

# UNDERSTANDING URBAN GROWTH PATTERNS: A LANDSCAPE ECOLOGY POINT OF VIEW

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## ABSTRACT:

Landscapes always change, as they are the expression of the constant interaction between natural and cultural forces in the environment. Applied to an urban/peri-urban case, changes are seen as a menace. By identifying the past urbanization patterns, policy makers and planners can gain better insight into the contributing factors that have resulted in the most problematic development patterns now and into the future. Remote sensing and GIS technology seem to be a proper and effective tool to understand and present the phenomenon. Thus, this study aims to identify and compare the development pattern in the town of Aydin, Turkey to highlight the underlying process by utilizing satellite images between 1986 and 2002. Population information obtained from the State Statistics Institute is used along with satellite images for the land use/land cover change analyses. Existing ancillary data and aerial photographs are also utilized. Several critical land resource impact indicators associated to urbanization are being elaborated: density of new urbanization, loss of agricultural areas, and loss of core habitat areas. The results indicate that urbanization pattern of the town of Aydin is not so impacting natural core habitats so far. However, the investigations yielded some warning signs with regards to the density of population and the agricultural land loss. The distribution of population is favoring the rural areas. This is causing lower rates of urbanization compared to other cities in Turkey. But the establishment of industrial areas would attract more people in the future. Therefore, the shift has to be occurred in the traditional land use management, which is only concerning those areas within the municipality boundary, to include the peripheral settlements and the landscape context.

## 1. INTRODUCTION

### 1.1 Landscape Change

Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Council of Europe, 2000). Due to this interaction landscape change is an inevitable fact. Forman (1997) describes change as the dynamics of alteration in spatial patterns (structure) and functioning over time. Since the ancient times, not only natural forces generate landscape change, but so does man in an increasing way (Antrop2000a). Change can occur slowly or fast paced leading to large differences in the significance we attach to these changes (Meffe and Carroll, 1994). Usually habitats have the ability to adapt themselves to changes generated by natural forces, but with respect to man induced changes such as urbanization, the transformation can be beyond the limits of resiliency.

Urbanization causes profound changes in the ecological functioning of the landscape and gradually results in a changing spatial structure. It is also a cultural and sociological change caused by the transformation of rural life styles into urban like ones. Alteration of life style changes people's perception about their environment, and the way they use this environment (Antrop, 2000a; Antrop, 2000b). Extension of the market economy and the trade were the forces behind this process. As a spreading phenomenon, the outcomes of urbanization vary according to the geographical and geopolitical position of the region (Timar, 1992). Landscape ecology is an important

approach to understand these complex interactions of ecological, cultural, sociological and also economic factors.

In landscape ecology the complex process of urbanization is regarded as a spatial diffusion caused by the interaction of many factors. Resulting physical and observable changes in the landscape pattern is the focus of landscape ecologist. Concepts such as patches, corridors and matrix by Forman and Godron (1986) are introduced in landscape ecology as basic elements to describe spatial patterns in natural and cultural landscapes (i.e. urban landscape). Spatial pattern refers to the holistic concept of structure in the landscape (Naveh and Libermann, 1984).

Urban planners and landscape architects frequently use concepts of spatial structures to express their ideas. When their spatial structure seldom refers to the real landscape pattern, the typical outcome is ill planned urban landscapes resulting in loss of diversity, coherence and identity. Application of scientific knowledge from landscape ecology is crucial to overcome this problem. Because spatial pattern can influence a variety of ecological phenomena, our ability to quantify changes in landscape structure through time may be crucial to our understanding of the dynamics of the landscapes. Remote sensing and GIS technology seem to be a proper and effective tool (Maktav, Erbek and Akgun, 2002) in this endeavor. Thus, this study aims to identify and compare the development pattern in the town of Aydin, Turkey between 1986 and 2002 to highlight the underlying process at play. In order to understand the urban growth pattern in the study area, a series of land resource impact indicators (Hasse and Lathrop, 2003) have been used for identifying the impact of new urban growth on three

specific critical land resources including; (1) density of new urbanization (2) loss of agricultural areas; (3) loss of core habitat areas. These indicators are tool for identifying least efficient and most highly impacting localities of urban growth.

## 1.2 Urbanization in Turkey

Urbanization, expressed as the proportion of people living in urban places (Vink, 1984), showed almost exponential growth since the end of 19<sup>th</sup> century (Antrop, 2004). Estimates indicate a level of urbanization in the world of only 1.6% around 1600 A.D. and 2.2% at the beginning of the 19<sup>th</sup> century and this is estimated to fluctuate between 4 and 7 % in the mid-19<sup>th</sup> century. Today the degree of urbanization exceeds 80% in developed countries (Antrop, 2004). In the case of developing countries, the level of urbanization is relatively lower, however, the speed of urbanization is five times faster than that of the developed countries (Lopez et al., 2001).

In Turkey, the rate of urbanization is higher than other developing countries, but it does not come close to the level in the highly industrialized developed countries (Keles, 2004). Urbanization speeded up after 1950s in Turkey. Between 1960 and 2000 the population rose from 6.9 million to 44 million indicating 6 times increase. In the same period the proportion of people living in urban places went up from 25.1% to 65% (DPT, 2000). Similarly, the number of cities increased approximately 31%. Those cities, whose population is exceeding 1 million, comprise 40% of the country's population. Rapid, sprawling and unplanned urbanization prevails in these cities. Especially in recent years, the dispersion of commercial and residential land uses from inner urban areas to outer urban ring is common due to demand for higher quality of life. Moreover, most of the immigrants from rural areas tend to live in the outer ring generating informal settlements. Hence, compared to outer ring, the rate of population increase is lower in urban core area. This compels the traditional management approaches to include the peripheral settlements and the landscape context.

Migration from rural areas to cities is the main factor of urban inflammation in Turkey. What pushes the people out of their village is the decline of agriculture sector in GNP since 1950s. Some conducting forces also plays role in urbanization. For example, the advances in the transportation network enable easy and speedy transfer of people and goods between cities. The progress made in the transportation and media sector encourage people to travel further distances. Moreover, people living in other countries prefer to live in cities after they return to Turkey. Industrialization plays a major role in the development of Turkish cities. As it is the case in other countries, industrialized cities grow much faster. This brings supporting industries such as construction and service sectors.

Turkey's national policy towards urbanization evolved in time. The Turkish constitution mentions, "planning" for the use of resources to promote economic and social development. Therefore, the related development issues of urbanization are included in the periodic 5-year development plans since the early 1960s. Initial plans did not favor the limitless growth of the cities, and promoted 'optimum urban size' concept that basically recommended a development correlated with the employment opportunities in the region. Later plans regarded urban development as the outcome of economic, social and especially industrial development, and suggested the utilization of it as a source to trigger economy. Starting around 1980, the

principal in the plans were to promote livable cities and answer the needs of urbanites instead of slowing the urbanization process in the nation. According to the plan, as a natural and inevitable result of development and industrialization, urbanization process must be managed best possible way, and the measures have to be taken to increase its contribution in the economic development. First time in the country's history, the notions of preventing uncontrolled development on agricultural lands, and socio-economic equity in the selection of new industrial sites took place in the development plans. The plans of early 1990s acknowledged some problems associated to urbanization mainly in the area of land resources, infrastructure, housing, education and health. Special emphasis was put on the completion of city plans and the efficient supervision of surrounding developments out of the city plan. The dramatic magnitude of migration to urban areas was recognized by the late 1990s. Thus, the policy development towards reducing the rate of migration was mentioned in the plans. The development plan of 2000-2005 suggested that the cities should meet the demands of globalization. Therefore, the establishment of international scale commercial centers (cities) and the extension of organized industrial district around the country were recommended along with the formation of techno-cities.

The policies and recommendations of the aforementioned development plans seem to be comprehensive and idealistic. However, the implication of the plans to real world situation is challenging. The measures suggested in the plans are ineffective. Existing laws are sometimes conflicting in interest, and not efficient enough to prevent unsuitable development in valuable sites as well as pollution. Most municipalities lack monitoring and enforcement tools, limiting the effectiveness of environmental regulations. But more important is the fact that local governments tend to prioritize economic over environmental goals in local development and land use planning. They are deficient in the environmental awareness and foresight required to anticipate the negative effects of uncontrolled urbanization. In addition, collaboration between urban planners, landscape architects, ecologists and other majors related to the management and development of urban landscapes is lacking.

Subsequently, unsustainable development of urban matrix prevails in Turkey. For example, the type of urbanization in Turkey causes social and economic erosion (Erturk, 1995). New urban landscapes have been superimposed rather than being integrated into the historic context. Architectural integrity of the cities is questionable. Pollution, traffic congestion, and increased travel time from home to work make urban life unbearable. The development of informal slum settlements is very common. Municipalities often struggle with establishing adequate infrastructure before the development takes over the area.

According to Wasilewski and Krukowski (2004) environmentally sound urban planning will only take place in the presence of mechanisms that safeguard environmental interest. Such mechanism may include procedures that provide a role for governments and programs to raise public awareness of the need to preserve open space and valuable landscapes. However, environmental interests in the preservation of open space remain marginal in Turkey. A typical urban development causes fragmentation in the natural or open space systems, hence diminishing ecological integrity in the urban and peri-urban matrix. Even though a considerable amount of agricultural land is lost due to urbanization (Esbah, 2004), local

communities do not consider land withdrawal from agricultural production a casual factor in the loss of rural landscape.

These problems are not indigenous to Turkey but seen in many countries one form or other. A more specific example, the town of Buyukcekmece in Istanbul, may help illustrating the magnitude of a typical case in Turkey. As one of the biggest towns in Istanbul, Buyukcekmece grew progressively in the form of satellite settlements on the east of the Buyukcekmece Lake and along the Sea of Marmara. The Trans European Motorway transits through the north and Istanbul- Edirne highway connects the city to major metropolitan area from the south. These access roads are one of the contributors of the development. Accordingly, the establishment of secondary housing projects took place along these arteries. Maktav, Erbek and Akgun (2001) investigated the urban growth in the area between 1970 and 1997 by using satellite images, ancillary data (i.e. population information, city maps) and remote sensing technology. Their results indicated approximately 288.2% overall population increase in 14 administrative units of the central district. The population increase in the two seashore districts is eye opening of 1335% and %2300 in the same period. The population difference exists between seasons (summers being the most crowded time). Unbalanced distribution of population- spatially and seasonally- causes a number of problems in terms of unsustainable land conversion. Thus, land use analysis' results yielded that while 93% of their study area was an agricultural landscape in 1984, the percentage of agricultural land dropped to 67% by 1998. In this 14 year period, the urban area expanded approximately 20% as a detriment of open systems. The most significant reason of urban growth is the migration. Also the local dam contributes to the agricultural land loss: Total of 10km<sup>2</sup> of land was occupied by water. In other words spatial structure and ecological function of the overall landscape was altered dramatically. Industrialization speeded up around the town since 1990, due to the town's close proximity to the major land and sea transportation routes and also the airport, hence changing socio-economic structure. The investigations showed that the urbanization, taking place in the Buyukcekmece district, was planned and the formation of the informal settings around the urban development was absent. From an ecological stand- point, though, the outcome was increasing horizontal and vertical difference in the structure of the landscape and changing function that signals the type of development in the close future. Although, the study area in this research, town of Aydin, possesses somewhat different socio-cultural, economic, and spatial attributes, the initial observations indicated that the development patterns exhibit similar outcomes.

## 2. METHOD

### 2.1 Study Area

Aydin province is located in the Aegean region of Turkey with a population of 950,757 people. The annual population growth rate is 14.2% in the 1990-2000 period (DIE, 2000). The study area, the town of Aydin, is centrally located in the province. It is also the administrative center of the province. The total study area is 62700 ha. Currently, population of the town is approximately 208,341 of which 143,267 is urban population. The annual urban population growth rate of the province center is 29.2%. The population density, which is the number of persons living in one square kilometer, is 121 in the province (DIE, 2000). However, this number goes up to 332 in the

province center. The town comprises 3 districts; City of Aydin, Dalama and Umurlu (Figure 1).

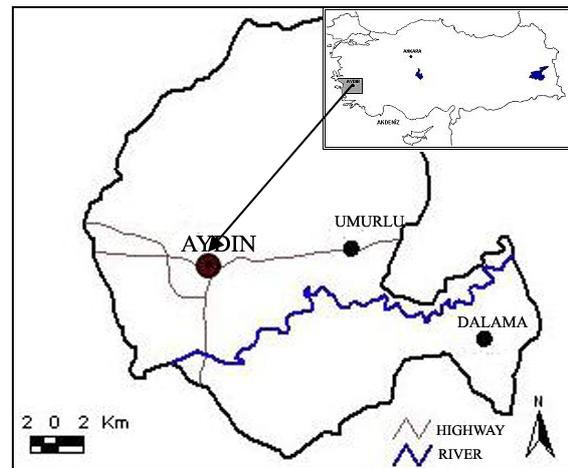


Figure 1. Study area

The northern part of the study area is a mountainous landscape including examples from the Mediterranean flora. Small villages of scarcely populated villages are embedded in this tectonic landscape where the villagers engage in olive and fig cultivation. In the south, the study area is dominated by an agricultural landscape, which is irrigated by the Big Meander River. The alluvial soils and the mild climate of this flat basin make agriculture possible year round. Here, mica-shist prevails in the soil. The plant palette of this landscape mainly includes cotton, wheat, corn, olive, fig, citrus, and vegetables. Some side industries are also booming, such as tourism, textile, and food processing. The largest settlement, the City of Aydin, is situated in between the transition zone from hilly natural landscape to flat agricultural landscape. A major highway traverses the town connecting neighboring two highly industrialized cities of Izmir and Denizli.

Because, agriculture has brought prosperity and economic nourishment to the area since the early ages, the city has received a vast amount of migration, and subsequently, expanded as the detriment of agricultural lands. Especially since 1990's some side factors also contributed to the growth of the city. The establishment of a state university, Adnan Menderes University, is one factor. The university is one of the major sources of government employment in the town. Another factor is the government policies that had made rapid industrialization a national priority.

### 2.2 Materials

In this study, a SPOT 2 XS dated 04.26.1986 and a LANDSAT 7ETM+ dated 10.28.2002 images were utilized. The boundary of the town and the point location of the districts were scanned from paper maps and overlaid on the satellite imageries. Also, 1/5000 scale black and white aerial photographs and high resolution IKONOS 2002 image of the study area were used for visual interpretations. The population information was obtained from the State Institute of Statistics in order to more closely evaluate land use change in relation to population change. An ERDAS 8.7 software was used for the digital processing along with ArcGIS 8.3.

### 2.3 Analyses

Two analytical approaches were pursued: (1) time-series analysis, and (2) land use analysis. The first approach included site visits, the visual interpretation of the aerials and satellite images and its comparison with official statistics such as population census (DIE, 2000), and information from previous studies on the same area. This phase generates reference information for further land use analysis. The second phase aims to detect the land use change automatically by utilizing satellite data acquisition. First, the images were geometrically registered to the UTM (Zone 35) coordinate system, and were clipped to the study area and its surrounding. . Already rectified SPOT and IKONOS images were used for the rectification of LANDSAT 7ETM+. The total of 32 ground points produced a final RMS error of 1.00 pixels. The investigations on the histograms of each band yielded that urban and soil surfaces were easily detectable with 3,5,7 band combination in the LANDSAT 7 ETM+. Also, 1,2,4 band combination was used in order to achieve the visual (color) compatibility with the SPOT 2 XS' 1,2,3 band combination. A contrast adjustment technique (Histogram Equalization) was applied to enhance the images. Second, supervised and unsupervised classifications (Lillesand and Kiefer, 1994) were conducted. The analysis of land use types in 1986 and 2002 were studied by comparing the results from the classified data for each year.

### 3. RESULTS

The results of the population information yielded the fact that the general population increase in the town of Aydin is less than the other national examples (i.e. Buyukcekmece). 19% of the population living in Aydin province resided in the town of Aydin in 1985. 15 years later, in 2002, 21% of the province population lived in the town (Table 1).

This indicates that the town of Aydin started to compete with other bigger towns in the province in terms of migration. This is most probably contributed by the increase of industrialization and service sectors in the town. However, the percentage of urban population in overall urban population of the province was 33.4% in 1985 and 31.5% in 2000. Number of people living in the town of Aydin increased 30.6% whereas the urban population went up from 144388 to 155776 indicating an only 7.3% increase. This means that most of the migrations are occurring to rural areas. This may also mean that the birth rate in those areas is higher than that of urbanites.

DISTRICT S	1985		2000	
	Overall Pop.	Urban Pop.	Overall Pop.	Urban Pop.
Aydin	117908	90449	180755	143267
Umurlu	17183	8201	19854	10436
Dalama	9297	2425	7732	2073
Total	144388	101075	208341	155776
∑Province	743419	302311	950757	493114

Table 1. Population of the town of Aydin 1985-2000

As far as the comparisons of the individual districts in the town, a general population increase prevails in two districts. The urban population in the central district, the City of Aydin,

increased 36.8% between 1985 and 2000. Umurlu district experienced 21.4% increase in urban population in the same period. However, the urban population declined around 14% in the district of Dalama. The poor showing of Dalama's population is related to its lack of potential in terms of job opportunities and also to its relatively remote location. Since the study uses the density of population as a land resource impact indicator of the most highly impacting localities of new urban growth, it can be concluded that the districts of Aydin and Umurlu is giving warning signals. Other impact indicators- loss of agricultural land and loss of core habitats- are highlighted in the land use analysis (Table 2).

LAND USE TYPES	1986		2002	
	AREA		AREA	
	(ha.)	%	(ha.)	%
PASTURE/NATURAL	40309	64.3	40052	63.9
AGRICULTURE	21778	34.7	20242	32.3
URBAN	485	0.8	2022	3.2
MINING	128	0.2	384	0.6
TOTAL	62700	100	62700	100

Table 2. Land use in the town of Aydin 1986-2002

The land use analysis showed that 64.3 % and 63.9% of the study area was constituted by pasture land and natural open systems in 1986 and 2002 respectively (Figure 1 and 2). This 0.6% decline in the area of natural systems is very low considering the rates of conversion stated for other cities in Turkey and abroad. The relatively low change in such areas is due to the fact that these areas are corresponding to the mountainous sites where the topography is not so convenient for construction. It can be concluded that the urban growth pattern in the town is not impacting ecologically valuable core natural habitats. However, the same fact does not apply for the third land resource impact indicator that is loss of agricultural land.

The decline in the agricultural areas is more noticeable (Figure 1 and 2). Agricultural lands decreased 7.05% within 16 years. Compared to the numbers from the Buyukcekmece case (26.4% decline in 14 years) the magnitude of conversion is not concerning. However the main reason of the transformation is urbanization, and monitoring of it necessary. Also an ecologically and economically sound development should be in the local agenda to mitigate the consequences experienced in the Buyukcekmece example.

In 1986, the share of agricultural areas in the total landscape was 34.7%, whereas, by the year 2002, urbanization worked as a detriment of agriculture and the percentage of agricultural lands in overall matrix dropped to 32.3. As illustrated in Figure 1 and 2, the major urbanized areas are located on or near the agricultural lands. Increase in the magnitude of urbanization directly affects the surrounding agricultural landscape. Therefore, an almost 4 times increase in the urban area is significant, because this is not only a change in the spatial structure but also a change in the ecological functioning of the landscape.

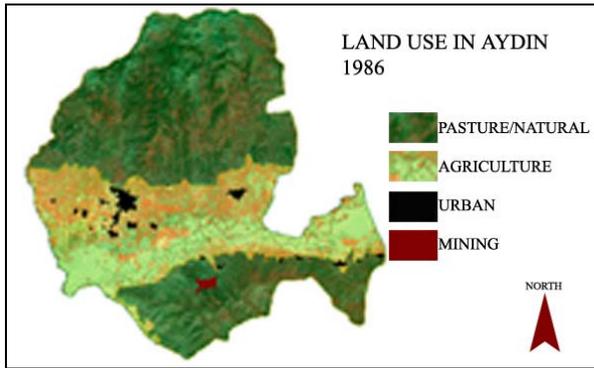


Figure 1. Land use types in the town of Aydin-1986

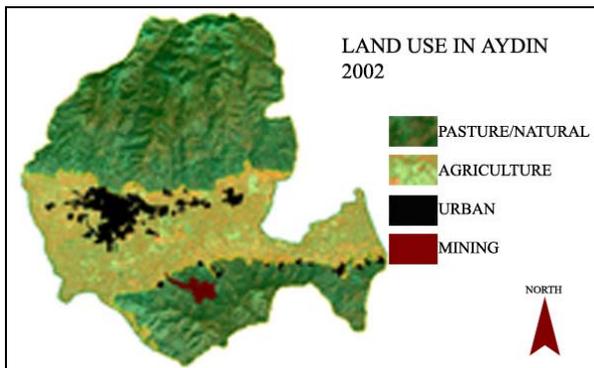


Figure 2. Land use types in the town of Aydin-2002

Aydin was an agricultural community in 1986 when the urban area was only 0.8%. The most common way of beginning land transformation, also called perforation, was already started: Urban settlements looked like holes in agricultural landscape. The alternative way to begin land transformation is dissection. As a spatial process dissection started around 1990s within the form of highway and road network. These dissecting elements function as barriers to movement of the species. The similar trend is also relevant to the case of Buyukcekmece.

In 2002, urbanized areas constituted 3.2% of the study area. Urban area of Dalama experienced the least growth in contrast to drastically changing Aydin. This is also because Dalama is not conveniently and closely located to a major access road. Socio-economic structure also changed, and still continues to change, towards industrialization. In figure 2, the city stretches towards Umurlu district on the east- along the major highway connecting Aydin to the neighboring major industrialized city, Denizli. Urban form is no longer compact. Rather it is stretched and scattered causing fragmentation in the open space system. Fragmentation is often stated as a threat to biodiversity in the literature (Forman, 1997), so it can be presumed that the ecological qualities of the landscape matrix are declining. Industrial land use types generate the fragmented landscape on the east. Generally, the amount of impervious surfaces is very high in such land use types, hence further contributing to the decline (in the form of ground water depletion, salinization etc.).

Another not so environmentally friendly activity is mining in the study area. Even though mining site is only 0.6% of the town of Aydin in 2002, it refers to 3 times increase since 1986.

More important than the rate of conversion is the location of the activity. As illustrated in Figure 2, mining location is not fairly close to the core habitat area of a natural landscape and the direction of its expansion is towards the edge of the habitat. Because, edge areas are less sensitive to impacts than ecologically sensitive core area, no major threat is generated in terms of species loss beyond the boundary of the mine.

## CONCLUSION

Landscape change is an inevitable fact, so is urban development. The population continues to increase in the world. The needs of this increasing population and the various amenities offered by urban landscape accelerate the urbanization process. The advancements in remote sensing and satellite technologies makes possible the understanding of dynamics involving in the process and also change in the spatial patterns of these areas with relation to their environments. An example from the town of Aydin is illustrated in this work.

Thus far, the urbanization pattern of the town of Aydin is not much detrimental to the its surroundings compared to other examples in Turkey. However, the investigations yielded some warning signs with regards to the density of population and the agricultural land loss. The distribution of population is favoring the rural areas. This is causing lower rates of land conversion in relation to other cities. But the establishment of industrial areas between the districts of Aydin and Umurlu would attract more people in the future. Therefore, the shift has to be occurred in the traditional land use management, which is only concerning those areas within the municipality boundary, to include the peripheral settlements and the landscape context. In order to establish larger scale, more comprehensive planning collaboration between different professions (related to the planning, management, and design of natural and man made landscapes) is necessary. Also, the utilization of principles from landscape ecology is equally beneficial.

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