

## SIMULATING LAND COVER CHANGE BY PROTECTIVE AND NON-PROTECTIVE SCENARIOS

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### Abstract:

Land cover changes caused by population growth and rapid urbanization and determination of land cover changes impact is compulsory for sustainable urban management policies. Therefore, simulation models have been densely used in planning studies. Cellular automata-based simulation models present significant contribution for monitoring land cover change analysis and determining the urbanization effects on natural areas in the rapid growing cities. The main goal of this study is to predict urban growth and to determine the probable land cover changes according to protected and non-protected scenarios in Istanbul Sancaktepe district which has experienced an enormous population growth in last years. The required historical land cover data for the model were generated from cadastral maps which have been generated since 1950s. For this purpose, change detection analysis was first made between 1961-2014 and weight coefficients were calculated to create simulation model by protected scenarios for 2030. In order to detect the damages of uncontrolled urbanization, the second simulation model was created by non-protected scenario. According to first scenario, approximately 10 % of forest area will be probably transformed into settlement and agricultural area by 2030. However, if the necessary precautions are not taken, namely uncontrolled urban growth occurs, this rate will be dramatically high.

### Keywords:

GIS  
Change Detection  
Land Cover Change  
Cellular Automata  
Urban Growth

### 1. Introduction

Uncontrolled urban growth is one of the most prevalent problems in the modern urban planning. Contemporary planning issues such as sustainable development, smart growth, and compact city are against scattered and extreme urban growth. In the urban growth studies, the damage caused by the urban growth is analysed through prediction models, by doing so the protection areas are determined.

From urban modelling techniques, cellular automata (CA) is suitable for modelling complex and dynamic natural phenomena such as urban areas. It is a convenient method for simulating urban systems because it is dynamic and directly compatible with the raster GIS. Cellular automata consist of basic elements such as grid, lattice, cell, interaction, neighbourhood, cell states, transformation rules, and starting position (Benenson and Torrens, 2004). CA is a system that divides a plane into cells and determines the state of each cell in the next generation relative to its neighbours. The state of the cells in the grid network indicates land cover. In this regard, geospatial information can be spread or changed on the grid network (Benenson and Torrens, 2004).

Our study area, Sancaktepe district with 19 neighbours is located on the Anatolian side of Istanbul. In the study, model input data were prepared by more than 70.000 parcel data from the establishment cadastre to 2014 were arranged in GIS environment. Two periods of land cover, three periods of transportation data, and four periods of settlement data were produced from these data. In addition, administrative borders, two period transportation, and one period building stock produced by Istanbul Metropolitan Municipality (IMM) and digital elevation model (DEM) data by Map General Command were used in the study. In this paper, until 2030, two different models of urban growth simulation have been generated and the results to be produced according to the scenarios of protection and non-protection of forest areas have been revealed.

### 2. Study area and methodology

#### 2.1 Study Area

According to the Turkey Statistical Institute, the population of the county in 2015 was determined to be 354,882 (URL 1). The region (Figure 1), which is a highly sensitive residential area due to its basin character, is increasing its importance due to the transportation facilities provided by the TEM motorway (URL 2).



Figure 1. Study area

## 2.2 Methodology

Considering the density of cadastral map production and zoning activities, four different time periods are emerging such as 1961, 1992, 2001 and 2014. The data generated from the digitized maps were kept in the geographic database and the attribute information was entered through the title deed. CA based SLEUTH software has been used to generate urban growth simulations. The software has been used in a number of projects around the world (Akin et al., 2014; Ayazli et al., 2014; Heinsch et al., 2012; Jantz and Goetz, 2005; Rafiee et al., 2009; Silva and Clarke, 2002; Wu et al., 2009; Dietzel et al., 2005).

The study was started with archive work. Suitability, zoning, accessibility, land cover, and socio-economic data needed by the simulation model stored in the geospatial database have been produced. Four land cover classes were used in the study such as settlement areas, agricultural areas, forests, and open spaces.

## 3. Results and conclusions

Rapid population growth and migration led to land use changes in the county since the past years which brought with it squatting, illegal settlement and uncontrolled urbanization.

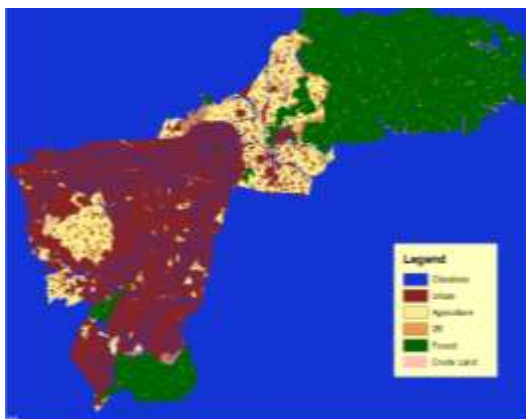


Figure 2. Urban growth simulation model by protective scenario

According to the simulation results, 10 % of forest areas are expected to be transformed into built-

up areas, agricultural areas and open spaces by protective scenario (Figure 2) and this rate will be 25 % if necessary precautions are not taken (Figure 3).

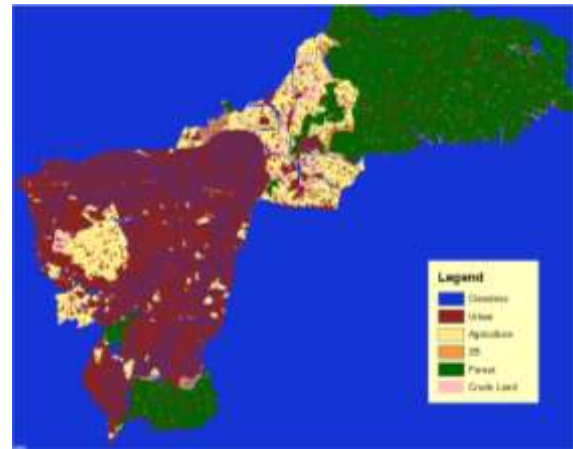


Figure 3. Urban growth simulation model by non-protective scenario

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## QORUNAN VƏ QORUNMAYAN SSENAİRİLƏR ƏSASINDA LANDŞAFT ÖRTÜYÜ DƏYİŞİKLİKLƏRİNİN SİMULYASIYASI

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Əhali artımı, güclü urbanizayisa nəticəsində landşaft örtüyü dəyişiklikləri və landşaft örtüyü dəyişikliklərinə təsirinin müəyyən edilməsi davamlı şəhər idarəetmə siyasətləri üçün məcburidir. Buna görə də, Simulyasiya modelləri planlaşdırma sahələrində sıx istifadə edilir. Hücrəsəl avtomat bazalı simulyasiya modelləri landşaft örtüyünün dəyişməsi təhlilini izləmək və sürətli böyüyən şəhərlərin təbii landşaftlarında urbanizasiyalaşma effektini öyrənmək üçün əhəmiyyətlidir. Bu işin əsas məqsədi son illərdə yüksək əhali artımı müşahidə edilən İstanbul Sancaktəpə mahalında qorunan və qorunmayan ssenarilərə görə ehtimal olunan landşaft örtüyünün dəyişməsinə müəyyənəşdirmək və şəhərdəki artımı proqnozlaşdırmaqdır. Model üçün tələb olunan tarixi landşaft örtüyü məlumatları 1950-ci illərdən bəri tərtib edilən kadastr xəritələrindən yaradılıb. Bu məqsədlə, dəyişməni aşkarlama təhlili ilk dəfə 1961-2014-ci illərdə edilib və 2030-cu il üçün qorunan ssenarilərlə simulyasiya modeli yaratmaq üçün çəki əmsalları hesablanmışdır. Nəzarətsiz şəhərləşmənin təhlükələrini təsbit etmək üçün, ikinci simulyasiya modeli qeyri-qorunan ssenari ilə yaradılmışdır. İlk ssenariyə görə, meşə sahəsinin təxminən 10% -i 2030-cu ilə qədər qəsəbə və kənd təsərrüfatı sahəsinə çevriləcəkdir. Bununla yanaşı, lazımi tədbirlər görülməsə, yəni nəzarətsiz şəhərləşmənin böyüməsi baş verərsə, bu nisbət çox yüksək olacaq.

**Açar sözlər:** CİS, dəyişikliklərin aşkarlanması, torpaq örtüyünün dəyişməsi, mobil avtomat, şəhər inkişafı

## ИЗМЕНЕНИЕ ПОКРЫТИЯ ЗЕМЛИ по ЗАЩИТНЫМ И НЕ ЗАЩИТНЫМ СЦЕНАРИЯм

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**Аннотация.** Изменения земного покрова, вызванные ростом населения и быстрой урбанизацией, а также определение воздействия изменений земного покрова, являются обязательными для политики устойчивого городского управления. Поэтому имитационные модели плотно использовались при планировании исследований. Имитационные модели на основе сотовых автоматов представляют значительный вклад для мониторинга анализа изменений земного покрова и определения влияния урбанизации на природные зоны в быстро растущих городах. Основная цель этого исследования состоит в том, чтобы предсказать рост городов и определить возможные изменения земного покрова в соответствии с защищенными и незащищенными сценариями в районе Стамбула Санкактепе, где в последние годы наблюдался огромный рост населения. Необходимые исторические данные о земном покрове для модели были получены из кадастровых карт, которые были созданы с 1950-х годов. Для этой цели сначала был проведен анализ обнаружения изменений в период с 1961 по 2014 год, и были рассчитаны весовые коэффициенты для создания имитационной модели по защищенным сценариям на 2030 год. Для выявления ущерба от неконтролируемой урбанизации вторая имитационная модель была создана по незащищенному сценарию, Согласно первому сценарию, к 1030 году примерно 10% лесных площадей, вероятно, будут преобразованы в поселения и сельскохозяйственные угодья. Однако, если не будут приняты необходимые меры предосторожности, а именно произойдет неконтролируемый рост городов, этот показатель будет чрезвычайно высоким.

**Ключевые слова:** ГИС, Обнаружение изменений, Изменение земного покрова, Сотовые автоматы, Городской рост