Effect of Urbanization on Groundwater Resources of Izmir City

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Abstract:

İzmir is the third largest city in Turkey. Fiftysix percent of the drinking water of İzmir city is provided from groundwater resources. Halkapınar (located on Bornova Plain) is one of the important groundwater resources areas. This region is providing 16 % of İzmir drinking resources. The water withdraws from the Halkapınar wells is about 30 million m3 in recent years. The groundwater levels of Bornova plain are range from 1 m to 10m. This plain had been used as agricultural lands until the 1950s, while today they have been opened for settlement. In 1965 Bornova accommodated half of its population in rural areas after receiving so much immigration. It was inevitable to open the citycentre to housing and to consider the surrounding village areas as urban areas. By the year 2000, the rural population had already been melted into the urban population. The agricultural areas in rural parts of the country will have completely disappeared in 50 years' time. Much of the surface of the plain is rendered impermeable by buildings, roads and surface coverings. Because of this covering, groundwater recharge is reduced and increases and accelerates runoff the plain. The groundwater recharge from precipitation was about 27 % in 1925, but this amount dropped to 13% in 2012. Groundwater recharge from precipitation will be 1% in 2030. Hydrodynamic of plain is change because of excessive urbanization. Groundwater level of the plain still high because tall building makes a barrier for groundwater recharge points.

Key words: Groundwater resources, urbanization, water quality, Izmir

1. INTRODUCTION

Mankind is the major geomorphic agent that affects the Earth's land surfaces (Sherlock, 1922,Underwood, 2001). Over 50% of the Earth's population now lives in cities and it is estimated that by 2025 this will increase to over 67% (Ramsey, 2003). Urbanization is the major processnow affecting the land. The development of cities inevitably increases paved surfaces and roofsand storm drains. Urbanization is an also major geomorphic process affecting groundwater systems (Sharp, 2010).

Although it is commonly stated, that groundwater recharge is reduced with urbanization because of the increase in impervious cover, the reverse is the more common condition urbanization increases groundwater recharge (Sharp et al., 2009). Asquith and Roussel (2007), DrouinBrisebois (2002), and Scheuler (1994). These problems have been seen many cities such as Izmir. Izmir has become the most important settlement of the Aegean Region from the ancient ages to the current era. Indeed, it is expressed that the city of Izmir actually includes three historical cities. The first city of Izmir is located in Bayrakli Bornova called as Smyrna in the 7th century B.C. This settlement is completely abandoned around 300 B.C. The second historical Izmir is located in Kadifekale hills (Pagos) around 300 B.C. The last Izmir is located at gulf of Izmir coasts.

Urbanization process of Izmir evaluated from the end of 19th century to present. In Figure 1, the all physical changes in urbanization process of Izmir is illustrated and following maps indicate periodic historical changes in Izmir

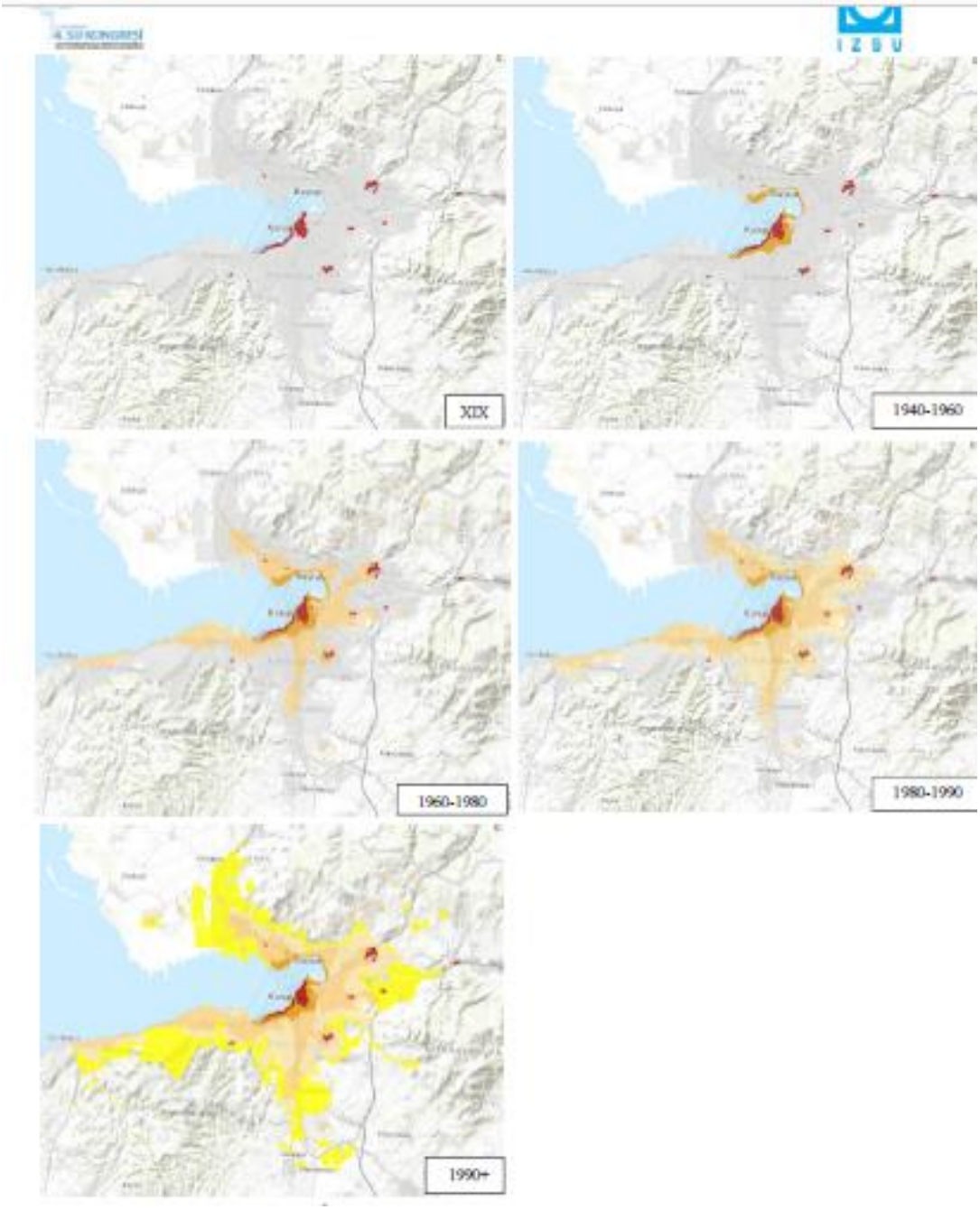

Figure 1. Settlement Areas from 19th Century to Present

Towards to the end of the 19th century, settlements were mainly centered in the coastal areas of the city. The growth of the city was directly proportioned to economic conditions of it. Industrial revolution revived the economics of the city during the 19th century. The city became a major external trade port in this century owing to its social, economic and urban development.

The construction of the port was the important improvement in terms of economic and social activities. Hotels, post offices, shipping companies and entertainment places were located in the port area and around it. The population of the city was about 150.000 at that time and the city was composed of a central part of Konak, Alsancak and Güzelyalı districts.

In the 1990s the expansion of city although is not as rapid as a previous period but many new settlements add to city borders. For instance, new housing areas increase between Karşıyaka and Çiğli on wetlands and expansion in Menemen Güzelbahçe Gaziemir Bornova corridors. The population of the city increased to 2,366.343 in the 1990s and some major transportation axes such as new ring road, Karşıyaka tunnels extended the city border to new geographical limits. Harbour starts to become major traffic reason in the city center and railway transportation increases the daily city commuters.
The study examines the stress that buildings had on groundwater resources area in 2001 and 2016 by using GIS geostatistical analysis. The changes argue the planning decisions and also warn for future crises. Although plans have been implied in the case the study results may lead to sets of further studies and prevention actions in case.

2. URBANIZATION IN STUDY AREA

Bornova is located some 11 km to the east of the provincial center of İzmir and the Gulf of İzmir Mt. Yamanlar, Mt. Spil and Mt. Nif surround the land of the town; the town's border approaches the Gulf of Izmir in the west (1 km); and the surface formations of the town consist of the plain and the mountains surrounding it. The plain had been used as agricultural lands until the 1950s, while today they have been opened for the university, industry, commerce, and settlement. Therefore groundwater recharge decreases extremely. The groundwater recharge from precipitation was about 27 % in 1925, but this amount dropped to 13% in 2012. Groundwater recharge from precipitation will be 1% in 2030 (Yazdani et al., 2017; Yazdani and Baba, 2017).
The settlement expansion illustrated in Figure 2. The total urbanization speeds from 1973 to 2012 is rapidly changed and almost whole is covered by settlements this trend is more ridicules in 2030 when new city center plan is applied.

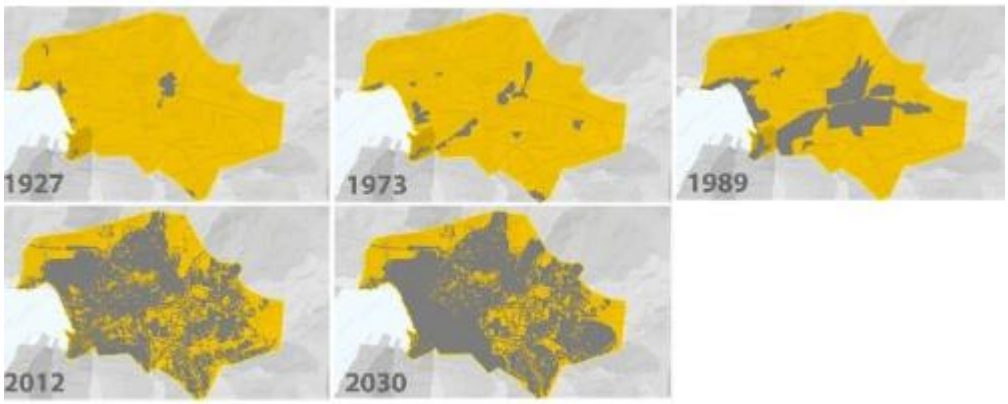

Figure 2. Spatial Changes from 1927 to 2030 in study area

Figure 3. Building floor number in 2016

The review of planning history in study area reveals that just like general characteristic of urbanization in Izmir the study area is also experienced both horizontal and vertical expansion. This becomes more signifying recently when height limitation for buildings in some area is removed. Figure 3. illustrate buildings floor number in 2016.

The evaluation of 2001 settlement map of İzmir and 2016 aerial photo and site observation of study area shows while in 2011 maximum height that observed in the field of study was around40m th is number reach to 200m in 2016. This extraordinary increase radically increases the building stress as well. As it shown in Figure 4. with a proximate calculation base on building footprint and floor numbers the building stress could evaluate as maximum 20.000 ton 2001 to 400.000 ton in 2016.

Figure 4. Building Stress number in 2016

For the better understanding of this change by applying Kriging Geostatistical analysis in ArcMap the proximate surface stress on ground layers could be shown in Figure 5. Studying urbanization background of site of the study reveals to the main outcome. Initially by rapid extension of settlement areas the site lose permeable surfaces and the by some planning criteria the stress on ground layers radically increase. Considering the importance of water sources in case of study these changes critically impacts on water circulation and the future of the city.

3. WATER RESOURCES OF PLAIN

The Bornova mélange (also called the 'Bornova flysch zone') forms the basement of the Miocene to Quaternary units around İzmir City (Figure 6a). The Bornova mélange is composed of varioussized blocks of Mesozoic limestones, cherts, submarine volcanic and serpentinites

Figure 5.Ground Stress Map in 2016

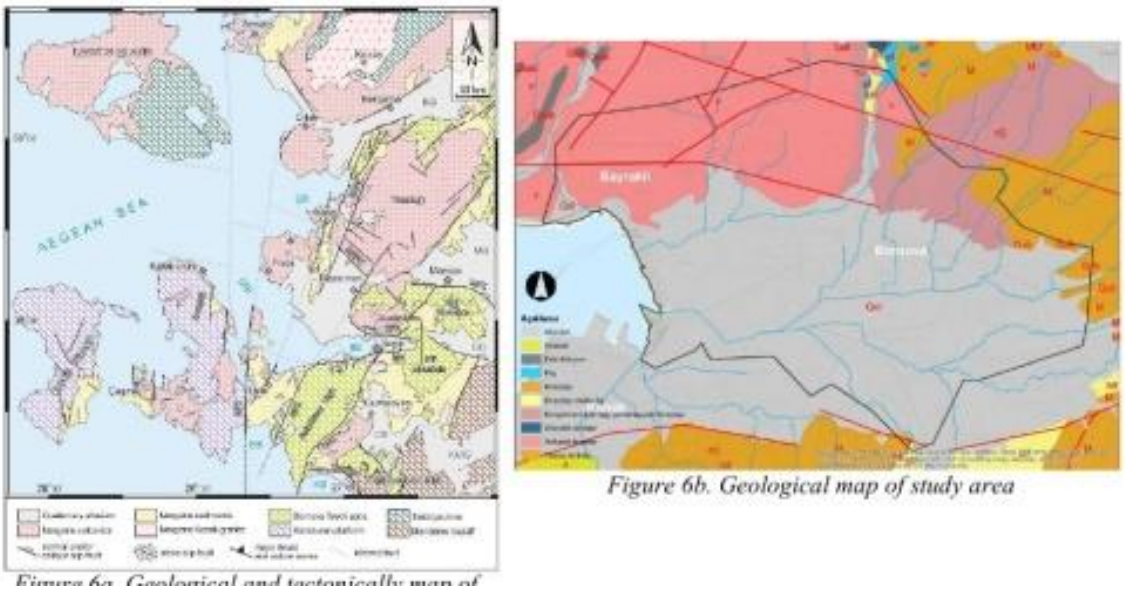

Figure 6b. Geological map of study area

Figure 6a. Geological and tectonically map of region (Uzel, et al., 2012)

embedded in a flyschtype sedimentary matrix (Erdoğan 1990; Okay et al. 1996). The Bornova mélange has undergone significant deformation, with a very low metamorphic grade (Erdoğan 1990; Okay & Siyako 1993; Okay & Altıner 2007; Uzel et al., 2012). Blocks of Mesozoic limestones is a karstic aquifer of the system and the other units of Bornova melange are impermeable rocks in the region. The Miocene units consisting primarily of conglomerates at the base, limestones, mudstones, and sandstoneshale alternations, unconformably overlies the basement rocks. Conglomerate, limestone, and sandstone of Miocene unit have porosity and permeability. These rocks also one of the aquifers of the system. The overlying unit is made up of calcalkaline volcanic rocks known as the Yamanlar volcanics which are composed of several lavas, pyroclastic rocks, dikes and domes of dacitic, andesitic, rhyolitic and basaltic compositions. These rocks include some water resources. Yamanlar volcanic have a jointed aquifers. Most part of the study area is consisting of quaternary units which are including gravel, sand and clay materials (Figure 6b). Quaternary is the one of the important aquifer for groundwater resources of İzmir City.

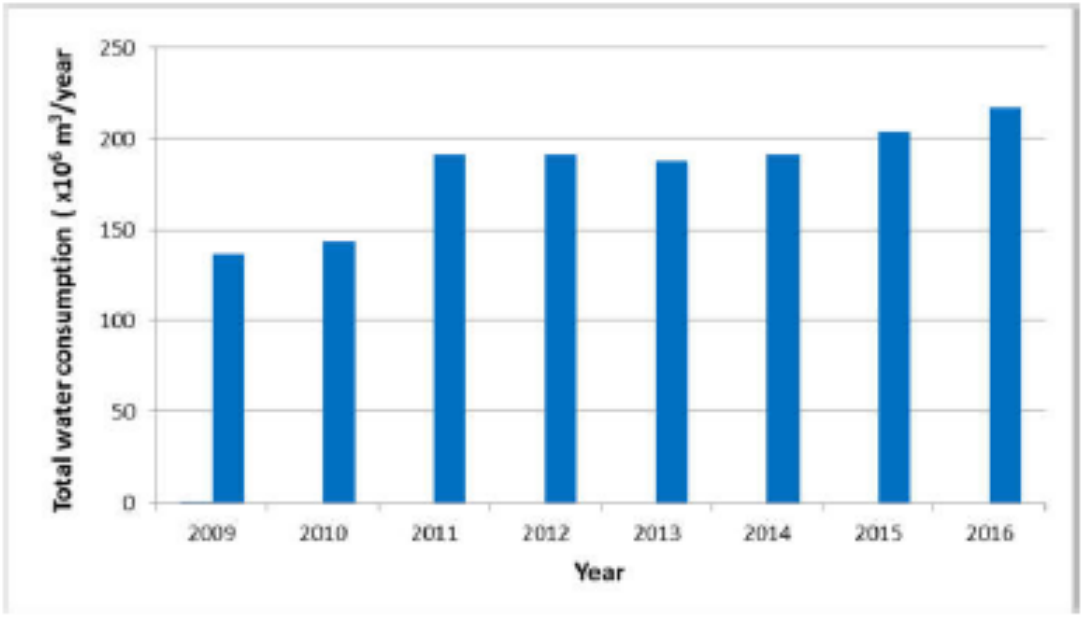

Figure 7. Total water consumption in Izmir city

İzmir city has a surface area of 12.019 km2 and has three river basins and significant groundwater resources but the water resources are very limited. Water consumption of İzmir has increased in recent years (Figure 7). The total water resources of İzmir Metropolitan Municipality (IMM) is about 2630 hm3/year, which corresponds to 3.5% of the water potential of Turkey. The total groundwater potential of IMM is 560 hm3/year. This water comes from Küçük Menderes Basin (231hm3), Gediz Basin (106 hm3), North Aegean Basin (65 hm3) and coastal area (158 hm3). Annual average water potential per person is 639 m3, which is about 60% lower than the average in Turkey (Murathan, 2015). Groundwater potential of İzmir is 560 hm3/year including springs (Baba, 2013; Baba, 2014; Murathan and Baba, 2015). According to 2016 data, 56% of the waters are provided from groundwater and 44% of surface water in İzmir City (Figure 8). Most of the groundwater resources come from karstic limestone in Sarıkız, Göksu, Menemen – Çavuşköy, Halkapınar, Pınarbaşı and Buca wells. Bornova Plain is one of the important regions for groundwater resources where have been used many years. Many wells were done in this region for irrigation and domestic purpose. The thickness of the alluvium range from 50 m to 150 m in the plain (Figure 9). The groundwater level is range from 2 to 65 m (Figure 10) and groundwater is generally flow east to west in the Bornova plain (Figure 11). Twentyfive wells have been operated by General Directorate of Water and Sewerage Administration (IZSU) in this region. About 15% of drinking water provided from southeast of

plain (Halkapınar Region). The water withdrawal from the Halkapınar wells is about 30 million m3 in recent years (Figure 12).

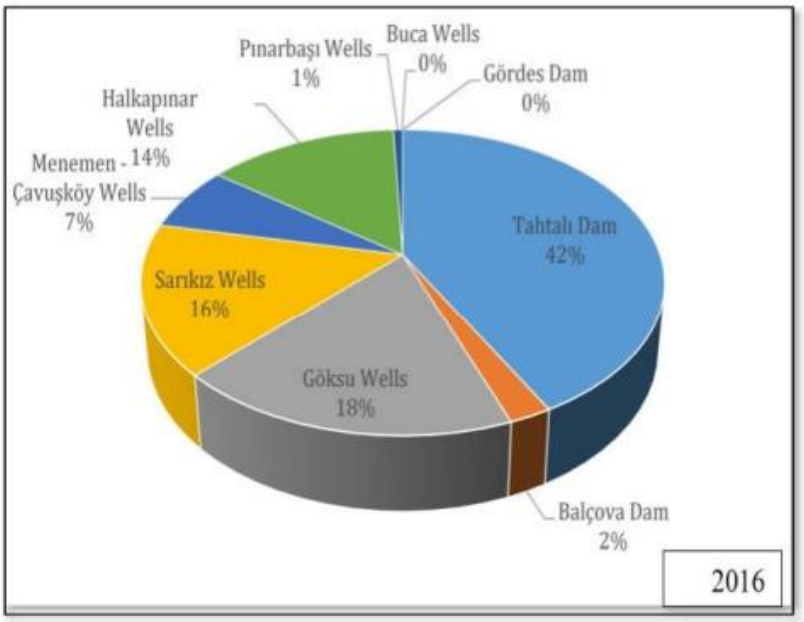

Figure 8. Distribution of water resources of Izmir

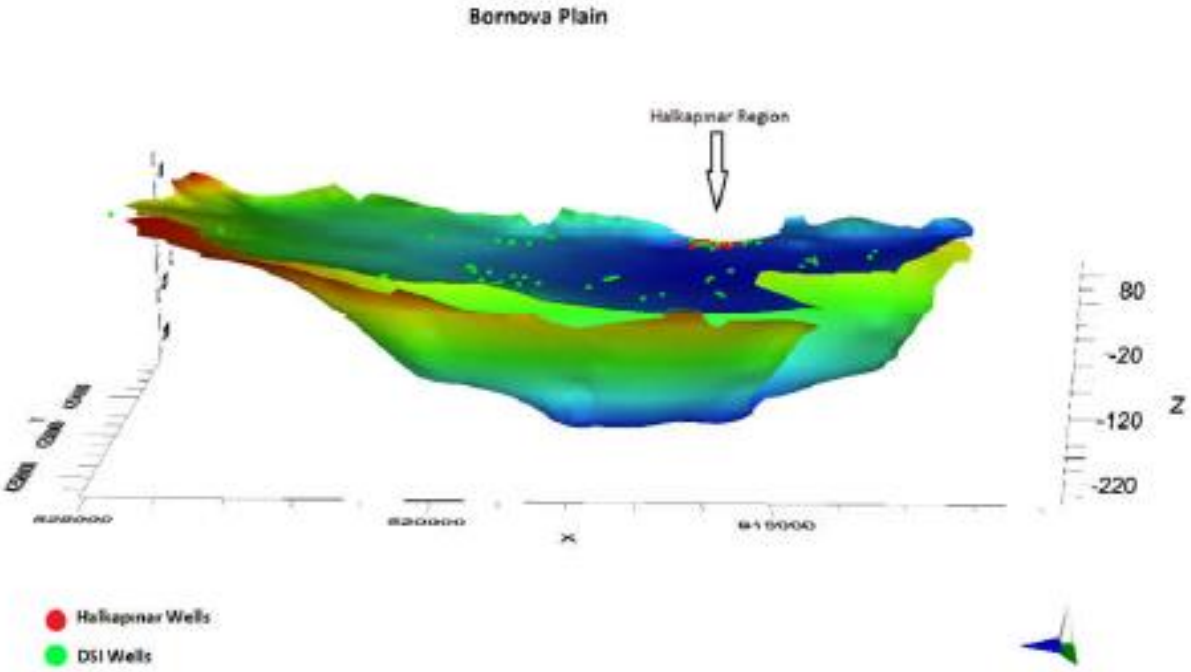

Figure 9. Thickness of alluvium in Bornova Plain

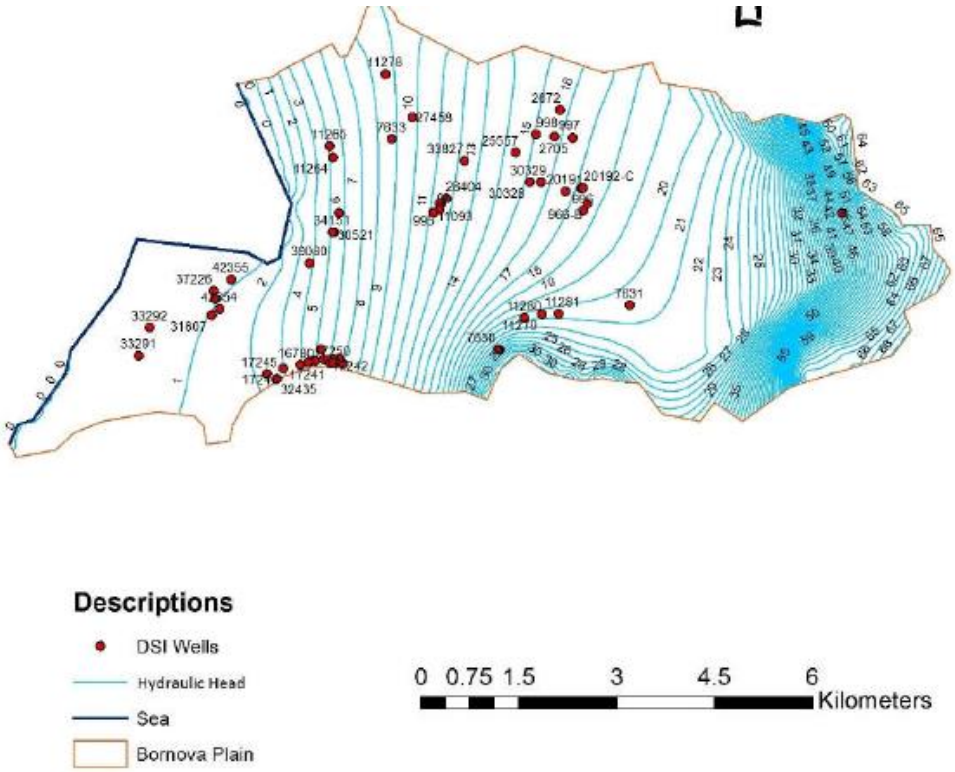

Figure 10: Groundwater table of Bornova Plain

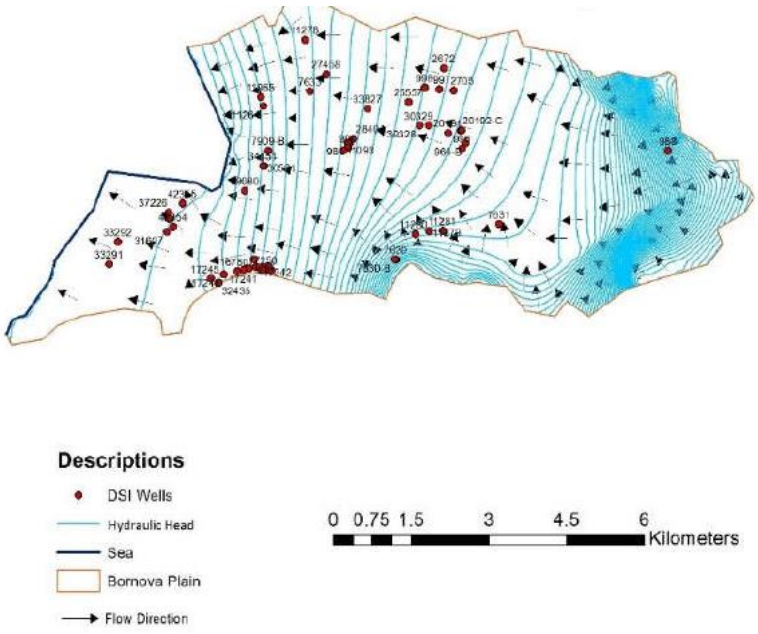

Figure 11: Groundwater flow map of Bornova Plain

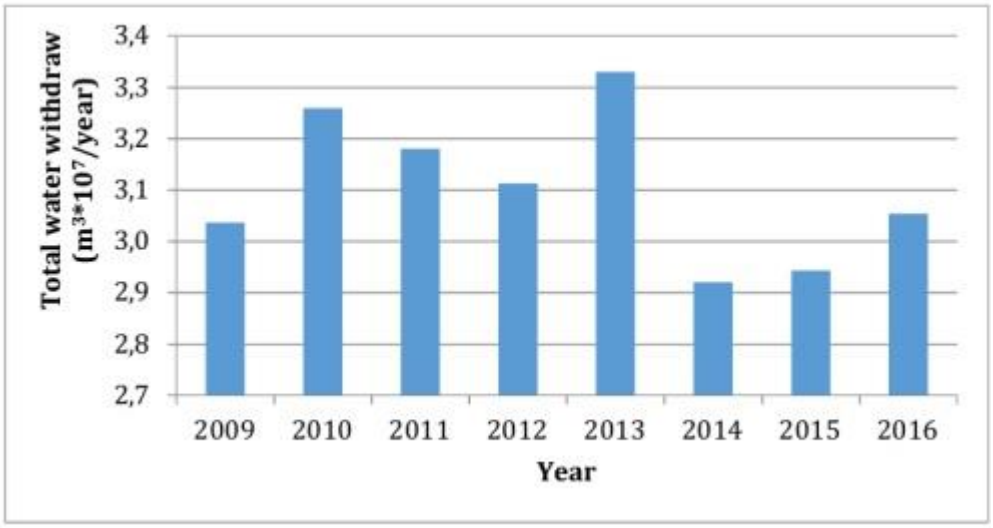

Figure 12. Water withdraw from Halkapınar wells

4. CONCLUSION

Urbanization reasons changes to the land surface by raising or lowering water levels, and
withdrawal of groundwater during or after construction and as a water resource that can cause subsidence and its accompanying effect. These all affect the hydrodynamic system region.

Studying the planning criteria and water resources in the plain show that these twocritical variables are investigated separately and although many study and research have done but the results are not applied in the planning process. The result picture is a warning, the planning decisions have been adopted to the site and constructions continue to threatening wate r resources. It seems a set of immediate reactions should take place, both surface and ground indicators should precisely be investigated, comprehensive model of plain should be establish ed and methods for reducing this impacts should be studied.

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