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Comparison of different GPS's used in different areas in our country's forestry

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Abstract

Aim of study: Terrestrial measurements have an important place in the production of spatial databases for use in forestry activities in Turkey. Terrestrial methods develop in parallel to the advancing technology while the mechanical measuring devices used in the past are replaced by computer-assisted digital measuring devices.

Area of study:. The Forestry Faculty area of Istanbul University at the European side of province of Istanbul was determined as study area for the present study.

Material and Methods: Global positioning systems (GPS) developed to collect satellite-based spatial data are among the devices derived from this technology. This study explored the possibilities to use this technology for forestry purposes and the performance of hand held Global Positioning System, Differential Global Positioning System (DGPS), DGPS-Continuously Operating Reference Stations (CORS) and Total Station on the areas representing the very closed forest area, open area and forest boundary selected for the study was assessed.

Main results: According to the results, DGPS CORS type GPS is the most accurate one for all three areas types. It was most accurate in closed forest area as the error margin in dense foliage was 3,41 m in horizontal and 3,88 m in vertical; 0,06 m in horizontal and 0,05 m in vertical for open area; 0,62 m in horizontal and 1,16 m in vertical for forest boundary.

Research highlights: It is predicted that DGPS CORS systems to be preferred in forestry operations requiring high sensitivity, whereas usage of hand held GPS systems for time saving.

Keywords: GPS, Forest Surveying, Cadastre, DGPS, CORS

Ülkemiz ormancılığında farklı alanlarda kullanılan farklı GPS'lerin kıyaslanması

Özet

Çalışmanın amacı: Türkiye'de ormancılık faaliyetlerinde kullanılmak üzere konumsal veritabanlarının üretilmesinde yersel ölçümler önemli bir yere sahiptir. Yersel yöntemler, teknolojik olarak gelişmekte ve geçmişte kullanılan mekanik ölçüm aletlerinin yerini bilgisayar destekli dijital cihazlar almaktadır. Konumsal verileri uydu desteğiyle toplamak amacıyla geliştirilen küresel konum belirleme sistemleri bu teknolojinin bir ürünüdür.

Çalışma alanı: Bu çalışmada İstanbul ili sınırları içerisinde Avrupa Yakasında bulunan İstanbul Üniversitesi Orman Fakültesi Kampüsü sınırları içerisinde kalan alan çalışma alanı olarak seçilmiştir.

Materyal ve Yöntem: Ormancılık amaçları doğrultusunda küresel konum belirleme sistemlerinden (GPS) yararlanma olanaklarının incelenmiş olduğu bu çalışma için seçilen çok kapalı orman alanı, açıklık alan ve orman sınır alanını temsil eden alanlar üzerinden El tipi GPS, diferansiyel küresel konum sistemi (DGPS), DGPS- gerçek zamanlı konum belirleme ağı (CORS) ve Total Station cihazlarının performansları irdelenmiştir.

Temel Sonuçlar: Buna göre her üç alanda da DGPS CORS tipi GPS daha az hata vermiştir. Çok kapalı orman alanlarında yatayda 3,41 m, düşeyde 3,88 m, açıklık alanda yatay 0,06 m, düşeyde 0,05 m, orman sınır alanında yatayda 0,62 m, düşeyde 1,16 m hata payları ile en az hatayı açıklık alanda vermiştir.

Araştırma vurguları: Yüksek hassasiyet gerektiren ormancılık çalışmalarında DGPS CORS sistemlerinin tercih edilmesi,zaman tasarrufu açısında ise el tipi GPS sistemlerinin kullanılması öngörülmektedir.

Anahtar Kelimeler: GPS, Ormancılık Ölçmeleri, Kadastro, DGPS, CORS

Introduction

Today, that natural resources are rapidly exploited and consumed due to ever increasing human population and environmental problems, requires the fact that the earth is effectively, efficiently and economically searched in a timely fashion. This is only possible through the implementation of space oriented technology (Erdem, 2011). The first ever introduction of Global Positioning System (GPS) was developed and put into practical use within US armed forces in 1973. The civilian use of the system was started soon afterwards with limited access and functionality.

The oldest method of delineating forests and woodlands were compass polygon. The angles of the brake lines were being recorded, checking through a magnetic compass, in short, the deviation of the brake line's direction from magnetic North. The length of the brake line on the other hand was optically recorded. Starting from 1965, photogrammetric method was started to become the common practice. The precision attained through the above method was supported and enhanced with terrestrial measurements. Lately, space borne remote sensing techniques have reached so extreme high precision that even they become a very sensible alternative in this undertaking (Aykut, 2001).

Land surveying cardinal points placed all along the country are generally very distant from one another to produce reliable results. Establishing interim middle points in forest cadastre is thus critical (Erdin, 1990). These new points, called polygon points were placed and their coordinates were calculated, depending upon the known coordinates of the cardinal points (Songu, 1987).

The information system is developed according to the information fields that the society needs and is named accordingly. The widespread implementation of information systems is concerned with inhabited environment. Information systems for different purposes are also created in this scope (Akyüz, 1993).

Global Positioning System (GPS) provides highly sensitive information for geographic information systems. The researches which have conducted in this field revealed a conclusion that highly sensitive data can be obtained to the forest information system with GPS (Tunay & Başaran, 1998).

Instead of using direct carrier phase measurements in GPS measurements for geodetic purposes, linear combinations and spatial difference methods are also applied. (Pırtı, 2004).

The GPS provides many users to precise and accurate length measurement, precise Doppler exchange measure, precise carrier phase measure, position information, and acquiring correction parameters on the occasion of ionospheric delay (Güngör, 2000).

Geographical data in the field of forestry must either be transferred to digital environment by performing field measurements or by using GPS devices to determine the point locations through satellites (Başkent, 1996).

In the conducted researches, results were obtained with 2% error in area calculations made with GPS in the forest (Domingue, 1994; Tremblay, 1995)

In Turkey, both general land and forest cadastre works are being conducted, using the nationwide land surveying triangulation. Due to the very nature of the task, terrestrial works are extremely time and labour consuming. Especially, in forestry related works, the above mentioned inefficiencies pose an important mishap. While performing the job, using classical method, it is possible to mention numerous hardships such as;

- No night time work is generally possible,
- Very susceptible to weather conditions,
- Measurements must definitely be validated through cardinal points,
- No long distance measurement is possible,
- Measuring is relatively time consuming and requires a crowded team,
- Polygon points must see each other (Turhan, 1993)

According to Ghaziani (2013), of the errors of GPS devices, different methods such as DGPS are used. Differential GPS is required to the base stations that the exact positions of them are known. Without knowing the exact position of the base station, the DGPS method does not work correctly. To overcome this problem, proposed method is not dependent to base station coordinates and distance-based DGPS is proposed.

In the scope of this study, different types of GPS devices were compared. Various terrain and land cover settings such as dense forest / foliage habitat, open habitats and timber/forest line were measured for spatial accuracy, implementing hand held GPS, DGPS, DGPS_CORS and total station.

Materials and Methods

Ground surveying has been the main method in producing the majority of base maps used in Turkish forestry practices. As the technology progresses, related methods are also improving in such a fast pace that all the mechanical surveying means of the recent past have been replaced with technology driven digital ones. Global positioning system can be considered as the farthest reach attained in this area for gathering the spatial data through non-terrestrial means. In this study designed to investigate the capabilities of this technology for forestry purposes, under different forest settings such as, full closure, open area, forest boundary, etc., positional accuracies of various GPS systems, i.e. hand-held GPS, DGPS, DGPS_CORS are measured and compared to the reference, ground surveying through a total station. As mentioned above the purpose of the study is to determine a dependable and cost efficient point recording tool which will be effectively used in forest cadastre. To achieve this goal, there different land cover settings were established within the study area. Using hand held GPS receiver, absolute spatial position; using GRS-1 DGPS via L-1/L-2 bands and European Geostationary Navigation Overlay Service(EGNOS) satellite and applying DGPS method, relative spatial position and using PGA-1 DGPS receiver and using L-1/L-2 bands and CORS based real time correction from Turkish National Permanent GPS Network (TNPGN), relative spatial position accuracies were measured and compared to terrestrial total station records. Within field work, in order to determine the error levels of each and every point, the records held from a total station measurement were used as validation and “Root Mean Square Error” (RMSE) was calculated for each point, using the below formula:

$$\mathrm{RMSE} = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2}$$

x_r = x coordinate held by using total staion
x_i = x coordinate held by using GPS receiver
y_r = y coordinate held by using total station
y_i = y coordinate held by using GPS receiver.

Study Area

The Forestry Faculty area of Istanbul University at the European side of province of Istanbul was determined as study area for the present study. As mentioned above, one of the aims of the study is to reveal the suitable global positioning system and equipment for forestry activities. In the scope of this aim, three study regions were chosen with different qualifications within the study area.

As known, the global positioning system receivers calculate the coordinates of the current point by analyzing the data received from the satellites in the orbit of the earth. Therefore, in order to perform the measurement, it would be the ideal setting if the top of the receiver is as open as possible. This kind of condition is most of the time hard to come by within the forests. In this study, the testing areas were chosen to represent three most common conditions in the forest habitats. These are chosen as:

Testing area which represents dense foliage habitat (Figure 1)

Testing area which represents open habitat (Figure 2)

Testing area which represents timber line that is between forest and open area (Figure 3).

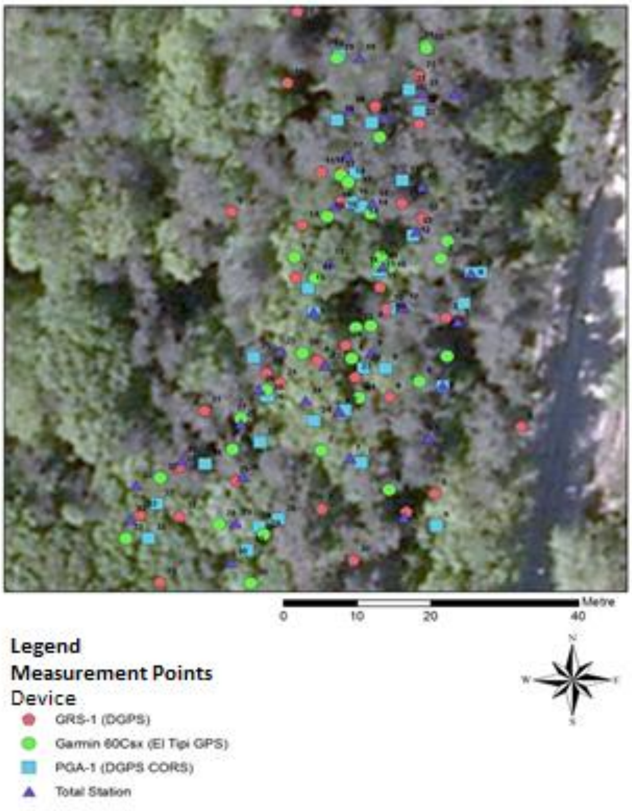

Figure 1. Testing area which represents closed forest area

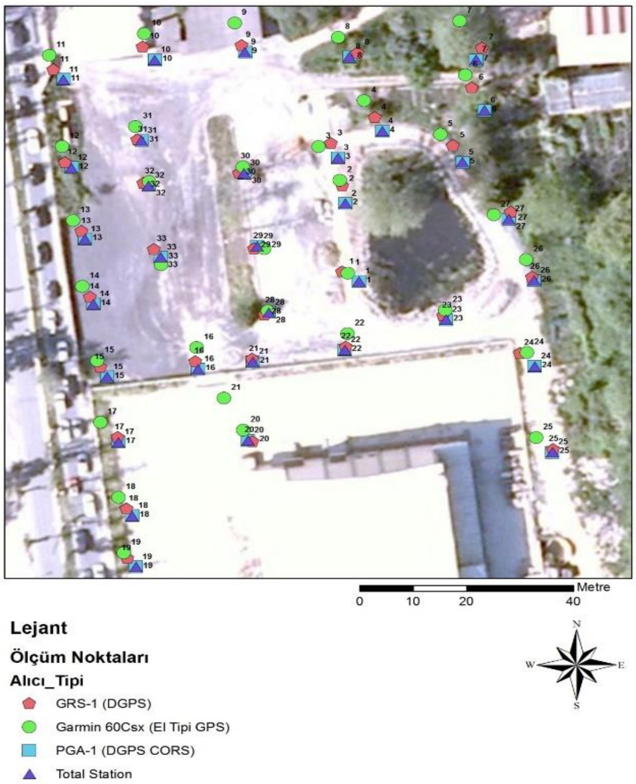

Figure 2. Testing area which represents open area

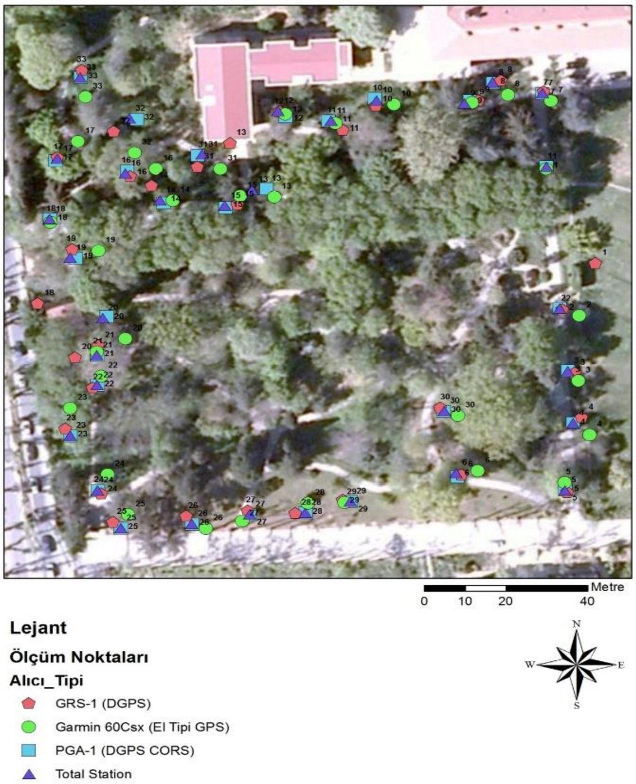

Figure 3. Testing area which represents timber line that is forest boundary

Results

Following the derivation of the necessary coordinates of all the data obtained as a result of the field studies, the data to be used in the database association and accuracy analyzes, the following processes were carried out at this stage.

The mean square error amounts calculated in the test area representing the very closed forest area for the point data are shown in Table 1, the calculated quadratic mean error amounts in the test field representing the open area are shown in Table 2, the amount of quadratic mean error calculated in the test area representing the forest boundary area is presented in Table 3 in detail.

Measurements under the very closed forest area produced the total RMSE of:

PGA-1 DGPS CORS, 3,41 m; GRS-1 DGPS, 7,82 m; hand held GPS 5,53 m in horizontal

PGA-1 DGPS CORS, 3,88 m; GRS-1 DGPS, 9,65 m; hand held GPS, 5,45 m in vertical under open area:

PGA-1 DGPS CORS, 0,06 m; GRS-1 DGPS, 2,03 m; hand held GPS, 4,35 m in horizontal

PGA-1 DGPS CORS, 0,05 m; GRS-1 DGPS, 2,01 m; hand held GPS 5,35 in vertical under forest boundary:

PGA-1 DGPS CORS, 0,62 m; GRS-1 DGPS, 4,27 m; hand held GPS, 4,23 m in horizontal

PGA-1 DGPS CORS, 1,16 m; GRS-1 DGPS, 6,97 m; hand held GPS 4,53 m in vertical

Today, it's become an absolute necessity to use global positioning systems in forests and forestry operations. It is believed that studies not requiring high precisions like wildlife mapping, forest fire monitoring and identification of sampling plots, etc, can very well benefit from the capability of hand held GPS devices, on the other hand, DGPS CORS would be a much better choice for studies like delineating forest frontiers and land cadastre type of works.

Table 1. Testing area which represents closed forest area

Sample N.	PGA-1 DGPS CORS Measurements		GRS-1 DGPS Measurements		Hand Held Measurements	
	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)
	RMSE	Absolute Error	RMSE	Absolute Error	RMSE	Absolute Error
1	0.00	0.01	5.7	7.2	8.6	8.6
2	0.01	0.01	38.7	13.2	4.5	14.0
3	7.98	10.4	1.8	4.8	9.7	9.8
4	0.07	2.8	23.8	24.6	5.8	8.3
5	20.6	1.6	8.2	1.7	8.5	6.4
6	4.6	3.7	0.9	1.2	4.6	2.9
7	1.7	3.0	8.5	9.5	4.0	2.9
8	0.8	2.6	7.1	5.0	8.0	5.1
9	2.9	2.5	7.5	6.8	4.0	9.2
10	1.8	1.0	2.2	5.9	6.1	1.3
11	0.9	2.7	3.1	4.7	0.6	6.8
12	0.8	2.3	2.1	5.8	6.8	7.3
13	2.8	5.5	3.6	4.4	11.8	7.5
14	1.6	1.3	10.0	2.6	1.5	5.4
15	4.8	21.2	13.5	6.8	3.0	2.9
16	2.2	0.7	1.0	6.4	1.9	3.2
17	2.8	5.1	2.4	4.0	3.0	2.6
18	2.2	3.1	9.3	16.3	10.7	0.1
19	2.8	5.1	10.9	23.0	3.1	1.3
20	1.9	1.6	2.2	1.7	2.9	3.3
21	1.9	4.8	2.6	3.4	7.0	1.6
22	5.4	10.9	6.5	3.9	7.7	0.9
23	5.2	6.5	4.4	13.4	7.0	2.0
24	3.2	1.5	4.3	15.1	7.3	2.0
25	3.7	3.6	3.8	9.5	6.2	1.1
26	1.5	2.2	13.5	16.8	8.0	6.0
27	3.8	0.3	10.5	27.9	0.9	5.9
28	7.9	8.9	1.1	1.8	7.7	5.8
29	3.3	2.3	13.5	21.9	4.2	6.1
30	2.8	4.6	16.6	27.1	4.1	9.4
31	3.2	1.1	8.1	0.3	7.1	9.5
32	3.9	2.1	4.4	7.6	3.4	10.4
33	3.7	3.1	6.7	14.1	2.9	10.6
Total RMSE	3.41		7.82		5.53	
RMSE Standart Deviation	3.59		7.45		2.80	
Average Absolute Error		3.88		9.65		5.45
Absolute Error Standart Deviation		4.06		7.83		3.46

Table 2. Testing area which represents open area

Sample N.	PGA-1 DGPS CORS Measurements		GRS-1 DGPS Measurements		Hand Held Measurements	
	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)
	RMSE	Absolute Error	RMSE	Absolute Error	RMSE	Absolute Error
1	0.00	0.01	3.7	1.6	2.7	8.9
2	0.00	0.01	3.8	2.3	5.0	7.9
3	0.04	0.02	3.4	3.6	4.4	9.5
4	0.05	0.04	3.2	6.0	7.3	12.6
5	0.06	0.06	4.0	4.5	7.2	12.9
6	0.08	0.04	5.4	3.8	8.3	9.7
7	0.09	0.11	2.7	0.9	8.7	9.5
8	0.09	0.02	1.7	5.0	4.6	7.9
9	0.06	0.06	1.6	3.6	6.4	7.6
10	0.07	0.04	3.6	1.7	5.9	7.5
11	0.09	0.06	2.8	0.7	5.8	6.0
12	0.09	0.05	1.7	1.8	4.8	6.0
13	0.04	0.06	1.8	0.3	4.5	5.5
14	0.03	0.06	1.6	1.6	4.3	6.2
15	0.04	0.04	2.4	1.6	3.9	6.1
16	0.03	0.03	1.8	1.4	4.6	4.3
17	0.07	0.03	1.0	2.3	5.4	4.1
18	0.08	0.05	1.8	1.9	4.6	3.4
19	0.08	0.00	2.5	1.8	3.7	3.0
20	0.05	0.09	0.9	3.6	2.4	4.0
21	0.03	0.07	0.6	2.4	9.4	8.4
22	0.04	0.09	0.7	2.6	3.4	2.7
23	0.05	0.05	1.0	2.2	2.0	3.9
24	0.06	0.05	3.9	0.5	3.2	4.7
25	0.09	0.02	0.6	1.1	4.4	2.3
26	0.07	0.01	0.8	0.9	4.7	1.8
27	0.07	0.07	1.6	0.5	3.0	1.5
28	0.06	0.06	0.9	0.7	0.5	0.8
29	0.03	0.02	0.8	1.5	1.4	1.8
30	0.04	0.04	0.9	1.2	1.3	1.8
31	0.05	0.03	0.8	1.2	3.2	0.4
32	0.09	0.07	1.1	0.7	0.8	0.5
33	0.03	0.03	2.1	0.8	1.6	3.5
Total RMSE	0.06		2.03		4.35	
RMSE Standart Deviation	0.03		1.23		2.20	
Average Absolute Error		0.05		2.01		5.35
Absolute Error Standart Deviation		0.06		1.38		3.34

Table 3. Testing area which represents timber line that is forest boundary

Sample N.	PGA-1 DGPS CORS Measurements		GRS-1 DGPS Measurements		Hand Held Measurements	
	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)	Horizontal (X, Y) (m)	Vertical (Z) (m)
	RMSE	Absolute Error	RMSE	Absolute Error	RMSE	Absolute Error
1	0.00	0.01	3.7	1.6	2.7	8.9
2	0.00	0.01	3.8	2.3	5.0	7.9
3	0.06	0.02	3.4	3.6	4.4	9.5
4	0.07	0.04	3.2	6.0	7.3	12.6
5	0.1	0.06	4.0	4.5	7.2	12.9
6	1.16	0.04	5.4	3.8	8.3	9.7
7	0.06	0.11	2.7	0.9	8.7	9.5
8	0.04	0.02	1.7	5.0	4.6	7.9
9	1.6	0.06	1.6	3.6	6.4	7.6
10	0.69	0.04	3.6	1.7	5.9	7.5
11	0.55	0.06	2.8	0.7	5.8	6.0
12	2.60	0.05	1.7	1.8	4.8	6.0
13	3.60	0.06	1.8	0.3	4.5	5.5
14	1.21	0.06	1.6	1.6	4.3	6.2
15	0.58	0.04	2.4	1.6	3.9	6.1
16	0.84	0.03	1.8	1.4	4.6	4.3
17	0.69	0.03	1.0	2.3	5.4	5.1
18	0.04	0.05	1.8	1.9	4.6	3.4
19	1.44	0.00	2.5	1.8	3.7	3.0
20	1.15	0.09	0.9	3.6	2.4	4.0
21	0.12	0.07	0.6	2.4	9.4	8.4
22	0.09	0.09	0.7	2.6	3.4	2.7
23	0.14	0.05	1.0	2.2	2.0	3.9
24	0.11	0.05	3.9	0.5	3.2	4.7
25	0.08	0.02	0.6	1.1	4.4	2.3
26	0.10	0.01	0.8	0.9	4.7	1.8
27	0.07	0.07	1.6	0.5	3.0	1.5
28	0.06	0.06	0.9	0.7	0.5	0.8
29	0.08	0.02	0.8	1.5	1.4	1.8
30	0.08	0.04	0.9	1.2	1.3	1.8
31	1.11	0.03	0.8	1.2	3.2	0.4
32	1.84	0.07	1.1	0.7	0.8	0.5
33	0.09	0.03	2.1	0.8	1.6	3.5
Total RMSE	0.06		2.03		4.35	
RMSE Standart Deviation	0.03		1.23		2.20	
Average Absolute Error		0.05		2.01		5.35
Absolute Error Standart Deviation		0.06		1.38		3.34

Discussion and Conclusion

In the light of the findings, it is suggested that the use of DGPS inside the forests and forest boundaries will not be useful with respect to accuracy and time.

The use of DGPS CORS systems will be more appropriate in activities that require high spatial accuracy such as positioning of ground control points in open areas (for photogrammetric and remote sensing activities) and cadastral boundary points.

According to all of the findings, robust results were obtained from DGPS CORS system in point-based activities in both forestlands and open areas. DGPS is not suitable for forestlands and areas surrounding the forests due to the EGNOS satellite connection problem. It can be suggested, however, that the use of hand held GPS systems may be appropriate depending on the type of activity and taking account of the two abovementioned concepts due to their positive effects time and negative effect on precision. For example; Today, the use of hand-held GPS receivers are great importance nowadays, which provide cost, precision and time savings in processes such as the identification of forest fire areas, the calculation of area sizes, coordination and control of fire.

As the most useful options with respect to precision and time required in the activities, it is suggested that DGPS will be appropriate to detect the location and boundaries of the storages for forest products and locate the fire watch towers, hand held GPS systems will be appropriate for regional activities such as locating the afforestation.

It is imperative to accuracy and time while collecting terrestrial data that are very important in forestry activities. Most of the activities focus on the most accurate and shortest time loss. At this point, it is necessary to ensure automation in data collection through the advanced technologies. The use of GPS systems is now inevitable to meet the abovementioned requirements during the collection of spatial data. In addition to their time saving advantages, GPS systems also have a disadvantage, which is the losses in accuracy of the activities in the forest areas. We are of the opinion that GPS systems should be used actively during the forestry activities. In addition to the advantages it brings from cost and time savings, we believe that GPS systems, which may be mentioned as disadvantages of sensitivity losses caused by work done in forest areas, should be used actively in forestry operations.

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