

## **Research Article**

# **The dynamics of growth of the territory of Ahwaz based on aerial and space information between 1955 and 2013**

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## **ABSTRACT**

Satellite images and geographic information system (GIS) are among the powerful tools that assist geographers and urban planners in the conduct of research and the usage of satellite images to understand existing conditions of geographical areas, man-made landscapes and also in benefitting from facilities. Therefore, in this study the use of remote sensing and GIS software capabilities for detecting changes in land covers and land uses, as well as changes in the dynamic growth of the territory of Ahvaz and ecological status on the basis of information obtained from satellite data was studied. The target population of the city of Ahvaz in 2013 is its legal scope and duration of the review of the changes from 1955 to 2013 is 58 years. In this study, the changes over the course of 58 years were discovered in Ahwaz and spectral changes statistics were extracted and provided as maps, charts and tables.

## **1. INTRODUCTION**

Current urban communities, unlike the simple and small settlements of the past where analyzing problems manually was possible have complex structure, and their management requires the use of a powerful tool for the collection, storage, and the analysis of the vast amount of information. Undoubtedly, GIS is one of the necessary technologies to achieve this important goal. GIS (Geography/ Geospatial Information System) is a powerful technique to convert large amount of spatial data into useful information, but lacks adequate and static spatial information. On the other hand, remote sensing is a powerful technique for collecting multi-temporal data. But there is a gap between data collection and using them. Many experts believe that access to the full potential of these two techniques is not possible unless these two technologies merge with each other, and even some have gone further and consider the success of Remote Sensing to be due to its ability to service GIS. The emergence of satellite images has created a new source of information for authorities and individuals involved in urban management. Now, drawing

on scales of 1: 5,000 to 1: 25,000 by detectors such as panchromatic spot system (with an accuracy of 10 meters) and Indian IRS (with an accuracy of 8.5 meters), is almost possible. Ikonos satellite images with an accuracy of one meter makes cartography on a scale of 1: 10000 practical. Through these means, reflection of urban land use changes around the world in the next 10 or 20 years will be possible with an increased precision revise. Using these facilities in many urban areas which are growing rapidly, particularly in underdeveloped countries where options of information sources due to lack of resources are limited, have a relatively high importance. Other necessities of this study are as follows:

1. Assessment of changes in the structure of Ahvaz city, including residential, industrial, green space and transportation network.
2. Assessment of changes in the central part of the metropolitan area during the historical process between the years 1955 to 2013.

Finally, with regard to the special features of satellite images, assessment and the study of images in different years is highly important for

the identification and study of the structures and patterns at different times and for many years as well as plans for the present and future of Ahvaz.

## 2. Research literature

Ahvaz is one of the metropolitan cities of Iran. The extent of the city of Ahvaz in legal border is 222 square kilometers, 300 square kilometers in terms of range of services and 895 square kilometers for shielding border. It has 8 regions, each of which has three or four districts. Based on the 1365 census, Ahvaz had a population of 579,826. The population reached 804,980 in 1996, and finally it reached 985,614 in 2006 (General Population and Housing Census, 2006). It should be noted that according to the latest estimate in 1390, the population of Ahvaz amounts to more than 1,110,000 (the Department of Planning and Development of the municipality of Ahvaz). In fact, most of the growth in the population of the city has happened between years 1355 to 1385, due to the 8-year war between Iran and Iraq and large emigration of people from cities and villages in war-torn areas, looking for work from other neighboring cities and provinces. Now, according to this hypothesis, it can be said that the city of Ahvaz, during these years, has experienced the most physical changes and replacement of agricultural lands into the residential and industrial and so on. In this paper, changes between years 1955 to 2013 using aerial photographs, remote sensing and GIS applications will be evaluated.

In 1980s and 1990s industry growth was aligned with GIS. The pace of growth in the late 20<sup>th</sup> century increased in a variety of systems. In Iran the following cases can be mentioned:

- Rahimiyan (1374), through research about Tehran, first evaluated the city based on natural and human factors and then explained the urban land uses in different parts and analyzed them through digital data and images. He created original, auxiliary and base maps, then analyzed them through geographical software and at the end presented the sample maps for residential development in Baghershahr.

- Brandon. R, Bottomly. B.A (1998) worked on rural areas of Arkansas in the United States using Lands at satellite's images. In this research, work with GPS, earth sampling, correspondence of earth source data and satellite images and GPS took place. He also used image-processing methods to perform image classification, changes detection and at the end, he provided land uses, covering changes maps and output maps.

## 3. Research Methodology

Present research is connected to the use of Remote Sensing and GIS software to detect changes in land covers and land uses, as well as changes in the dynamic growth of the territory of the city of Ahvaz and the state of its ecology based on information taken from satellite data.

### Secondary objectives

- The detection of changes in land uses is based on the satellite data taken between years 1955 to 2013. In fact, with the help of the changes presented in the images, the areas where the greatest changes have taken place can be identified and therefore taking action in accordance with that land use would be possible.

- Assessment of changes in the physical development of the city of Ahvaz, both in terms of quantity and quality and direction of urban development.

- Provision of various thematic maps of changes in the city by using satellite data in from different periods.

- Evaluation of ecological changes of Ahvaz with an emphasis on green space and changes at Karoun River during the target period.

- The impact of the oil industry, expansion and industrialization of Ahvaz on ecology.

- The roles of geomorphology and tectonic phenomena in the physical development process or underdevelopment of the city of Ahvaz.

### Research hypotheses

- GIS applications and Remote Sensing can be used to discover the dynamic changes in Ahvaz's territory and evaluate them in terms of both quality and quantity.

- With the help of Remote Sensing data and multi-temporal satellite images, land use maps and also changes in land uses can be provided.
- The urban land use per capita has decreased over the studied period.
- Most changes have happened in the residential areas.

This study is an applied one. The data include library research, field studies, Remote Sensing and aerial photos. The data were provided from comprehensive and detailed plans, preparation of land, population and housing census, statistical yearbooks and so on. Remote Sensing data that are required digitally are provided through the Remote Sensing center. Since the Remote Sensing techniques that are used in large cities and in smaller projects are weak, and since the texture of city centers with high density of buildings and high-rise buildings work more incompletely and since the output of these techniques should be compared with the real-world phenomena, we have to carry out field studies. In this study, field work is on view so that we can compare the results of satellite data with ground realities.

Since the data are obtained in the form of digital data, these must be analyzed using Remote Sensing and GIS applications (U.S.

Department of Transportation, 2011). In general, software Geomatica PCI, Arc GIS, Arc view, Auto cad, Excel, etc. have been used.

The target population of the city of Ahwaz is the official scope in 2013, and the duration of the evaluation of these 58 years of changes is from 1955 to 2013.

The data collection tools:

Topographic maps: These maps are used as a reference for studies and the overall structure for geo-referencing satellite images and other scanned maps. In this study, two types of topographic maps with scale of 1: 50000 and digital maps with scale of 1: 25,000 were used.

Geological maps: For analysis of tectonic and geological characteristics of the study area geological maps in small and medium scales, such as 1: 250,000 and 1: 100,000 and applied large-scales maps such as 1: 25,000 and 1: 10,000 from the Oil Ministry have been used.

The images used in the study are taken by satellites Lands at, IRS and SPOT. To study Karoun River from the beginning to the end of the metropolitan area, aerial photos taken in 1955 were used. The photos are scanned and geo-referenced, and finally are used for evaluation of changes in land uses within the city.

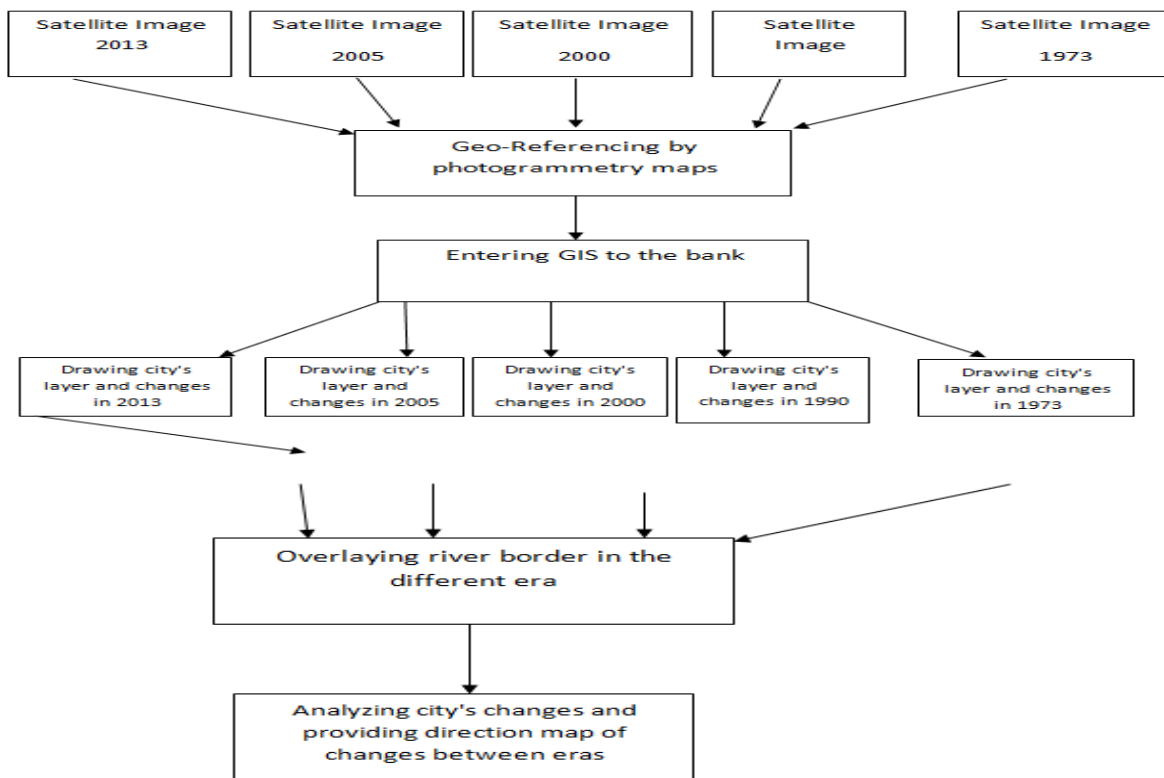


Diagram 1: Procedures and Methods of research (Author)

#### 4. Research findings

In the research, satellite images were used to study the process of Ahvaz's changes process. Images used in this study are were taken by Landsat satellite and by this satellite, detector MSS images in 1973, and Detector TM images in 1990 and also detector ETM images in 2000, 2005 and 2013 were used. All used images have been used on the basis of geo-referenced

satellite images from 2000. The important point which was accrued in preparation of images was that images belonged to the summer chapters and were from the same and certain month of the year, which is due to the similarity of environmental conditions in selected periods. Specifications of these images which were provided by Space Organization of the country are mentioned in Table 1 below.

**Table 1:** Specifications of the images used in the study process (Iranian Space agency)

Producer country	Resolution (m)	Bands	Date	Satellite
US	80	4	06/03/1973	LANDSAT4_MSS
US	30	7	04/17/1990	LANDSAT4_TM
US	30	9	05/22/2000	LANDSAT7_ETM
US	30	8	06/05/2005	LANDSAT7_ETM
US	30	8	05/04/2013	LANDSAT7_ETM

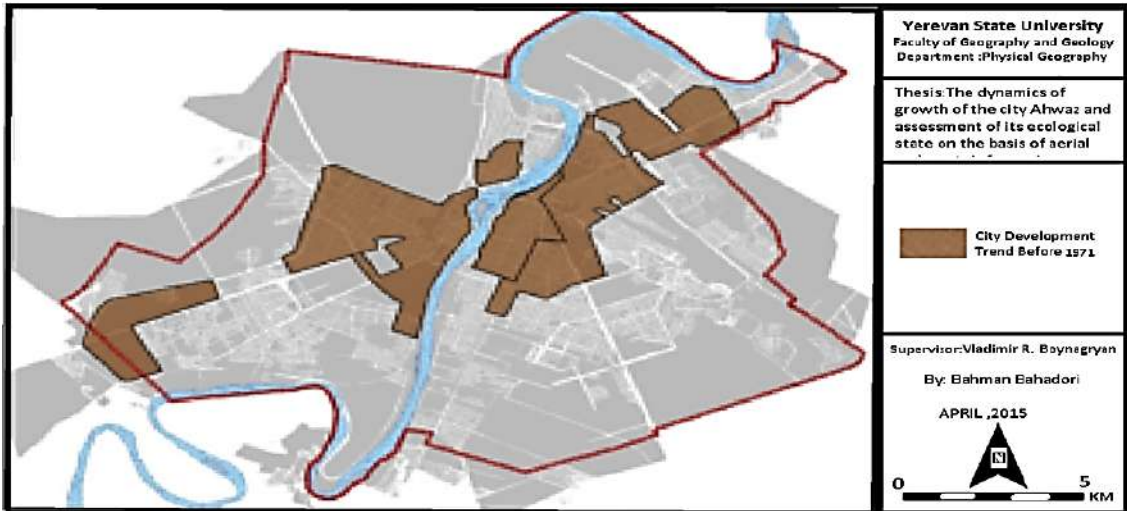
**Table 2:** control points and the RMS error (Iranian Space agency)

Date	error RMS	Check Points
1973	0.34-0.49	20
1990	0.34-0.49	23
2005	0.39-0.45	23
2013	0.41-0.44	23

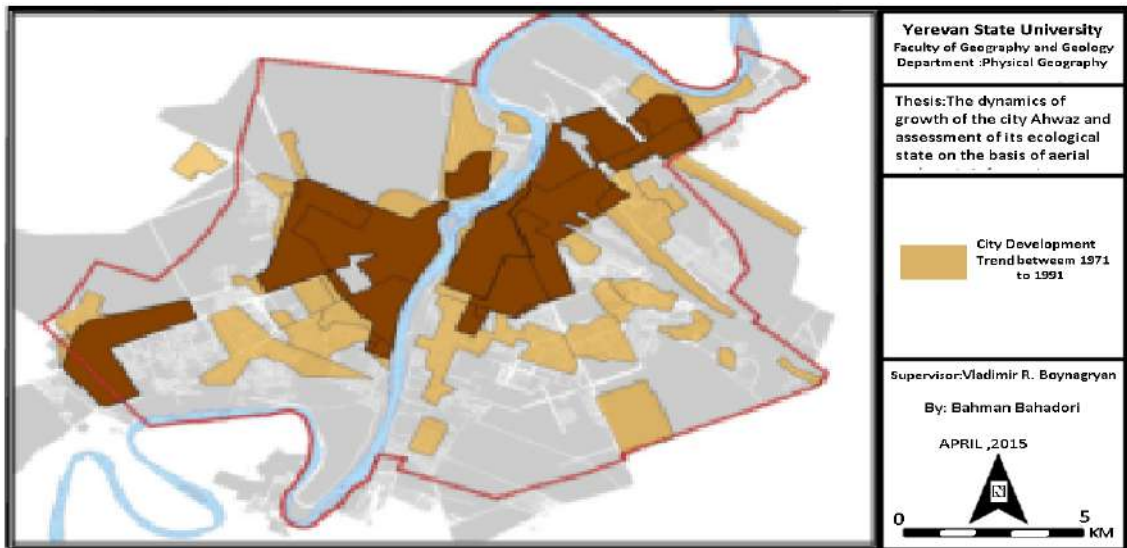
At first, the initial core of Ahvaz has been formed in the East of Karoun River and its further expansion continued toward the West of River. As the maps drawn from aerial photos in year 1973 (Map 1) show, concentration of urban texture started at the center, but separate areas also have grown toward the northeast and southwest. Thus the growth of the urban textures due to the river's bend can be seen on both sides of it. Gradually, expansion of new settlements around the downtown core and away from the river provided the ground for a concentrated expansion. That's why Ahvaz has not grown linearly along the river, but its road network in many parts has moved away from the river. At first development of the city under the influence of climatic and environmental conditions has been formed organically. But in the later periods of growth, the checkered textures too were added in its neighborhood. Currently the concentration of commercial activities within the old texture of East of the River and its high density and compactness

have formed an active but disorganized field, but in the West River, since the city's development was on the basis of a pre-determined plan, a more orderly form can be seen in the urban fabric.

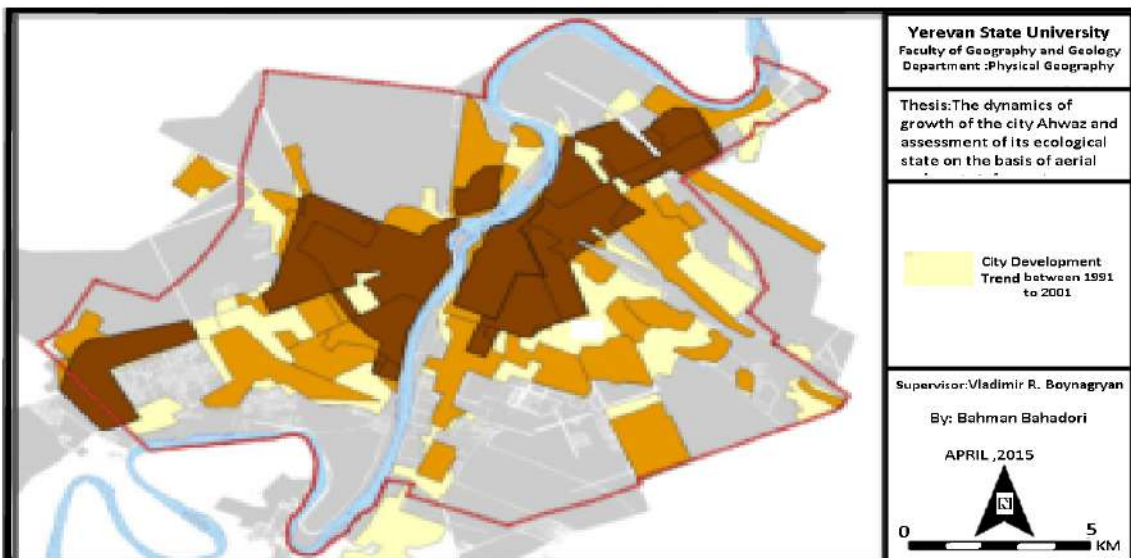
Between years 1973 and 1990 (Map 2) expansion of the city has gone further around the urban axes. During this period, factories and industries have had a significant impact in determining direction of urban development. Urban growth along the main route of the city has moved development directions away from the river and has spread it around it. In this period dissociations which existed between textures and urban centers have gradually disappeared, and continuity and connection between different areas of the city are established. In this period, along with aspects and states of desirable development of the city such as scope designed for Kianpars, there are undesirable Marginalization such as Hasir Abad, and its gradual connection to the city as well (Ahvaz Comprehensive plan).



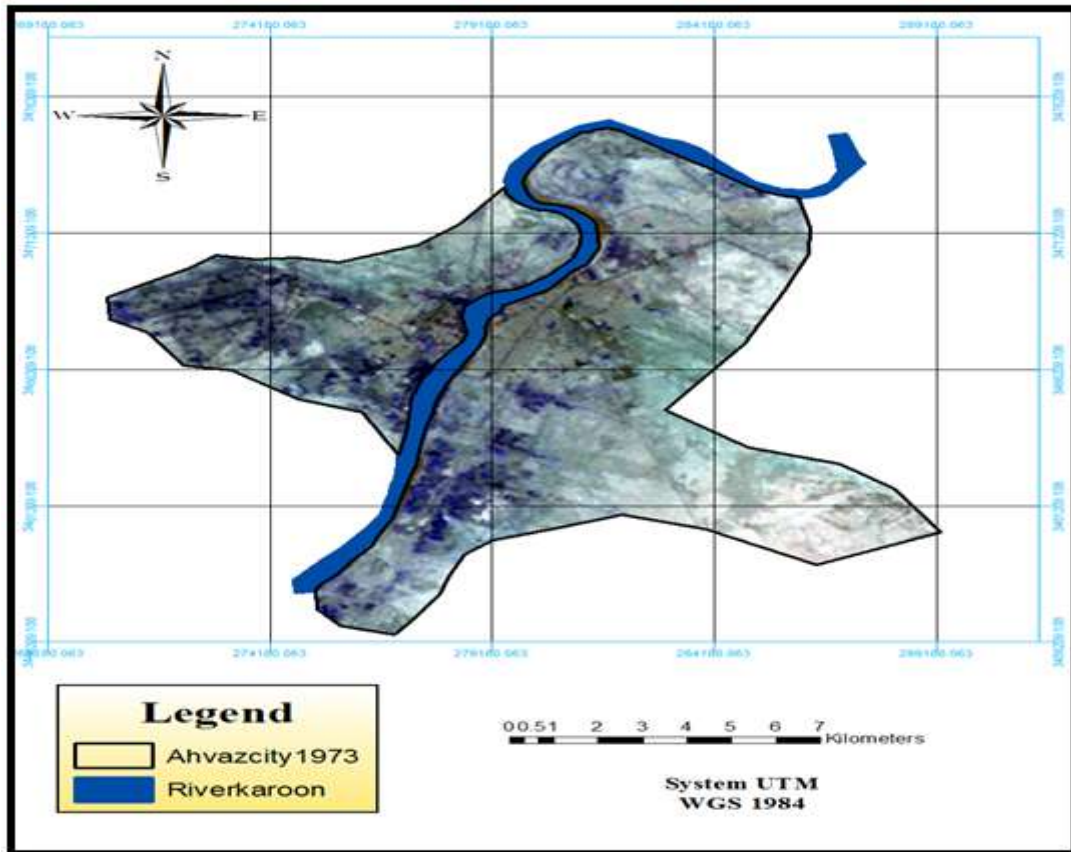
Map 1: The development of the city prior to 1973 (Author)



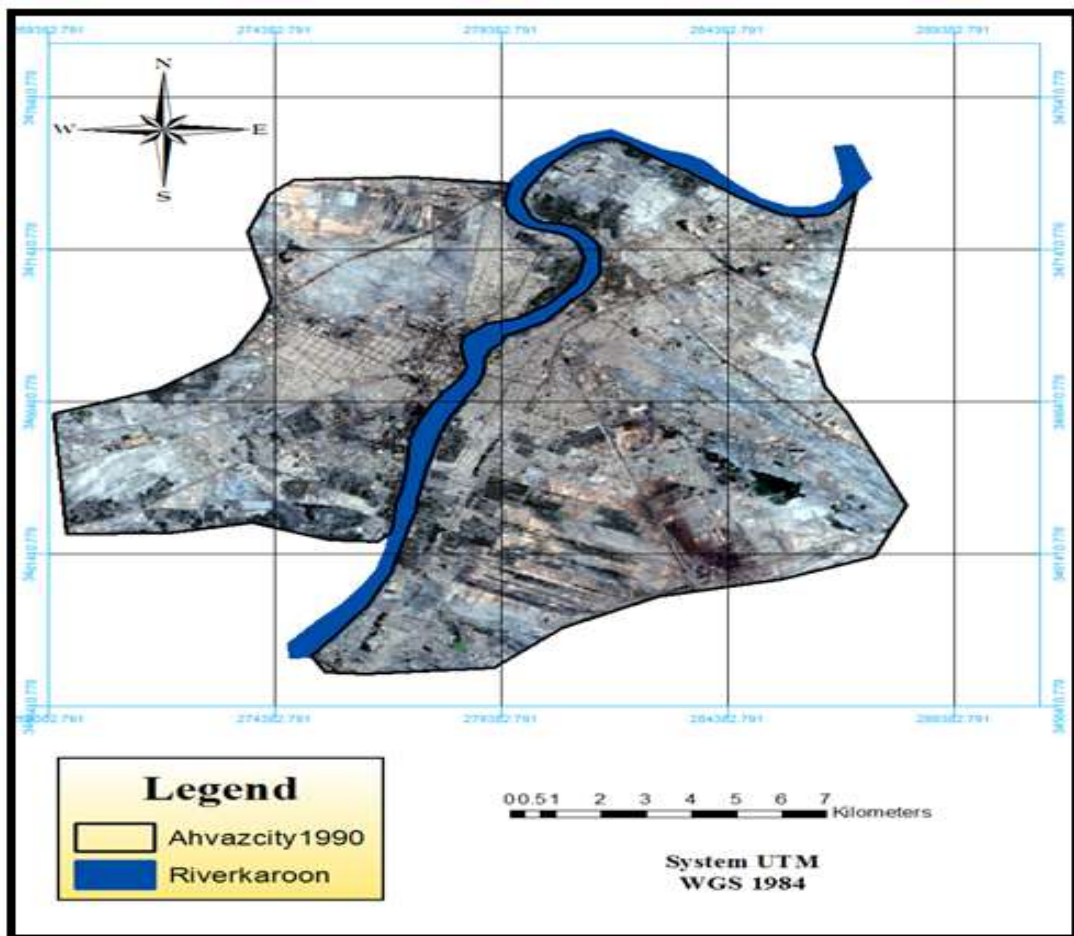
Map 2: The development of the city between 1971 and 1991 (Author)



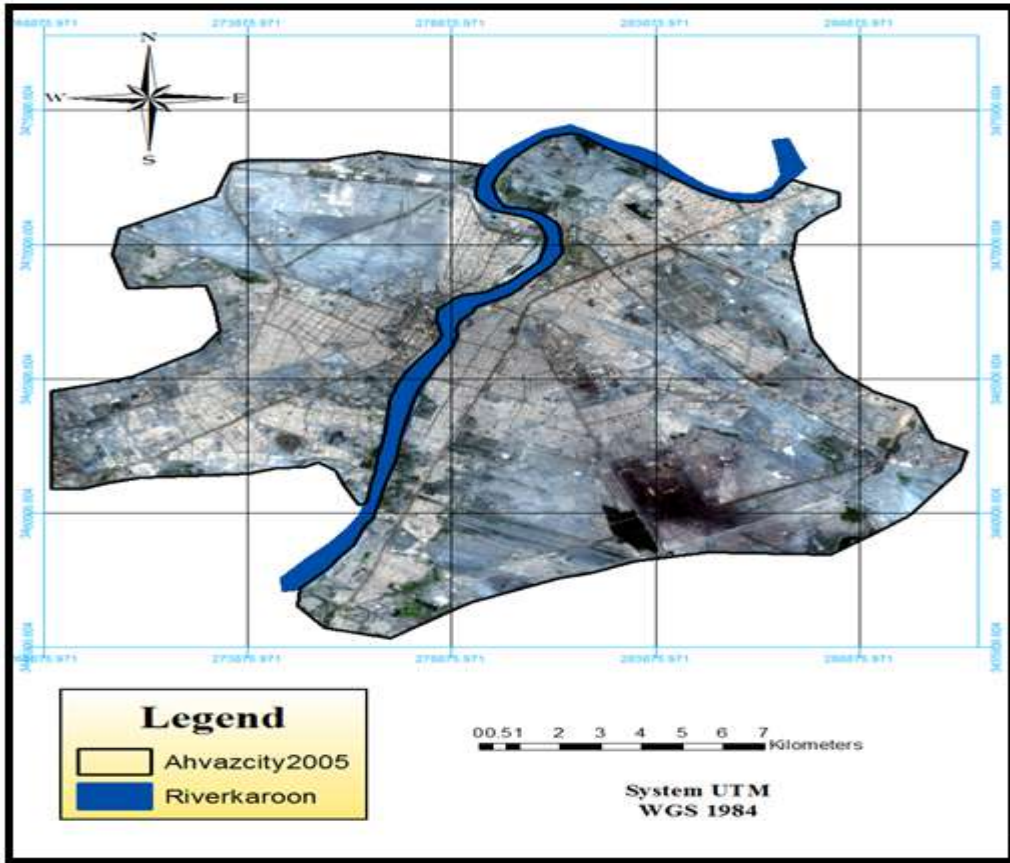
Map 2: The development of the city between 1991 and 2001 (Author)



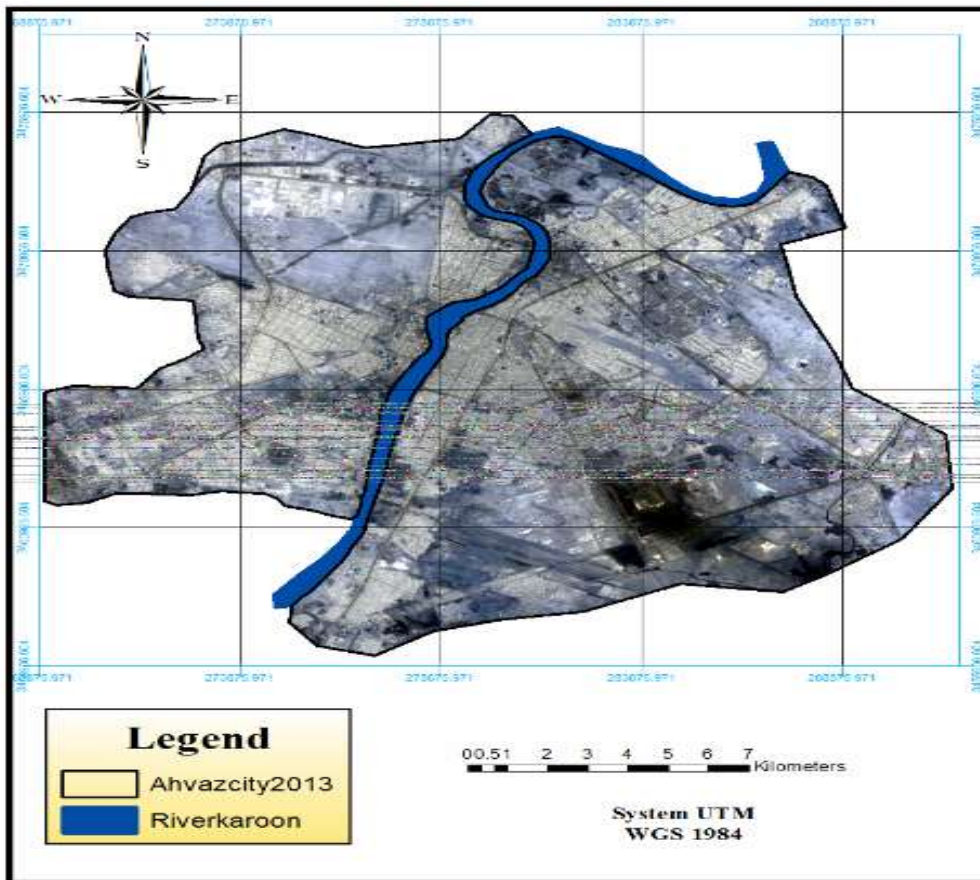
Map (4): Changes of the territory of Ahvaz 1973(Author)



Map (5): Changes of the territory of Ahvaz 1990 (Author)



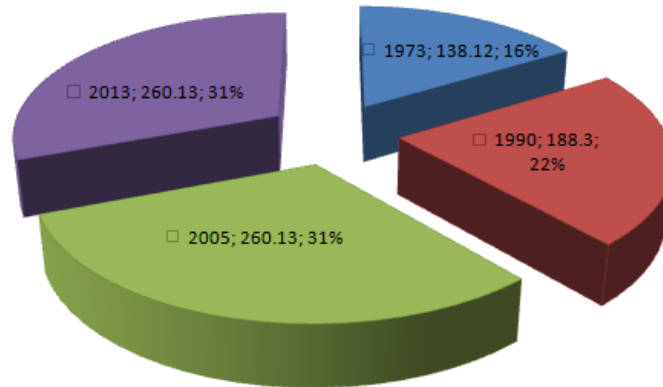
Map (6): Changes of the territory of Ahvaz 2005 (Author)



Map (7): Changes of the territory of Ahvaz 2013 (Author)

**Table 3:** Extent of Ahvaz between 1973 and 2013 (Author)

Date	Area (KM)
1973	138.12
1990	188.3
2005	260.13
2013	260.13

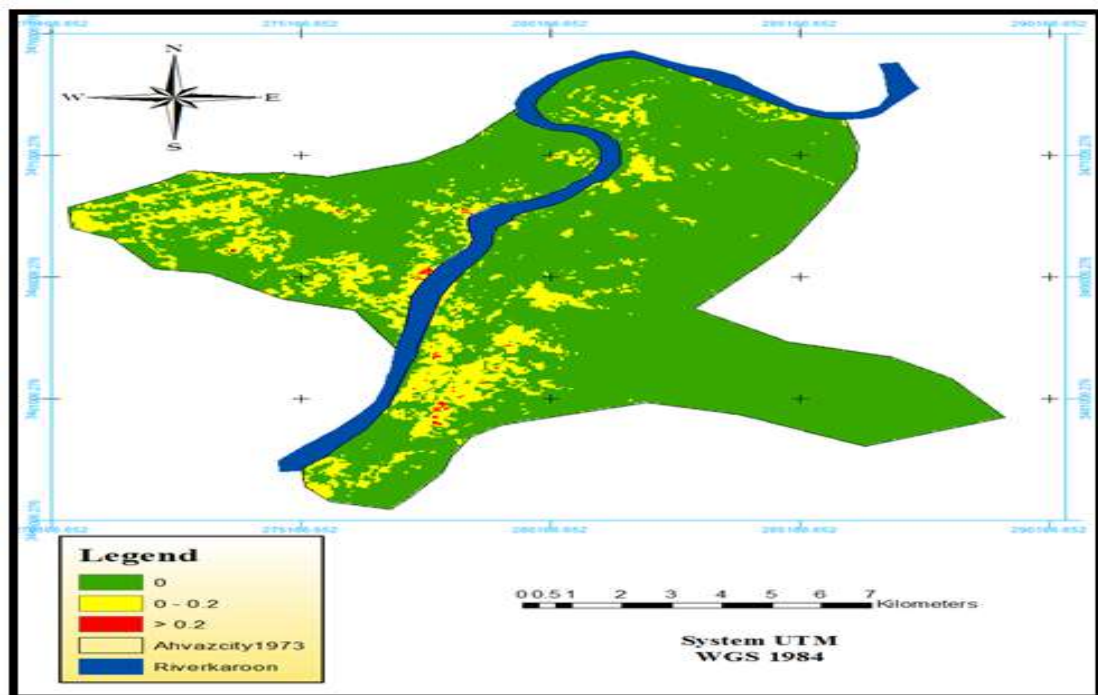


**Chart 1:** The percentages allocated between 1973 and 2013 in terms of Ahvaz city's limits (Author)

As it is shown in the table and chart above, the extent of the city of Ahvaz between 2005 and 2013 had no significant change, and with an area of 260.13 square kilometers have the largest area compared to other years, and then year 1990, with an area of 188.3 square kilometers is placed in the second rank and

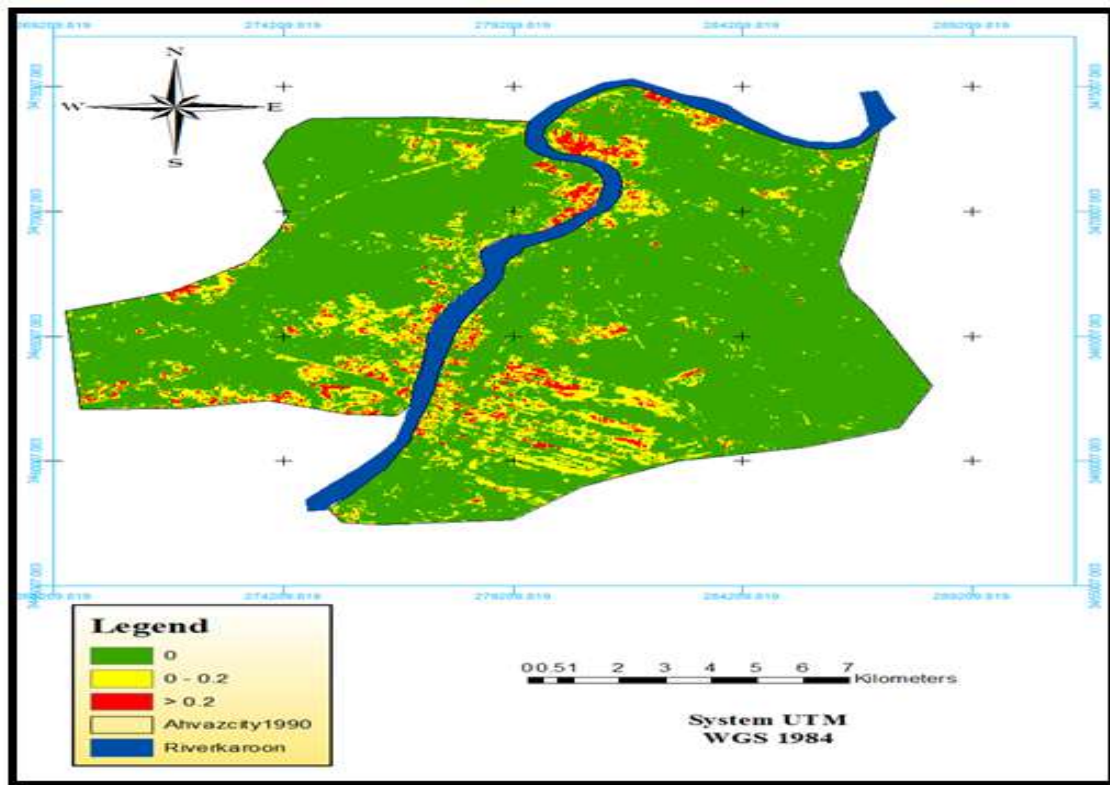
finally the year 1973, with an area of 138.12 square kilometers and the percentage of 16% is placed in the third rank.

According to the table and graph above, it can be concluded that due to population growth, urbanization between 1973 and 2013 nearly doubled.

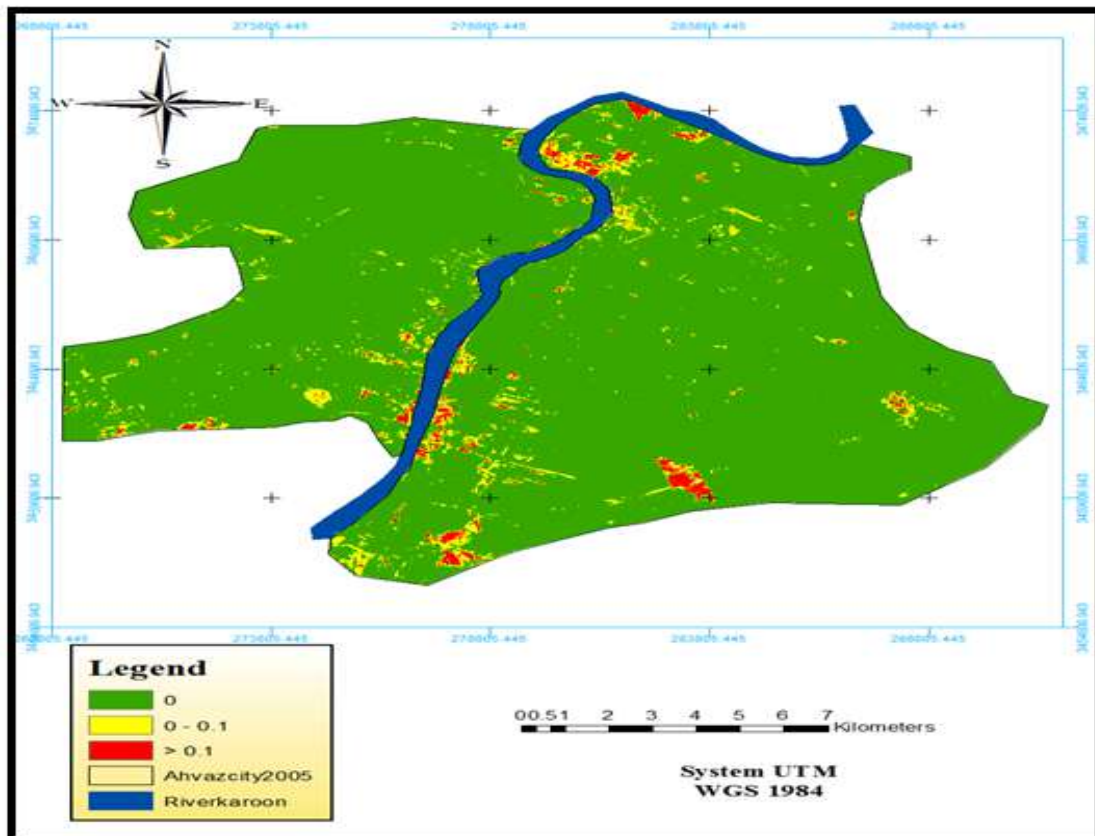


**Map (8):** The year 1973 NDVI vegetation covering index based on satellite Landsat MSS image (Author)

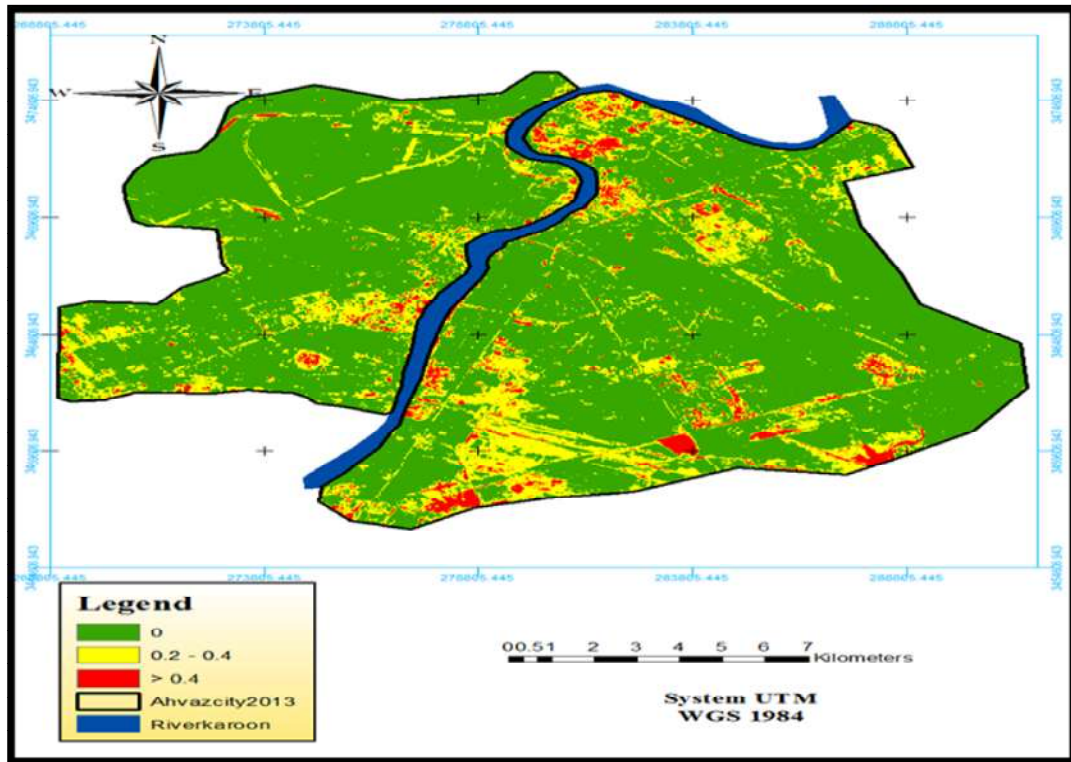




Map (9): The year 1990 NDVI vegetation-covering index based on satellite Landsat TM image (Author)



Map (10): The year 2005 NDVI vegetation-covering index based on satellite Landsat ETM image (Author)



Map (11): The year 2013 NDVI vegetation-covering index based on satellite Landsat ETM image (Author)

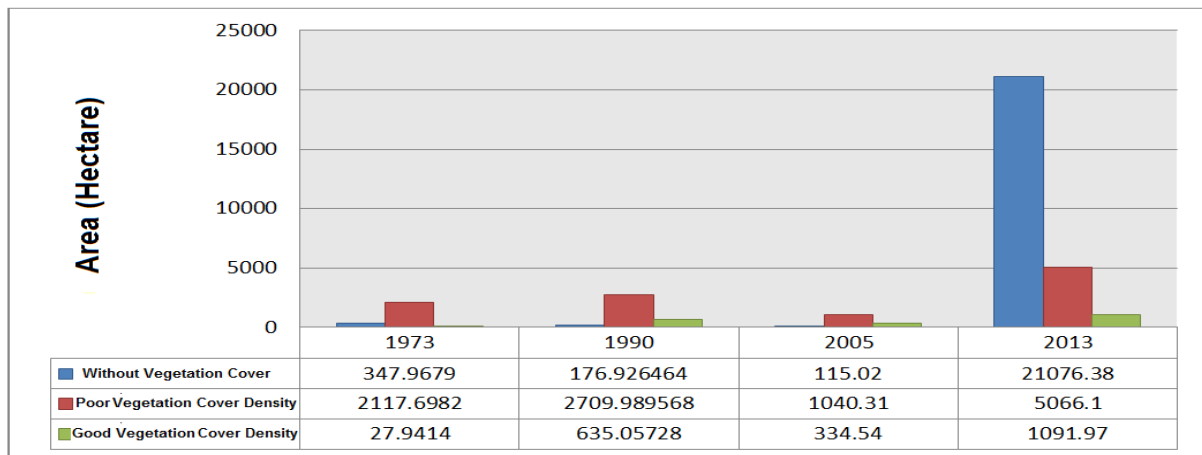


Diagram 2: The trend of changes in the vegetation index between 1973 and 2013 in the city's territory (Author)

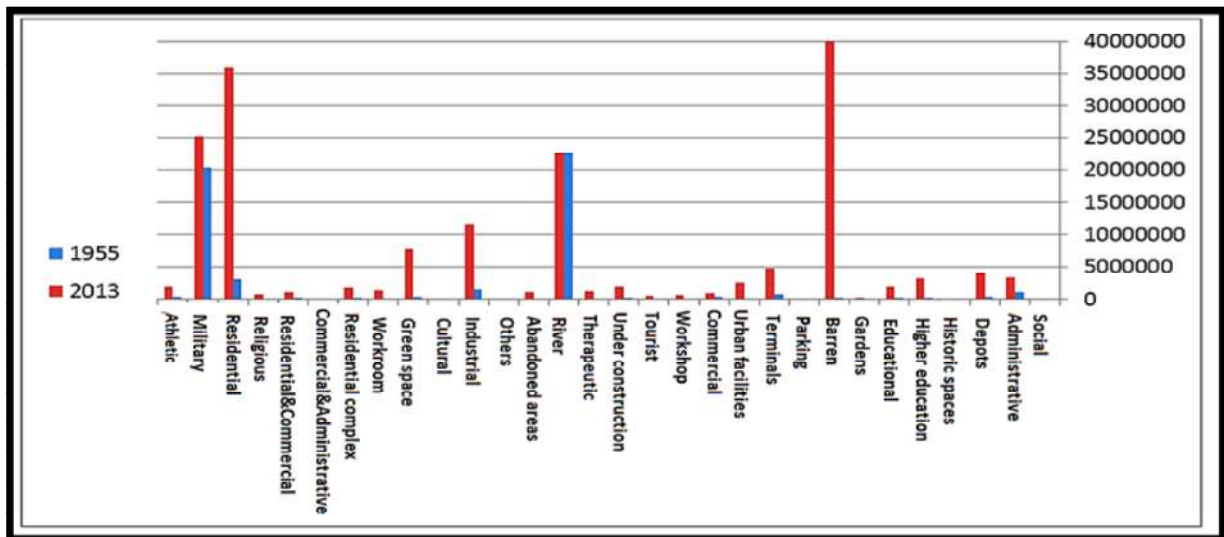


Diagram 3: changes in the land uses between 1955 and 2013 in the city of Ahwaz (Author)

## 5. CONCLUSION

With the help of Remote Sensing data and multi-temporal satellite images, the condition of land uses and also land uses changes can be provided. As it can be understood from the contents, when satellite images are provided, land uses can be identified at the time, and after identifying land uses through satellite images taken in two years, they can be extracted and changed into the map by various mathematical and fuzzy functions.

Also remote sensing and GIS software can be used to detect changes and evaluate them in terms of quality and quantity. With these software, even amount and percentage of changes with any unit can be calculated. It can be said that this would be impossible manually or will have a very large error, and the planning will face many problems. As it was mentioned, the trend of the changes of Ahvaz over the course of 58 years was discovered and also changes statistics in form of spectral data were extracted and were provided as maps, charts and tables. So the software are great help in interpretation of the city's changes.

Ahvaz urban land use changes are summarized as follows:

- Social land use area has reached from 0.08 hectares in 1955 to 0.98 hectares in 2013.
- Administrative land use has increased from 103 hectares in 1955 to 333 hectares in 2013.
- Warehouse land use has increased from 42 hectares in 1955 to 412 hectares in 2013.
- Historical land use has been unchanged and with 1.93 hectares.
- Higher Education land use has increased from 19.94 hectares in 1955 to 316 hectares in 2013.
- Educational land use has increased from 24 hectares in 1955 to 187 hectares in 2013.
- Wastelands in Ahwaz city has increased from 27.61 hectares in 1955 to 7651 hectares in 2013.
- Gardens land use has increased from 0.12 hectares in 1955 to 20.65 hectares in 2013.
- Freight and passenger terminals land use has increased from 73.37 hectares in 1955 to 482 hectares in 2013.

- Municipal facilities and equipment land use has increased from 6.34 hectares in 1955 to 253.4 hectares in 2013.

- Commercial land use has increased from 43 hectares in 1955 to 90.28 hectares in 2013.

- River land use has been unchanged and with 94.23 hectares.

Most of the land use changes and increases have been in the military - police, residential and heavy industry sections. Among the reasons for this would be the industrialization of the city of Ahvaz, the imposed war and the spread of garrisons, military bases and police in the city of Ahvaz, the development of the housing sectors in the past 15 years and the boom in residential construction after 8-year Iran-Iraq war.

There are some urban land uses in the city of Ahvaz in 2013 including oil installations, residences, farms, fields and palm groves that had not existed in 1955. These land uses allocate 1925 hectares of area. The largest area with 1166 hectares belongs to farms and the lowest with 0.31 hectares belongs to livestock land use.

It should be noted that the classes without vegetation covering, such as residential lands are the lands that are suitable for development. Among reasons for increase in classes without vegetation are 5-year development plans, discovery of oil and gas reserves, invest in energy sectors and development and reconstruction in the province after the war that led to the emigration of war-torn cities and villages areas and other cities in the province and neighboring provinces to Ahvaz. Population growth and subsequently increase in urban growth and development has created residential areas, factories, development of industries, development of residential areas, commercial spaces and the development of welfare-service facilities between 1973 and 2013.

## 6. Recommendations

Due to the growing population and high extension and physical changes of Ahvaz, methods should be taken to avoid one-sided and

distorted planning and urban areas progress without research. The following cases can be noted in this regard:

- Necessity of attention to the geological and tectonic situation of the city and region based on its seismic condition and providing earthquake hazard zoning map.
- Using the geomorphology science in design, urban planning and determination of physical development aspects.
- Creation of green spaces, green belts and public recreation centers in the physical development process of the city to prevent the growing trend of horizontal and outspread development of Ahwaz from happening.
- Avoiding illegal settlement and relocation, and removal of new housing regions in the urban territory, which populate little population and low number of households.
- Scientific and efficient management requires knowledge of the extent and direction of the future development of the city. This is achievable through dynamic models that predict the future development of the city. Thus, the use of new techniques such as cellular method is necessary.
- To avoid irregular pattern growth and directional extension of the city, planning for places located in the dominant extension directions and physical development should be a priority.
- The creation of the new cities or towns in dominant extension directions of Ahwaz can prevent the spread of aimless and unrestrained extensions of the city.
- Supervision of construction and land transference.
- Planning for preventing air, water, soil and sewage pollution of Ahwaz.
- Attention to the dust phenomenon in Ahwaz, which has created a lot of problems for citizens in the recent years.
- Implementing plans for enabling control of the status of the residents changes in Ahwaz city in order to improve ecological conditions.
- Integrating green landscapes, gardens and roof gardens to increase biodiversity and also to reduce or eliminate the urban heat island effect.
- Residents using the principles of ecology only consume their share of land resources.
- Considering the concept of garbage and waste means that the city has an ecosystem or closed cycle of recycling, regeneration and production of fertilizer.
- The city should use new technologies such as solar cooling and combined production system.
- Easy mobility and accessibility via public transportation systems with the lowest environmental impacts should be provided.
- Using local materials and prefabricated building systems.
- Polluting and exothermic industries are out of the major causes of the heat islands in Ahwaz; it is necessary that these thermal areas and Industries to be moved to areas outside the city.
- Ahwaz barren lands due to water evaporation and saline soil surface have a salt layer and it causes the release of thermal radiation. Therefore, it is necessary to change the land use of these types of lands with proper management, and due to the lack of vegetation covering in the suburb and city itself, planting trees, parks and green spaces should be built.
- To improve the ecological condition of the city, it is necessary to take advantage of the water element in the design of the urban environment, with the construction and completion of Karoun diversion channels in the eastern and western fronts. According to the topographic situation of the region and urban lands slope toward the River and with the usage of height difference of Karoun River and the surrounding lands and by building multiple channels in the directions perpendicular to the Karun River, increasing vegetation cover and green spaces and lands under cultivation in the suburbs of city that is economically important, enjoying the water element in the design environment, improving the appearance of the city and moderating its climate can be reached. In addition, the construction of artificial lakes in the lowlands suburbs can modify the climate of the region. Also in the crowded and exothermic squares, fountains, trees and decorative plants can be built to reduce, adjust and soften weather.

- Creation of artificial lakes, parks and green spaces with appropriate and balanced distribution across the city for lower the temperature, reducing air pollution and softening the weather can bring about positive effects. In this regard, the development of the green spaces such as tree plantings, green roofs, vertical green spaces, urban green areas and green belts in the city of Ahvaz and the surrounding area considering the climatic conditions is essential. That's because the city has a very low green space per capita. This deficiency is considered from the main reasons for the lack of green space in the city of Ahvaz. Among the major causes of this problem, the lack of garden urban corridors, crude water channel for continuous irrigation of green spaces and also the lack of training people to protect seedlings and green spaces can be noted.

- Incentive policies such as relief tax for units which plant trees in the indoor and outdoor spaces of their fields can be helpful. Also afforestation on a regional scale can stabilize temperature and sand dune, reduce dust storms and protect agricultural lands. The destructive effects of the sand dunes cut off communication lines, fill riverbeds and irrigation canals, threaten agricultural lands and residential areas and cause air pollution, respiratory infections and allergies for a variety of city residents.

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