_O^2 + m_T^2 + m_S^2)^{1/2}$$

M	**1/1000**
$\mathbf{m_P}$	0.32 m.

4.3. Positional Error of Point According to the Application Made

When the distributions of the errors in the map sheets investigated as a result of the application made, it was observed that a majority of the error accumulations were within ± 4 error margin. Table 2 gives frequencies of each map sheet within ± 4 error margin and their percentages according to the number of points.

Table 2. Distribution in between ±4 Frequency

Map sheet	**± 4 Frequency**	**Percent**
20-J-2	265	89%
20-K-4	969	84%
20-K-1	1557	93%
20-K-2	170	97%

The values found for each map sheet in the direction of x (mx), in the direction of y (my) and positional errors of point are given in Table 3.

Table 3. Positional errors

Map sheet	**my(cm)**	**mx(cm)**	**mp(cm)**
20-J-2	42,4	30,6	36,8
20-K-4	35,1	37,5	36,3
20-K-1	35,8	29,8	33,6
20-K-2	25,6	37,9	32,4

The weighted averages of the mx, my and mp errors of the points in all map sheets are given in Table 4.

Table 4. Mean Square Error of Coordinates

My(cm)	Mx(cm)	Mp(cm)
35,7	33,2	34,5

The positional error of point margin, which is 28.2 cm according to the regulations and 32 cm according to the draft regulations, was found to be 34.5 cm in the present study. Positional errors were investigated according to RPLSM, the draft regulations and The Findings Obtained and a compatibility test was administered (Table 5).

Table 5. Analysis of Findings Obtained

Map Sheet	RPLSM (28.2 cm)		Draft Regulation (32 cm)		Findings Obtained (34.5 cm)	
	ACCEPT	*REJECT*	*ACCEPT*	*REJECT*	*ACCEPT*	*REJECT*
20-J-2	41	108	57	92	64	85
20-K-4	205	382	248	339	267	320
20-K-1	549	302	602	249	648	203
20-K-2	7	81	9	79	9	79
Total	802	873	916	759	988	687

6. CONCLUSION

In the present study, when the map sheets were investigated according to RPLSM, Draft Regulations and the Findings Obtained, the positional errors that were found were 50 % less than the points accepted according to RPLSM, which takes into account only the drawing errors and digitalization errors. When measurement errors are added to this (according to the draft regulations), the number of accepted points rises above 50 %. In the present study, the number of accepted points was found to reach 60 %. According to these results, it was determined that the error margin had to be raised from 28.2 cm to 35 cm. However, due to the effects of the abovementioned errors, the measurement error of 15 cm. was found to be an average of 20 cm.

The crude errors, on the other hand, stemmed from the fact that the place of the point could not be accurately determined, in other words, while these points were being indicated in the software, they were not placed in their appropriate places. In order to prevent such errors, the points must have been indicated on the map sheet beforehand.

In the applications investigated and implemented, it was found that in order for the digitalization procedure to be more sensitive and form a base for the Geographical Information Systems, which have become a necessity today,

- Classic map sheets must be scanned with high-resolution scanners
- Projective transformation must be used; if this transformation can not be used, points must be placed sensitively on frames in the affin transformation
- The operator who performs digitalization must be experienced and careful.

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