



## POPULATION DISTRIBUTION BY GEOMORPHOLOGICAL UNITS IN YALOVA\*

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### ABSTRACT

The relationship between geomorphological units in Yalova province located in the east of the Sea of Marmara and the distribution of population was examined in this study. Geographical Information Systems (GIS) techniques, color digital orthophotos and data from TSI (Turkey Statistical Institute) were used in order to perform the study.

The current areas of settlement in the study were grouped by identifying the geomorphological units which they have been established upon. Population data (1965-2012) obtained from TSI (Turkey Statistical Institute) were arranged by comparing them with geological and geomorphological maps. According to this, 86% (183689) of the present population of Yalova province was determined to live in the flat valley bases, while 11% (23496) of it was determined to live in plateau areas. However, some geomorphological problems (earthquakes, floods etc.) can also be encountered although plateaus and valley bases may seem to be appropriate places for human activities. As seen in the recent past, the effects of these problems continue to be felt today from time to time. Therefore, it is necessary to perform detailed studies on the natural risk factors and their effects that influence province areas and to reveal the soil properties of the new residential areas to be opened for settlement in comprehensive studies.

**Key Words:** Population, Geomorphology, Geographical Information Systems (GIS), Yalova.

## YALOVA'DA NÜFUSUN JEOMORFOLOJİK BİRİMLERE GÖRE DAĞILIŞI

### ÖZET

Bu çalışmada, Marmara Denizi'nin doğusunda yer alan Yalova şehrindeki jeomorfolojik birimler ile nüfusun dağılışı arasındaki ilişki incelenmiştir. Çalışmayı gerçekleştirmek için Coğrafi Bilgi Sistemleri

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(CBS) teknikleri ile 0,45 cm çözünürlükteki renkli sayısal ortofotolardan ve TÜİK'nun verilerinden yararlanılmıştır.

Çalışmada mevcut yerleşim alanları, kurulmuş oldukları jeomorfolojik birimler tespit edilerek gruplandırılmıştır. TÜİK'den elde edilen nüfus verileri (1965-2012) ise jeoloji ve jeomorfoloji haritaları ile karşılaştırılarak düzenlenmiştir. Buna göre Yalova şehrinin günümüzdeki nüfusunun % 86 (183689)'sının ova vadi tabanlarında, % 11 (23496)'inin ise platoluk sahalarda yaşadığı tespit edilmiştir. Ancak, her ne kadar platolarla ova ve vadi tabanları beşeri aktiviteler yönüyle uygun sahalara olarak görülseler de bazı jeomorfolojik kaynaklı problemlerle (deprem, sel, taşkın vb.) karşılaşabilmektedir. Bu problemlerin etkileri yakın geçmişte görüldüğü gibi günümüzde de zaman zaman hissedilmeye devam etmektedir. Bu nedenle şehir alanını etkileyen doğal risk faktörleri ve etkileri hakkında daha detaylı çalışmaların yapılması, yerleşime yeni açılacak alanlarda zemin özelliklerinin detaylı çalışmalarla ortaya konulması gerekmektedir.

**Anahtar Kelimeler:** Nüfus, jeomorfoloji, Coğrafi Bilgi Sistemleri (CBS), Yalova.

## 1. INTRODUCTION

The distribution of the population on earth takes place under the influence of natural and human factors. Therefore, physical elements should also be evaluated together with economic factors in order to understand population and settlement geography as well as their problems (Yıldız, 2006; Balcı Akova, 2009; Atasoy and Özşahin, 2012). One of these elements is geomorphology. The effects of geomorphological elements on the population distribution are considerably so much especially in a mountainous and rough country like Turkey. It is not quite possible to fully understand the problems associated with the settlement without revealing the mutual interaction between physical condition and human beings (Bilgin, 1967: 82; Yıldız, 2006; Balcı Akova, 2009; Atalay, 2011).

Yalova is one of the areas chosen as a place of settlement since the early periods of its history. Estimating the settlement to begin in the Neolithic Era (8000-5500 B.C.), there are no accurate information on the establishment of Yalova. However, it was estimated to be founded by Bithynians who established a kingdom on the east of the Sea of Marmara in 7th century B.C. Yalova region, where various nationalities lived from Bithynians to Byzantines and the Seljuks, has continued its existence as a place of settlement until today after its conquest by the Ottoman State in 1326. While it was a town of Izmit until 1901, Yalova has been included among the districts of Istanbul in 1930. It was made a province on 6 June, 1995 (Yalova Provincial Special Administration, 2013).

According to the administrative division of today, it has 6 districts, including central district, such as Altınova, Armutlu, Çınarcık, Çiftlikköy and Termal, and 43 villages. It also has a total of 9 town municipalities: 1 in the central district, 3 in Altınova (Kaytazdere, Tavşanlı, Subaşı), 4 in Çınarcık (Koruköy, Teşvikiye, Kocadere, Esenköy), and 1 in Çiftlikköy (Taşköprü). According to TSI data of 2012, total area of the province, where 211799 people live, is approximately 847 km<sup>2</sup>. The arithmetic population density is 250 people according to this detail. Of the residential areas in the province (5635 hectares), where urban settlement is dense, approximately 4509 hectares are used as urban settlement areas, whereas 1126 hectares are used as rural settlement areas (Bahadır, 2007).

## Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014



A significant part of Yalova is constituted by not very high masses and mountainous areas. The region, known as Daz Mountain (921 m) in Samanlı Mountains constitutes its highest point. Approximately 70 km long in east-west direction and 15-20 km in width, this area bears the feature of a horst under the effect of the North Anatolian Fault Zone (NAFZ). In this case, the Gulf of Izmit on the north of Yalova and Gemlik Bay and Iznik Lake on its south have graben features (Ardel, 1949; Bilgin, 1967; Akartuna, 1968; Meriç et al., 1999).

Formed of rocks in various ages and types from Precambrian to present, research area is very much affected also from current tectonic movements. Geographical formation with different properties have emerged across the province since diversity in geological-structure also affect the geomorphological structure (Ardel, 1949; Bilgin, 1967; Akartuna, 1968; Meriç et al., 1999).

The explanation of the relationship between geomorphological structure and demographic characteristics of Yalova province is necessary for minimizing the problems that may arise in this context. Because river and valley bases in the research area, where population is dense, are exposed to both mass movements and floods. Moreover, the problem of soil liquefaction has become the main reason for damages in structures and building foundations in the past earthquakes. (Bahadır, 2007; Zarif et al., 2004). These natural disasters reveal the importance of geomorphology on population and settlement. Therefore, this study aimed at contributing to do planning of a sustainable and more permanent planning by revealing the distribution characteristics of the population in Yalova according to geomorphological units.

## 2. LOCATION OF STUDY AREA

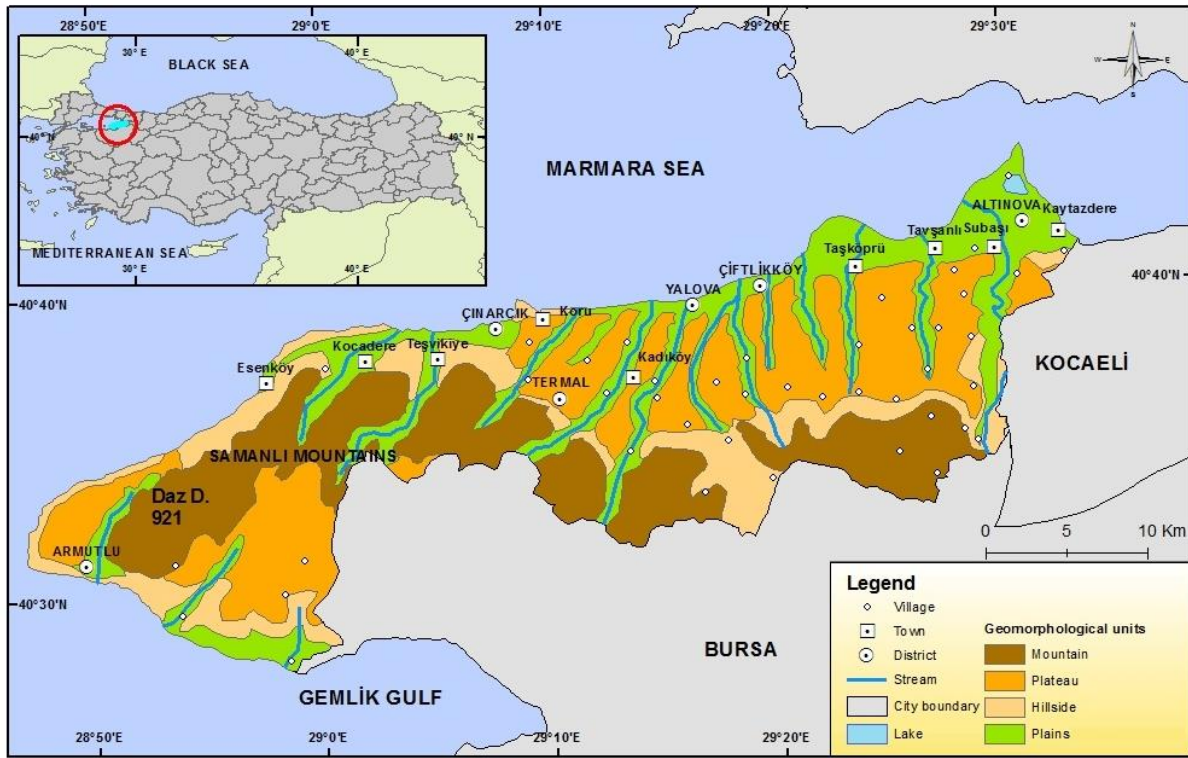
Yalova is located at the northwest of Turkey and at the southeast part of Marmara Region between 28° 45' and 29° 35' East longitudes, 40° 28' and 40° 45' North latitudes. Built on the northern coast of the Armutlu Peninsula and the northern slopes of Samanlı Mountains, the province is situated at G2-c2, G21-c3, G21-c4, G22-d1, G22-d2, G22-d3, G22-d4, G22-c1, G22-c2, G22-c3, G22-c4, G23-d1, H21-b1, H21-b2 sheets of 1/25000 scale topographic maps. The Sea of Marmara in the north and west of Yalova, Kocaeli in its east, Bursa province and Gemlik Bay in its south are located (Figure 1).

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### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014





**Figure 1.** Location of Yalova Province and Main Geomorphological Units Distribution Map

### 3. MATERIALS AND METHODS

1:25000 scale topographic maps, 1:100.000-scale geological maps, 0,45 cm resolution color digital orthophotos and constitute and TSI data constitute the data sources of the study.

In the study, firstly 1/100000 scale geological map sheets were scanned in JPEG format at high resolution, later it was digitized and database was created, and the distribution of the lithological units was determined by using ArcGIS 10.2 software. 1/25000 scale vector data are used as main base for determining geomorphological features of the area. The main geomorphological units in the research area were determined from 1/25000 scale topographic map. 0,45 cm resolution color digital orthophotos, produced by General Command of Mapping during the creation of the maps. In the final stage, geomorphological units, upon which each settlement was established, were identified and the grouping was performed. Population data between 1960-2012, obtained from TSI were also organized in accordance with the purpose of the study. The obtained data were interpreted and evaluated in the light of current literature and land examinations from a geographical point of view.

### 4. RESULTS

Yalove province has morphological features where all main geomorphological units can be seen (Figure 4). Morphological features and the distribution of population according to geomorphological features were explained below.

The unit that has the most extensive distribution among geomorphological units in Yalova is plateau land of 239 km<sup>2</sup> and 30 % ratio. Yalova province has the appearance of a plateau in

#### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014

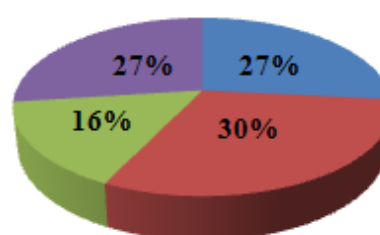


general. Lands in the south of Armutlu district and in the south of Çınarcık ve Yalova'nın are plateaus in character. Particularly, the environment of Armutlu district are topography plateaus in character which are pierced by short rivers. This area is in an average of 80-100 m in elevation. There are also medium-height hills in the area. The heights of the hilly areas vary between 300-250 meters. Plateau lands, towards to Bozburun in the west, have been smoothed well enough to regard them as flat lands. Plateau lands, whose heights are between 200-400 meters, are stated as low-plateau, whereas those, which are between 400-700 meters, are called high plateau lands (Bahadır, 2007; Table 1; Figure 2, 4).

**Table 1.** The Main Geomorphological Units in Yalova and Spatial Distribution

Geomorphological Units	Area	
	Km <sup>2</sup>	%
Mountain	208,1	26,6
Plateau	239,0	30,6
Slope	123,1	15,7
Plain	211,7	27,1
<b>Total</b>	<b>781,9</b>	<b>100,0</b>

■ Mountain ■ Plateau ■ Slope ■ Plain



**Figure 2.** Spatial Distribution of the Main Geomorphological Units in Yalova (%)

In the province, unit that occupies the maximal area in terms of areal size is plain after plateau areas (Table 1, Figures 2, 4). The most important plain lands are Altinova and Taskopru plains in Hersek and Laledere delta plains. Formed by Yalakdere, Hersek Delta has an elongation of 4.5 km between Altinova village and Hersek Cape. Having an approximately a surface area of 25 km<sup>2</sup>, there is a lagoon in the northeast of the delta plain. The topography of Hersek Delta's elongation within the sea can be traced back to -45 (Alpar and Güneysu, 1999; Zarif et al., 2004). Laledere Delta, created by Laledere, is the second largest delta plain in the province. Topography rises suddenly towards the south of delta plain formed by Neogene sediments. The reason for this rise is the normal faults which are often debated whether they are active today or not (Alpar, 2005; Tunç et al., 2011; Figure 3). However, stream and valley bases are exposed to mass movements as well as floods. The central district of Yalova, in particular, has been established in the flat alluvial soils where river meets the sea. The emergence of liquefaction problem on the alluvial ground arises a dangerous situation in terms of settlement there (Zarif al., 2004).

Other plains in the research area are Kocadere, Güngörmez, Selimandıra ve Eyrek Dere delta plains which line up towards the west of coast of Yalova (Figure 4). Formed by Koca Derem the space that delta plain takes is 1.1 km<sup>2</sup>, its coast length is 0.9 km and width is 1.5 km. The surface area of Gungormez Dere delta is 1.9 km<sup>2</sup>, its length is 1.9 km and its width is 1.6 km. Selimandıra Dere delta's surface area is 2.9 km<sup>2</sup>, its length is 2.4 km and its width is 2.4 km. The area of delta formed by Eyrek Dere is 2.88 km<sup>2</sup>, its coast length is 2.8 km and its width is 1.9 km (Kurt, 2013).

The mountainous areas are dominant with 208.1 km<sup>2</sup> and the ratio of 27 % in terms of arrangement of areal greatness after plain and valley bases (Table 1, Figures 2, 4). Slope comes at the last with an area of 123.1 km<sup>2</sup> and ratio of 16 % (Table 1, Figures 3, 4). Mountainous areas,

### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014

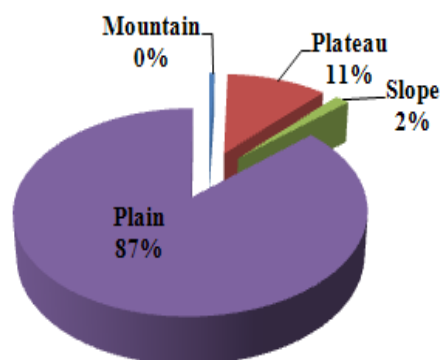


which make up a significant part of lands in Yalova province, form masses that are not very high. Samanlı Mountains extend in an area approximately 70 km in length and 15-20 km in width in East-West direction (Bilgin, 1967). These mountains, carrying characteristic of horst in their basis, are formed from metamorphics and volcanics (Ardel, 1949). Daz Mountain (921 m) constitutes the highest point of Samanlı Mountains situated between the grabens of the Gulf of Izmit in the north and Gemlik Bay in the south (Bilgin, 1967; Figure 4). Their northern slopes are split by short-sized streams and are in the feature of a defective topography. Their southern slopes are split much less and have a less defective topography with extensive flat lands. The reasons for these differences in topography are the continuation of new lithological formations that are resistant to erosion, subsidences and landslides that emerge from violent earthquakes occurred at the northern fault zone time to time and the formation of slope fractures in river valleys (Ardel, 1949; Bahadır, 2007;).

Significant differences are observed in the distribution of population in Yalova according to geomorphological units. Population becomes dense particularly in plateau areas, slope and flat bases of plains. Situating at these areas, the central district of Yalova, Altınova, Çiftlikköy, Termal and Çınarcık are the most densely populated districts (Table 2, Figure 3,4).

**Table 2.** Amount of Population by Geomorphological Unit Distribution (2012)

Geomorphological Units	Area	
	Population	%
Mountain	1242	0,6
Plateau	23496	11,1
Slope	3372	1,6
Plain	183639	86,7
<b>Total</b>	<b>211799</b>	<b>100,0</b>



**Figure 2.** Spatial Distribution of the Main Geomorphological Units in Yalova (%)

The 87 % (183639 people) of the total population in Yalova live in the plain (Tables 2, 3; Figures 3, 4). This situation can also be understood from the number of people affected by frequently seen geomorphological problems in plain and valley bases. Because these lands are under great risk both due to the condition of their bases and their close proximity to fault lines (Şahin and Tari, 2000; Yüksel et al., 2000; Alpat, 2005; Tercan, 2005). Çınarcık, Çiftlikköy and central district, found in the research area, can be considered as the most risky areas from this aspect. The most affected areas in Yalova, during the Marmara earthquake of 17 August 1999, which is one of the greatest earthquakes in Turkey, are these places. Plain and valley bases are exposed to mass movements as well as floods. The central district of Yalova, in particular, has been established in the flat alluvial soils where the river meets with the sea ( Figure 4). It is also a risky area for settlement due to the liquefaction problems on the ground (Zarif et al., 2004).

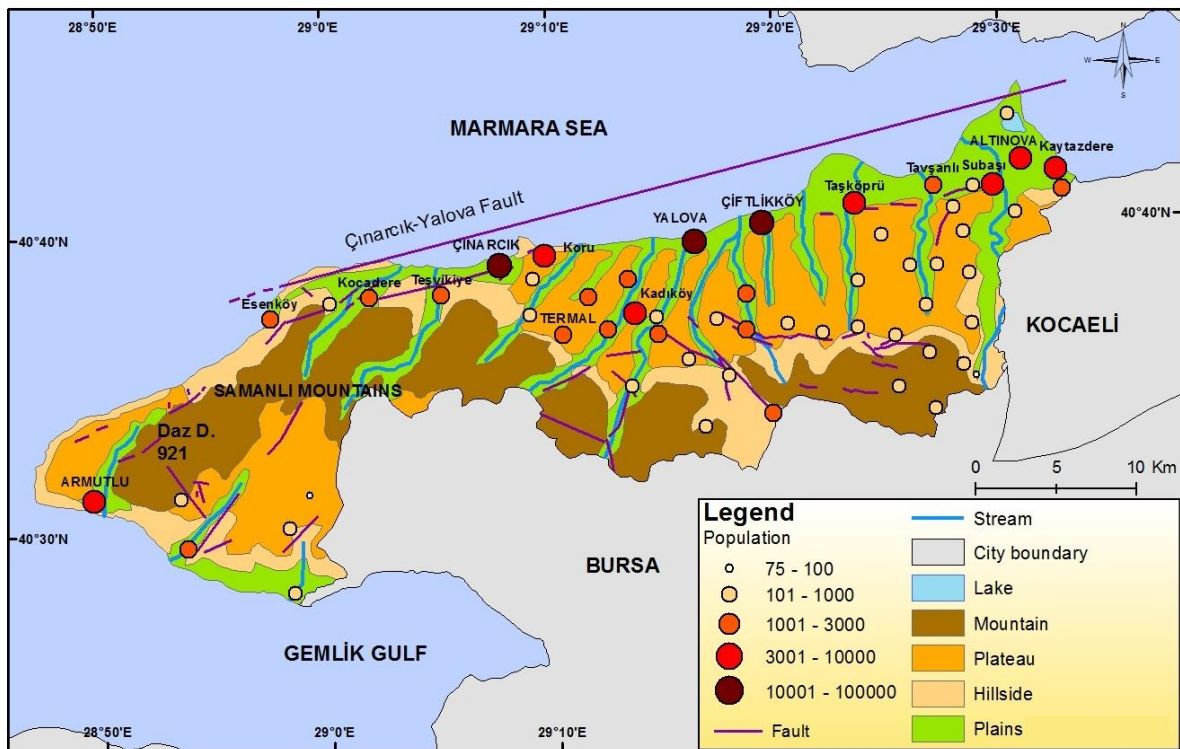
Another problem encountered in the plain and valley bases is the flooding of agricultural lands due to the accumulation of water in flat regions during the days of heavy showers in the months of spring. The most important of these streams is Selimandıra River valley bed. However, the plain and valley bases are very desirable fields in terms of human use since they have favorable

#### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014



climate and soil properties. The presence of fertile alluvial soil has become the cause of intensive agricultural activities. Agricultural activities in the province are intensely performed, particularly, in the flat lands of Laledere Delta, Hersek Delta, Çiftlikköy, Tasköprü and Yalova plains situated in the northern regions of the research area and in the flat places situated behind the coast in the southwest. Vegetables, fruits and olive farming and greenhouse cultivation is common in these areas. Vegetables farming is carried out in an area of approximately 1420 hectares (Özdemir and Bahadır, 2007). Another element of attraction in plain lands are coastal tourism and industrialization (Olçay, 2012). These lands are used for touristic purposes since low-coasts enabled the development of the beaches. Industrial institutions in Yalova province are located within the boundaries of Altinova and Çiftlikköy districts. Particularly, the certain advantages of these two districts, such as the flatness and wide-area coverage of the coastal areas, the presence of water resources, sea, land and air transportation, and their close proximity to Istanbul and Kocaeli provinces have also caused industry-based growth in population. The coastal plains are one of the most densely populated places in Yalova in terms of population distribution because of all these reasons (Tables 2, 3; Figures 3,4).



**Figure 4.** Distribution Map of Population by Geomorphological Unit in Yalova Province

The second geomorphologic units in terms of population density are plateau lands in the state of surface erosion (Tables 2, 3; Figures 3, 4). Approximately 11 % (23496 people) of the population live in these areas. The geographical formation in the research area to be reviewed in this context are located between Armutlu-Bozburun and Çınarcık-Çiftlikköy. Pierced by short-sized streams, these areas are of 80-100 m in height on average (Figure. 4). The main factors in the population distribution in plateau areas are economic activities based on agriculture and animal husbandry. Especially, dry farming (in the south of Çiftlikköy), olive cultivation (Armutlu), animal husbandry and bee-keeping activities (Gacik village and Laledere Village) are carried out.

#### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014

The third geomorphological unit in terms of population density in Yalova are slope (Tables 2, 3; Figures 3, 4). 3372 people live in these areas throughout the province (2 %). The slope of Samanlı Mountains facing north and south are areas where the proclivity is very high. Their slopes rates are changed approximately about 20-30 %. Less-slopped regions, where slopes meet with plain, are areas suitable for the settlement of the population. The forested slopes of Samanlı Mountains generally are less favorable for settlement since the flat plains are scarce and the population distribution is quite sparse in comparison with plain. In addition, mass movements occasionally become effective in Çiftlikköy, Taşköprü, Altınova and near surroundings that are located in the regions where mountains combine with plain and valley bases. Çiftlikköy district is particularly under the threat of landslides. Another landslide area is a 1-6 m thick segregation level on Kılıç Formation.

The least densely populated areas in Yalova are the mountainous aread with the population of 1242 people (0.6 %) (Tables 2, 3; Figures 3, 4). The mountainous areas in the province are represented by Samanlı Mountains. These regions have become the center of life for people in terms of pasture and animal husbandary activities.

Areas of limited population and settlement in Yalova province are bare rocky areas and elevated coasts. These areas are the higher parts of Samanlı Mountains, elevated coastal areas around Çınarcık and wetland areas in the north of Hersek Delta (Figure 4).

The variation that the relationship between population and geomorphology in Yalova shows according to years is extremely important. Because a significant population growth is seen in Yalova (Table 3). A rapid population increase has occurred in Yalova from 1965 to 1999 where intense population movement was experienced after becoming a province (1995). The population of Yalova, which was 54574 people in 1965, and 163584 people in 2000, has increased to 211799 people in 2012 (Table 3). While nearly 3000 people, who lost their lives after the Marmara earthquake occurred on 17 August 1999, were expected to be reflected in the population, a reduction of about 7000 people has attracted attention in the population census of 2000 (Table 3). This is due to those who lost their lives in the earthquake as well as a temporary migration out of the province. The annual population growth rate of the province in the periods of 1990-2000 is approximately around 22 o%.

**Table 3.** Population Number (Person) in Geomorphological Units (1965-2012)

Geomorphology	Years									
	1965	1970	1975	1980	1985	1990	2000	2007	2010	2012
Mountain	2240	2112	1882	1907	1574	1848	1941	1348	1361	1242
Plateau	18836	16859	17743	21842	21817	26213	23620	23165	25093	23496
Slope	2560	2606	2783	3106	3333	3657	3742	3458	3524	3372
Plain	30938	35383	47615	71133	86795	109936	134281	153787	173763	183689
<b>Total</b>	<b>54574</b>	<b>56960</b>	<b>70023</b>	<b>97988</b>	<b>113519</b>	<b>141654</b>	<b>163584</b>	<b>181758</b>	<b>203741</b>	<b>211799</b>

Yalova variability experienced in this population, as evaluated by geomorphological units, from past to present is understood to be the same. Accordingly, for the period 1965 until 2012, the population is greatest geomorphological units of the plains, at least the unit has continued as the mountainous areas (Table 3).

### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014



## 5. CONCLUSION

The 86% (183639) of the population is understood to be living in the valley and plain bases when the distribution of the population in Yalova province into geomorphological units is evaluated. This has continued so between 1965-2012 without showing any further changes except population growth. However, plain and valley bases also encounter with geomorphological problems (earthquake, floods, etc.) in addition to these high population values. The financial losses that emerge as a result of occasional floods or earthquakes also support this situation. Yalova is one of the leading areas fall under great risk of seismicity since it is especially located on the North Anatolian Fault Zone. Therefore, it is necessary to make a land survey while constructing places of settlement, industrial and other facilities.

The main determinative factor in the distribution of the population into geomorphological units is that these units are human-related. Because people have prepared, from the past to the present day, landforms where they can meet with their human and economic in the easiest way. According to this, the most appropriate areas for settlement in terms of natural features appears before us as areas where the population is dense.

The distribution of the population in Yalova into geomorphological units constituted both advantages and disadvantages. Even though plain and valley bases are suitable for agricultural production, they bear disadvantages in terms of geomorphological risks. Therefore proper planning should be made and be implemented for a sustainable population and settlement environment.

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### Turkish Studies

*International Periodical For the Languages, Literature and History of Turkish or Turkic*  
Volume 9/1 Winter 2014

