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ANALYSIS OF GEOGRAPHIC/URBAN INFORMATION SYSTEM WEB PRESENTATIONS OF LOCAL GOVERMENTS IN TURKEY

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ABSTRACT: Web sites are media environments, which ease our life, provide rapid access to requested information, constantly updated and provide information to people who wants to be informed. As Geographical Information Systems (GIS) has developed parallel to technology and integrated to new Technologies, use of this technology has become more popular. This technology is used as GIS integration by local governments in municipality websites. GIS provide better services in local governments and used in decision making mechanisms, taxing, planning in substructure and upper structure studies and for assisting in each matter within the scope of municipality's assignment area.

Web sites are tracking mechanisms which provides updated information about the municipalities they are builded for and shares plans via internet. Incompatible and unstandardized structure of municipality web sites, cause disintegration especially for GIS supported applications in mapping and prevent creating a system. First criteria in creating a website, studying applications in it and reconstruction is to define the purpose of applications and standards in design of these websites.

In this study, website profiles of local governments in Turkey are studied in terms of City Guide and E-Municipality applications and comparative analyses are made. Correspondingly, similarities, differences and deficiencies are revealed. According to the required results it is concluded that data structure and web content is not of standards and it is needed to be standardized in international terms.

Keywords:*Local Government, GIS, Urban Information System, E-Municipality,City Guide*

1. INTRODUCTION

Technological developments increase everyday. Especially communication technologies have developed extraordinarily since last 30 years and still developing. Developing information technologies have made it easy to access worldwide information and sources of information. In other words, it has become one of the basis of globalization. Now distances has no importance for accessing or sending information. Each kind of information can be transferred to digital media especially by developments in internet and data exchange is possible all around the world.

Globalization, changes in democracy and transition to information society by the changes in sense of citizen and change in local governments and international regulations bring production of e-applications. These applications have a lot of benefits for institutions. Information and communication technologies are of great potential for public sector as in private sector. Information technologies have served a lot of opportunity for increasing the quality of internal management efficiency and quality of public services which are served to citizens (Moon, 2002). Studies emphasize that information and communication technologies provide operational efficiency, decrease in costs, quality of service, conformability, renovation and big potential of experience for private and public sectors (Ndou, 2004).

Applications provide savings from a lot of bureaucratic procedures, personnel expenses, time, space, etc. in comparison to traditional method. Municipalities,

which are local government institutions, have gone through a reconstruction process in this e-transformation process. A lot of municipality have started to give electronic municipality services. Web technologies provide new possibilities and opportunities to municipalities in performance management, public relations, participative management, social responsibility and e-business/service/trade areas (Henden, 2004).

Geographic Information Systems (GIS) are the most important search and application device in electronically municipality services. Citizens are able to access maps with Geographic information, construction plans, building permits, addresses. Today, GIS is an essential device for some municipalities and a lot of municipality transfer their verbal, paper or CAD data to GIS media. Web applications are the best platforms for serving GIS transformed data to citizens.

GIS and information technologies serve efficient devices to local governments for valuation and management of sources. These devices provide storage, valuation, analyzing, service, report and modelling of spatial data (Fosu and Ashiagbor, 2012). Primary benefits of GIS for local governments are; efficiency, income growth, increase in accuracy rate, decision support, management of sources and saving of time, money and work labour as it provides task automation [URL1]. By these benefits, GIS are able to be used as a very strong device in local governments for planning, social development, environmental protection, integration in public security, infrastructure management, waste site selection, transport planning, health, education, modelling, mobilization management, urban studies, land and construction management (Tataroğlu, 2007; Zhou and Charnpratheep 1996; Charnpratheep et al. 1997; Das 2016; Reitsma 1990; Sui 1992, 1998; Miller 1994; Clarke and Gaydos 1998; Arentze et al. 1998; Arsanjani,2013; Gupta, 2016; Fortney 1996; Fraile 2016; Trammell and Pratt 1998; Erdi and Ilgaz 2014). GIS and Urban Information Systems are provided for the benefit of local managements as a gift of developing information technologies and make great contribution for efforts in solving increasing and complicating urban problems (Pektaş, 2009).

There are data standards which constitute Geographic Information Systems and make it an exact information system. Standardization states contracts and rules developed by users for providing integrity and openness for the subjects that differences are not desired. International standardization approach aims change in goods and services by removing global technical obstacles. So, general purposes of standardization can be ordered as; avoiding lost of time and cost, providing efficient use of information, avoiding information loss, easing information transfer and increasing quality (Anonymous, 2012). GIS/Urban Information System standards are determined by international institutions and establishments for interoperability. The most important of these data standards are; Inspire, Dublin Core, Open Geospatial Consortium and ISO/TC211.

European Union Spatial Information Infrastructure Interference (INSPIRE) is established in the control of European Commission General Directorate of Environment in 2001. It aims providing consistent and shareable information for supporting Europe policy in environment, agriculture, transportation and a lot of sectors in local, regional and national level.

E-applications of municipalities, which are installed by GIS infrastructure, require a lot of spatial data for planning, informing, managing and etc. purposes about the place which is lived in. These data are gathered from various sources and in different standards, protected and served to users in different types and forms. In Turkey, local and central governments serve these data with different standards and figures in conformity with today's technology.

In this study, website profiles of local governments in Turkey are studied with regards to Urban Guide and E-municipality applications and results are given in tables. Also, resemblances, differences and deficiencies are presented.

2. MATERIAL AND METHODS

Turkey is between the 36° and 42° north latitudes and 26° and 45° south meridians. Turkey's lands are roughly like a rectangle. It is 1600 kilometers length and 800 kilometers width. It is the biggest 37th country of the world with regard to square measure. Generally, Turkey is a country with large amount of its lands are in Anatolia and a small part is in the Europe continent. Turkey's population data is 79.814.871 according to 2016 [URL2]. Turkey has 30 Metropolitan Municipality, 51 City Municipality and 919 District Municipality.

City Guide is an application which is applied for municipalities and introduces their physical structure spatially and enable some cultural inquiries. Urban Guide generally enable accessibility of city's important places, avenue, street, address searches locationally, location information for surveying, satellite images, construction information, Cartographic presentations, etc. information.

Necessities of information age in developing and globalizing world, has brought great responsibilities to local managements. Individuals', institutions', which means users, expectations from municipalities increase constantly due to technological developments. For this reason, local governments serve a system via internet, on which citizens are provided service and can do almost all their works without going to municipality buildings. This system is called as E-Municipality application. E-Municipality application provides a citizen oriented, more regular system to users with activity, efficiency, transparency, accountability, non-repetitive structure.
In this study, City Guide, which includes GIS/ Urban Information System applications of local governments in Turkey and content of E-Municipality applications are studied from municipalities' websites and results are shown as tables. ArcGIS software is used for questioning and analyzing required data.

3. RESULTS AND DISCUSSIONS

Municipalities can be established in our country in settlement areas which has 5000 and more population. Municipalities are local governments which fulfil needs of citizens in local ground. In 2012, settlements with over 750.000 population are called as metropolis by the 6360 numbered Law. In this study, Metropolitan Municipalities', City Municipalities' and District Municipalities', which are one of the local government units in Turkey, websites are considered separately with regards to City Guide and E-Municipality applications.

3.1. City Guide Applications

3.1.1. City Guide Applications of Metropolitan Municipalities

There was 16 Metropolitan Municipalities in our country but it has increased to 30 in 2012 by 6360 numbered Metropolis Law (Figure 1). Each Metropolis has their own specific City Guides.

Figure 1. Metropolitan Municipalities in Turkey

In almost all City Guides in Metropolitan Municipality websites, there are cultural areas, health institutions, governmental agencies, educational institutions, contact detail searching and address searching. Applications of City Guides of Metropolitan Municipalities are shown in Table 1.

Table 1 Applications of City Guides of Metropolitan Municipalities

Country	Cultural Areas	Address Searching	Governmental Agencies	Educational İnstitutions	Health İnstitutions	Contact Detail Searching	Pharmacy On Duty
Adana							
Ankara	×	×	×	×	×	×	×
Antalya							
Aydin	×	×	×	×	×	×	×
Balikesir	×				×	×	×
Bursa						×	×
Denizli	×	×			×	×	×
Diyarbakir							
Erzurum							
Eskişehir							
Gaziantep							
Hatay							
İstanbul	×	×			×	×	×
İzmir	×	×	×	×	×	×	×
K.Maraş							×
Kayseri	×	×	×	×	×	×	×
Kocaeli	×	×	×	×	×		×
Konya	×	×	×	×	×	×	×
Malatya							×
Manisa	×	×	×	×	×	×	×
Mardin							
Mersin							
Muğla							
Ordu	×	×	×	×	×	×	×
Sakarya							
Samsun							
Ş.Urfa	×	×	×	×	×	×	×
Tekirdağ							×
Trabzon							
Van							

In Metropolitan Municipalities, map and GIS related other applications are; 360º virtual tour, 3D city guide, address information system, transportation information system, changes of satellite images through years, sheet index change and GIS for children. Table 2 shows which municipalities have these applications.

Table 2. Metropolitan Municipalities City Guide GIS/CIS related applications

Country	Zoning Status	3d City Guide	Changes Of Satellite İmages Through Years	Cemetery Information System	Sheet İndex Change	Transportation Information System	360º Virtual Tour	Address İnformation System	GIS For Children
Adana									
Ankara				×		×	×		
Antalya									
Aydin							×		
Balikesir	×						×		
Bursa		×		×		×	×		
Denizli	×			×			×	×	
Diyarbakir				×			×		
Erzurum							×		
Eskişehir				×					
Gaziantep									
Hatay									
İstanbul			×		×		×		
İzmir		×	×	×	×				
K.Maraş									
Kayseri		×	×	×		×			
Kocaeli									
Konya	×	×	×	×	×	×	×		×
Malatya	×			×					
Manisa	×								
Mardin									
Mersin									
Muğla									
Ordu	×								
Sakarya				×			×		
Samsun									
Ş.Urfa	×						×		
Tekirdağ				×			×		
Trabzon	×			×					

Van									

According to Table 1, it is seen that the most successful cities are Ankara, Aydın, İzmir, Kayseri, Kocaeli, Konya, Manisa, Ordu and Şanlıurfa. The most common application is Pharmacy on Duty with 53,33% rate. Other applications are; 40% cultural area, health institutions, transportation and 360^{O} virtual tour. While address application is 36, 67%, rate of questioning government agencies is 30%. The least common applications are address information system with 3,33% and GIS applications for children. It is determined that Address Information System, which is based upon ArcGIS software, is only available in city of Denizli (Figure 2). GIS application for children is available only in Konya city (Figure 3).

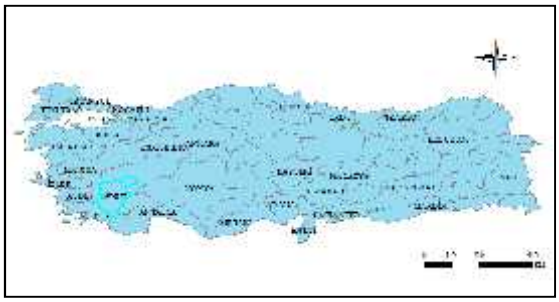

Figure 2. Metropolitan Municipalities which have Address Information System Application

Figure 3. Metropolitan Municipalities which have GIS Application for children

3.1.2. City Guide Applications of City Municipalities

There are 51 City Municipality in Turkey (Figure 4).

Figure 4. City Municipalities in Turkey

City based numbers and percentiles of city municipalities'applications in city guides are given in Table 3. According to Table 3, the most common city guide application in city municipalities is address application with rate of 35,29% (18 pieces). Other applications are cultural area (33,33%), transportation (31,37%) and governmental agencies, education, health, 360^{0}virtual tour (29,41%). The least common applications are 3D city guide with the rate of 1,96%, 3D cemetery information system, transportation information system and address information system applications.

Table 3. City guide applications in City Municipalities

Application	**Quantity**	**%**
Cultural Areas	17	33.33
Address Searching	18	35.29
Governmental Agencies	15	29.41
Educational Institutions	15	29.41
Health Institutions	15	29.41
Contact Detail Searching	16	31.37
Zonıng Status	14	27.45
3d City Guide	1	1.96
Changes Of Satellite Images Through Years	2	3.92
Cemetery Informatıon System	7	13.72
3D Cemetery Informatıon System	1	1.96
Transportation Information System	1	1.96
360º Virtual Tour	15	29.41
Address Information System	1	1.96
Pharmacy on Duty	12	23.53

There are both cultural and transportation applications at the same time in 16 city municipalities (Figure5). Address information system and Pharmacy on Duty applications only take place in Düzce City Municipality (Figure6).

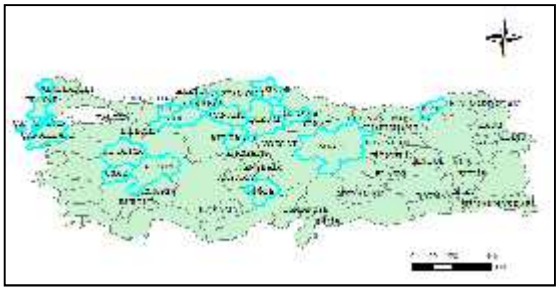

Figure 5. City Municipalities which have cultural area and transportation applications

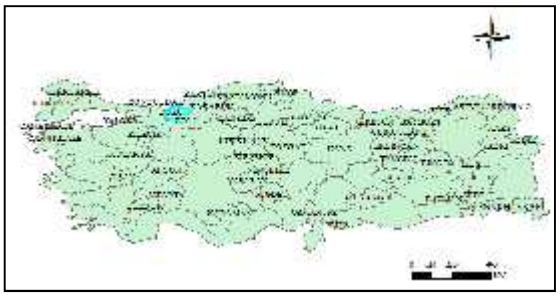

Figure 6. City Municipalities which have Address information system and Pharmacy on Duty applications

3.1.3. District Municipalities City Guide Application

There are 919 District Municipalities in Turkey and they have same features with city municipalities with regards to City Guide content. Only 172 of 919 District Municipality has City Guide application. The most common applications in 172 District Municipalities are cultural area, address, health institutions, governmental agencies, transportation, education institutes and zoning status applications as in City Municipalities.
One of the most common and frequently used searchings in City guides is Address Searchings. Diagram 1 shows searched districts of cities in District City Guides. According to Diagram 1, it is seen that districts' websites of developed cities such as Ankara, İstanbul, Bursa and Kocaeli have more address search applications.

Diagram 1. Address search in District Municipalities

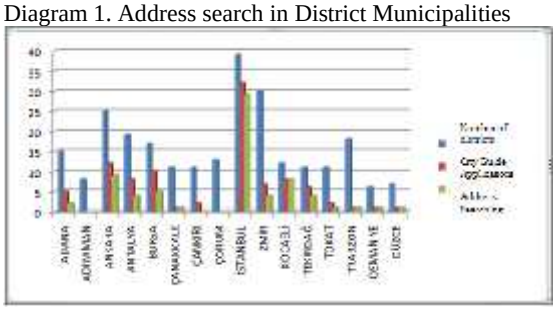

Diagram 2 shows distribution of cities' districts with Pharmacy on Duty application. According to Diagram2, Pharmacy on Duty application is most commonly used in districts of İstanbul and Ankara cities. Pharmacy on Duty and Address Information system is only available in İstanbul city Zeytinburnu District (Figure 7).

Diagram 2. Pharmacy on Duty Application in District Municipalities

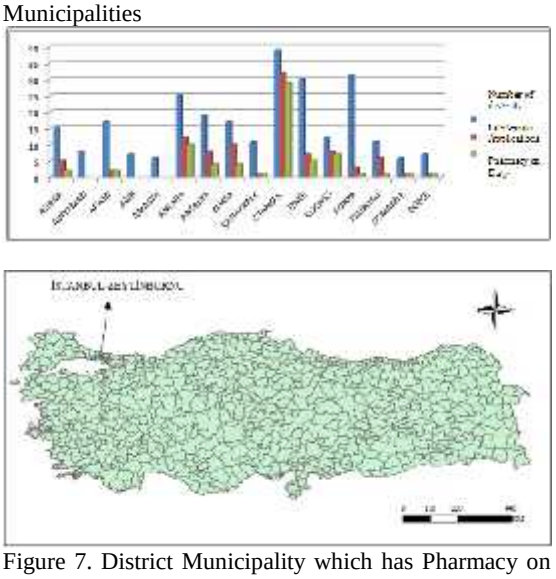

Figure 7. District Municipality which has Pharmacy on Duty and Address Information System Application

3.2. E-Municipality Applications

3.2.1. Metropolitan Municipality E-Municipality Applications

Metropolitan Municipalities aim providing quality service to citizens with E-Municipality application. For this reason, user satisfaction is desired via online system with citizen focused contents. E- Municipality applications make it possible to access information such as knowledge acquisition, payment, registry search, demand/complain, marriage service, declaration, document tracking, public transportation service schedule, building abrasion rates, garbage collection times, chimney cleaning, theater e-ticket, e-market, e-library, e-blood bank, career employment, e-pay roll and land market value.
Table 4 and 5 show E-Municipality applications of Metropolitan Municipalities' in their websites.

Table 4. E-Municipality applications of Metropolitan Municipalities

Country	Access Information	Payment	Registry Search	Demand/Complain	Marriage Service	Declaration	Document Tracking	Public Transportation Service Schedule	Career Employment
Adana	×	×		×		×	×		
Ankara		×	×			×		×	
Antalya	×	×			×		×		
Aydin	×	×		×					
Balikesir		×	×						
Bursa		×					×	×	
Denizli		×					×		
Diyarbakir		×			×				
Erzurum									
Eskişehir	×					×			
Gaziantep		×						×	
Hatay									
İstanbul		×						×	
İzmir		×				×			
K.Maraş	×	×					×	×	
Kayseri									
Kocaeli		×					×	×	
Konya	×	×					×		
Malatya	×	×	×	×	×	×	×		
Manisa		×							
Mardin									
Mersin	×	×						×	
Muğla		×	×						
Ordu	×		×	×					
Sakarya						×			
Samsun									
Ş.Urfa		×	×	×					
Tekirdağ	×	×	×	×					×
Trabzon		×							
Van	×	×		×					

Table 5. Metropolitan Municipalities GIS/CIS content E-Municipality Applications

Country	Building Abrasion Rates	Garbage Collection Times	Chimney Cleaning	Theater E-Ticket	E-Market	E-Library	E-Blood Bank	E-Pay Roll	Land Market Value
Adana								×	
Ankara			×						
Antalya				×	×				
Aydin									
Balikesir								×	
Bursa						×		×	
Denizli									
Diyarbakir									
Erzurum									
Eskişehir									
Gaziantep									
Hatay									
İstanbul									
İzmir						×			
K.Maraş						×			
Kayseri									
Kocaeli									
Konya									
Malatya	×	×				×			×
Manisa	×								×
Mardin									
Mersin									
Muğla									
Ordu									
Sakarya									
Samsun									
Ş.Urfa	×								×
Tekirdağ	×								×
Trabzon									
Van									

According to Table 4 and 5, it is seen that Malatya is the most successful city with regards to E-Municipality applications in Metropolitan Municipality websites. Table 6 shows E-Municipality applications' availability in 30 Metropolitan Municipality. According to Table 6 the most common E-Municipality application in Metropolitan Municipalities is Online Payment with 73,33% rate. 11 of (36,67%) of 30 Metropolitan Municipality are of Knowledge Acquisition application. Document tracking application is of 26,67% rate. Career employment, garbage collecting hours, chimney cleaning, theater e ticket, e-market applications are available only in 1 Metropolitan Municipality (3,33%). E-Blood application is not available in any of the Metropolitan Municipalities.

Table 6. Number of E-Municipality Applications in Metropolitan Municipalities

Applications	Quantity
Access Information	11
Payment	22
Registry Search	7
Demand/Complain	7
Marriage Service	3
Declaration	6
Document Tracking	8
Public Transportation Service Schedule	7
Career Employment	1
Building Abrasion Rates	4
Garbage Collection Times	1
Chimney Cleaning	1
Theater E-Ticket	1
E-Market	1
E-Library	4
E-Blood Bank	0
E-Pay Roll	3
Land Market Value	4

According to analysis executed with ArcGIS; Chimney cleaning application is only available in Ankara Metropolitan Municipalities (Figure8), theater e-ticket application is only available in Antalya Metropolitan Municipalities (Figure 9) and career employment searching is only available in Tekirdağ Metropolitan Municipalities (Figure 10).

Figure 8. Metropolitan Municipalities E-Municipality Application/ Chimney Cleaning

Figure 9. Metropolitan Municipalities E-Municipality Application/Theater E-Ticket

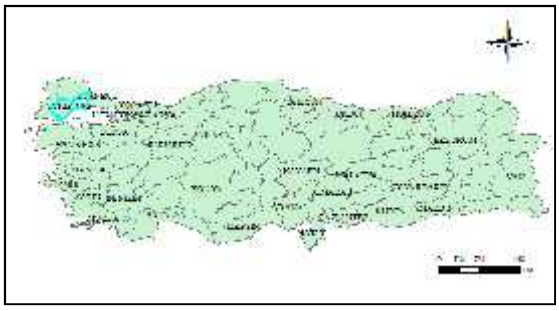

Figure 10. Metropolitan Municipalities E-Municipality Application/Career Employment

3.2.2. Metropolitan Municipalities E-Municipality Applications

Numerical illustration of 51 MetropolitanMunicipalities' web sites' e-municipality applications are given in Table 7.

Table 7. Number of E-Municipality applications in City Municipalities

Applications	Quantity	Percentage
Access Information	51/17	33.33%
Payment	51/37	72.55%
Registry Search	51/25	49.01%
Demand/Complain	51/21	41.18%
Marriage Service	51/13	25.49%
Declaration	51/14	27.45%
Document Tracking	51/12	23.53%
Public Transportation Service Schedule	51/0	0%
Career Employment	51/23	45.09%
Building Abrasion Rates	51/4	7.84%
Garbage Collection Times	51/0	0%
Chimney Cleaning	51/0	0%
Theater E-Ticket	51/0	0%
E-Market	51/0	0%
E-Library	51/1	1.96%
E-Blood Bank	51/0	0%
E-Pay Roll	51/3	5.88%
Land Market Value	51/27	52.94%

Payment, declaration, land market price searching's, which are commonly used E-Municipality applications in City Municipalities, analysis with ArcGIS are shown in Figure 1.21, Figure 1.22 and Figure 1.23. Payment application is available in 37 cities (Figure 11). E-declaration application is available in 14 cities in total, which are Kırklareli, Edirne, Yalova, Afyon, Bartın, Karabük, Çankırı, Yozgat, Kırşehir, Sivas, Niğde, Osmaniye, Adıyaman and Batman (Figure 12). Also, land market value application is available in 27 cities (Figure 13).

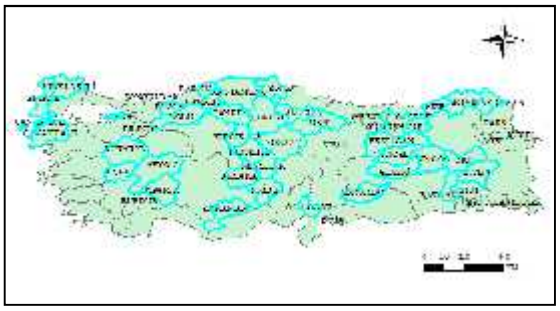

Figure 11. Cities which have Payment Application in City Municipality websites

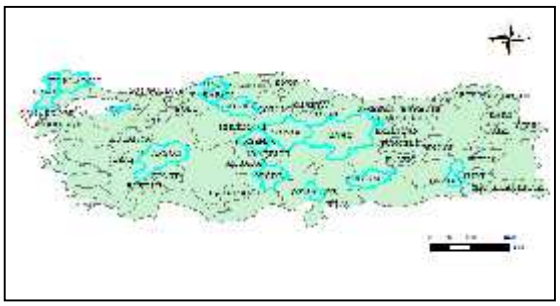

Figure 12. Cities which have Declaration Application in City Municipality websites

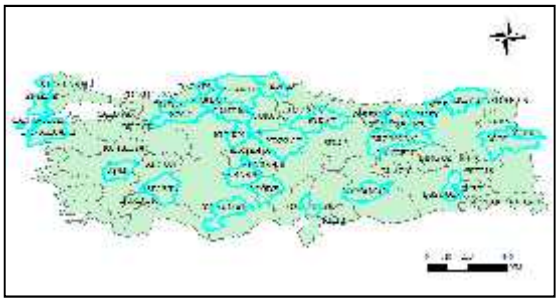

Figure 13. Cities which have Land Market Value Application in City Municipality websites

3.2.3. District Municipalities E-Municipalities Applications

In Turkey, 323 of 919 district municipality have e-municipality application. 277 of 323 district municipality have debt payment application, 195 have land market value application, 112 have registry search application, 189 have building abrasion rate application, 96 have request/complain application, 92 have declaration application and 82 have information acquisition application. Figure 14 shows 82 district municipality which have information acquisition application. Additionally; there are e-marriage (65), document tracking (50), garbage collection hours (15), e-pay roll (15), e-library (10), e-blood bank (3), career employment (2) and transportation hours (1) applications. Transportation hour is only available in Ulubey district of Uşak city (Figure 15). But there are not chimney cleaning, theater e-ticket and e-market applications.

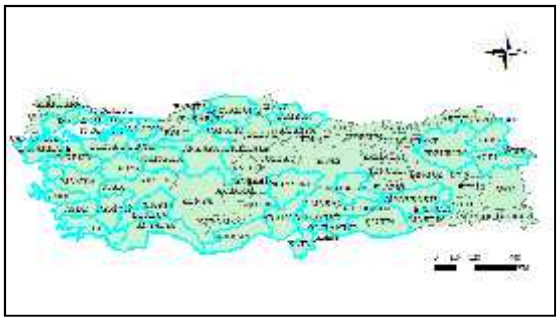

Figure 14. Cities which have information acquisition application in their district municipalities.

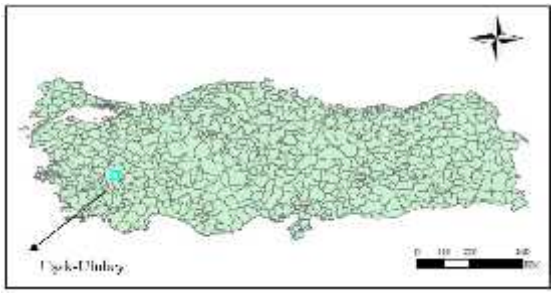

Figure 15. Cities which have transportation hours applications in their district municipalities

3.3. Study of GIS/CIS Applications in Local Governments of Developed Countries

Websites of developed countries' state/cities are searched. Generally each country has below subjects in their websites.

- Environmental quality
- Natural environment
- Waste management
- Health
- Tourism
- Urban planning
- Land management
- Housing
- Culture
- Infrastructure
- Air and noise
- Public areas
- Energy saving
- Education

4. CONCLUSIONS

The study has revealed the necessity of web services and 30 metropolitan municipality, 51 city municipality and 919 district municipalities of these cities are studied. These municipalities' websites are studied as city guide and E-municipality applications. As a result of this study, it is seen that the most common applications of city guide are; cultural area, address, governmental agency, educational institutions, health institutions and organizations, transportation information, zoning status, 360º virtual tour and pharmacy on duty searching's. In E-municipality application, information acquisition, payment, registry search, request and complain, e-wedding, declaration, document tracking, building abrasion rates, market value searches are commonly used applications. It is seen that there is only one different application in the websites of some municipalities between city guide and e-municipality applications.

It is seen that applications of websites in developed countries are more environmental and human focused. When studying applications of websites in Turkey, it is seen that they are different from applications in the world. There are not satisfying applications, which citizens are involved in management, in municipality websites in Turkey. Websites of municipalities are not applicable for paying bills, accessing cam images of of the city, information about tenders and applications, sufficient and transparent management understanding which citizens can involve in management. There are only applications which can be called as service for citizens.

It is seen that there are not a standardization in index and visuality of the websites and each website are created by different software companies upon request of administrators. It is necessary to provide a standardization considering existing INSPIRE fundamental principles.

Consequently, it is necessary to produce a system for all municipalities in Turkey by considering INSPIRE principles which will gather Geographic data, unite data which are coming from different sources, eliminating people or institutions that will prevent using and sharing information and easing use of Geographic data and preventing data repetition. All municipalities should have same system and data infrastructure by this system. Correspondingly, webpage design differences, which are sourced due to various web designers used by municipalities, will be eliminated and a single type of system visuality will be created. So municipalities will be able to use and publish most common data and searching applications with the same website design according to size and needs of municipalities. Also, creating standardization for municipalities will solve previous integrated data problem, differences in applications and searching's, data sharing problems.

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DETERMINATION OF TEMPORARY SHELTER AREAS IN NATURAL DISASTERS BY GIS: A CASE STUDY, GÖLCÜK/TURKEY

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ABSTRACT: Disaster is a natural or human-induced event that adversely affects the individual or the society. The magnitude of a disaster is measured by directly proportional to the damage it causes. In order to bring disaster and damage to a minimum level, it is quite important to plan and implement the evacuation and to place the victims in a safer region. Therefore, in this study the most suitable temporary shelter site selection will be investigated by the multi-criteria decision analysis method based on GIS for Kocaeli Gölcük district. For this purpose, 15 criteria were determined by considering literature search, the mutual interviews with the disaster experts and priorities of the Gölcük district. Analytical Hierarchy Process (AHP) was used to determine the criteria weights. Analyses were made using ArcGIS, QGIS, and ERDAS software. All raster maps were classified at the same scale, the classification was completed by giving the highest score for the most suitable conditions and the lowest score for the unsuitable conditions. Classified raster maps were used in the overlay analysis on GIS and suitability map of temporary shelter areas was obtained for Gölcük district. As a result, 243.900 m^2 of temporary shelter region was selected by a manual process from the most and very suitable areas within the boundary of the Gölcük.

Keywords: *GIS, Multi-Criteria Decision Analysis, Natural Disaster, Temporary Shelter*

1. INTRODUCTION

Being prepared for disasters will ensure that there is an opportunity to prevent possible losses and have an idea of how to act in the event of a disaster. Disaster management is defined as the planning, directing, supporting, coordinating and effective implementation of activities to be carried out at the stages of damage mitigation, preparation, intervention, and recovery in order to prevent disasters and reduce their damages (Poser and Dransch, 2010). The development of a rapid and effective disaster management system is very important in order to prevent the negative consequences of disasters. For this purpose, it is necessary to determine the risks that may lead to a disaster and to take precautions to prevent or minimize these risks at the most appropriate level. The role of a temporary shelter is to provide to those needing to seek immediate relief after a natural disaster. In the event of a disaster quickly directing the people from their living region to shelter areas provides the reduction of the possible losses. Additionally, it prevents the disappearances, cause quick intervention of injured people by medical teams and helps the professional teams to complete their work in a more comfortable way. In a temporary shelter area, there should be no risk of direct disaster impact and basic facilities such as electricity, water, sewerage and communication should be available for people's daily lives. In addition, the proximity of these areas to markets, warehouses, and health centers needs to be assessed in advance for the purpose of providing food, drinking water, and other supplies. Geographical features such as closeness to water resources, proximity to transportation networks, morphological characteristics, climatic characteristics, hydrographic characteristics, soil characteristics, proximity to vegetation cover and environment are important in determining these sites (Özdemir, 2002).

There are various studies related to shelter area selection and logistics in disaster management. Yi and Özdamar (2004) proposed a dynamic and fuzzy coordination logistic model to manage disaster reaction activities and they applied their study on Istanbul earthquake data. Zhu et al. (2010) worked on emergency source repositories and capacities and proposed a model to minimize total cost. Mete and Zabinsky (2010) included a detailed literature for the problem of location selection and distribution in the medical supplies procurement process in disaster management and proposed a stochastic programming model for this problematic structure. Lixin et al. (2012) reviewed the disaster management system in China and made suggestions to improve the quality of the system by analyzing the distresses. Soltani et al. (2015) applied the Delphi method for temporary shelter areas after major earthquakes in three stages and determined the 21 criteria collected under 4 main headings which can be chosen as the criteria for the best temporary gathering area location. Xu et al., (2016) was introduced seven principles (i.e., safety, control of land use, nearest evacuation point, economic constraints, appropriate travel distance/time, maximum coverage and population capacity) to guide the planning of earthquake evacuation shelters using an iterative solution method to the multi-criteria model based on GIS.

In this study, the problem of determining the most suitable temporary shelter areas for disaster management was discussed. 15 criteria were selected and Analytical Hierarchy Process (AHP) was used to determine the criteria weights. The Multi-Criteria Decision Analysis (MCDA), which is used extensively in location selection problems (Doerner et al., 2009; Nobre et al., 2009; Reubens et al., 2011) and others (Kavzoglu et al., 2014; Shokati et al., 2016), was used together with GIS to decide suitable temporary shelter areas in Gölcük.

2. STUDY AREA AND DATA

In the study, the most suitable temporary shelter areas were determined in the Kocaeli/Gölcük by the MCDA. Gölcük is located on the southern coast of the Gulf of Izmit and towards the east of the Gulf, with a width of up to 2 km. The town area has approximately 228 km^2. Figure 1 shows the study area.

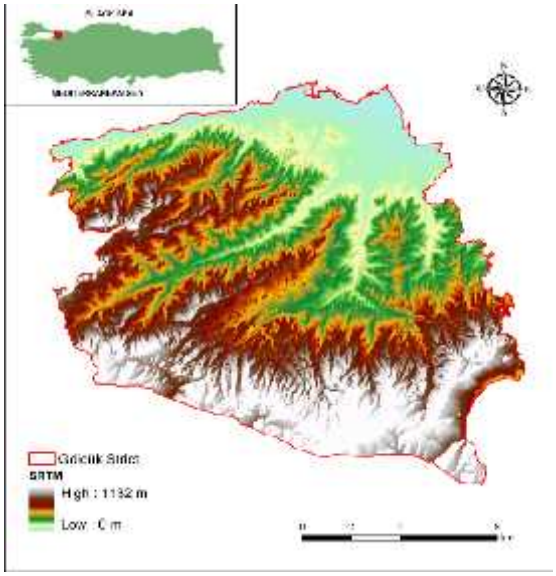

Figure.1 The study area

Table 1 shows the type, scale and product year of the data used for the criteria. The criteria details were generally obtained from the CAD data and digital maps. The land slope was produced from ASTER Global DEM data. Especially, the CAD data is constantly updated by the Gölcük Municipality.

Table 1 Type, scale and year of the data

Map	Type	Scale	Year
Plan	CAD	1/1000	2016
	Fuel stations and flammable material storage		
	Road networks		
	Security centers		
	Existing buildings		
	Electricity transmission line		

	Medical centers		
	Polluting industries		
	Cultural heritage		
	Water supply		
	Electrical supply		
Land slope	ASTER Global DEM	30m	2015
Fault	Vector map	1/5000	2010
Landslide	Digital Map	1/25000	2002
Geology	Digital Map	1/25000	2000
Flood	Digital Map	1/5000	2010

3. METHOD AND ANALYSIS

It is important to consider alternatives for decision makers in multi-criteria decision analysis, to rank alternatives according to their importance, and to choose the one with the highest priority among alternatives for decision making (Jahanshahloo et al., 2006). Figure 2 shows the work flow steps of the analysis for the study. In this study initially, 15 criteria were determined by considering literature search, the mutual interviews with the disaster experts and priorities of the Gölcük town. The spatial and attribute data for the criterions were obtained from digital maps and satellite images. The accuracy and reliability of the data were tested during the selection data. It has been taken into consideration that spatial data were generated in the same coordinate system and close accuracy. In addition, the attribute data has been confirmed by metadata's or consultation with organization authorities.

Vector maps of each criterion were transformed to raster format with 10x10m cell size by various spatial analyses (distance analysis, density analysis, slope analysis, view analysis, buffer analysis, etc.). Analyses were made with the aid of ArcGIS, QGIS, and ERDAS. The raster format maps obtained as a result of the spatial analysis were classified according to pre-determined conditions. The classification process was based on a range of 0-5 points. All raster maps were classified at the same scale, the classification was completed by giving the highest score (5) for the most suitable conditions and the lowest score (0) for the unsuitable conditions.

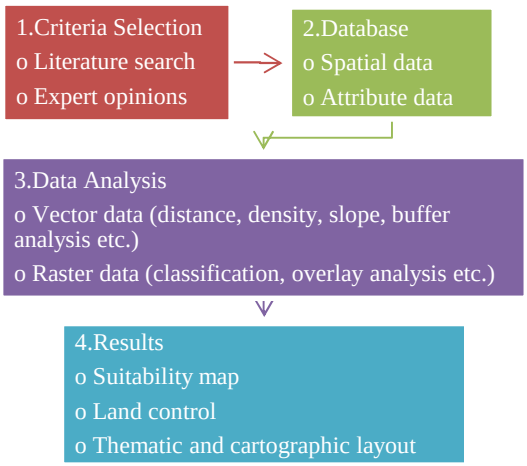

Figure.2 The workflow of the analysis

Determination of the weights of the criteria is another important part of the MCDA. At this stage, it is necessary to take advantage of previous experiences and expert opinions. However, since expert opinions often produce subjective results, it is important that the decisions made are confirmed by multiple decision-making analyses, such as the Analytic Hierarchy Process (AHP). The AHP was first proposed by Myers and Alpert in 1968 and developed in 1977 as a model by Saaty to solve decision-making problems (Myers and Alpert, 1968; Saaty, 1977). AHP is a method of decision-making and estimation that gives percentage distributions of decision points in terms of factors affecting the decision, which are used when the decision hierarchy can be defined. The AHP holdouts a benchmark on a decision hierarchy, using a pre-defined comparison scale, factors that influence decision making and, the significance of decision points in terms of these factors. Thus, the differences in importance are transformed into percentages on the decision points. Criterion weights were determined using the AHP method from surveys conducted by experts on disaster.

Table 2 shows the criteria's, analysis methods, classification methods, classification intervals, class points and criterion weights. In addition, Figure 3 shows the 15 classified raster maps used in the overlay analysis.

Table 2 Criteria, analysis, classification method, classification interval, class points and criterion weights

Criteria	Analysis Method	Classification Method	Classification Interval*	Class Point	Criterion Weight
Suitable distance from fuel stations and flammable material storage areas	Distance (Straight Line)	Manuel	0 - 30 30 - 14883.24	0 5	0.13 (%13)
Proximity to road networks	Distance (Straight Line)	Natural breaks	0 - 513.89 513.89 - 4396.46 4396.46 - 8279.04 8279.04 - 12161.61 12161.61 - 14938.76	5 4 3 2 1	0.05 (%5)
Proximity to security centers	Distance (Straight Line)	Natural breaks	0 - 836.28 836.28 - 4119.37 4119.37 - 7402.46 7402.46 - 10685.55 10685.55 - 13036.58	5 4 3 2 1	0.03 (%3)

Suitable distance from existing buildings	Distance (Straight Line)	Manuel	0 - 30 30 - 7000	0 5	0.09 (%9)
Land slope	Reclassification	Natural breaks	0% - 8.01% 8.01% - 15.75% 15.75% - 23.49% 23.49% - 31.51% 31.51% - 70.76%	5 4 3 2 1	0.04 (%4)
Suitable distance from electricity transmission line	Distance (Straight Line)	Manuel	0 - 30 30 - 13004.99	0 5	0.09 (%9)
Suitable distance from fault lines	Distance (Straight Line)	Manuel	0 - 500 500 - 1000 1000 - 5000 5000 - 7500 7500 - 13000	1 2 3 4 5	0.04 (%4)
Suitable distance from landslide risk areas	Reclassification	Manuel	Low-Risk Area Risk Area High-Risk Area No Risk	3 2 1 5	0.13 (%13)
Geological structure	Reclassification	Manuel	Soft Rock Hard Rock Firm Soil Alluvium	4 5 3 1	0.05 (%5)
Proximity to medical centers	Distance (Straight Line)	Natural breaks	0 - 1273.33 1273.33 - 3017.78 3017.78 - 5407.68 5407.68 - 8681.82 8681.82 - 13167.38	5 4 3 2 1	0.11 (%11)
Suitable distance from polluting industries	Distance (Straight Line)	Manuel	0 - 250 250 - 20000	0 5	0.06 (%6)
Suitable distance from cultural heritage areas	Distance (Straight Line)	Manuel	0 - 500 500 - 13500	0 5	0.02 (%2)
Proximity to water supply	Distance (Straight Line)	Manuel	0 - 1000 1000 - 3000 3000 - 5000 5000 - 7500 7500 - 13500	5 4 3 2 1	0.07 (%7)
Suitable distance from flood areas	Reclassification	Manuel	Flood Risk No Flood Risk	0 5	0.06 (%6)
Proximity to electrical supply	Distance (Straight Line)	Manuel	0 - 500 500 - 1500 1500 - 4000 4000 - 10000 10000 - 15000	5 4 3 2 1	0.04 (%4)

* The unit of distance is the meter.

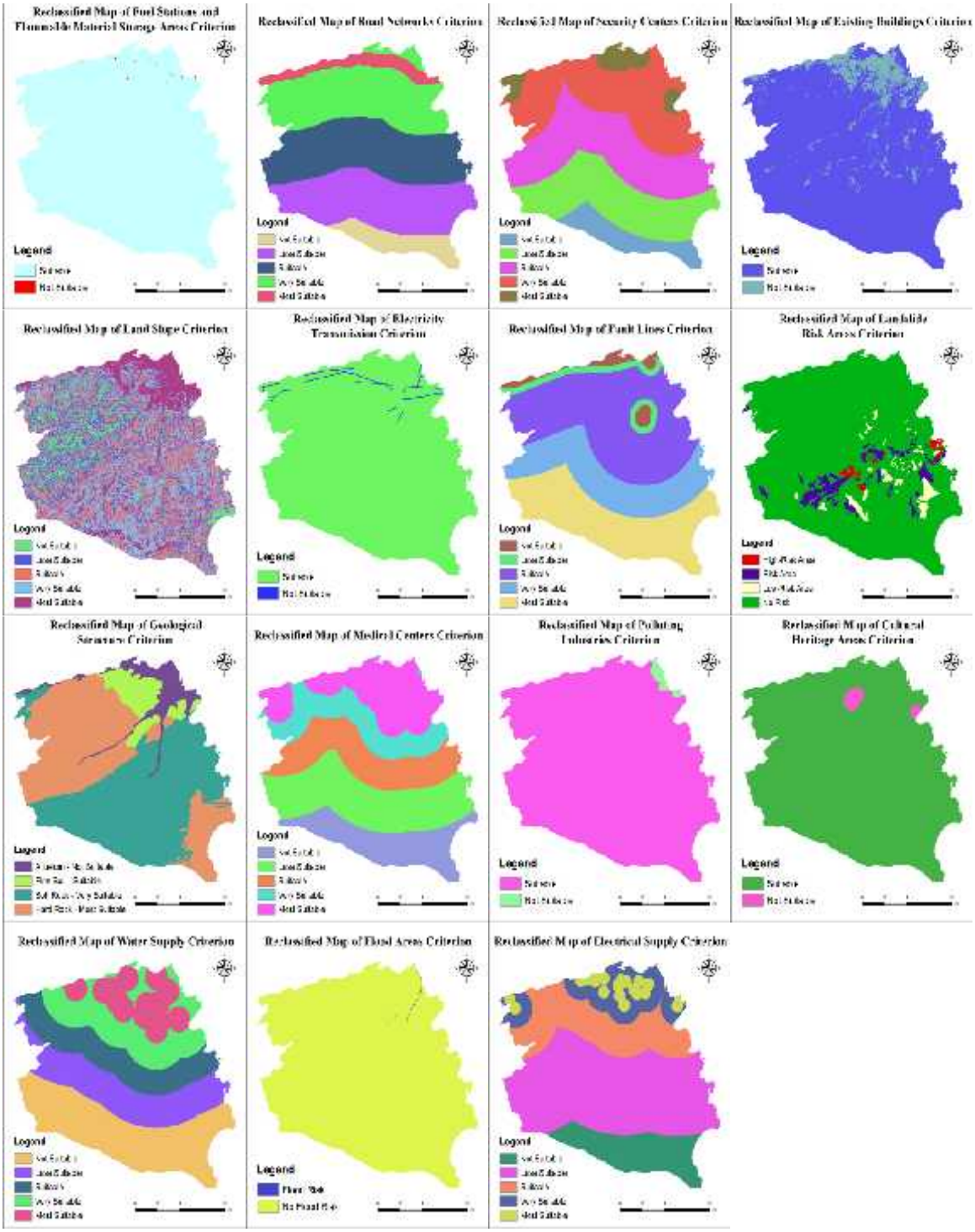

Figure.3 Classified raster maps of criteria

Classified and weighted maps were combined with the help of overlay analysis to obtain a suitable areas result map. Weighted sum method was applied in overlay analysis. In the weighted sum based overlay analysis, the total scores of the cells for the result map were determined by multiplying the scores given to each cell by the weight values in the maps classified in the same cell dimensions. In most cases, the result map was categorized so that each class was considered to be not suitable, less suitable, suitable, very suitable, and most suitable.

In Figure 4, the suitability map of temporary shelter areas in Gölcük was showed. As a result of the overlay analysis, not suitable, less suitable, suitable, very suitable and most suitable areas were classified and colored as red, orange, light green, light blue and blue, respectively. The result map coordinate system is WGS84 UTM Zone 35N. Figure 3 depict that the most suitable areas are located in the north and northwest of

the Gölcük town where the population is more intense. In Table 3, the size of classified regions was showed. According to the Sphere Project, which is based on the Humanitarian Charter Convention, international humanitarian principles and conditions, the human rights convention, the Refugee Law, the International Committee of the Red Cross (ICRC) and NGO law, the per capita area including infrastructure services are defined as 45 m^2. By 2016, the population of the Gölcük is 156,901 with reference to Turkish Statistical Institute. Accordingly, temporary shelter area of approximately 7.06 km^2 is needed in Gölcük. This demand can be supplied with the most suitable and very suitable areas.

Table 3 Size of classified regions

Class	Area size (km^2)	Area size (%)
Not suitable	17.79	7.9
Less suitable	63.28	28.1
Suitable	104.28	46.4
Very suitable	36.46	16.2
Most suitable	3.17	1.4
Total	224.98	100

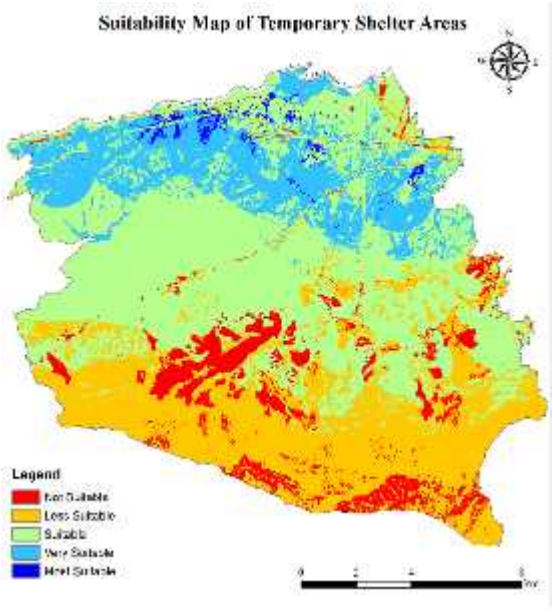

Figure. 4 The suitability map of temporary shelter areas

The selected temporary shelter areas in Gölcük town are shown in Figure 5. 243.900 m^2 of temporary shelter is selected by a manual process from the most and very suitable areas within the boundary of the Gölcük.

Figure. 5 Selected temporary shelter areas in Gölcük town

4. CONCLUSION

This study has contributed to the Gölcük district be more prepared against disasters that might occur in the future. This study has critical importance for quickly routing the victims to the temporary shelter areas, minimizing the potential losses, completing the professional teamwork in a more comfortable way, avoiding disappearances and intervention of the health care teams to the injured people in a fastest way. For this purpose, suitability map of shelter areas was obtained by GIS technology. A multi-criteria decision process was applied and the criteria weights were determined by the analytical hierarchical process to obtain more accuracy results. According to suitability map, the most suitable areas are located in the north and northwest of the Gölcük town. Especially in the southern, where people are infrequently populated, there are not suitable places for temporary

shelter areas. Specified regions indicate the probability of alternatives being the best decision.

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VALUATION OF RESIDENCES THROUGH UTILIZING RATIO OF INTEGRATED CAPITALISATION

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ABSTRACT: Right after the Second World War, determining the value of real properties gained importance in the countries, in which citizens had the right for real property possession. As for our country, importance of evaluating real estates noticed in late 1990's. Now in Turkey, evaluation is the only method for the determining of the market value of real properties used by private and public sector.

Today, several methods have been used for evaluating real properties. One of them is the ratio of integrated capitalisation within income method. This method provides quite fast and accurate results for bankers, real estate consultants and judicial system operating in related market.

Through using this method, evaluation of the residences in a region, located in Centre District, Province of Erzincan is aimed. Selling and renting values have been researched for integrated capitalisation ratios in evaluation of residences located in project field. Through utilizing integrated capitalisation ratios; market values of the residences, located in project field and whose revenues are known, can be determined. In the same way, through utilizing related ratio, current rental values of residences located in project field and whose selling values are known can be determined.

Keywords: *Valuation, Integrated Capitalisation, Income Method, Capitalisation Rate*

1. INTRODUCTION

Nowadays, real properties are also regarded as an investment tool along with human's basic needs like shelter and trade. Being valuable, originated from ownership and ownership originated rights of real properties used for living and trade purposes, requires a need for determination of real properties' possible trade values.

Properties which are not possible to move one place to another and fixed in current location like land, building site and building (house/flat/residence, apartment, factory/plant/facility etc.) are called real properties/estates.

As for evaluation of real properties; it means to determine the value of a real property in a definite time objectively, independently and neutrally by evaluating agents related to real property like characteristic, utility, neighbourhood, using conditions.

It comprises independent and neutral evaluation of possible value of a real property, a real property project or rights and benefits originating from a real property in a definite time (UDES).

It is the prediction of defined value in evaluation date of a real property, a real property project or real rights based on independent, neutral and unbiased criteria (Çağdaş, 2012).

According to Capital Market Committee, evaluation; "is to independently and neutrally determine possible value of a real property, a real property project or rights and benefits originating from a real property in a definite time.

2. METHODS FOR VALUATION OF REAL PROPERTY

Real properties can be evaluated one of three widely used evaluation methods. These three main methods have also sub-groups. These sub-groups are;

a) Comparison,
b) Income,
c) Cost

Purpose of the comparison methods to evaluate related real property through analysis of comparable sample real properties. Urban area and development data are basic comparison criteria. Fort this reason, samples and building sites whose values will be determined should be in the same region and possess same characteristic and similar development data.

To sum up, It means to determine the current value by comparing realised sales outcomes. Method can be especially applied for unconstructed parcels or partly constructed parcels. It requires getting generally attainable information from land registers, sale contracts, building contracts in which flat(s) or floor(s) is given in return to landowner, Chamber of Real Estate Agents' Lowest Price Lists, Capital Market Committee Registrations, National Property sales and loan agreements (Ertaş 2015).

Parcels should be appropriate with each other compared to location, quality, density and price levels. So, basically, according to similarities of fundamental data, a price comparison is realised. Considering the evaluations mentioned above, features of evaluating and comparing parcels are written down suggested norm table.The point not to be forgotten is that, parcel qualities should indicate adequate similarities with each other.

Basis of income method in a constructed parcel is the net income that can be acquired continuously from land and its building facilities. Because of limited using period of a building and unlimited using period of land; while turning net revenue into money, its equivalent to

a) Ground,
b) Building and
c) Additional facilities

is separated. Principally, value of ground is determined by "comparison method" (Köktürk ve ark).

Income Method is appropriate for evaluation of constructed parcels and rental revenue getting buildings like apartments, stores and office blocks by preference. Income isn't equal to the gross rental value's money equivalent. Income Method is also quite sensitive in letting predictions. Expert should be experienced to be able to decide usual rental value in a neighbourhood by utilizing related method.

In income value determining;

a) Construction year and economic using period,
b) Gross and net amount of revenue,
c) Square meter prices of each floors,
d) Sum of residential/housing areas

should be carefully designated.

As for Cost Method, it's appropriate for detached or semi-detached buildings/houses, industrial facilities and public buildings.

Object (cost) value= ground value + building (production along with additional facilities and business properties) value- technical deterioration (originating from functional or economic deterioration) value losses.

Production cost, by using building indexes, can be converted into evaluation date values. Value losses sourced by aging depend on remaining using period of building facilities. Building object value, production expenses and remaining economic using period are crucial. Ground value is depended on construction permission given according to development plan and related act & regulations. It is also depended on regional location, traffic condition, infrastructure expenditures and using opportunities.

3. COMPARISON METHOD WITH RATIO OF INTEGRATED CAPITALISATION

Capitalisation Ratio is defined as the ratio that turns real properties annual net operating income into market value. As for integrated capitalisation ratio, it's determined through dividing highly similar real properties' (land + building + equipment's) net income by sale price in local market (Ertaş, 2016).

Integrated capitalisation is calculated through dividing highly similar real properties' net incomes by sale values in local market (1).

$$k_{büt} = \left(\frac{\frac{G_1}{D_1} + \frac{G_2}{D_2} + ... + \frac{G_n}{D_n}}{n} \right) \quad (1)$$

correlation is taken into consideration. When this correlation is divided into its compounds (land + building + equipment's), correlation no. (2) is obtained.

$$k_{büt} = k_a \frac{D_a}{D_{taş}} + k_y \frac{D_y}{D_{taş}} = \frac{G_{tnet}}{D_{taş}} \quad (2)$$

Comparison Method by utilizing integrated capitalisation ratio is applied by using comparable real properties' sale and net income values that are similar compared to building type and its age, type of residence, using type, its location, etc. Firstly, real properties are classified according to various qualities. Applying for each class separately, classified real properties' net income and sale values are examined. By using obtained data, real properties' capitalisation ratios are calculated and their means are solved. So, mean ratio for the related class is determined. This ratio provides us to evaluate similar real properties without dividing them into their compounds.

Net income is calculated by 3 correlations.

$$D_{knet} = D_{kyıl} - ZG_{kira} \quad (3)$$

4. APPLICATIONS

By utilizing determined integrated capitalisation ratio of similar residences located in Project field (Map 1) composed of a part of Yavuz Selim Neighbourhood, Province of Erzincan, Centre District, and small part of Demirkent Municipality; evaluation of other real properties in the same region is aimed.

Map 1 Project Field

Determining market value of real properties are required for a great many of transactions like loan, mortgage, tax, trade, renting, nationalization. So, fair evaluation of real properties to preserve the rights of related parties has a great importance. In evaluation process, preferred method and considered objective values are formed the first procedure steps to determine real value of properties. In practice, reason for preference of comparison method with integrated capitalisation ratio is that almost all residences located in project field are highly similar buildings with each other.

This method cannot be used when there is no measurable data available.

Gathering Data

Essential data for evaluation are gathered by utilizing survey table shown in Table 1. Renting value, sale value / time, age, data shown under the title of isolation, real properties' owners, inhabitants shown in prepared table are obtained by statements of local real estate agents.

Table 1 Survey Table (including information of real property)

Flat			**Building No:**
Area(m²)	**Rental Value(TL)**	**Sale Value/Year**	**Construction Type** ☐ Carcass ☐ Masonry ☐ Wooden ☐ Prefabricated
Age			
Floor No ☐ Ground ☐ Top ☐ Intermediate	**Isolation** ☐ Present ☐ Absent	**Frontage** ☐ East ☐ West ☐ North ☐ South	**Residence Type** ☐ Detached ☐ Housing Estate ☐ Apartment
Numberof Floor	**Road Width (m)**	**Parking/ Garage** ☐ Present ☐ Absent	**Garden (m²)**
Closest Attraction Type	**Distance to Closest Attraction (m)**	**Location in Block** ☐ Corner ☐ Intermediate	**Landscape** ☐ Present ☐ Absent
Others			

Development plans obtained from related municipalities is evaluated in NETCAD program and data titles called as area, road width, garden, distance to closest attraction point are achieved shown in table. Data called as "Other" and shown under the related title in table is achieved from physical researchs in project field.

Over 150 data have been collected in the project area nevertheless data exceeding 10% of the average value are eliminated and only 120 data were used.

A separate table is prepared for every flat, located in project field, which forms data for evaluation study. Buildings located in project field and their flats are numbered according to cadastre parcel number principles after connecting with municipality development plans (Map 2).

Map 2 Residences in Project Field (in numbered condition)

While calculating capitalisation ratio of similar real properties located in Project Field; last five year's selling values and current rental values of real properties are used. Sales in 2016 are accepted as sales in April, sales before 2016 are accepted as sales in June of related years. Consumer Price Index (TÜFE) is applied for updating sale prices related to the sales realised before 2016.For the reason that urbanization and planning processes have not been completed yet in our country, real property value increases more than TÜFE Index. For this reason, TÜFE index of 2016 is taken into consideration and its weight is reduced throughout past years. Last five years are studied to diminish possible faults. In updating calculation, correlation no.4 is used in coefficient of weight.

$$p = \frac{1}{2016 - yıl} \qquad D_{sgd} = D_s . p \qquad (4)$$

4.2 Calculating Data

Similar real properties located in Project Field, firstly regarding their location (intermediate parcel and corner parcel), then regarding their floor (ground floor, intermediate floor, top floor), are classified. Integrated capitalisation ratio of each class is calculated separately.

Table 2 Ground Floor – Corner Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,1	2190/4	2	152	9900	9306	61,22	155 000	2013	193 213,53	179 688,58	1 182,16	5,179	G - D	Kş.	SM – 260
S,2	2146/5	2	175	9900	9306	53,18	170 000	2014	194 123,19	180 534,56	1 031,63	5,155	G - D	Kş.	ÇOP – 20
S,6	2147/1	1	155	8880	8347,2	53,85	158 000	2014	180 420,37	167 790,95	1 082,52	4,976	B - K	Kş.	ÇOP – 90
S,8	2087/1	2	162	9000	8460	52,22	163 000	2014	186 129,88	173 100,79	1 068,52	4,887	K - B	Kş.	O – 270
S,8	2087/4	1	162	8760	8234,4	50,83	146 000	2013	181 994,68	169 225,05	1 044,78	4,865	D - G	Kş.	O – 200
S,10	2085/1	1	156	8400	7896	50,62	175 000	2016	175 000,00	162 750,00	1 043,27	4,852	B - K	Kş.	O – 80
S,11	2015/5	1	167	11 400	10 716	67,17	206 000	2014	235 231,63	218 765,41	1 309,97	4,898	D - G	Kş.	PYA – 10
S,12	2022/10	1	149	8400	7896	52,99	145 000	2014	165 575,66	153 985,36	1 033,46	5,128	G - B	Kş.	C – 30
S,14	D,106/3	1	160	9600	9024	56,4	166000	2014	189 555,58	176 286,69	1 101,79	5,119	G - B	Kş.	SM – 225
S,15	1858/5	1	131	9000	8460	64,58	171 000	2015	182 142,58	169 392,60	1 293,07	4,994	G - B	Kş.	PYA – 5
S,16	1584/1	2	100	4800	4512	45,12	72 000	2014	82 216,88	76 461,70	764,62	5,901	D - K	Kş.	PYA – 75
S,16	1586/5	1	100	4680	4399,2	43,99	73 000	2014	83 358,78	77 523,67	775,24	5,675	K - D	Kş.	PYA – 70
S,17	2190/1	3	153	9300	8742	57,14	195 000	2016	195 000	181 350	1 185,29	4,821	K - B	Kş.	PYA – 10
S,17	2190/5	1	153	9600	9024	58,98	190 000	2015	202 380,64	188 214,00	1 230,16	4,795	G - B	Kş.	SM – 200
A,4	2088/1	1	100	8400	7896	78,96	175 000	2016	175 000	162 750	1 627,50	4,852	G - B	Kş.	PYA – 3
AVR.			145	8668	8148	56,28	157333,3		174756,23	162521,29	1118,27	5,073			

Table 3 Ground Floor – Intermediate Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,1	1591/1	1	152	9000	8460	55,66	170 000	2015	181 077,42	168 402	1 107,91	5,024	K - D	Ar.	SM – 245
S,1	1591/3	2	152	9600	9024	59,37	178 000	2015	189 598,71	176 326,81	1 160,04	5,118	G - D	Ar.	SM – 270
S,1	2190/2	1	152	9300	8742	57,51	149 000	2013	185 734,30	172 732,89	1 136,40	5,061	G - B	Ar.	SM – 210
S,1	2190/3	1	152	9300	8742	57,51	148 000	2013	184 487,76	171 573, 61	1 128,77	5,095	G - B	Ar.	SM – 235
S,2	2146/7	2	175	9000	8460	48,34	171 000	2015	182 142,58	169 392,60	967,96	4,994	G - D	Ar.	ÇOP – 30
S,4	D,1840/1	1	161	8400	7896	49,04	150 000	2014	171 285,17	159 295,20	989,41	4,957	K - D	Ar.	C – 250
S,4	D,1840/3	1	161	8520	8008,8	49,74	140 000	2013	174 515,45	162 299,36	1 008,07	4,935	K - D	Ar.	C – 280
S,5	1858/2	2	172	7200	6768	39,35	100 000	2011	146 969,37	136 681,52	794,66	4,952	G - D	Ar.	SM – 300
S,5	1858/3	1	172	7200	6768	39,35	115 000	2013	143 351,97	133 317,33	775,10	5,077	G - B	Ar.	SM – 320
S,5	2016/1	1	172	6960	6542,4	38,04	104 000	2012	140 396,95	130 569,17	759,12	5,011	D - G	Ar.	SM – 290
S,5	2016/4	2	172	7080	6655,2	38,69	125 000	2014	142 737,64	132 746,00	771,78	5,013	B - G	Ar.	O – 340
S,5	2016/5	2	172	7200	6768	39,35	110 000	2012	148 496,78	138 102,00	802,92	4,901	B - G	Ar.	O – 350
S,5	2016/9	2	172	6900	6486	37,71	110 000	2013	137 119,28	127 520,93	741,40	5,086	D - K	Ar.	SM – 350
S,5	2016/10	1	172	6960	6542,4	38,04	115 000	2013	143 351,97	133 317,33	775,10	4,907	D - G	Ar.	SM – 340
S,6	2147/7	1	155	8400	7896	50,94	120 000	2011	176 363,25	164 017,82	1 058,18	4,814	B - K	Ar.	ÇOP – 150
S,6	2147/8	2	155	8700	8178	52,76	145 000	2013	180 748,14	168 095,77	1 084,49	4,865	B - G	Ar.	ÇOP – 120
S,8	2087/2	1	162	8700	8178	50,48	135 000	2012	182 246,04	169 488,82	1 046,23	4,825	K - D	Ar.	O – 240
S,8	2087/6	1	162	8400	7896	48,74	140 000	2013	174 515,45	162 299,36	1 001,85	5,074	B - K	Ar.	O – 280
S,9	2021/1	2	200	9600	9024	45,12	162 000	2013	201 939,30	187 803,55	939,02	4,805	G - D	Ar.	C – 230
S,9	2021/3	2	200	9900	9306	46,53	155 000	2012	209 245,46	194 598,28	972,99	4,782	G - D	Ar.	C – 300
S,9	2021/8	2	200	10560	9926,4	49,63	194 000	2014	221 528,81	206 021,80	1 030,11	4,818	G - D	Ar.	PYA – 10
S,9	2022/5	1	200	9600	9024	45,12	166 000	2013	206 925,46	192 440,67	962,20	4,690	G - B	Ar.	C – 180
S,11	2015/4	2	167	10 800	10 152	60,79	185 000	2013	230 609,70	214 467,02	1 284,23	4,734	B - G	Ar.	PYA – 10
S,12	2022/10	2	149	8160	7670,4	51,48	127 000	2013	158 310,44	147 228,71	988,11	5,210	G - B	Ar.	C – 30
S,13	2086/1	2	100	6300	5922	59,22	111 000	2014	126 751,02	117 878,45	1 178,78	5,024	G - D	Ar.	O – 130
S,13	2086/3	1	100	6600	6204	62,04	117 000	2014	133 602,43	124 250,26	1 242,50	4,993	G - B	Ar.	O – 130
S,14	D,105/4	1	160	9000	8460	52,88	165 000	2015	175 751,61	163 449,00	1 021,56	5,176	G - B	Ar.	SM – 120
S,14	D,105/7	2	160	8820	8290,8	51,82	150 000	2014	171 285,17	159 295,20	995,60	5,205	G - D	Ar.	SM – 130
S,15	1858/7	1	131	7800	7332	55,97	153 000	2015	162 969,67	151 561,80	1 156,96	4,838	G - B	Ar.	SM – 260
S,16	1586/8	1	100	4620	4342,8	43,43	77 000	2015	82 017,42	76 276,20	762,762	5,694	D - G	Ar.	PYA – 20
A,6	1584/7	1	114	6600	6204	54,42	110 000	2013	137 119,28	127 520,93	1 118,60	4,865	G - B	Ar.	O – 25
A,6	2085/6	2	112	7200	6768	60,43	135 000	2015	143 796,77	133 731,00	1 194,03	5,051	B – G	Ar.	O – 110
A,7	1584/3	1	132	7800	7332	55,55	160 000	2016	160 000	148 800	1 127,27	4,927	B – K	Ar.	O – 150
A,8	1858/1	1	162	10800	10152	62,67	187 000	2014	213 535,51	198 588,02	1 225,85	5,112	K - D	Ar.	SM – 250
AVR.			156,8	8264,12	7768,27	50,23	140559		168250,77	156473,22	23420,86	4,989			

Table 4 Intermediate Floor(s) – Corner Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,1	2190/4	4	152	10440	9813,6	64,56	168 000	2013	209 418,53	194 759,24	1 281,31	5,039	G - D	Kş.	SM – 260
S,2	2146/1	3	175	9600	9024	51,57	186 000	2015	198 119,99	184 251,60	1 052,87	4,898	G - B	Kş.	ÇOP – 10
S,3	2145/1	3	181	10200	9588	52,97	172 000	2013	214 404,69	199 396	1 101,64	4,808	G - B	Kş.	O – 60
S,5	2016/7	3	172	9000	8460	49,19	145 000	2013	180 748,14	168 095,77	977,30	5,033	G - B	Kş.	PYA – 3
S,6	2145/6	3	155	9600	9024	58,22	183 000	2015	194 924,51	181 279,80	1 169,55	4,978	G - B	Kş.	ÇOP – 55
S,6	2147/1	3	155	9420	8854,8	57,13	171 000	2014	195 265,09	181 596,53	1 171,59	4,876	B – K	Kş.	ÇOP – 90
S,7	2147/5	4	188	12000	11280	60	200000	2014	228 380,22	212 393,60	1 129,75	5,311	B – K	Kş.	PYA – 5
S,8	2087/4	3	162	9900	9306	57,44	185 000	2015	202 380,64	188 214,00	1 161,81	4,944	D – G	Kş.	O – 200
S,9	2021/7	4	200	10800	10152	50,76	201 000	2015	214 097,41	199 110,59	995,55	5,099	G - D	Kş.	PYA – 10
S,10	2085/1	3	156	9600	9024	57,85	169 000	2014	192 981,29	179 472,60	1 150,46	5,028	B – K	Kş.	O – 80
S,13	2086/1	3	124	7800	7332	59,13	153 000	2015	162 969,67	151 561,80	1 222,27	4,838	G - B	Kş.	ÇOP – 115
S,14	D,106/3	4	160	10200	9588	59,92	209 000	2016	209 000	194 370	1 214,81	4,933	G - D	Kş.	SM – 250
S,15	1858/5	3	154	10800	10152	62,26	210 000	2015	223 683,87	208 026,00	1 350,82	4,880	G - B	Kş.	PYA – 5
S,17	2190/1	6	168	10560	9926,4	59,09	220 000	2016	220 000	204 600	1 217,86	4,852	K - B	Kş.	PYA – 10
S,17	2190/5	4	168	10800	10152	60,43	229 000	2016	229 000	212 970	1 267,68	4,767	G - B	Kş.	SM – 200
A,2	D,1885/5	2	140	9240	8685,6	62,04	184 000	2015	195 989,67	182 270,40	1 301,93	4,765	G - D	Kş.	M – 20
A,8	1858/1	4	162	11520	10828,8	66,84	203 000	2014	231 805,92	215 579,51	1 330,74	5,023	K - B	Kş.	SM – 250
AVR.			163	10087	9482	58,2	187529		206069	191644	1125,71	4,945			

Table 5 Intermediate Floor – Intermediate Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,1	1591/1	3	152	9900	9306	61,22	172 000	2014	196 406,99	182 658,50	1 201,70	5,051	K - D	Ar.	SM – 245
S,1	1591/3	4	152	10200	9588	63,08	186 000	2014	212 393,60	197 526,05	1 299,51	4,854	G - D	Ar.	SM – 270
S,1	2190/2	3	152	9840	9249,6	60,85	160 000	2013	199 446,22	185 484,99	1 220,30	4,987	G - B	Ar.	SM – 210
S,2	2146/4	3	175	9900	9306	53,18	176 000	2014	200 974,59	186 906,37	1 068,04	4,979	G - B	Ar.	ÇOP – 70
S,2	2146/5	4	175	10800	10152	58,01	205 000	2015	218 358,06	203 072,99	1 160,42	4,999	G - D	Ar.	ÇOP – 25
S,2	2146/6	3	175	9900	9306	53,18	184 000	2015	195 989,67	182 270,40	1 041,54	5,106	G - B	Ar.	ÇOP – 20
S,3	2145/3	3	181	9900	9306	53,18	156 000	2012	210 595,43	195 853,75	1 082,06	4,751	G - B	Ar.	O – 60
S,3	2145/5	3	181	10500	9870	54,53	180 000	2013	224 377,00	208 670,61	1 152,88	4,730	G - B	Ar.	ÇOP – 30
S,4	1840/2	3	161	9600	9024	56,05	185 000	2016	185 000	172 050	1 068,63	5,245	K - D	Ar.	O – 325
S,5	1858/3	4	172	7920	7444,8	43,28	152 000	2015	161 904,51	150 571,20	875 41	4,944	G - D	Ar.	SM – 320
S,5	2016/3	3	172	7800	7332	42,63	130 000	2013	162 050,06	150 706,55	876,20	4,865	B – K	Ar.	O – 300
S,5	2016/7	4	172	8760	8234,4	47,87	155 000	2014	176 994,67	164 605,04	957,01	5,002	G - D	Ar.	PYA – 3
S,5	2016/10	3	172	7800	7332	42,63	114 000	2012	153 896,66	143 123,89	832,12	5,123	D - G	Ar.	SM – 340
S,6	2147/7	3	155	9300	8742	56,40	190 000	2016	190 000	176 700	1 140	4,947	B – K	Ar.	ÇOP – 150
S,6	2147/8	3	155	9240	8685,6	56,04	168 000	2014	191 839,38	178 410,63	1 151,04	4,868	B – K	Ar.	ÇOP – 120
S,7	2147/4	4	168	10200	9588	57,07	203 000	2016	203 000	188 790	1 123,75	5,079	D – K	Ar.	ÇOP – 30
S,8	2087/6	4	162	9600	9024	55,70	192 000	2016	192 000	178 560	1 102,22	5,054	B – G	Ar.	O – 280
S,9	2021/10	3	200	9600	9024	45,12	192 000	2016	192 000	178 560	892,8	5,054	G - B	Ar.	ÇOP – 15
S,12	2022/1	4	149	9000	8460	56,78	175 000	2015	186 403,22	173 355,00	1 163,46	4,880	G - D	Ar.	C – 20
S,12	2022/2	4	149	8700	8178	54,89	160 000	2014	182 704,18	169 914,88	1 140,37	4,813	G - D	Ar.	C – 60
S,12	2022/4	3	149	8880	8347,2	56,02	175 000	2015	186 403,22	173 355,00	1 163,46	4,815	G - B	Ar.	C – 110
S,13	2086/3	3	124	7800	7332	59,13	125 000	2013	155 817,36	144 910,15	1 168,63	5,060	G - B	Ar.	ÇOP – 110

S,14	D,105/6	4	160	9720	9136,8	57,10	145 000	2012	195 745,75	182 043,55	1 137,77	5,019	G - D	Ar.	SM – 130
S,16	1587/4	3	100	5100	4794	47,94	88 000	2016	88 000	81 840	818,4	5,858	B – K	Ar.	O – 150
A,3	D,1236/1	3	140	8400	7896	56,4	165 000	2015	175 751,61	163 449,00	1 167,49	4,831	K – D	Ar.	M – 15
A,5	1580/1	3	136	8100	7614	55,98	153 000	2015	162 969,67	151 561,80	1 114,42	5,024	K – D	Ar.	SM – 150
A,6	2085/6	3	135	7800	7332	54,31	150 000	2015	159 774,19	148 590,00	1 100,67	4,934	B – K	Ar.	O – 120
AVR.			158,3	9046,67	8503,87	54,02	164296,30		183733,19	170871,86	6852,83	4,995			

Table 6 Top Floor – Intermediate Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,2	2146/4	5	175	9780	9193,2	52,53	190 000	2016	190 000	176 700	1 009,71	5,203	G – B	Ar.	ÇOP – 70
S,3	2145/4	5	181	10440	9813,6	54,22	215 000	2016	215 000	199 950	1 104,70	4,908	G – B	Ar.	ÇOP – 25
S,3	2145/5	6	181	10200	9588	52,97	168 000	2013	209 418,53	194 759,24	1 076,02	4,923	G – D	Ar.	ÇOP – 30
S,5	2016/3	5	172	7500	7050	40,99	148 000	2015	157 643,87	146 608,80	852,38	4,809	B – K	Ar.	O – 300
S,6	2147/8	5	155	9120	8572,8	55,31	187 000	2016	187 000	173 910	1 122	4,929	B – K	Ar.	ÇOP – 120
S,8	2087/2	5	162	9600	9024	55,70	153 000	2013	190 720,45	177 370,02	1 094,88	5,088	K – D	Ar.	O – 240
S,9	2021/5	5	200	9780	9193,2	45,97	167 000	2014	190 697,48	177 348,66	886,74	5,184	G – B	Ar.	C – 335
S,9	2021/7	5	200	11040	10377,6	51,89	216000	2016	216000	200 880	1004,40	5,166	G – B	Ar.	PYA – 10
S,9	2021/8	6	200	11160	10490,4	52,45	214 000	2015	227 944,51	211 988,39	1059,94	4,949	G – D	Ar.	PYA – 10
S,12	2022/4	6	149	8520	8008,8	53,75	154 000	2014	175 852,77	163 543,08	1 097,60	4,897	G – D	Ar.	C – 110
S,13	2086/1	6	124	7500	7050	56,85	146 000	2015	155 513,54	144 627,60	1 166,35	4,875	G – D	Ar.	ÇOP – 115
S,14	D,105/1	6	160	9600	9024	56,4	140 000	2012	188 995,90	175 766,18	1098,54	5,134	G – D	Ar.	SM – 140
S,15	1858/7	6	154	8700	8178	53,10	165 000	2015	175 751,61	163 449,00	1 061,36	5,003	G – D	Ar.	SM – 260
S,16	1586/8	5	100	4680	4399,2	43,99	82 000	2016	82 000	76 260	762,6	5,769	D – G	Ar.	PYA – 20
AVR.			165	9116	8568,77	51,87	167500		183038,48	170225,78	1028,37	5,060			

Table 7 Top Floor – Corner Apartments

Sequence No	Block/ Building No	Apartment No	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	$D_{syıl}$	D_{sgd}	D_{snet}	D_{sbr}	k (%)	CY	AK	U_c (m)
S,1	1591/1	6	152	9900	9306	61,22	183 000	2015	194 924,51	181 279,80	1 192,63	5,133	K – B	Kş.	SM – 245
S,1	1591/3	5	152	10200	9588	63,08	184 000	2014	210 109,80	195 402,12	1 285,54	4,907	G - B	Kş.	SM – 270
S,1	2190/4	6	152	10320	9700,8	63,82	182 000	2014	207 826,00	193 278,18	1 271,57	5,019	G – D	Kş.	SM – 260
S,5	2016/8	5	172	8700	8178	47,55	185 000	2016	185 000	172 050	1000,29	4,753	G – B	Kş.	PYA – 3
S,6	2145/6	5	155	9420	8854,8	57,13	170 000	2014	194 123,19	180 534,56	1 164,74	4,905	G – B	Kş.	ÇOP – 55
S,17	2190/1	9	168	10500	9870	58,75	225 000	2016	225 000	209 250	1 245,54	4,717	K – B	Kş.	PYA – 10
A,1	1584/7	11	136	7800	7332	53,91	122 000	2013	152 077,74	141 432,30	1 039,94	5,184	K – D	Kş.	O – 25
A,5	1580/1	6	136	7920	7444,8	54,74	150000	2015	159 774,19	148 590,00	1 092,57	5,010	K – B	Kş.	SM – 150
AVR.			153	9345	8784,30	57,53	175125		191104,43	177727,12	1161,60	4,954			

In this way, integrated capitalisation ratio of flats in seperate locations is calculated.

$$D_{knet} = D_{kyıl} - ZG_{kira} \quad (5)$$

$$D_{snet} = D_{sgd} - ZG_{satış} \quad (6)$$

$$D_{sgd} = D_s\left(\frac{TFER}{TFER_s}\right) \quad (7)$$

$$D_{kbr} = \frac{D_{knet}}{F} \quad (8)$$

$$D_{sbr} = \frac{D_{snet}}{F} \quad (9)$$

$$k = \frac{D_{knet}}{D_{snet}} \quad (10)$$

5. CONCLUSION

Similar residences' integrated capitalisation ratios located in project field calculated as in Table 8, utilizing correlations from 5 to 10

Table 8 Residences Arranged According to Their Locations (with respect to unit rental andselling values)

Location	F (m^2)	$D_{kyıl}$	D_{knet}	D_{kbr}	D_s	D_{sgd}	D_{snet}	D_{sbr}	k (%)	Index Rent	Index Sale
Ground-Intermediate	157	8264,12	7768,27	50,23	140559	168250,77	156473,22	996,64	4,989	100,00	100,00
Top Flat-Intermediate	165	9116	8568,77	51,87	167500	183038,48	170225,78	1031,67	5,060	103,26	103,51
Intermediate Flat-Intermediate	158	9046,67	8503,87	54,02	164296,30	183733,19	170871,86	1081,47	4,995	105,55	108,51
Ground-Corner	145	8668	8148	56,28	157333,3	174756,23	162521,29	1120,84	5,073	112,04	112,46
Top Flat-Corner	153	9345	8784,30	57,53	175125	191104,43	177727,12	1161,60	4,954	114,53	116,55
Intermediate Flat-Corner	163	10087	9482	58,2	187529	206069	191644	1175,71	4,945	115,87	117,97

Residences shown in table with respect to their locations are arranged according to Unit Sale (Dsbr) and Unit Rental (Dkbr) Values. When examining rental and selling indexes in last two columns of Table 8, following conclusions can be reached;

a) Unit Sale Valuesare always more than Unit Rental Values.
b) Because of first clause,increase rate of sale value is greater than increase rate of rental value.
c) In locational sequencing, residences located in the corner are more valuable than residences located in intermediate floors.
d) Thereare no considerable diferences among integrated capitalisation ratios.
e) Most valuable place among corner and intermediate located real properties is intermediate floor.
f) Value-based locational sequencing is Ground Floor Intermediate – Top Floor Intermediate – Intermediate Floor Intermediate–Ground Floor Corner – Top Floor Corner – Intermediate Floor Corner respectively.
g) Value of intermediate floor corner residence is about 18% more valuable than ground floor intermediate residance.

The k rates by the calculations can be used in similar characteristics areas.

By utilizing similar residences' determined integrated capitalisation ratio, sale values of residences located in project field whose renting revenues are knownand also renting values of residences whose sale prices are known can be determined. In order to calculate sale values

$$D_{satış} = \frac{G_{net}}{k_{büt}} \quad (11)$$

Correlation can be applied for determinig flats' sale values by utilizing flats' renting revenues.

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ABBREVIATIONS

A,1 : Apartment No:1
A,2 : Apartment No:2
A,3 : Apartment No:3
A,4 : Apartment No:4

A,5 : Apartment No:5
A,6 : Apartment No:6
A,7 : Apartment No:7
A,8 : Apartment No:8
A/B No: Block/Building Number
AK : Location in Block
Ar. : Intermediate
B : West
kbüt : IntegratedCapitalisation Ratio
C : Mosque
CY : Frontage
ÇOP : Playground
D : East
Dk : Rental Value (TL) / month
Dkbr : Unit Rental Value (TL)
Dknet : Annual Net Rental Value (TL) / year
Dkyıl : Annual Rental Value (TL) / year
D No: Flat Number
Dsyıl : SaleYear (TL)
Ds : Sale Value (TL)
Dsgd : Sale Value Updated according to Consumer Price Index (TL)
Dsbr : Unit Sale Value (TL)
Dsnet : Net Sale Value (TL)
F : Area m2
G : South
K : North
Kş. : Corner
k : Rental Capitalisation Ratio (%)
M : Market
O : School
ORT : Average
PYA : Park
S,1 : Housing Estate Number
S/A : Housing Estate/Apartment
SM : Supermarket
TFER : Consumer Price Index of April 2016
TFERS : Price Index of June of Sale's Year
Uc : Distance to Closest Attraction Point(m)
ZGkira : Compulsory Expenses to Renting (Real Estate Agent's Commission + Collection Difficulties + Real Estate Tax and Expenditures+ Permanent Equipment Expenses)= % 6
ZGsatış : Compulsory Expenses for Sale(Real Estate Agent's Commission + Sale Tax and Expenditures + Income Tax)= % 7

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ANALYSIS OF THE PEDESTRIAN ACCIDENTS IN TURKEY

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ABSTRACT:
This study summarizes the methods and findings of a study on pedestrian safety in Turkey. The analyses were conducted for individual provinces as well as for the country as a whole for the years from 2013 to 2015 using data maintained by the Turkish Statistical Institute. An examination of the national level results indicated that despite the equal distribution of women and men in national population, men constitute the 70% of the fatality in pedestrian accidents and 57% of the injuries. It was found that 65+ age group had the highest rate of accident involvement and fatality rates per million population. The lowest accident involvement rates were observed in the 25-64 age group, while the lowest fatality rates were observed in the 15-24 age group. Province level analysis provided a comparative analysis of pedestrian safety records across the 81 provinces. The comparisons were performed in relative terms. In this case study, pedestrian accident involvements and fatalities per million registered vehicle and population were used as the measures of exposure. Clustering analysis were performed to reveal some patterns based on geographic location of the provinces. The results showed that accident involvement and fatality rates per million population were not significantly clustered. Fatality rates per million registered vehicles were significantly clustered 90% confidence level and pedestrian accident involvement rates per million registered vehicles were significantly clustered 95% confidence level.

Keywords: *Pedestrian Accidents, Pedestrian Safety, Clustering Analysis*

1. INTRODUCTION

Pedestrians, the most vulnerable road users, should have a level of importance in traffic. Road traffic regulations primarily aim to achieve fast and uninterrupted traffic streams. This importance is ignored most of the time. According to the World Health Organization (WHO), approximately 275,000 pedestrians die annually in traffic accidents. This number corresponds to 22% of all fatalities caused by accidents (WHO, 2015). Previous studies have shown that pedestrian safety is an important problem, not only in developing countries, but also in developed countries (Zhu et al., 2013). Pedestrians constitute 26% of the accident fatalities in China, 16% in Germany, 47% in Honduras, 30% in Mexico, 39% in Romania, 23% in United Kingdom and 14% in the US (WHO, 2016).

In 2015, 1,810 pedestrians died and 34,720 pedestrians were injured in traffic accidents. Therefore, pedestrians constituted 24% of the fatalities by accident in Turkey (TurkStat, 2016a). Like many other countries, there is no data available to show the pedestrian mobility in traffic in Turkey. The pedestrian fatalities per billion vehicle-km should be calculated to make a reliable comparison between countries. However, as most of the pedestrian fatalities occur in urban roads, which do not publish vehicle-km values, the pedestrian fatality per billion vehicle-km may not be calculated in a reliable manner.

Therefore, the fatality rates of pedestrians in accidents is calculated using alternative measures. In 2015, 23 pedestrians for every million citizens died in traffic accidents in Turkey (TurkStat, 2016a; TurkStat, 2016b). The average rate of European Union (EU) countries is 11, however there are significant variations among countries. For example, while in the Netherlands, this rate is 3, in Germany it is 7, in Belgium 9, in Hungary 15, in Poland 29, in Latvia 35 and in Lithuania it is 37 (EC, 2016). It is 17 in the US (NHTSA, 2016). When the total number of pedestrians involved in traffic accidents are considered, 464 pedestrians per million population were involved in an accident in Turkey (TurkStat, 2016a; TurkStat, 2016b). In the US, 215 pedestrians per million population were involved in traffic accidents (NHTSA, 2016). For EU countries, the number of pedestrians involved in traffic accidents is not published.

When the literature is reviewed, studies regarding pedestrian safety in Turkey are limited. In the existing studies, the descriptive statistical analysis of pedestrian accidents were made (e.g. accident locations, date and time of the accidents, road type and environmental characteristics and driver errors) (Ozkan, 2002; Hoskal, 2006). In a recent study, pedestrian accidents occurred around bus stops in selected corridors of Ankara were examined and the factors effective in these accidents were investigated (Yuksekol, 2012). Additionally, there are studies, which review design problems of pedestrian facilities in the cities and the effects of such cases on the traffic safety (Kaplan et al., 2015; Caputcu et al., 2016).

There are no studies available in Turkey that analyses pedestrian safety by gender or age groups. Another research gap in pedestrian safety is the province level comparisons of the pedestrian safety. To fill these gaps in the literature, the first stage of this study examines pedestrian accident involvement and fatality rates that are calculated based on gender and age at the national level. In the second stage of the study, pedestrian accident involvement and fatality rates were calculated at the provincial level by using different measures of exposure. Then, clustering analyses were applied to investigate whether these rates are correlated to geographically or not.

2. METHODOLOGY

In Turkey, pedestrian accidents are being reported and kept by traffic police and gendarmerie departments based on the area of responsibility. The aggregate statistics of these accidents are published by the Turkish Statistical Institute (TurkStat). The statistics published by TurkStat, prior to 2013, only included the accidents that were the responsibility of police. The statistics after 2013 include the pedestrian accidents from police and gendarme areas. Additionally, Turkey has started to implement the recommended post-accident 30-day observation period at the international level since 2015. Therefore, while only the fatalities occurring at the accident locations were recorded prior to 2015, after 2015 any fatalities that occurred within 30 days of the accident were accepted as accidental fatalities and were represented that way in the statistics. According to statistics from 2015, 1,810 pedestrians died in traffic accidents, and 612 of these deaths (33.8%) occurred at the accident locations and 1,198 (66.2%) occurred within 30 days following the accident (TurkStat, 2016a). These figures explicitly reveal the significance of using data from 2015 on-ward in studies to be conducted on pedestrian fatalities in Turkey.

National level pedestrian accident statistics include the distribution of fatalities and injuries by gender, age and the type of accident location (urban or rural). Provincial level statistics include only the number of fatalities and injuries. There is no information about the number of pedestrian accidents at the national level nor at provincial level.

In this study, pedestrian involvement (fatality or injury) and the fatality rates in the accidents were calculated both at the national and provincial levels. While calculating the fatality rates, since 2016 data were not published yet, data from 2015, when the 30-day rule was initiated, were used. While calculating the accident involvement rates using data from 2013, when the police and gendarmerie data started to be published together, and afterwards were used.

Once the aggregate statistics regarding pedestrian accidents were provided in the analyses at the national level. The distribution of the pedestrians involved in an accident by gender was presented. Then, the number of pedestrian fatalities and the number of pedestrians involved in accidents per million population were analysed based on gender and age. In the discussion part of the study, the results of these analysis were compared with the results of the previous studies in the literature. In the analysis at provincial level, the number of pedestrians involved in an accident and the number of pedestrian fatalities per million population and per million registered vehicles were calculated.

For the convenience of expression, the following abbreviations shall be used:

- FMP, for pedestrian fatality per million population;
- FMV, for pedestrian fatality per million registered vehicles;
- PIMP, for the number of pedestrians involved in an accident per million population;
- PIMV, for the number of pedestrians involved in an accident per million registered vehicles.

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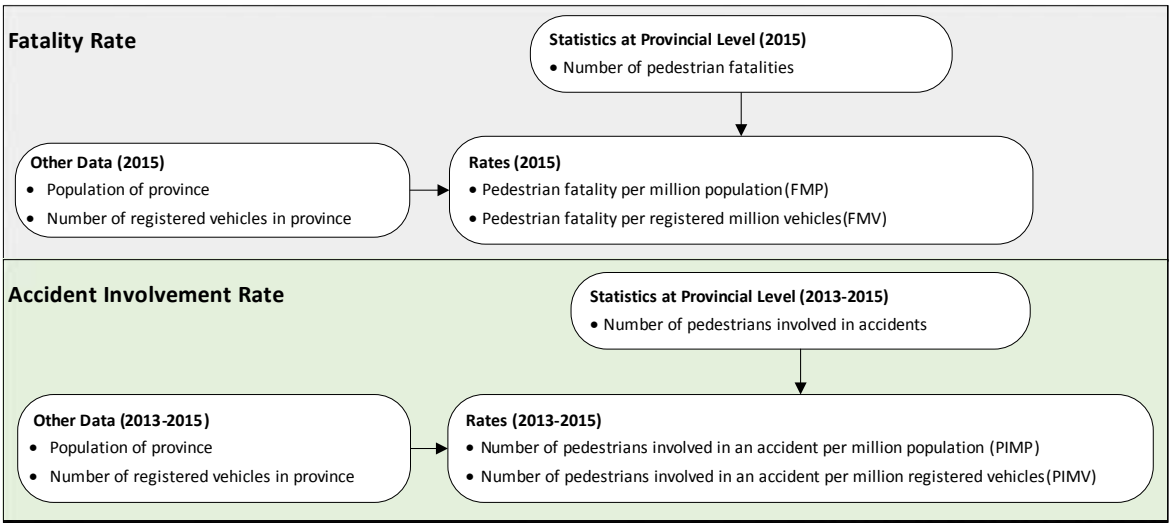

Figure 1. Methodology used in the calculation of accident rates at provincial level.

Methodology used in the calculation of accident rates at the provincial level is summarized in Figure 1. PIAMP and PIAMV rates were calculated using the following formulations.

$$PIMP_i = \frac{1}{3}\sum_{j=2013}^{2015} 10^6\left(\frac{Fatality_{ij} + Injury_{ij}}{Population_{ij}}\right) \quad (1)$$

$$PIMV_i = \frac{1}{3}\sum_{j=2013}^{2015} 10^6\left(\frac{Fatality_{ij} + Injury_{ij}}{Vehicle_{ij}}\right) \quad (2)$$

where, i refers to the index used for provinces; j refers to the index used for years; the words 'Fatality' refers to pedestrian fatalities; 'Injury' refers to the pedestrian injuries; 'Population' refers to the population of province; 'Vehicle' refers to the number of registered vehicles in province.

These rates were presented by using thematic maps in the Geographical Information Systems (GIS) environment. Then clustering analysis was performed to investigate whether these rates show any spatial correlation or not. During clustering analysis, Global Moran's I method was used. Moran's I value varies between -1 and 1. Positive Moran's I value indicates the clustering of similar values whereas negative Moran's I value indicates the clustering of dissimilar values. 0 indicates that there is no clustering. The following formulation was used in the calculation of Moran's I value (Moran, 1950).

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}(x_i - \bar{X})(x_j - \bar{X})}{\left(\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\right)\left(\sum_{i=1}^{N}(x_i - \bar{X})^2\right)} \quad (3)$$

where, $\bar{X}$ refers to the mean of the variable; X_i refers to the value of the variable at a point; X_j refers to the value of the variable at another point; W_{ij} refers to the spatial weight between the relative locations of i and j points. The Z-score value, which indicates whether Moran's I was statistically significant or not, is calculated by the following formulation.

$$Z = \frac{I - E(I)}{\sqrt{V(I)}} \quad (4)$$

where the E(I) value refers to the expected value of the I, which is equal to -1/(N-1). V(I) shows the variance of the I value. Moran's I analysis indicates a clustering approach but does not provide information regarding whether low or high values are clustered. If a clustering case is determined, it may be necessary to check General G statistics to understand the clustering of low or high values. If General G values are above the expected value of G, statistics suggest that the high values are clustered. If General G values are lower than the expected value of G instead, then the lower values are clustered. The General G statistic, its expected value and the Z-score were calculated using the following formulations (Erdogan, 2009).

$$G = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}x_i x_j}{\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j} \quad (5)$$

$$E(G) = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}}{N(N-1)} \quad (6)$$

$$Z = \frac{G - E(G)}{\sqrt{V(G)}} \quad (7)$$

3. FINDINGS

3.1 Findings at the National Level

In 2015, 1,810 pedestrians died and 34,720 pedestrians were injured in traffic accidents in Turkey. These values constitute 24% of all fatalities and 11.4% of the injuries in traffic accidents. According to TurkStat, while 95.2% of pedestrians (34,790 pedestrians) were involved in accidents in urban areas, only 4.8% (1,740 pedestrians) were involved in accidents in rural areas. While only 4.1% (1,426) of the pedestrians involved in accidents in urban areas died, this ratio increased to 22.1% (384 pedestrians) in rural areas (TurkStat, 2016a).

The 2015 *FMP* value in Turkey was calculated as 23 and the *FMV* value was calculated as 91 (TurkStat 2016a; TurkStat 2016b). The rate of pedestrian involvement in traffic accidents, between 2013-2015, are given in Table 1. As shown in Table 1, *PIMP* and *PIMV* values have only showed minor changes between the years.

The *PIMP* values by gender and age are provided in Table 2. The key points of this table are summarized below.

- The 65+ age group has a significant lead on the highest *PIMP* value both in women and men. The 25-64 age group has the lowest *PIMP* value.
- 0-14 and 65+ age groups have significantly higher *PIMP* values in men than in women.
- The 15-24 and 25-64 age groups have *PIMP* values that are comparatively close between women and men.
- As men are significantly more involved in pedestrian accidents than women (see Table 3), the *PIMP* values in the whole population show the same trend in men.

In Table 3, the distribution of fatalities and injuries due to pedestrian accidents by gender is provided. Fatalities in 2015 are approximately three times more than the previous year. 68.5% of these fatalities in women (409 fatalities) and 65.0% in men (789 fatalities) occurred during the post-accident period. This emphasizes the importance of the improvement made in 2015 regarding the new data collection process. Men constitute 70% of the fatalities and 57% of the injuries. These values are high despite the equal distribution of women and men in the national population. The results also show that the number of pedestrians involved in accidents is increasing.

The *FMP* values in 2015 are grouped by gender and age in Figure 2 (TurkStat 2016a; TurkStat 2016b). In all age groups, the *FMP* value for men are higher than those for women. This difference becomes more apparent in the 65+ age group. The 65+ age group has the highest *FMP* value by far, for both women and men. The second group with the highest *FMP* value is the 25-64 age group. The 15-24 age group had the lowest *FMP* value.

Table 1. PIMP and PIMV values between 2013-2015.

Years	Population	Registered Vehicle	PIMP	PIMV
2013	76,667,864	17,939,447	435	1859
2014	77,695,904	18,828,721	457	1886
2015	78,741,053	19,994,472	464	1827

Table 2. PIMP by gender and age (TurkStat 2016a; TurkStat 2016b).

Years	Age	Woman	Man	Population
2013	0-14	400.2	620.4	513.3
	15-24	415.6	423.5	419.6
	25-64	314.7	371.6	343.3
	65+	536.2	1209.6	829.0
2014	0-14	413.5	654.0	537.0
	15-24	482.6	431.9	456.6
	25-64	325.7	380.1	353.1
	65+	594.2	1258.0	883.6
2015	0-14	428.5	680.7	558.0
	15-24	449.9	444.3	447.0
	25-64	342.7	371.9	357.4
	65+	603.3	1252.4	887.4

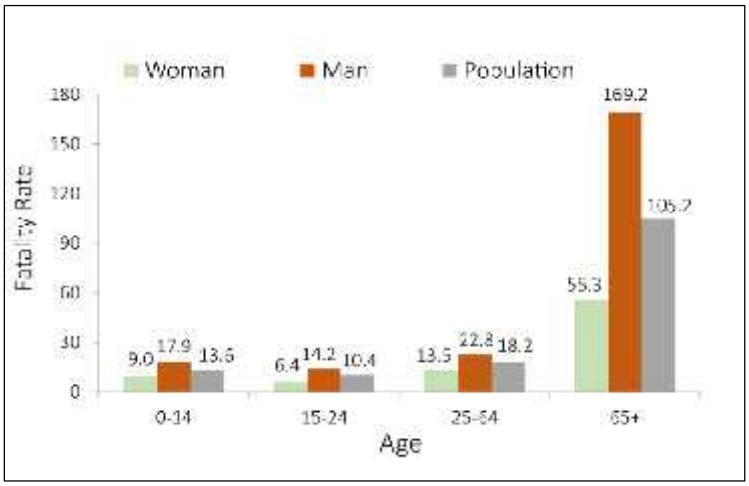

Figure 2. FMP by gender and age in 2015 (TurkStat 2016a; TurkStat 2016b).

Table 3. Distribution of fatalities and injuries in pedestrian accidents by gender (TurkStat 2016a).

Years	Fatality			Injury			Involved in Accident		
	Woman	Man	Population	Woman	Man	Population	Woman	Man	Population
2013	183 (28.0%)	470 (72.0%)	653 (100.0%)	13,984 (42.8%)	18,718 (57.2%)	32,702 (100.0%)	14,167 (42.5%)	19,188 (57.5%)	33,355 (100.0%)
2014	172 (28.8%)	425 (71.2%)	597 (100.0%)	15,159 (43.4%)	19,755 (56.6%)	34,914 (100.0%)	15,331 (43.2%)	20,180 (56.8%)	35,511 (100.0%)
2015*	597 (33.0%)	1,213 (67.0%)	1810 (100.0%)	15,262 (44.0%)	19,458 (56.0%)	34,720 (100.0%)	15,859 (43.4%)	20,671 (56.6%)	36,530 (100.0%)

* In Turkey, post-accident 30-day observation period was initiated in 2015.

3.2 Findings at the Provincial Level

In the analysis at provincial level, the *FMP* and *FMV* values were calculated using 2015 data, and *PIMP* and *PIMV* values were calculated using the data between 2013 and 2015. In the statistical analysis, at the provincial level, a very high correlation was found between pedestrian fatalities and both population and the number of registered vehicles (for both, r=0.97). Likewise, a very high correlation was found between the number of pedestrians involved in accidents and both population and the number of registered vehicles (*r=0.92* and *r=0.94*, respectively).

In 2015, the highest pedestrian fatalities occurred in Istanbul (176 fatality 14.5%), Ankara (94 fatality 7.7%) and in Izmir (64 fatality, 5.3%) which are the most crowded provinces. On the other hand, nobody died in pedestrian accidents in Tunceli; only 1 person died in Batman, Nevşehir, Hakkari, Karaman, Gümüşhane, Ardahan and Bayburt; and that 2 people died in Siirt, Bilecik, Sinop, Iğdır, Bartın, Artvin and Kilis. At this point, it is necessary to pay attention to the fact that the rates calculated by using small fatality numbers may substantially change based on small changes in fatality numbers. The fatality rates of provinces, where only one fatality occurred, would increase by three times if 2 more fatalities occur. This may be prevented by increasing the number of data years and using more representative average values for each province. Since it is necessary to use data from 2015 onward, in a study to be conducted in Turkey on pedestrian fatality rates and as 2016 data were not published, only the 2015 data might be used in this study.

In 2015, the mean *FMP* value at the province level was 15.2. The standard deviation of this value is 7.3. In Figure 3, the *FMP* values are shown on a thematic map. While preparing this map, five groups were selected as the region at least one standard deviation below the mean value (*FMP*<7.9), the regions below one standard deviation of the mean value (7.9<*FMP*<15.2), the regions above one standard deviation of the mean value (15.2<*FMP*<22.5), the regions above two standard deviations of the mean value (22.5<*FMP*<29.8), and the regions at least two standard deviations above the mean value (*FMP*>29.8). The reason for selecting such a grouping refers to the acceptance that the values within the range of one standard deviation below and above the mean value is part of the acceptable variability in the data. The values below and above this range are considered for relatively low and high values. The results of Moran's I analysis showed that *FMP* values were not significantly clustered at a 95% confidence level (*I:-0.09; Z-score:-0.83 and p-value:0.41*). As seen in Figure 3, provinces with high and/or low *FMP* value were randomly distributed. The *FMP* value is at least two standard deviations above the mean value in Bolu (38.8), Uşak (34.6), Şırnak (31.6), Çankırı (31.4), Bingöl (30.1). The provinces with the lowest FMP value have been Tunceli (0), Batman (1.8), Nevşehir (3.5), Hakkari (3.7), Ordu (4.1), Karaman (4.2), Diyarbakır (4.4), Siirt (6.4), Gümüşhane (7.1), Isparta (7.2) and Aksaray (7.8).

The mean *FMV* value at the province level was calculated as 81.7 (standard deviation: 84.2). The high coefficient of variation (*cv=1.03*) indicates that there is too much variability between the provinces. In Figure 4, *FMV* values are shown on the thematic map. While creating this map, ranges of one standard deviation to the right and left of the mean value were selected like in Figure 3. The results of Moran's I analysis showed that *FMV* values were not significantly clustered at 95% confidence level (*I:0.14; Z-score:1.94 and p-value:0,051*). On the other hand, there was a clustering at 90% confidence level (*p-value:0,051<0.10*). Because of this trend, red and maroon colours indicate that provinces with high *FMV* values were accumulated to the east of the map (see Figure 4). In the Bingöl (537.3) and Şırnak (485.8) provinces, *FMV* values are significantly higher than other cities (*FMV* in Van, which has third highest value, is 248.9). When the provinces with *FMV* values below the mean value are considered, they were all seen to be within a standard deviation range. When Figure 3 and 4 analysed together, it is found that that Bingöl and Şırnak are the provinces with the highest values in both measure of exposures. In 2015, 8 pedestrians in Bingöl and 15 pedestrians in Şırnak died in traffic accidents.

When the pedestrian accident statistics between 2013 and 2015 are reviewed, 30% of the pedestrians were involved in accidents in Istanbul (3458 pedestrians, 11.6%), Ankara (2778 pedestrians, 9.3%) and in Izmir (2180 pedestrians, 7.4%). Provinces where the pedestrians least involved in accidents had been Tunceli (18), Ardahan (26), Bayburt (32) and Iğdır (40). During this period, *PIMP* mean value at province level was found as 399 (standard deviation:140). The results of Moran's I analysis showed that *PIMP* values of the cities

were not significantly clustered at a 95% confidence level and that they were randomly distributed (*I:0.04; Z-score:0.62 and p-value:0.53*) (see Figure 5). In Kilis (987.1) and Elazığ (721.7), *PIAMP* values are significantly higher than other cities. On the other hand, in Muş (173), Batman (184), Kars (189), Hakkari (199), Bitlis (200), Tunceli (205), Iğdır (211), Diyarbakır (230), Şanlıurfa (233), İstanbul (240) and Edirne (248), *PIMP* values are at least one standard deviation below the national average. It is remarkable that Istanbul, where the pedestrians are involved in traffic accidents the most, is listed in this group.

Between 2013 and 2015, the mean *PIMV* value at province level was found as 2293 (standard deviation: 1687). Like in *FMV* values, it is seen here as well that there is too much variability between the provinces (*cv:0.74*). *PIMV* values were highest in Siirt (10685), Bingöl (8805), Ağrı (6311), Şırnak (6289), Hakkari (5934), Van (5871) and Elazığ (4188). According to the results of Moran's I analysis, *PIMV* values were observed to cluster significantly at the 95% confidence level (*I:-0.09; Z-score:-0.83 and p-value:0.41*). General G statistic, which determines the type of this clustering showed that the cities with high *PIMV* values clustered (*G:10-6>E(G):0*). This trend is clearly seen in Figure 6. Local Moran's I analysis results indicating the clustering regions (see Figure 7). According to results of Local Moran's I clustering of high-high values were identified.

After investigation of the spatial correlations, statistical correlations between pedestrian accident rates (i.e. FMP, FMV, PIMP and PIMV) and provincial level indicators (i.e. income per capita, urbanization and literacy ratio) were examined. Results indicated that all of the correlations were weak, except the moderate negative correlations between provincial level literacy ratios and both FMV and PIMV values (*r=-0.48* and *r=-0.57*, respectively).

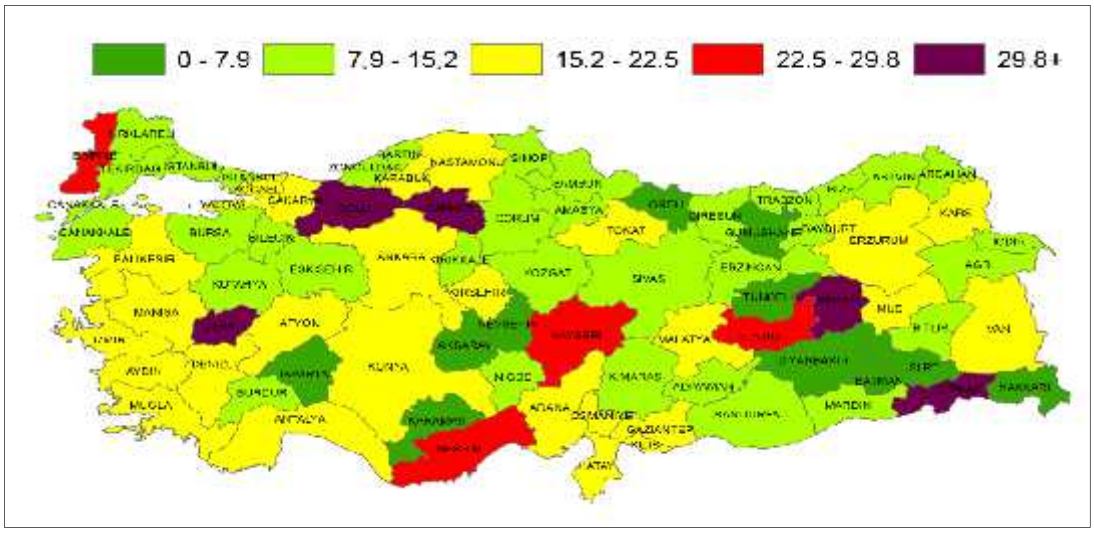

Figure 3. FMP values in 2015.

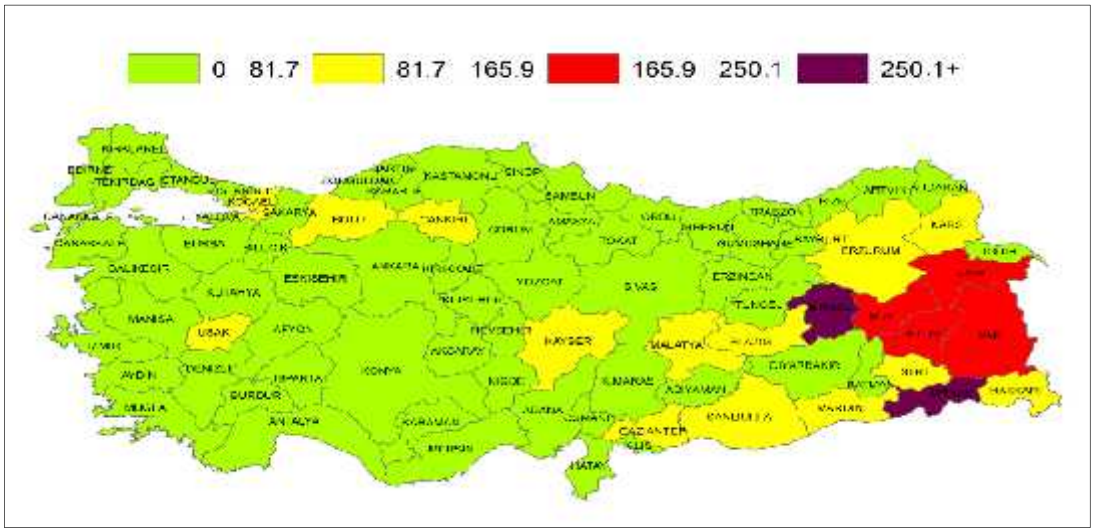

Figure 4. FMV values in 2015.

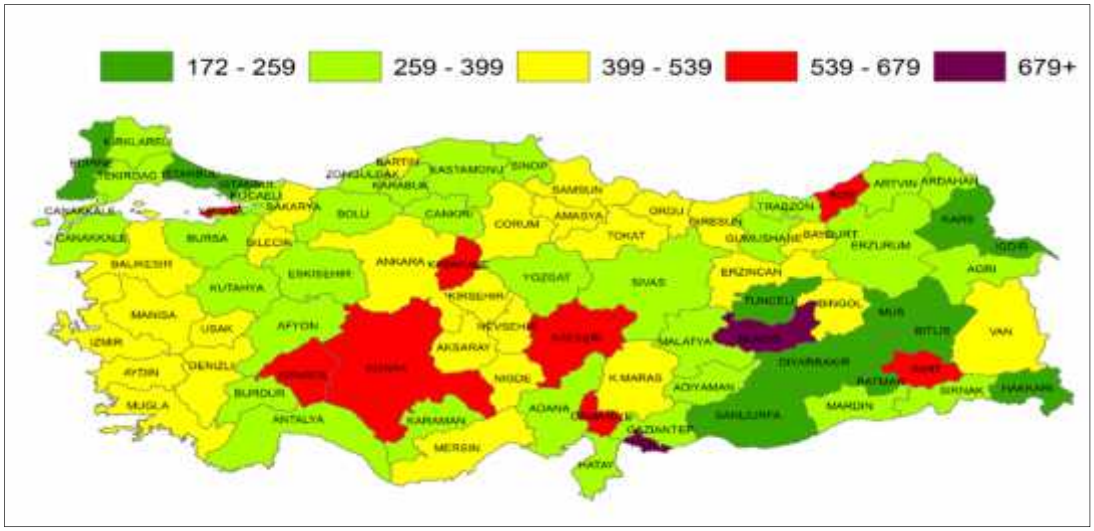

Figure 5. Average PIMP values between 2013 and 2015.

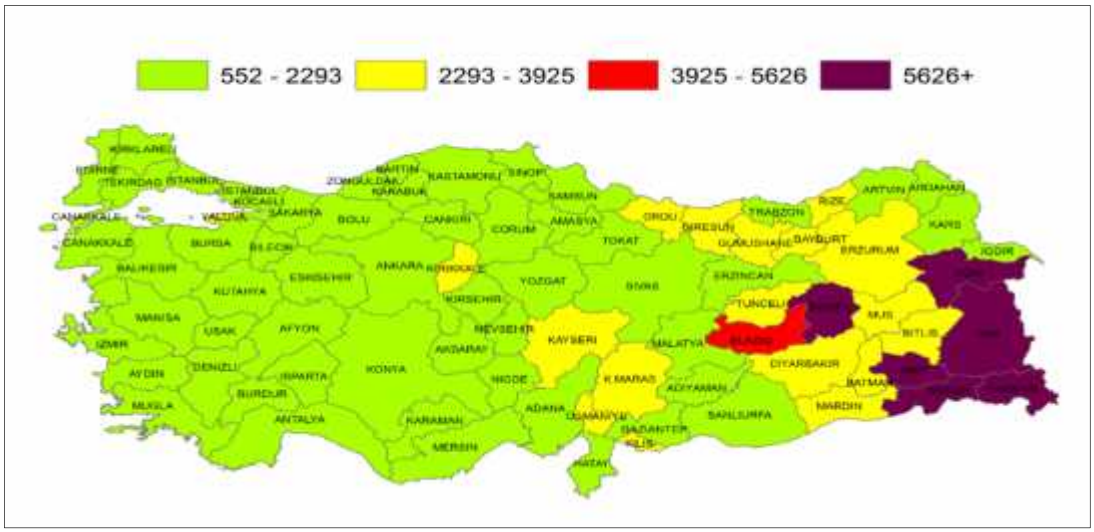

Figure 6. Average PIMV values between 2013 and 2015.

Figure 7. General G statistic for PIMV values.

4. DISCUSSION AND CONLUSION

Walking is one of the primary modes of transportation; therefore, it is necessary to provide safer pedestrian environments to encourage people to walk more frequently (Kim et al., 2008). Pedestrian characteristics (e.g. age, weight, height, gender), driver characteristics (e.g. age, intoxicated driving, speed behaviour), vehicle characteristics (e.g. vehicle body type, impact speed), temporal, environmental, land use and traffic control characteristics (e.g. existence of traffic signals) are the significant factors contributing severity of the pedestrian accidents (Henary et al., 2006; Kim et al., 2008; Onieva-García et al., 2016). Traffic education, engineering interventions, strict enforcement of traffic regulations have been proven to be effective strategies to prevent these accidents (Pucher and Dijkstra, 2003). For instance, many previous studies showed that older pedestrians do not take into account their slower walking speeds and frequently engage in more dangerous crossings (Charthy et al., 1995; Oxley et al., 1997). Sheppard and Pattinson (1986) indicated that older pedestrians get benefit from advices to choose safer walking routes. Crossing facilities with pedestrian islands in the middle of road, adopting green light periods to the walking speed of older people are some of the successfully implemented engineering interventions to improve pedestrian safety (Bernhoft and Carstensen, 2008).

Pedestrian fatalities in traffic accidents have a significant share among other fatalities in traffic accidents both in developed and developing countries. Globally, pedestrian fatality constitutes 22% of the fatalities in traffic accidents. It is 24% in Turkey (TurkStat, 2016a). When the statistics are reviewed, it is seen that the pedestrian fatalities in Turkey are high compared to the mobility in the traffic. However, the studies on pedestrian safety in Turkey are quite limited. In this study, the pedestrian accidents in Turkey were examined in detail at national level and at provincial level to fill the gaps the literature.

In Turkey, many pedestrians (95.2%) were involved in accidents in urban areas in 2015. On the other hand, the fatality percentage (22.1%) of the pedestrians involved in accidents in rural areas is more than five times of those involved in residential areas (4.1%). The higher fatality percentage in rural areas with high speed limits are in line with the studies in the literature. The previous studies showed that the fatality risk, which is at 10% level in crashes at 50 km/h, increased to 50% at 70 km/h and to 75% at 85 km/h (Davis, 2001; Rosén, 2009; Richards, 2010 and Tefft, 2013).

When the distribution of fatality in pedestrian accidents by gender are reviewed, despite the equal distribution in the population, men constitute 70% of the fatalities. It is necessary to investigate the mobility levels and risk perceptions of women and men in pedestrian traffic in detail to explain the causes of this case. The values obtained in this study are similar to the results of the previous studies. In 2014, men who represent 49% of the population in the US constituted 70% of the fatality in pedestrian accidents (NHTSA, 2016). Likewise, it was published that fatality of men in pedestrian accidents constitute 76% of the fatalities in South Africa and 66% in Spain (Mabunda et al. 2008; Onieva-García et al., 2016).

Tthe 65+ years age group has the highest *FMP* value by far both in women and men. Similarly, in many studies in the literature, the *FMP* value in pedestrian accidents increased, depending on the increasing age (65 years and later) (Henary et al., 2006; Bernhoft and Carstensen, 2008; Kim et al., 2008; Mohamed et al., 2013; NHTSA, 2016; Onieva-García, 2016). This situation is explained by the substantial damage in the body caused by the traffic accidents in older population due to the physical deterioration because of aging (Mohamed et al., 2013). The 65+ years age group had the highest *PIMP* values in Turkey. This is contradictory to the results of the studies in the literature. In the previous studies, it was mentioned that *PIMP* values were not higher in 65+ years age group (NHTSA, 2016), and that they were even lower (Onieva-García et al., 2016). This situation was explained by the avoidance of older age group from risky behaviours in pedestrian traffic and by higher compliance with traffic rules (Oxley et al., 1997; Holland, 2007; Bernhoft, 2008). In studies in United States of America and in Spain, it was revealed that *PIMP* values are higher in 15-24 years age group (NHTSA, 2016; Onieva-García et al., 2016). The reason for this situation was indicated to be the risky behaviours of the young population in the pedestrian traffic (e.g. using mobile phone, listening to music) (Pollack et al., 2014).

In this study, to remain consistent with previous studies, four age groups of 0-14, 15-24, 25-64 and 65+ were used. In the literature, the 25-64 years and 65+ years age groups were divided into smaller age ranges within themselves. Likewise, publishing the age groups of those involved in accidents in Turkey in more details would allow more comprehensive analyses. The number of pedestrians involved in accidents in Istanbul, Ankara and Izmir are the highest for those who died in these accidents. According to the results of the clustering analysis performed, *FMN* and *PIMP* values were not clustered and were randomly distributed. On the other hand, provinces with high *PIMP* values were significantly clustered at a 95% confidence level and *FMN* values were significantly clustered at a 90% confidence level. When these results are reviewed, while no clustering is observed in the analysis conducted using the million population measure, clustering behaviour is observed in the analysis made using million registered vehicle. It is necessary to repeat these analyses using province level vehicle-km values to explain the causes of these results in more detail. The statistical correlations between pedestrian accident rates and provincial level indicators indicated that there were moderate negative correlations between provincial level literacy ratios and both FMV and PIMV values ($r=-0.48$ and $r=-0.57$, respectively). However, it is difficult to explain the causes of this behaviour with aggregate data used in this study. It should be further analysed using accident level disaggregate data.

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EVALUATION OF ACCURACY OF DEMS OBTAINED FROM UAV-POINT CLOUDS FOR DIFFERENT TOPOGRAPHICAL AREAS

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ABSTRACT: The main objective of the study was to examine accuracies of DEMs (Digital Elevation Models) with different topographical structures generated by using the Unmanned Aerial Vehicle (UAV) point clouds. Two different terrains with flat and sloping topographical structures were selected for the study, and DEMs of these terrains were generated using eight interpolation techniques (Kriging, Natural Neighbor, Radial Basis Function Triangulation with Linear interpolation, Nearest Neighbor, Invers Distance to a Power, Local Polynomial and Minimum Curvature). The accuracies of DEMs were tested by calculating the statistic methods with the help of the control points obtained by land surveying techniques. At the end of the study, it was observed that in DEMs prepared for both flat (study area 1) and sloping (study area 2) terrains, Kriging interpolation method yields the best results as study area 1 and 2, respectively. In addition, the results were examined using Shapiro-Wilk and ANOVA: Friedman tests. After observing with the Shapiro-Wilk test that the data has a normal distribution, it was statistically determined through the parametric ANOVA: Friedman test that there is no difference between the variables.

Keywords: *Digital Elevation Model; Unmanned Aerial Vehicles; Kriging; ANOVA.*

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1. INTRODUCTION

Digital Elevation Models are topographical products which provide important information about the surface of the Earth and are used in many different applications such as modelling water flow (Jain and Singh, 2003), flood simulation and management (Honghai and Altinakar, 2011) and (Ramlal and Baban, 2008),terrain visualization and mapping (Spark and Williams, 1996). The accuracy of such applications depends on the accuracy of the produced Digital Elevation Model (Januchowski et al., 2010). Therefore, Digital Elevation Models with various accuracies can be prepared using different techniques depending on the desired accuracy. The most prominent techniques to prepare Digital Elevation Models are photogrammetric methods with stereo data (Hohle, 2009) and (Kraus, 2007), airborne laser scanning (Vosselman and Maas, 2010), radar interferometry (Arun, 2013) and land surveying (Wilson and Gallant, 2000).

Due to land surveys, traditional methods to prepare Digital Elevation Models have high cost and is time consuming (Uysal et al., 2015). The use of photogrammetric methods has therefore become very common due to the advantages they provide in terms of time, accuracy and costs when preparing Digital Elevation Models. One of these methods, LIDAR systems, has become a preferred method for Digital Elevation Model preparation thanks to its three dimensional information gathering capability, which is very effective for wide areas. However, the biggest disadvantage of these platforms is their high cost, especially in small areas of study (Remondino et al., 2011). Thus, there emerged a need for different techniques to produce data in applications in small study areas. In the last ten years, with the increase in the number of firms producing them, the costs of Unmanned Aerial Vehicles have decreased substantially, thus eliminating the problematic cost issue related to these platforms.

The use of these vehicles is becoming more and more common due to decreased costs of UAVs for different applications, eg. meteorological studies, natural disaster management, forest fire detection and control, agricultural product monitoring, mapping and three-dimensional city and terrain modelling (Ruzgienė, 2015), (Mesas-Carrascosa, 2014) and (Austin, 2010). It is believed that Unmanned Aerial Vehicles will be a significant alternative to the traditional mapping methods by allowing the production of maps at low costs while providing high spatial and temporal resolution (Colomina and Molina, 2014) and (Sauerbier and Eisenbeiss, 2010).

In scientific literature, it is accepted that the accuracy of the Digital Elevation Model depends on many factors such as topographic variance, sampling density, interpolation techniques and spatial resolution (Aguilar et al., 2005), (Gong et al., 2000) and (Kienzle, 2004). In the study conducted, using the point clouds obtained from UAV GatewingX100 images, the impact of the topographical variance and the different interpolation methods on the accuracy of the prepared Digital Elevation Model is investigated.

1.1. Study area and data set

Two different areas with distinct terrain structures were chosen to prepare Digital Elevation Models. Study area 1 (12 hectares) was selected in the area where KTU School of Divinity is located (latitude 40º 59ʹ 06.60ʺ and longitude 39º 48ʹ 45.87ʺ) which has a fairly flat topographical structure without much elevation. Topographic elevation of study area 1 is between approximately 20m and 40m. Study area 2 (40 hectares) was selected in the area where KTU Farabi hospital is located (latitude 40º 59ʹ 32.97ʺand longitude 39º 46ʹ 13.86ʺ) and it has a more sloping terrain. Topographic elevation in this area ranged from 80 to 170 m with slopes from 10° to 58°, approximately (Figure 1).

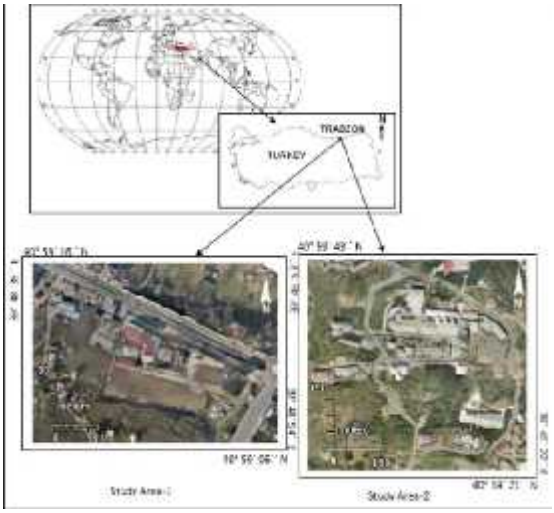


Figure 1. Study areas

1.2. GATEWINGX100 UNMANNED AERIAL VEHICLE

GatewingX100 Unmanned Aerial Vehicle (UAV) was produced by the firm Trimble to be used in photogrammetric mapping efforts. This vehicle consists of elements such as a Ricoh GR Digital IV digital camera, modem (2.4 Ghz), ground control station, launcher and electronic components known as ebox, like GPS, INS etc.

GatewingX100 UAV has a 1-meter wing span and weighs around 2 kilograms. This vehicle, which can capture very high spatial resolution images from 150-200 meter average heights, can also take a photo in hot, cold, and lightly rainy weather conditions and in up to 60 km/h winds. The camera used is very light and can capture very high quality images. Thanks to the ISO range it offers, it is able to generate high quality images in various light conditions. The camera used, with its technical specifications are shown in table 1.

Table 1. Technical specifications of Ricoh GR Digital IV digital camera

Image Sensor	1/1.7-inch CCD (total pixels: approx. 10.40 million pixels)
Focal length	f=6.0 mm (equivalent to 28 mm for 35 mm film cameras)
F-aperture	F1.9 – F9 (exposure control with both aperture and ND filter when F8.0-F11 displays in auto shooting mode) F8.0-F11 displays in auto shooting mode)
Shutter Speed *1 Movie	1/30 - 1/2000 sec.
ISO Sensitivity (Standard Output Sensitivity)	AUTO, AUTO-HI, ISO80 – 3200 (1EV, 1/3EV, selectable steps)
Weight	Approx. 219 g (including the supplied battery and SD memory
Operating Temperature Range	0ºC- 40ºC

2. INTERPOLATION METHODS

2.1. Kriging

Kriging developed by D.G. Krige is a geostatistical gridding interpolation method. Kriging is a very flexible method (Surfer guide 8.0, 2002). Making use of irregularly spaced data sets, the visually appealing maps are producted (Vohat et al., 2013). So, shape functions within the framework of meshless methods are constructed by using Kriging technique (Zhu et al., 2014). The principle of the Kriging technique is a variogram model, and this method uses weighted linear combinations (Yılmaz, 2009). The model of the method is presented here in below (Eq.1)

$$\gamma(\mathbf{x}_i, \mathbf{x}_j) = \frac{1}{2}E[\mathbf{Z}(\mathbf{x}_1) - \mathbf{Z}(\mathbf{x}_2)^2] = \gamma(\mathbf{h}),\ \|\mathbf{h}\| = \|\mathbf{x}_1 - \mathbf{x}_2\|,\ \mathbf{Z}_p = \mu(\mathbf{P}) + \varepsilon(\mathbf{P}) \quad (1)$$

Where $\gamma(x_i, x_j)$ represents the semi variogram model giving a certain relation between any two nodes x_i and x_j, h is a lag vector which indicates the Euclidean distance between any two nodes. μ represents constant mean and ε represents random errors. Z_p is the variable interest (Zhu et al., 2014) and (Yılmaz, 2009).

2.2. Natural Neighbor

The Natural Neighbour method bases on the average mean. The method uses the distance –dependent weights of reference points to the grid corner. The method classified the data on the reference points with irregular distribution, and by using the Triangular Irregular Network (TIN) functions it realizes interpolation process (Yılmaz, 2009). The theory of the method is given in Eq.2.

$$G(x, y) = \sum_{i=1}^{n} w_i f(x_i, y_i) \quad (2)$$

Where $G(x, y)$ represents the natural neighbour estimation at (x, y), n is the number of nearest neighbour used for interpolation. $f(x_i, y_i)$ is the observed value at (x_i, y_i) and w_i is the weight function (Yılmaz, 2009).

2.3. Radial Basis Function

Radial basis function (RBF) method has been used for their simplicity and ease of implementation in multivariate scattered data approximation. Furthermore RBF has been preferred as a method for the numerical solution of partial differential equations (Driscoll and Heryudono, 2007). The RBF interpolation method is explained as follows (Eq.3);

$$s(x) = \sum_{i=1}^{n} \lambda_i \varphi(\|x - x_i\|) + p(x) \quad (3)$$

Where interpolates the data are $(x_1, f_1), \ldots, (x_n, f_n)$. n pair wise different points are $x_1, \ldots x_n$ and data $f_1, \ldots f_n$. λ_i is the coefficients. $i = 1, \ldots, n$. $\varphi(\ )$ is RBF, $\|.\|$ represents the Euclidean distance. p is from Π_n, the space of polynomials of degree less than or equal to m (Gutmann, 2001).

2.4. Triangulation with Linear interpolation

Triangulation with Linear Interpolation method uses triangles, which are created by drawing lines between data points by optimal Delaunay triangulation. The original points are connected in such a way that no triangle edges are intersected by other triangles. A sequential search then establishes the triangle in which each grid node is contained. Using the gradients of the selected triangle a value is interpolated for the grid node. The heights of the data points are preserved by interpolator, so the original data are used to define the triangles. Therefore, this method is an exact interpolator (Surfer guide 8.0, 2002).

2.5. Nearest Neighbor

The method is very simple to implement and is commonly used (Prasantha et al., 2009). The nearest neighbour assigns the value of the nearest point to each grid node. When data are already evenly spaced, this method is useful. Besides, when the data are nearly on a grid with only a few missing values, this method is effective for filling in the holes in the data (Surfer guide 8.0, 2002). Sometimes with nearly complete grids of data, there are areas of missing data desired to exclude from the grid file. In this case, the Search Ellipse can be set to a certain value, so the areas of no data are assigned the blanking value in the grid file. By setting the search ellipse radii to values less than the distance between data

values in file, the blanking value is assigned at all grid nodes where data values do not exist (Yılmaz, 2009).

2.6. Invers Distance to a Power

Algorithm of Inverse Distance to a Power (IDP) method is based on a quite simple (Yılmaz, 2009). It is a weighted average interpolator, and this interpolator can be either a smoothing or an exact. Data is weighted during interpolation so that the influence of one point relative to another declines with distance from the grid node, with Invers Distance to a Power (Surfer guide 8.0., 2002), (Vohat et al., 2013) and (Yang et al., 2004). The greater the weighting power, the less effect points far from the grid node has during interpolation. As the power increases, the grid node value approaches the value of the nearest point. For a smaller power, the weights are more evenly distributed among the neighboring data points (Eq.4) (Surfer guide 8.0., 2002).

$$\hat{z}_j = \frac{\sum_{i=1}^{n} \frac{z_i}{h_{ij}^{\beta}}}{\sum_{i=1}^{n} \frac{1}{h_{ij}^{\beta}}} \qquad (4)$$

$$h_{ij} = \sqrt{d_{ij}^2 + \delta^2}$$

Where h_{ij} is the effective separation distance between grid node, j and the neighbouring point i. $\hat{z}_j$ is the interpolated value for grid node j. Z_i are the neighbouring points. d_{ij} is the distance between the grid node j and the neighbouring point i. β is the weighting power (the power parameter), and δ is the smoothing parameter (Yılmaz, 2009).

2.7. Polynomial Regression Method

Polynomial regression method uses weighted least squares fit with data within grid nodes' search ellipse to assigns values to grid nodes (Surfer guide 8.0., 2002). The method does not predict unknown Z values, so it is not an interpolator (Yılmaz, 2009). The local least squares parameters are computed by minimizing the weighted sum of squared residuals as above (Eq.5) ;

$$\{(x_i, y_i, z_i) \; for \; i = 1, 2, 3 \ldots . N\} \qquad (5)$$
$$Minimize \sum_{i=1}^{N} W_i [F(x_i, y_i) - z_i]^2$$

Where x_i, y_i, z_i represent known coordinates of datum i; W_i is the weight for datum i; $F(x_i, y_i)$ represents local polynomial (Surfer guide 8.0., 2002).

2.8. Minimum Curvature

The Minimum Surface Curvature method developed by (Briggs, 1974) is commonly used in earth sciences. According to the method, when the total curvature of a surface is minimized under the constraint that the surface honors the values in the gadded positions, the following Eq.6, which can be solved iteratively, apply (Cooke , 1993)

$$\frac{\partial^4 P}{\partial x^4} + 2\frac{\partial^4 P}{\partial x^2 \partial y^2} + \frac{\partial^4 P}{\partial y^4} = 0 \qquad (6)$$
$$0 = P_{i+2,j} + P_{i,j+2} + P_{i-2,j} + P_{i,j-2} + 2(P_{i+1,j+1} + P_{i-1,j+1} + P_{i+1,j-1} + P_{i-1,j-1}) - 8(P_{i+1,j} + P_{i-1,j} + P_{i,j-1} + P_{i,j+1}) + 20P_{i,j}$$

Gaged locations are obtained from the solution as their values are always honoured.

2.9. Modified Shepard's Method

The modified quadratic Shepard's method proposed by (Shepard, 1968) has been efficiently implemented for the multivariate interpolation of large scattered data sets. There are many advantages, such as numerical efficiency, good reproduction quality, stability and inherent parallelism (Lazzaro and Montefusco, 2002). The principle of the modified quadratic Shepard's method is given as below (Eq.7).

$$F(x) = \sum_{k=1}^{N} W_k(x) R_k(x) \qquad (7)$$

where

$$R_k(x) = \sum_{j \in I_k} c_j^k \varphi(\|x - x_j^k\|_2)$$

and

$$W_k(x) = \left[\frac{(r_W - r_k)_+}{r_W r_k}\right]^p \Big/ \sum_{k=1}^{N} \left[\frac{(r_W - r_k)_+}{r_W r_k}\right]^p$$

In Eq.7, N represents the number of scatter points in the set. $R_k(x)$ represent the prescribed function values at the scatter points. $W_k(x)$ are the weight functions assigned to each scatter point (Lazzaro and Montefusco, 2002).

3. METHODOLOGY

Methodology of this study was shown in Figure 2. Each phase of the study was explained step by step as the procedure of DEM production.

Figure 2. Workflow of the study

3.1. Flight planning and taking of the photographs

Before taking the photos, Ground Control Points (GCPs), which would be used to orient the photographs, were homogeneously selected and marked in ground. The coordinates of these GCPs were determined using Continuously Operating Reference Station-Turkey (CORS-TR) Global Positioning System (GPS) technique. There were 10 marked points for the first

study area and 15 for the second. Pre-flight planning for the terrain was performed using Gatewing Quickfield software. Parameters such as overlap ratio, surface area to be captured, flight route, flight altitude, and determination of takeoff and landing points were all defined on the maps uploaded online to the ground control station and the software then prepared the flight plan based on this map.

This information was later uploaded from the ground control station to the Unmanned Aerial Vehicle in the field. To prevent any errors, the flight process was started after necessary controls were made (weather conditions in the study area, battery status of the aerial vehicle and its camera, the storage status of the memory card, flight controls, engine status of the vehicle and the working condition of the navigation, etc.). The flight process was completed by taking photographs throughout the determined route. By the end of the flight, 91 images overlapped 90%, which have 5 cm GSD (Ground Sample Distance), were taken for the first study area and 160 images overlapped 90%, which were 4 cm GSD, for the second.

3.2. Data processing and DEM generation

The main objective of the evaluation process was to produce the georeferenced three dimensional point cloud using the overlapped images (Siebert and Teizer., 2014). The interior orientation of the photographs was performed with Stretchout software. Afterwards, the exterior orientation process was started and performed with Photoscan software using the ground control points with known coordinates that were marked in the terrain. After the exterior orientation process the error rates in x direction with 2.3 cm, in y direction with 2.3 cm and in z direction with 1.9 cm were obtained for the first study area. The error rates for second study area were calculated in x, y and z direction with 1 cm, 2 cm and 11 cm, respectively. After the exterior orientation process, georeferenced three-dimensional dense point clouds and orthomosaics of the study areas were produced (Figure 3).

a)

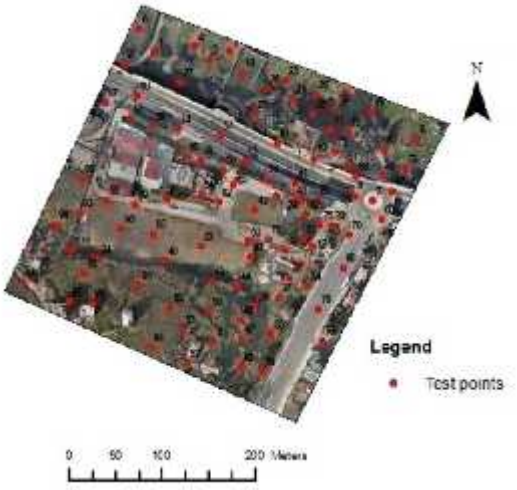
b)

Figure 3. Georeferenced three-dimensional dense point clouds a) Study area1 b) Study area2

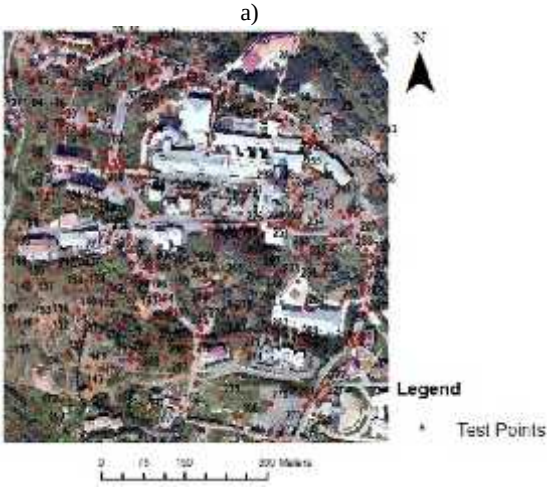
Produced dense point clouds contained all details of the terrain (ground (soil, grass, road…) and non-ground (building, tree…) details). Because of this, for filtering the non-ground details the non-ground points were removed by using the Agisoft PhotoScan Professional software according their elevations. The dense point clouds were then exported as files with a ".las" extension and this georeferenced three-dimensional point cloud was used to prepare the Digital Elevation Model with 1 meter grid size. Digital Elevation Models of both study areas were produced using different interpolation methods that are included in the Surfer 12 software.

4. RESULT AND DISCUSSION

Results of study were evaluated by using accuracy analysis and statistical tests. Firstly, accuracy analysis was conducted to compare the elevation values of test points obtained through land surveys in the study area with the elevation values obtained from the DEMs. In this study, the vertical accuracy of the produced DEMs were determined by means of field measurements at two study areas. 100 and 300 test points as reference were established in the study area 1 and 2 respectively (Figure 4).



a)



b)

Figure 4. a) Test points for study area 1, b) Test points for study area 2

Horizontal and vertical positions of the test points were obtained with tacheometric measurements. The errors of the elevation values were then calculated by subtracting the elevation value of the corresponding test points from the elevation value of each point in the Digital Elevation Model. For each test site, the root mean square error (RMSE), standard deviation (SD) (residuals calculated by subtracting the measured elevation of a given benchmark from its elevation in the produced DEM), mean error (ME) and mean absolute error (MAE) were calculated between the measured elevations of the Total Station benchmarks (test points) and their elevations in the produced DEM. The calculated statistics are given in Figure 5, which also shows the minimum and maximum elevation errors of the benchmarks. The mathematical equations of the ME, MAE and RMSE are given as Eq.8, Eq.9, Eq.10 and Eq.11 respectively.

$$ME = \frac{1}{n}\sum_{i=1}^{n}(Z_{DEi} - Z_{REi}) \quad (8)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}(|Z_{DEi} - Z_{REi}|) \quad (9)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Z_{DEi} - Z_{REi})^2} \quad (10)$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(Z_{DEi} - Z_{REi})}{n}} \quad (11)$$

Z_{DEi} in Eq. (8, 9, 10 and 11) refers to the elevation value of the corresponding points in the Digital Elevation Model, Z_{REi} refers to the elevation value of the point as calculated by the tacheometric measurements in the field and n refers to the number of points.

RMSE, MAE, ME and SD were calculated for each interpolation method for study area 1 and 2 in Figure 5. As seen in Figure 5, minimum and maximum of RMSE were computed 11.4 cm - 18.8 cm and 19.3 cm - 27.3 cm for study area 1 and 2, respectively. The calculated minimum and maximum values of SD range from 9 cm to 17.7 cm and from 20.7 cm to 31 cm for study area 1 and 2, respectively. The lowest ME value was calculated at 0.9 cm and 0.8 cm and the highest ME value was calculated at 4.4 cm and 3 cm for study area 1 and 2, respectively. Minimum and maximum of MAE were computed 9.9 cm - 15.2 cm for study area 1 and 17 cm - 24.8 cm for study area 2.

Secondly, the obtained results were analyzed statistically. The Shapiro-Wilk test was applied to check whether the reference points that were used had a normal distribution. As a result of this test, it was observed that since the skewness and kurtosis values for the points of both study areas are between -1.5 and +1.5 (Tabachnick and Fidell 2013), the reference points have a normal distribution. Later, with this data that was determined to have a normal distribution, the ANOVA: Friedman test was used to measure the significance of the means that were obtained through different interpolation methods. H_0 hypothesis claimed that "there is no difference between the variables." P-value was thus calculated at 0.17 for the first study area and 0.30 for the second. As $p>0.05$, H_0 hypothesis was accepted at 95% confidence interval. Thus, it was statistically concluded that there was no difference between the variables.

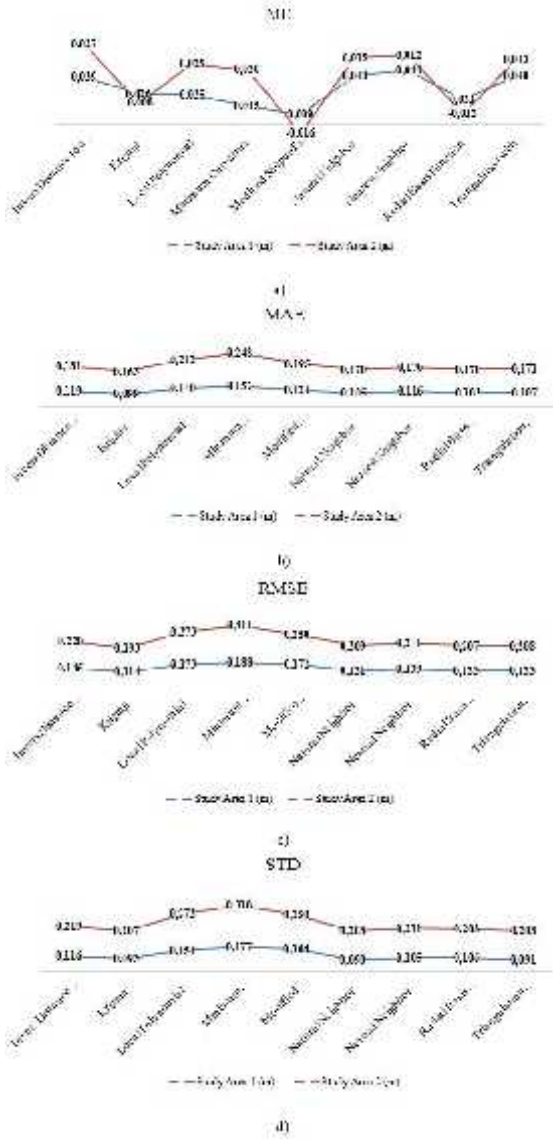


Figure 5. The calculated statistics a) ME, b) MAE, c) RMSE, d)SD.

5. CONCLUSION

In this study, the objective was to determine the most appropriate interpolation method for Digital Elevation Model preparation in different terrains with various topographical structures, using UAV-point clouds. At the end of the study, in the DEMs produced for both flat and sloping terrains, RMSE, SD, ME and MAE were achieved for the Kriging interpolation method, generally. Therefore, it can be stated that the most accurate interpolation method to represent the terrain surfaces of the study areas is the Kriging method. In both study areas, Kriging interpolation method was followed by Natural Neighbour, Radial Basis Function and Triangulation with Linear Interpolation methods.

The lowest accurate interpolation method is minimum curvature for each study areas.

In the event of missing or incorrect DEM data, the ability to obtain accurate new data using the appropriate interpolation methods may be time efficient and economically beneficial for the users. In addition, using UAV to gather these data would be highly beneficial for the users in terms of time, cost and accuracy.

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