

GLOBAL CLIMATE CHANGE

EDITOR

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YILDIZ TECHNICAL UNIVERSITY
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POSSIBLE EFFECTS OF CLIMATE CHANGE ON WATER MANAGEMENT IN ISTANBUL

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Abstract

The effects of global climate change became increasingly sensible. Particularly, precipitation and temperature variations are valid for Turkey in general, as well as Istanbul. Precipitation and temperature changes of Istanbul will cause growth of current water management problems and lead to new problems. In this study, meaning of global climate changes for Istanbul and its effects on water management are evaluated from a geographic perspective.

The effects of global climate changes on water management in Istanbul will be on "water shortage" and "flood and flash flood" first. Both issues will directly and indirectly cause significant problems and losses in Istanbul and their effectiveness will progress under the control of global climate change. In vulnerability and mitigation studies for shortage of water, flood and flash flood problems in Istanbul, "Physical Planning" based on watersheds and integrated perspective must be included; especially for new and large projects, assessments such as "Land Potential" and "Benefit-Cost Analysis" should not be neglected. Urban regeneration projects including such approaches may be an opportunity to reduce possible negative impacts of climate changes on water management in Istanbul.

Key Words: Istanbul, Climate Change, Water Management, Effects, Vulnerability and Mitigation.

Introduction

The results of scientific researches (Christensen et al., 2007; Smith et al., 2008; TWB 2012; EPA, 2013; NOAA 2013) reveal developments and dimensions of global climate changes in more details every day. Increase in average temperatures and changes in precipitation and such changes becoming more evident gradually draw attention as major elements of global climate change. Changes of climatic elements, such as temperature and precipitation, on a global scale are effective on Mediterranean and also Turkey (Fig. 1, 2) and, it is accepted that the effects of climate change in Turkey will be sensible more significantly in the near future (Önol and Semazzi, 2009; Önol et al., 2009; MEU, 2011; Tatlı and Türkeş, 2011; Vardar et al., 2011). Major cities and interaction areas are the sensitive areas of this issue. In this study, it is intended to address possible problems that may be caused in Istanbul and its surroundings by global climate change with a cause and effect and precautions approach. In this context, considering the water supply, rain water and alternative water resources, water needs, land use, constructions, every kind of hardground and urban infrastructure, roads, rainfall, surface runoff characteristics and etc. for Istanbul, main focus is current geographical features and

impacts of climate change on these subjects. The current climate, land use, geological, geomorphological and hydrographic and population data are used. Data analysis was carried out with the Geographic Information Systems and Remote Sensing technologies.

Common result of the researches is in the direction of Mediterranean region, where Turkey is also included, being under the influence of warmer, drier and less windy climate conditions than today during the period of 2000–2100. It is foreseen that the temperatures will be 3–4ºC higher in the seas and coastlines, and in the inner parts 4–5ºC higher than today in Summer, and in winter and fall 2–3 ºC, 3–4ºC respectively, higher than today (Türkeş et al., 2000; Christensen et al., 2007; Dalfes et al., 2007; Lionello et al., 2012; TWB, 2012; Planton et al., 2012; EPA, 2013).

These regional projections also cover Turkey. The effects of these climate changes in global perspective on Turkey will cause dominancy of sub-tropical weather conditions in wider areas than today. Areal expansion of arid and semiarid regions and extension of drought periods in Anatolia in summer are also the expected climatic developments (Türkeş, 1998; Türkeş et al., 2000; Dalfes et al., 2007; Önol and Semazzi, 2009; Önol et al., 2009; Türkeş and Tatlı, 2009; Türkeş et al., 2009; MEU, 2011; Öztürk et al., 2011; Tatlı and Türkeş, 2011; Erlat and Türkeş, 2012; Kadıoğlu, 2012; Önol and Ünal, 2012; Erlat and Türkeş, 2013). The intensity of warm and arid climate characteristics that will influence Anatolia will vary depending on geomorphological features such as altitude, the coastal and inner regions, degrees of aspect and roughness. The ratio of the rise in temperatures and decrease of precipitation that will affect Turkey will vary seasonally under the control of continental degree and geomorphological characteristics.

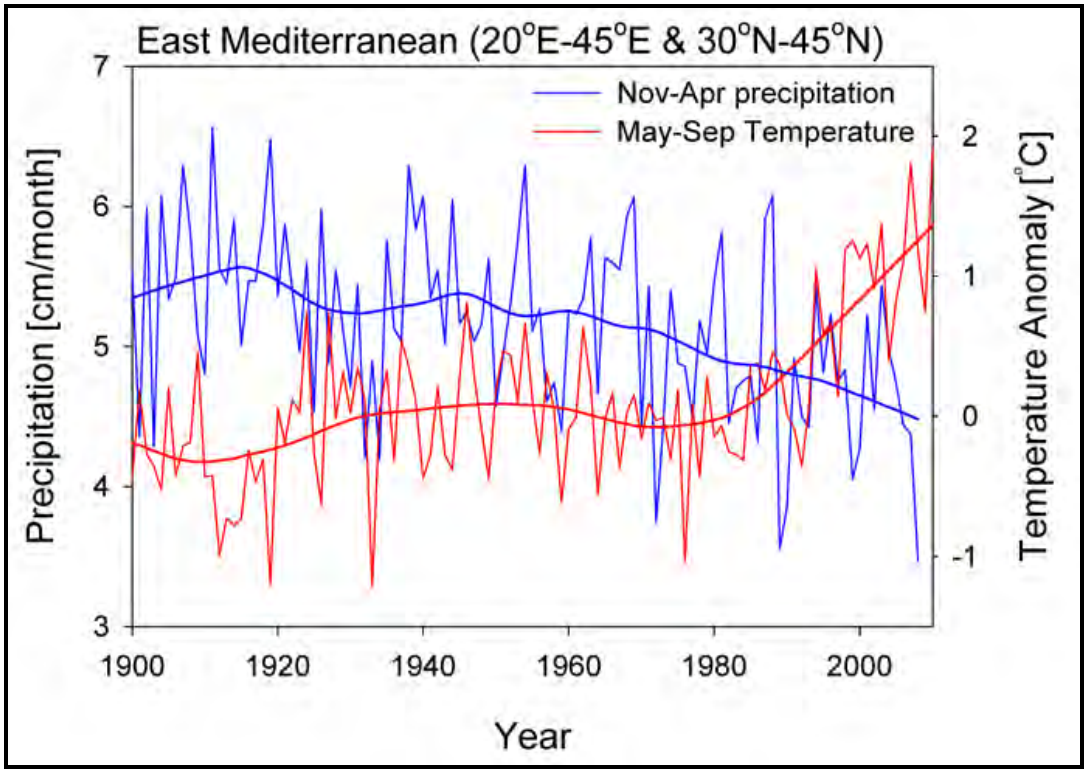


Fig. 1: Observed wintertime precipitation (blue), which contributes most to the annual budget, and summertime temperature (red), which is most important with respect to evaporative drying, with their long-term trend for the eastern Mediterranean region (TWB, 2012).

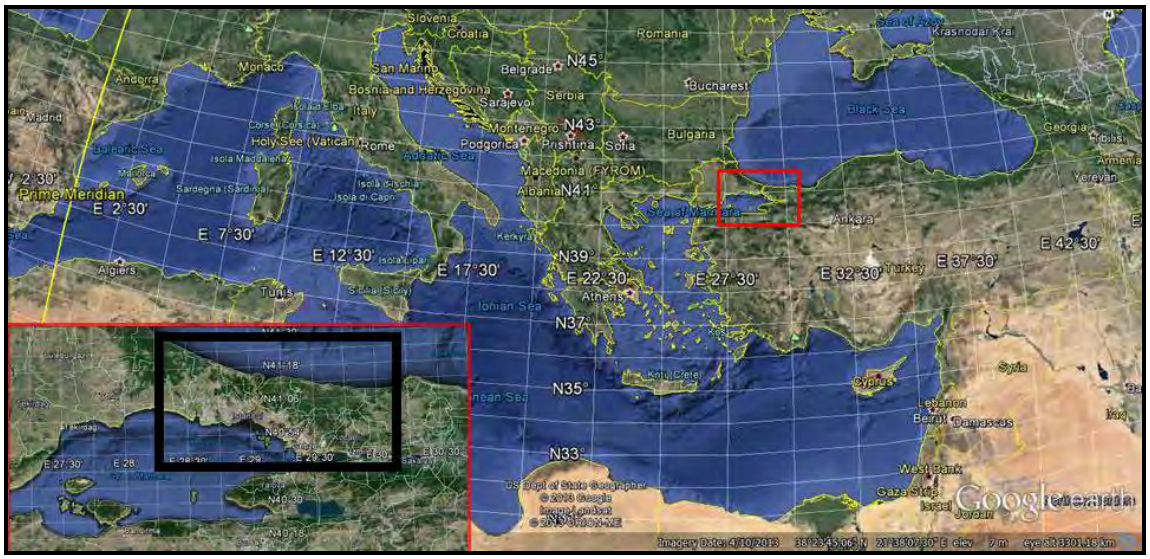


Fig. 2: Location features of study area.

According to the research results, it is expected that rainfall will significantly decrease during summer; this decrease may vary regionally and it will be between around 10% and 40%, and there will be annually average 25-30% decrease of precipitation than today (Christensen et al., 2007; Dalfes et al., 2007; Lionello et al., 2012; Planton et al., 2012). Another differentiation of precipitation is that, there will be more rainfall, and snowfall will decrease gradually and it will rain mostly during winter and spring. Rise in summer temperatures, longer summer periods and increase in numbers of arid and hot days during the year are the expected developments (Tatlı and Türkeş, 2011; Erlat and Türkeş, 2012; Kadıoğlu, 2012; Önol and Ünal, 2012; Erlat and Türkeş, 2013). Despite the regional differences, warm and arid weather conditions that are foreseen to influence Turkey and summarized above: will bring along agricultural and ecosystem problems, water loss due to severe evaporation, decrease in the amounts of precipitation and consequently decrease in water resources (water scarcity), floods and flash floods caused by sudden and heavy torrential rain, severe erosion, expected desertification depending on the continental severity, forest fires, and etc.

Possible effects of climate change on Istanbul

Historical peninsula and the south of Thracian and Anatolian coasts of the Bosporus being the center, Istanbul has an urban settlement dissemination spreading along the shores of Sea of Marmara in the east, up to Tekirdağ city borders in the west. Urban development and corresponding constructions are on the main axis towards east-west direction, along the southern coast of the historical peninsula (Fig. 2, 3).

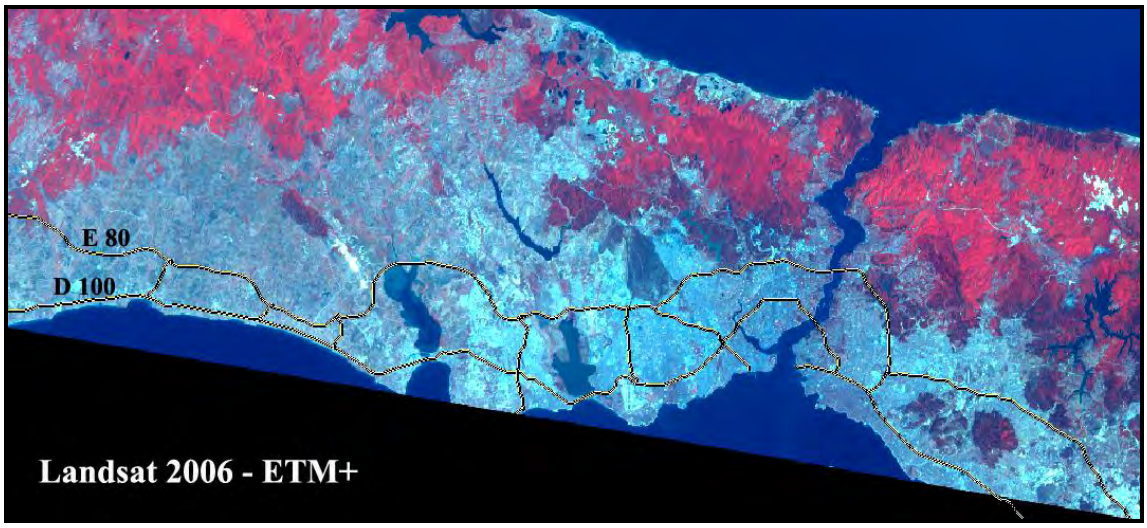


Fig. 3: Satellite image of Istanbul region and motorways. In band 4,2,1 combinations, red color on image represents vegetation.

Because of its latitude (Fig. 2) and effectiveness of atmospheric circulation, Istanbul and its surrounding will feel the effects of climate change more significantly. It is possible to refer to the rise of average temperatures, decrease of annual precipitation, precipitation as rain and sudden and downpour in certain periods of the year, stronger summer heats and their effectiveness in longer periods as projected climatic differentiations in Istanbul and its surroundings.

It is possible to classify the potential adverse effects of climate change on Istanbul and its close vicinity as physical, economic and social dimensions. These effects are in connection with each other and they must be considered as a whole. The main triggering factor is the differentiation, which has been described and summarized earlier, of climate elements like precipitation and wind. The major impact of climate change on Istanbul is related to water. In the next 50 and 100-year periods, Istanbul will gradually feel increasingly severe potable water shortage due to climate change and at the same time will be affected by the floods and flash floods in the magnitude of a disaster and will suffer. These effects will directly or indirectly cause loss of economic, social and unrecoverable natural resources and lead to ecosystem problems.

Water scarcity

As per today"s population characteristics, Istanbul is considered to be in need of daily average 2 million m^3 water (ISKI, 2013). According to the data of Statistical Institute of Turkey (TUIK, 2013), it has been understood that population of Istanbul will continue to grow in the next 50-year period (Avcı 2011). This situation points out that water needs of Istanbul will increase more and more in the future.

Very important water resources for Istanbul are the dams (Fig. 4) and rivers. Both of them will be affected significantly and in a short term by the changes that may occur in the fundamental elements of climate, such as precipitation and temperature. Water reservoirs of Istanbul are the dams; they are fed by the precipitation falling on the dam watershed as rain and snow. Moreover, permanent water flow from the streams out of the dam basin contributes

feeding the dam. Natural water loss of Istanbul dams occurs by the evaporation due to summer temperatures. The change in precipitation because of the decrease in precipitation and climate change in the direction of increase in temperatures will decrease supply of dams and also lead to water losses by evaporation. Therefore, the losses of water collected in the dams due to reasons other than natural causes of human use will increase. Moreover, rising temperatures and short precipitation will contribute to lower underground water levels and increase in water loss. Rising air and water temperatures will lead to an increase of degraded organic materials in water, a change in food chain and a decrease in the amount of dissolved oxygen in water. These changes will cause gradual decrease in the amounts of water collected in the dams, deterioration in the quality of water and insufficiency to meet the water needs of Istanbul.

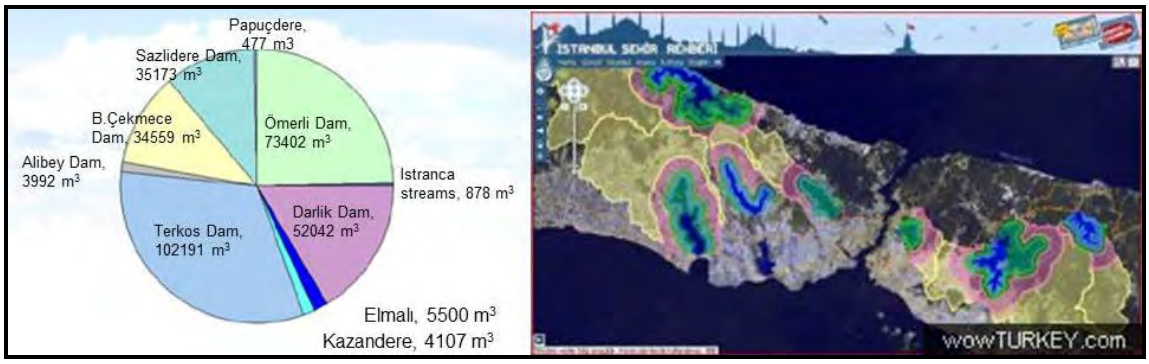


Fig. 4: As of June 28, 2007, the amount of usable fresh water (million cubic meters) according to sources and water basins in Istanbul (ISKI, 2013).

The streams in Istanbul and its close vicinity are the water resources that directly or indirectly contribute to the water needs of Istanbul. Basically, they are fed by rain and melting snow. The expected developments related to climate changes will also influence these rivers and cause changes on their flow and regime characteristics and water quality. These changes will cause decrease in the average flows of these streams contributing to the water needs of Istanbul during the year, gaining a flashflood flow regime characteristic by sudden torrential rainfall and significant damage in water quality because of the organic and inorganic suspended load. This corruption will have a gradually growing trend. Decrease in the amounts of the flow will cause increase in water needs of Istanbul, corruption of stream regimes will lead to disruptions of water supply during the year and damages to the water quality will diminish the usefulness of the coming water.

Floods and flash floods

Population projections and urban regeneration projects indicate that urban area and constructions will continue to grow. Current urban constructional activities are in nature of preventing the surface runoff of Istanbul (Turoğlu, 2010a; Turoğlu, 2010b; Turoğlu, 2011a). In the implementation of structuring and transportation projects, natural flow accumulation and natural flow directions have been ignored. Urban development of Istanbul encouraged main arterial motorways in the east-west direction and connecting roads in the north-south direction. The natural flow directions of Istanbul and its close vicinity from the water section line towards east-west direction are towards the Black Sea in the north (to the north) and Sea of Marmara towards the south (to the south). In this case, main motorways like D100 and E80

intersect these drainage systems in a way preventing the natural flow (Turoğlu, 2010a; Turoğlu, 2010b; Turoğlu, 2011a, Turoğlu 2011b). And also, the North Marmara Motorway (NMM) which is ongoing construction has been designed with the same approach (Fig. 5). Connections of main arterial motorways are always in north-south direction and passing through the valley bottoms (Fig. 6) that have natural flow channels in the same direction. In the implementation of road projects, passages of creek beds were done either by filling or insufficient box or pipe culverts (Turoğlu, 2010a; Turoğlu, 2011a; Turoğlu, 2011b). Defective creek improvement projects are other implementations that block surface runoff. Istanbul creeks that have been taken into concrete channels with inadequate cross-sections cannot be successful on carrying water from extraordinary precipitation. The low bridges that reduce cross-sectional areas are defective projects that block surface runoff of underpasses, which are not in line with natural flow systems of surface drainage, in Istanbul.

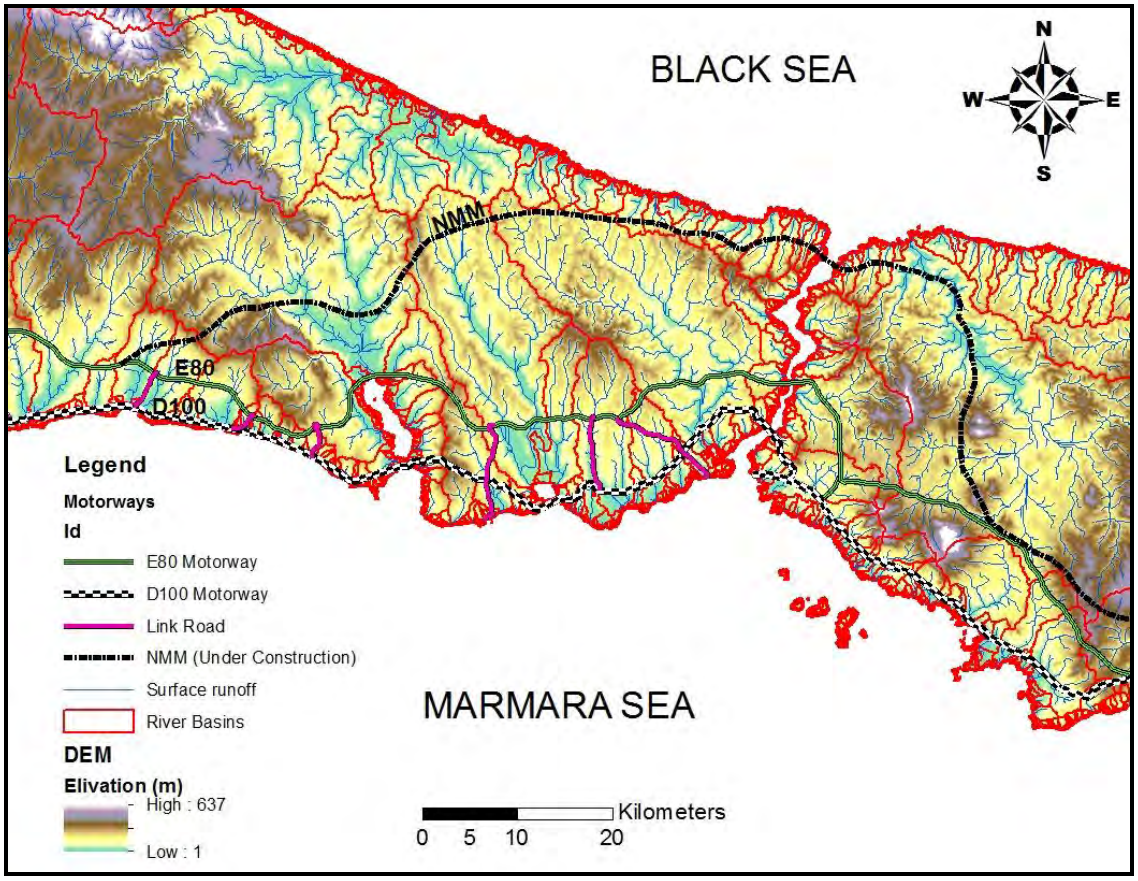


Fig. 5: The natural flow accumulation and flow direction together with Digital Elevation Model (DEM) of Istanbul region. Surface flows in river basins have been prevented by E80 and D100 highways.

Today, Istanbul often suffers from floods and flash floods due to construction problems outlined above. Some of these floods and flash floods occur in the magnitude of a disaster that causes loss of life and property (Turoğlu, 2010a). Floods and flash floods that occur in Istanbul due to climate change will continue while their frequency and severity increase more and more, because sudden and severe torrential downpours will be one of major effects of climate change on precipitation patterns. This significant change of precipitation pattern will cause the floods and flash floods to become a much bigger problem for Istanbul because of

the urban structure outlined above. Insufficient open and closed rainwater drainage systems and malfunction of the existing ones will play a role that increases this effect.

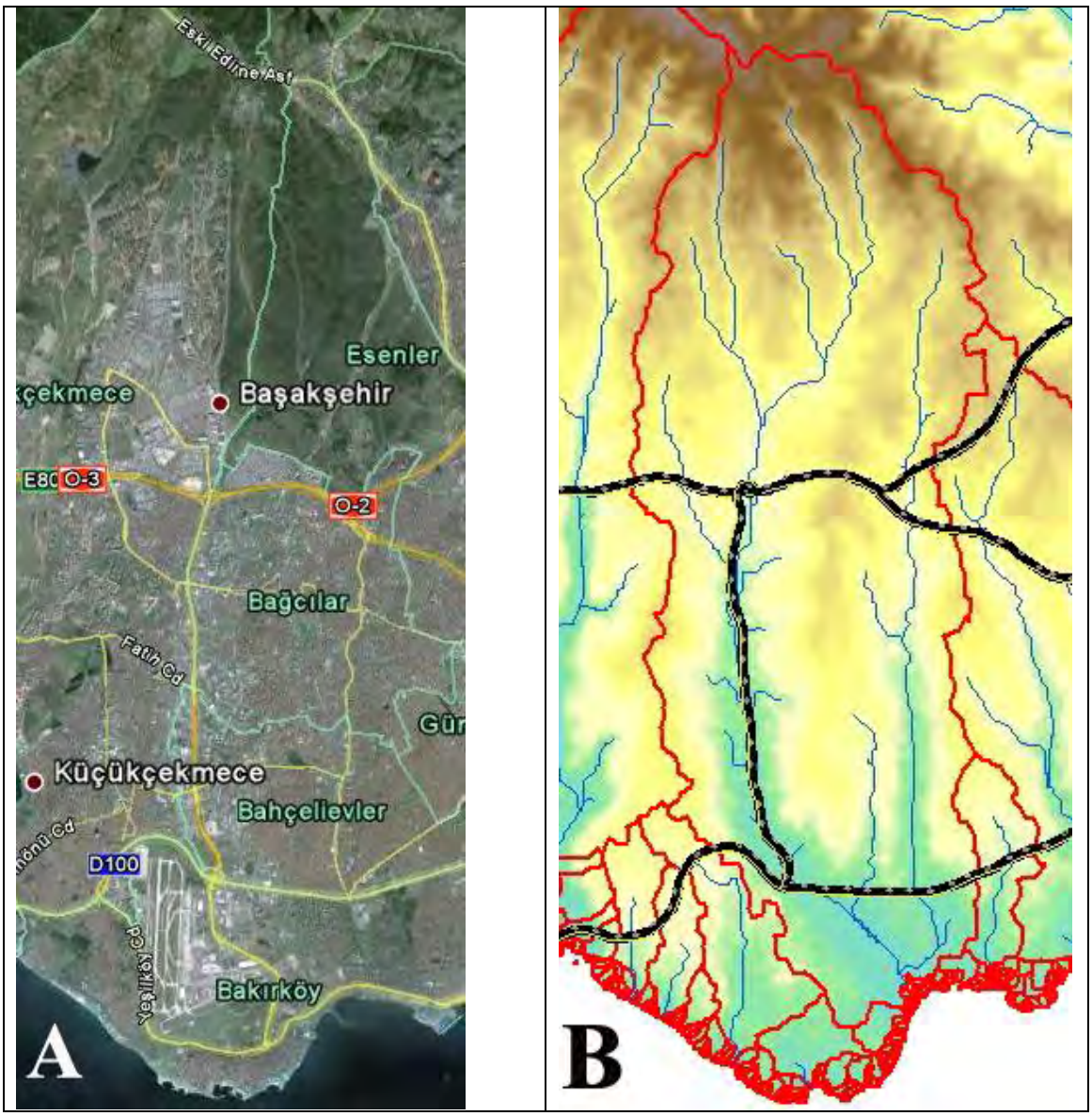


Fig. 6: Mostly, the natural flow accumulation and flow direction overlap one another with motorways in Istanbul Upper. The above example belongs to the Ayamama creek basin in west part of Istanbul.

Climate change, vulnerability, mitigation

For Turkey, climate change adaptation reports have been prepared by various institutions and organizations (UNDP, 2007; Özdemir et al., 2009; RTNCCAP, 2011; Talu et al., 2011). However, vast majority of these reports are studies that cover general principals. Yet, geographical location of Turkey, shape and distribution characteristics of its lands and seas and its landforms and land use characteristics will cause occurrence of the impacts of climate change in specific types and severity in different places of Turkey. Therefore, the problems and results that may occur will vary. Istanbul must be evaluated in this perspective. Geographical characteristics of Istanbul may cause experiencing the effects of climate change in different dimensions than expected. Geomorphological or hydrographic or landuse-

landcover characteristics are striking with their unique characters. In this context, urban development and construction projects of Istanbul already have water management problems even under the current climate conditions. Preventing these problems from reaching larger scales is possible by conducting new projects planned for Istanbul while considering the foregoing approaches and climate change fact. On this subject, "Urban Transformation" project-related implementations can be an opportunity. The sensitivity on taking into account the principles of hardground planning, protection of green areas, natural flow and flow accumulation has a special importance. Watershed-based and integrated "Physical Planning" should not be ignored in the analysis and evaluation of vulnerability and mitigation due to the effects of climate change. Particularly for new and large-scaled projects, Land Potential and Benefit-Cost Analysis must be cared.

Conclusion and Suggestions:

In the near future, climatic and hydrographic differentiation, such as less average annual precipitation, sudden torrential rain in precipitation pattern, flashflood characterized runoff, higher average temperatures and evaporation than today must be expected in Istanbul and its close vicinity.

The vital effect of changing climatic conditions for Istanbul will emerge with the shortage of drinkable and usable water. Drought will cause supply insufficiency of dams that are the water reservoirs and high temperatures will lead to water loss due to evaporation. Despite water shortage due to natural causes, the fact that water needs of Istanbul will increase in the future will push water problem of Istanbul to larger magnitudes.

Changes in precipitation regime will encourage floods and flash floods. Sudden and severe torrential downpours will cause floods and flash floods in the nature of a frequent disaster because of the mistakes on types and choices of common land use and defective infrastructure projects in Istanbul. Frequency and severity of the floods and flash floods will be increasing depending on the effectiveness of the change.

Water management for Istanbul must be handled with an integrated approach, in which climate change, geomorphological characteristics of the region, and geographical features such as stream watersheds, natural flow accumulation and flow directions, any kind of constructions and land use are considered all together.

Urban transformation studies for Istanbul can be accepted as an important opportunity for minimizing the effects of climate change on Istanbul and prevention of damages. In this context, implementation projects for urban transformation must be conducted with "Physical Planning" approaches. Watershed-based studies must be considered; Land Potential and Benefit-Cost analysis must be made for new projects; in addition, Population Projections for 20, 30 and 50 years and socio-economic possibilities and variables must be taken into account.

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