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Land use/land cover change modelling of Ergene River Basin in western Turkey using CORINE land use/land cover data

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Abstract. Land use planning is a useful tool to find a balance among the competing and sometimes contradictory uses in order to achieve food security, economic growth, energy supply, nature conversation and other objectives. In this study, modelling land use/land cover change of Ergene River Basin in Western Turkey between the years of 1990 and 2012 was investigated. The CORINE land use/landcover data and ArcGIS software were used to detect land use/land cover change between the years, 1990–2000, 2000–2006 and 2006–2012. As a results, the artificial area (including settlement area and industrial zone) and water bodies increased by 39.4% and 47.9%, due to industrial development and new reservoirs construction, respectively, while wetlands and agricultural areas decreased by 1.1%, 1.0% and 32.1%, respectively. The change in the agricultural areas into industrial area corresponds to about 13,000 hectares, which is considered threatening not only natural resources but also food security since the basin has the most productive arable land of Turkey.

Key words: Land use/land cover change, CORINE, Ergene, Turkey.

INTRODUCTION

Land is a scarce resource increasingly affected by the competition of mutually exclusive uses. Fertile land in rural areas becomes scarcer due to population growth, pollution, erosion and desertification, effects of climate change, urbanization etc. On the remaining land, local, national and international users with different socioeconomic status and power compete to achieve food security, economic growth, energy supply, nature conversation and other objectives. An integrated land use planning can help to find a balance among these competing and sometimes contradictory uses (Wehrmann, 2011).

The integrated approach to planning the use and management of land resources entails the involvement of all stakeholders in the process of decision making on the future of the land, and the identification and evaluation of all biophysical and socio-economic attributes of land units. This requires the identification and establishment of a

use or non-use of each land unit that is technically appropriate, economically viable, socially acceptable and environmentally non-degrading (FAO, 1995). Land-use changes have important implications for future changes in the Earth's climate and, consequently, great implications for subsequent land-use change (Agarwal et al., 1999). Vitousek (1994) notes that 'three of the well-documented global changes are increasing concentrations of carbon dioxide in the atmosphere; alterations in the biochemistry of the global nitrogen cycle; and on-going land-use/land-cover change'.

Land use planning and necessary supporting data are crucial to developing countries that are usually under severe environmental and demographic strains (FAO, 1995). In Ergene River Basin in Western Turkey, land degradation has been exacerbated for the past 30 years with the introduction of industry leading to land use changes. Miss-use and miss-management of the land in the basin are more common than in the other basins of Turkey. While 81.76% of the total basin area is potentially cultivated area, present cultivated area occupies % 65 of the total basin area, which reveals the 22.776% of this area is miss-used and –managed, i.e., used beyond their capability classes (Cangir et al., 1996; Cangir & Boyraz, 2001; Konukcu et al., 2004; Kocaman et al., 2007).

Although land degradation in Ergene River Basin was reported by many authors, land use change has not been studied. The objective of this study was to investigate the land use/land cover change of Ergene River Basin in Western Turkey between the years of 1990 and 2012 using CORINE land cover data.

MATERIALS AND METHODS

Ergene River Basin, located in Marmara Region and in the middle of Trakya, is bordered by Istranca Mountain ranges in the north, Ganos Mountain ranges in the southeast and Koru Mountain ranges in the east (Fig. 1). The total length of the river from Istranca Mountain where it arises to the Aegean Sea in the Saroz Golf where it discharges is 283 km. The basin occupies about 1.4% of Turkey with 11,000 km^2 area and accommodates 1,150,000 people. The northern part of the basin has typical terrestrials climate characterised by hot and dry summers and cold winters whereas the southern part has Mediterranean climate dominated by hot and dry summers and mild and rainy winters. The long-term annual average precipitation is around 600 mm, humidity is about 70% and temperature is mm, 13 °C (Action Plan, 2008; Konukcu et al., 2016a). The basin comprises of two main Rivers, namely, Maritsa and Ergene, and 67 sub watersheds. Corlu Creek, Suluca Creek, Luleburgaz Creek, Babaeski (Seytan) Creek, Teke Creek, Hayrabolu Creek and main stream are the main tributaries of Ergene River basin. The total renewable water water resources of the baisn is around 1.73 billon m^3, one third of which is surface water with 1.33 billion m^3 and the remaining part with about 0.4 billon m^3 is underground water resources (Konukcu et al., 2016a). The hydrology map of the basin is presented in Fig. 2 whreas the elevation, soil and forest maps of the basin are illustrated in Figs 3, 4 respectively.

Figure 1. Location of Ergene River Basin.

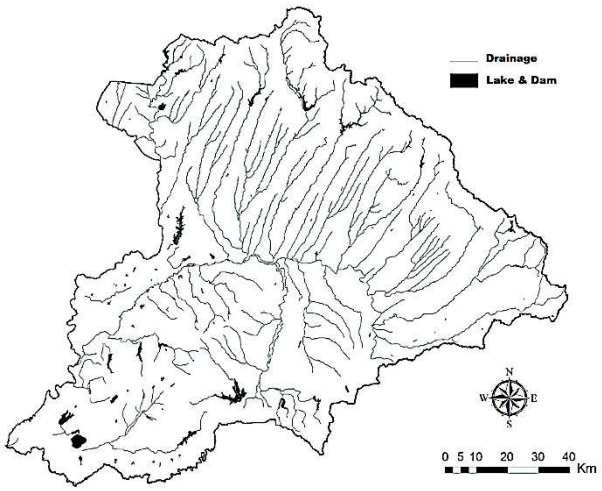

Figure 2. Hydrology map of Ergene River Basin.

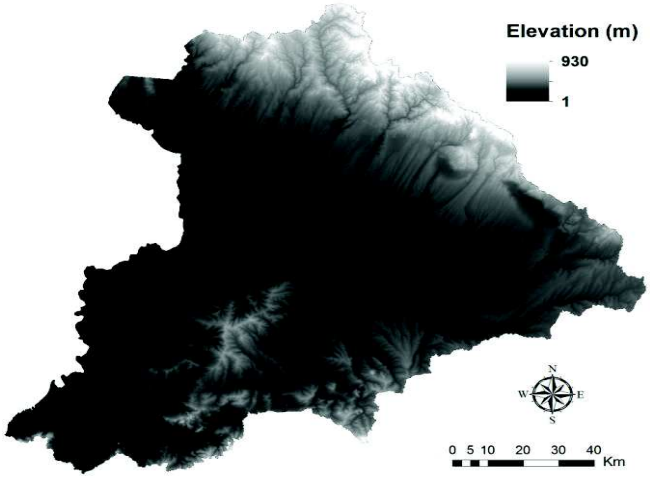

Figure 3. Elevation map of Ergene River Basin.

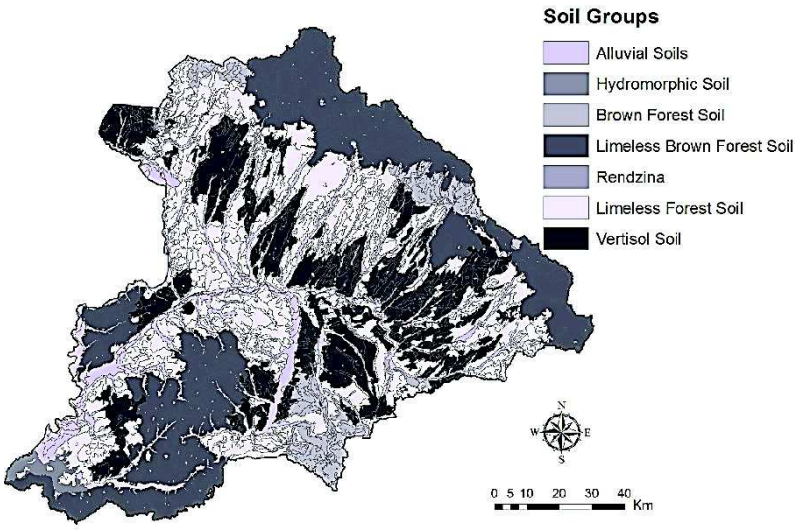

Figure 4. Soil map of Ergene River Basin.

In the modelling of land use/land cover changes, CORINE land use/land cover (CLC) maps of Ergene River basin for the years 1990, 2000, 2006 & 2012 and ArcGIS based model was used.

The CORINE (Co-ORdinated INformation on the Environment) data series was established by the European Community (EC) as a means of compiling geo-spatial environmental information in a standardised and comparable manner across the European continent. The (CLC) inventory is a Pan-European landuse and landcover mapping programme. It supplies spatial data on the state of the European environmental landscape and how it is changing over time. Based on the interpretation of satellite imagery, CLC provides national scale maps of land use and land cover change on a six year basis for thirty nine countries in Europe. The data series are used in a wide range of social and environmental applications by the varioius national environmental agencies, private companies, environmental researchers and academics. The fact that it is a pan-European dataset means it is useful for policy-making and for comparative environmental analysis and assessment throughout Europe. Corine 2012, the fourth instalment in the series is now complete, alongside to base years of 1990, 2000 and 2006. The CORINE land cover nomenclature is hierarchical and distinguishes 44 classes at the third level, 15 classes at the second level and five classes at the first level. The five classes in the first level are atificial surfaces, agricultural areas, forests and semi-natural areas wetlands and water bodies. Additional national levels can be mapped but should be aggregated to level 3 for the European data integration. No unclassified areas should appear in the final version of the data set. (Lydon & Smith, 2014). The land use land/land cover data of Ergene River Basin in 1990, 2000, 2006 & 2012 for the five classes in the first level are presented in Table 1.

Table 1. The land use land/land cover data of Ergene River Basin in 1990, 2000, 2006 & 2012 for the five classes in the first level in CORINE land cover nomenclature

Code Explanation	Area (ha)	Area (%)
Year 1990		
Artificial surfaces	34,764.26	2.40
Agricultural areas	1,154,121.93	79.72
Forests and semi-natural areas	246,875.37	17.05
Wetlands	5,053.15	0.35
Water bodies	6,948.36	0.48
Total	1,447,763.07	100
Year 2000		
Artificial surfaces	45,184.91	3.12
Agricultural areas	1,144,458.65	79.05
Forests and semi-natural areas	245,822.99	16.98
Wetlands	3,684.74	0.25
Water bodies	8,611.78	0.59
Total	1,447,763.07	100
Year 2006		
Artificial surfaces	46,169.25	3.19
Agricultural areas	1,143,562.06	78.99
Forests and semi-natural areas	245,743.62	16.97
Wetlands	3,449.17	0.24
Water bodies	8,838.97	0.61
Total	1,447,763.07	100
Year 2012		
Artificial surfaces	48,463.83	3.35
Agricultural areas	1,141,081.66	78.82
Forests and semi-natural areas	244,509.39	16.89
Wetlands	3,432.98	0.24
Water bodies	10,275.21	0.71
Total	1,447,763.07	100

In addition to EEA CORINE land use/land cover classes 12 additional fourth stage codes developped for Turkey were also used. These codes for Turkey were:

1121. Discontinues urban in cities
1122. Discontinues urban in rural areas
2111. Non-irrigated arable land
2112. Non-irrigated arable land, green houses
2121. Irrigated arable land
2122. Irrigated arable land, green houses
2221. Fruit trees and berry plantations, non-irrigated
2222. Fruit trees and berry plantations, irrigated
2421. Complex cultivation, non-irrigated
2422. Complex cultivation, irrigated
3321. Bare rocks
3322. Bare rocks with very high salt content.

The satellite and ancillary data used in the CLC modelling were Landsat5-TM satellite image with 30 m resolution for the year 1990; Landsat7-ETM satellite image with 30 m resolution for year 2000; satellite image Spot4&5 / IRSP6 satellite image with

20 m resolution for year 2006; satellite image Spot5 with 5 m resolution for the year 2012; 1/25,000 scale raster topographic maps, irrigation data; 1/100,000 scale forest map and 1/25,000 scale soil map.

RESULTS AND DISCUSSION

The land use/land cover changes between 1990 and 2000, between 2000 and 2006, between 2006 and 2012 are shown in Figs 5, 6 & 7, respectively, whereas the land use/land cover changes between 1990 and 2012 is summarised in in Table 2.

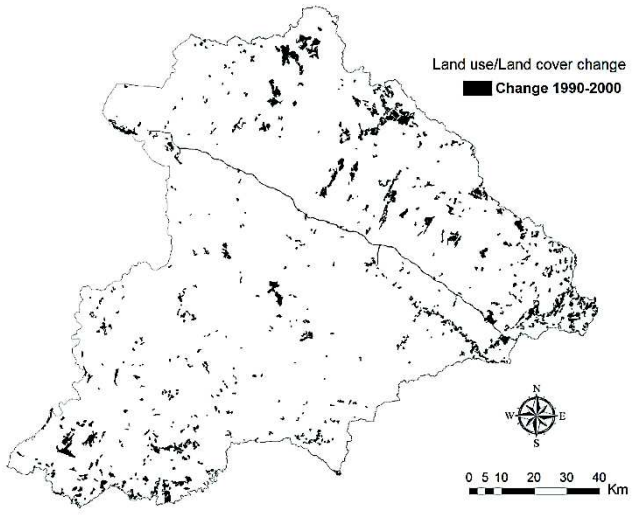

Figure 5. CORINE land use/land cover change between 1990 and 2000.

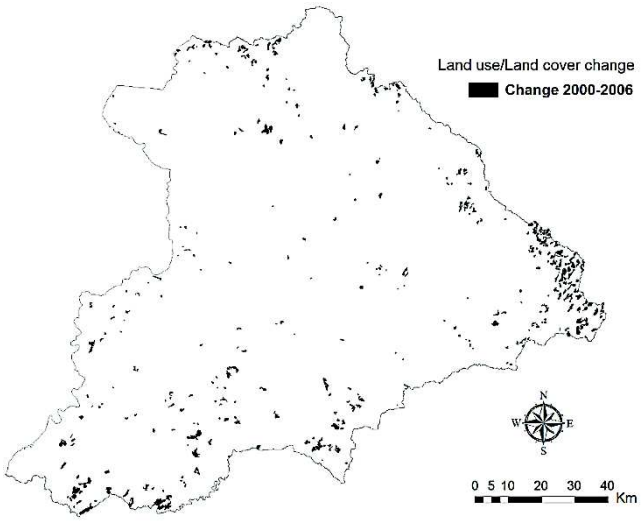

Figure 6. CORINE land use/land cover change between 2000 and 2006.

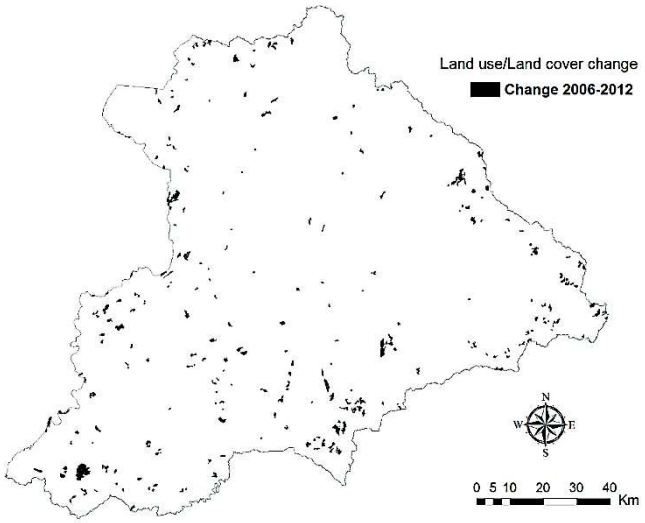

Figure 7. CORINE land use/land cover change between 2006 and 2011.

Table 2. Land use/land cover change of Ergene River Basin between 1990 and 2012

Land Use	1990		2012		Land use/land cover change (%)
	Area (%)	Area (Hectare)	Area (%)	Area (Hectare)	
Artificial area	2.4	34,764.26	3.3	48,460.67	+39.4
Agricultural Area	79.7	1,154,121.93	78.8	1,141,081.66	-1.1
Forests and semi natural areas	17.1	246,875.37	16.9	244,509.39	-1.0
Wetlands	0.3	5,053.15	0.2	3,432.98	-32.1
Water bodies	0.5	6,948.36	0.7	10,275.21	+47.9

Table 1 & 2 show that majority of Ergene River Basin, almost 80%, is occupied by land use class of agricultural area, which is followed by the land use classes of forests and semi natural areas, artificial area, water bodies and wetlands, respectively.

It seems that natural areas were turned into agricultural areas or settlements generally in terms of variations in land use/land cover. Important variations were occurred especially in 231 (pasture) and 2111, 2121, 2421 (different agricultural areas) coded regions. Also, change of agricultural areas into urbanized or industrialized areas was widely observed. Development of both Turkey and Ergene River Basin after 1990 seems also to affect urbanization rate. Rapid increases in industrialization and building industrial areas on agricultural land and pastures are the main problems in Ergene River Basin. Pressure on agricultural areas and pastures and decrease in their sizes can be seen from Table 2. This also means to the increase in contamination. In each time periods, changes towards 512-water bodies can be observed. These changes correspond to the newly constructed dams and ponds. Because of industrial forestry in the northern part of the basin, change of 324 (changes in vegetation) into 311, 312, 313 widely seen in time periods. Afforestation works in the last decade has a big impact on forestry.

The ongoing land use changes from natural area, especially agricultural, forests and semi natural areas, into urban and industrial area are seen as a threat for sustainability of

land, water, biodiversity and other natural bodies (Konukcu et al., 2016b). Sonter & Lawrie (2007) stated that land capability is the inherent physical capacity of the land to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. Using land beyond its capability impacts can include loss of valuable soils by water and wind erosion on agricultural land, soil structure decline, soil acidification.

Most of the Ergene River basin soils are deep, fertile and suitable for agricultural production and mechanization (Eyupoglu et al., 2001). Kocaman et al. (2007) reported that 81.76% of basin is potentially cultivated land, 70% of which is under erosion hazard varying in intensity (0.74 t per haper year at average), namely 25.3% light, 34.6% moderate, 8.6 strong and 1.5% very strong, while the rest has no such problem, which is sourced by land use change and land use beyond their classes.

Similarly, Alturk (2017) indicated that water availability in Ergene River basin for human and nature will be endangered in the future (after 2050) due to combined effects of land use change and climate change, flooding and subsequent erosion hazards.

The basin is of great importance for Turkey in wheat and sunflower production. Deveci (2015) found that, by climate change, sunflower yield will decreased up to 22% while, unlike other region of Turkey, wheat yield will increase up to 50% between the years 2076–2085 when compared to the measured data of 2012. This tells that Thrace Region/Ergene River Basin is vital to ensure food safety of Turkey with this increase in wheat yield. Therefore, land use change, particularly transformation of agricultural areas into other classes, should be prevented.

CONCLUSIONS

As a result, the most important pressure in Ergene River Basin is on 231 (pasture) and 2111 (dryland agricultural) where maximum decrease were observed. While the artificial area (including settlement area and industrial zone) and water bodies due to new reservoirs construction increased by 39.4 and 47.9%, respectively, wetlands and agricultural areas decreased dramatically. This dramatic changes in agricultural areas to industrial area has been threatening not only natural resources but also food security since the basin has the most productive arable land of Turkey.

The decision maker is aiming to increase industrial areas in the region in the future. It is inevitable that this increase in industrial areas will cause urbanization to growth by triggering immigration to the region. It, in particular, will lead to a decrease in cultivated land and pastures. To prevent or decrease the speed of land use/land cover change in a sustainable and manageable ways, the following measures are to be taken:

- development of industrial area should be allowed only in organised industrial zone;
- population growth, migration into the region and subsequent urbanisation should carefully be managed;
- regulations permitting urbanisation on agricultural area, particularly on the land with capability classes of I, II and II, should be banned.

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