

Prospects on Land Use of Alahsa Governorate and Its Effects on Urban Heat Island

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ABSTRACT: The aim of this study is to investigate land use pattern of Alahsa Governorate and its effects on urban heat island. Data used to analyze the land use of the governorate was collected from Alahsa Municipality. While, data collected to study the urban heat island of the governorate was collected from authorized bodies who control weather station networks over Alahsa Governorate, Eastern Province, Saudi Arabia. A considerable increase in urban growth in Alahsa Governorate took place. The urban land increased from 15706.9 in 2004 to 24649.1 Acres in 2014, with an increase of almost 9000 Acres. Moreover, the approved expected urban growth is 38000 Acres by 2029 adding approximately 19000 Acres of lands. On the other hand, the data analyzed confirm an increase in intensity of the urban heat island of the governorate counted for 2.0 degree reaching 2.3 degree from 2004 to 2014. Such increase is considerable whenever human health and comfort are the concern. This study confirms a direct relation between urban land use and the intensity of the urban heat island of the governorate. As the urban land increases, the intensity of the urban heat island increases. So far the urban development of the governorate is recognized and evident. The governorate is experiencing high pace of urban development with considerable increasing levels of urbanization. Unless decision makers and strategic planner are aware of the consequence of rapid, uncontrolled, unstudied expansion of urban areas, unpleasant climate will result reflecting negatively in human comfort and health. The study recommends, more attention to strategic planning of the governorate supported and enforced by decision makers, urban planner and relative authorized organizations.

KEYWORDS: Land Use, Alahsa Governorate, Meteorological Weather Station Network, Urban Heat Island.

1. INTRODUCTION

Land use pattern is an essential quantitative indicator whenever the level of urbanization is the concern. Level of urbanization is measured based on specific criteria that may include any/ some/ all of the following:

- The concentration or size of populations.
- The process in which the in-migration of people to cities blends into an urban lifestyle.
- The process in which urban culture spreads to agricultural villages.
- The predominant type of economic activity.
- The development of urban areas and their urban characteristics such as specific services and facilities.
- The process in which the proportion of people living in an urban area increases.

Although the third and the fifth criteria are directly affected by land usage, all above mentioned criteria are affected by land use pattern. In many developing countries, towns are expanding and an increasing proportion of the land is being taken up for urban land uses, replacing fields, farms, forests and open spaces. As a result, the majority of urban inhabitants in the world today experiences distinctive and often

unpleasant climatic conditions[7]. Man through his activities to build cities has altered the climate in various ways. He changed the physical surface of the land. Urban man and his activities produce a significant amount of heat. Moreover, his urban activities produce great quantities of pollutants that affect the global balance [9].

The rapid expansion of cities in the developing world is being achieved primarily through the incorporation of large numbers of rural people into the new urban setting. The estimated results of rapid urban growth in the developing countries, are 17 out of the 21 mega-cities of the world will be in these developing countries. [11]. Physical expansion of individual major cities has pushed urban land uses to grow beyond the gazette city boundaries to produce continuous urban landscape merging surrounding areas.

The expansion of cities have been swallowing rural communities for two centuries[2]. Brookfield (1991) added that, many suburbs in European cities still preserve the rural road patterns; turned green areas of villages into urban parks, and preserve few of the old rural houses. In Asia cities many rural communities have more recently been swallowed up by the city, becoming the older urban villages. Some have been swept away altogether in the interests of urban renewal and more balanced urban planning. The effects of land use on climate and environment is evident by previous studies [3, 4, 5,7,8,9, 10,12 and 13]. Development and change of land use over time affect ambient temperature, relative humidity, wind speed, and hence, human comfort. Sham Sani (1987) commented that, observations indicate that the commercial centers are usually several degrees warmer than the surrounding countryside, a phenomenon known as the heat island effect. While Cardelino (1991) commented that, the effects of urban areas on environment and the consequent formation of heat islands have far-reaching implications on human thermal comfort, energy utilization for air conditioning, and policy planning. He added that:

“Two important effects take place as a result of cities growth and development: the amount of trees is reduced and there is an increase in ambient temperature due to the urban heat island effect”.

This study focus on investigating the land use pattern of Alhasa Governorate and its implication on urban heat island.

2. METHODOLOGY

In addition to extensive literature reviewed and extracted, data used for the purpose of this study were gathered from both governmental and nongovernmental authorized bodies.

Concerning land use of Alahsa governorate, data was collected from Alahsa Municipality as main source of authenticated most updated records.

On the other hand, data collected to study the urban heat island of the governorate was collected from authorized administrations who control weather station networks over Alahsa Governorate, Eastern Province, Saudi Arabia.

3. RESULTS AND ANALYSIS

3.1 LAND USE

Alahsa Governorate is located in the South-eastern corner of Saudi Arabia occupying the southern part of the eastern region between 17-26 latitudes and 48-55 longitudes. It covers a vast area of around 530 000 km², representing 68% of the area of the eastern region and 24% of the area of Saudi Arabia. It is considered as the largest oases in the Arabic Peninsula [5]. The Governorate consists of many cities and villages in addition to the most famous empty desert that is called Empty Quarter. Hofuf and Mubarraz are the oldest and most developed urban cities [1]. Hofuf city is considered as the capital city because of its economic role in the region. Its economic role increased after the discovery of oil in Eastern Province of the Kingdom in 1939. Several oil centers are in Alahsa Governorate. The most famous field, Al-Ghawar, is part of the governorate. It is the largest oil field which provides more than half of the cumulative oil production of Saudi Arabia [1]. Alahsa Governorate passed over four stages of urban development:

3.1.1 First Stage before 1963

The stage is considered as the origination phase. The phase was characterized as the phase of looking for the best position to stabilize population making use of the presence of wells and springs as a source of permanent water for drinking and agriculture. Wherever springs and water wells are located, communities are formed. Hofuf and Mubarraz cities are famous for their permanent springs and water wells that help in formalizing the cities and affect the level of urbanization by increasing the rate of migration. They are characterized by tribal groupings communities having their own lands and natural resources [1]. The stability of the region was supported by the discovery of oil in 1939 in Eastern region that led to the evolution of national income and creation of municipal system that affects action plans for development.

3.1.2 Second Stage from 1963-1973

It is considered as growth and configuration phase. During these ten years the region passed through many urban growth stages. Documented economic and social changes were recorded during this decade with noticed urban growth rates and development especially in the development of transport networks. Five-year development programs started with the concurrent trebling increase in oil prices. That directly affected the whole country income and lead to doubling of national incomes. New neighborhoods were built at both Hofuf and Mubarraz towns. At that stage, major services and Government departments were centered at Hofuf town and a transportation system connected the town with Mubarraz town. Therefore, at this stage Hofuf was considered as administrative capital of the surrounding territory [1]. Population grown as well as commercial activities increased on main streets in the heart of the conurbation. The expansion of development at that time was in southern and Western directions of the region and its commercial centers.

3.1.3 Third Stage from 1973-1994

The stage is considered as the evolution phase. Reflecting the accumulation of wealth and escalating economic development, substantial urban growth rates were recorded in Alahsa specifically in Hofuf and Mubarraz. This phase was characterized by urban extension towards the West and South, resulting in the emergence of residential buildings on both sides of the new roads that stretch beyond the capital of Hofuf. Due to the increased migration of nomads new districts were formed [1].

3.1.4 Fourth Stage from 1994- 2012

The recent recorded phase. A considerable increase in urban growth in Alahsa Governorate took place. The land use for buildings increased from 7649 to 22869 Acre. Hofuf city grew from 3730 to 14877 Acre that influenced the current urban development. Figure 1 below shows the four urban growth stages.

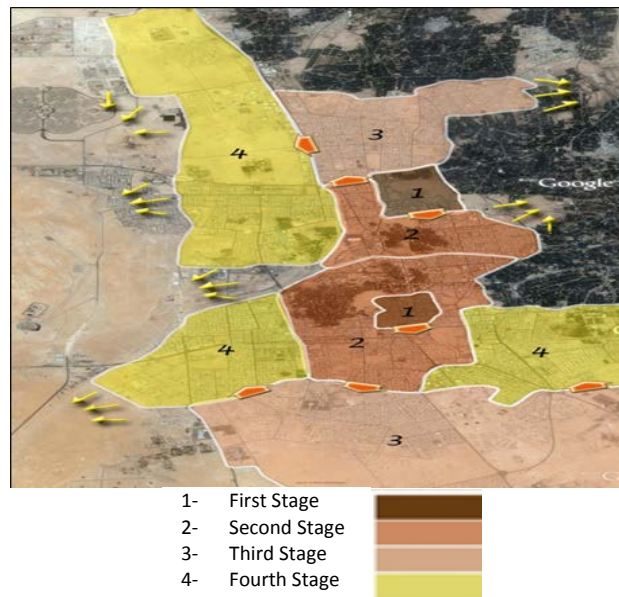


Fig. 1 Stages of urban growth in Alahsa Governorate

While Figure 2 below depicts the urban development with the planned growth until 2029 [1]. The land use increased from 15706.9 in 2004 to 24649.1 Acres in 2014, with an increase of almost 9000 Acres. Moreover, the approved expected urban growth is 38000 Acres by 2029 adding approximately 19000 Acres of lands.

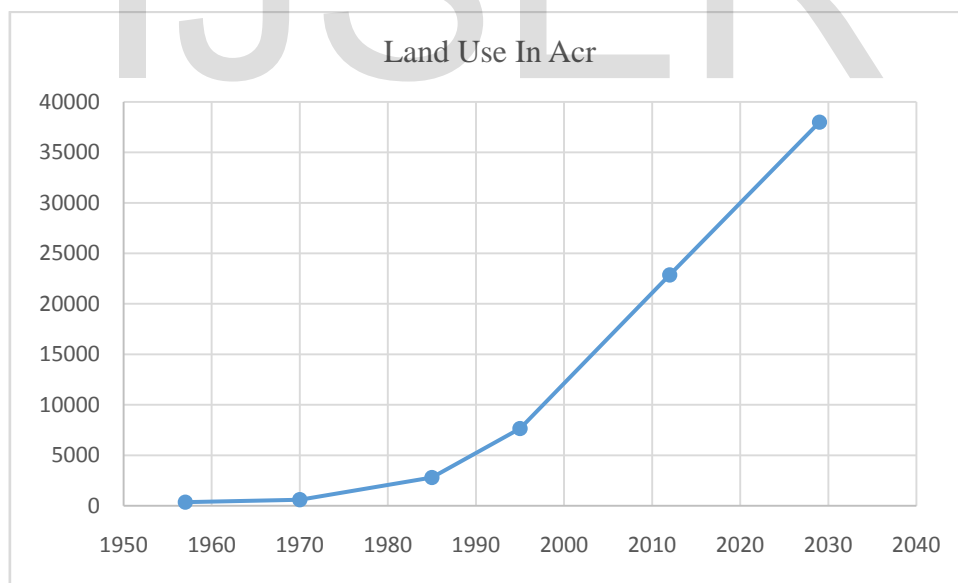


Fig. 2 Approved urban growth in Acres till 2029

Land use in Alahsa Governorate changed from period to period to cope with the gradual development of Alahsa. The change is either on location or function. For example, transferal of Alahsa airport from southern Hofuf to southwest of the city and customize its old location to

accommodate King Faisal University expansions. The governorate experience tremendous land use changes specifically with in its central area. The land used for small and local industrial activities are turned into commercial land. Moreover, the governorate is experiencing change in the commercial land that were concentrated in the central area between Hofuf and Mubarraz cities. Urban growth for the governorate led to emergence of secondary commercial centres on main roads of the cities. The lack land associated with declining trend to horizontal expansion of the market within the centre reflect on high rents of shops that led to suburban expansion. On the other hand the residential land has grown dramatically on the outskirts of the city through the approved plans and switched from the Centre of the regions to give way to commercial use and management services. Chart. 1 below depicts the land use in Alahsa governorate. It illustrate the varies percentages of land use from Residential, Empty Spaces, Commercial, Educational, Industrial, Entertainment and Public Parks, Governmental, Agricultural, Roads and parking lots to Cemeteries. The emptyno built area is 48 percent which is the highest percentage among other land use, followed by 20% of land used for transportation and parking lots. Although, the agricultural land occupied 10%, land used for parks and entertainments is less than 2%.

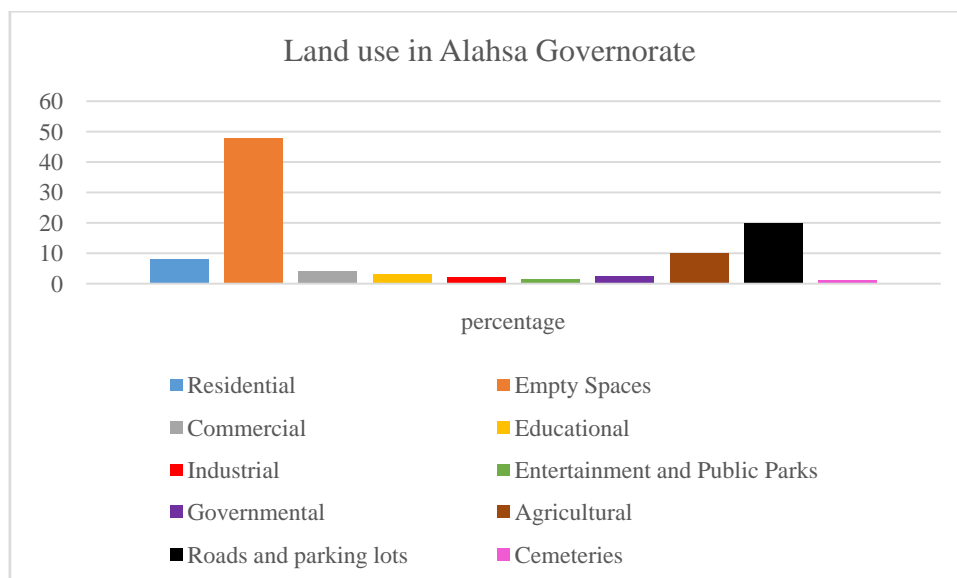


Chart. 1 Stages of Urban Growth by Function

3.2 Urban Heat Island

Comprehensive and long investigation done for the purpose of this study confirm that, there are only three weather stations covering Alahsa Governorate:

3.2.1 ALAHSA METEOROLOGICAL STATION (AMS)

It is counted as the main and oldest authorized governmental meteorological station in the region. It is under ministry of Defense and Aviation, presidency of Meteorology and Environmental Protection, National Meteorology and Environmental Center authority. It is Alahsa Airport properties, located at 25 17 53 N Latitude and 49 29 11E Longitude, 178.17 m Elevation.

3.2.2 COLLEGE OF ENGINEERING METEOROLOGICAL STATION (CEMS)

The station is located inside King Faisal University. It is controlled by King Abdulaziz City for Science and Technology and College of Engineering at King Faisal University. It is established before about three years. Although its data are very recent, data retrieval process on hold waiting for renewing of contract between King Faisal University and King Abdulaziz City.

3.2.3 TRAINING, AGRICULTURAL & VETERINARY RESEARCH CENTER METEOROLOGICAL STATION (TAVRC)

This station is located inside King Faisal University too, at 25.3401 latitude and 49.5968 longitude within the premises of the Training, Agricultural & Veterinary Research Center. The data provided by the authorized bodies is for less than two years. It is for 2013 and 2014 only.

Valazquez-Lozada (2002) [8] defined the urban heat island as the difference in temperature between the urban and rural areas. The data collected from AMS is for 2004 and 2014 for three months that are counted as the hottest months of the year, June, July and August (Mohammed Ataa 1999[5]). While for TAVRC, according to the purpose of the study, the data used from this station are confined to 2014 to match the data collected from AMS while data for 2013 is excluded from analysis. As TRCMS is located within the most populated well developed urban area in Hofuf city and AMS is located at the far end of the city in the less populated and less developed area, these stations are used mainly to investigate the temperature pattern over the Governorate. Chart 2. below shows the average maximum temperature measured in degree Celsius at TAVRC and AMS during June, July and August 2014. The difference in maximum temperature between the two stations is counted formore than 1.5 °C. It reached 2.0 °C during June, 2014 which confirmed that the city centers are always hotter than suburban areas[4].

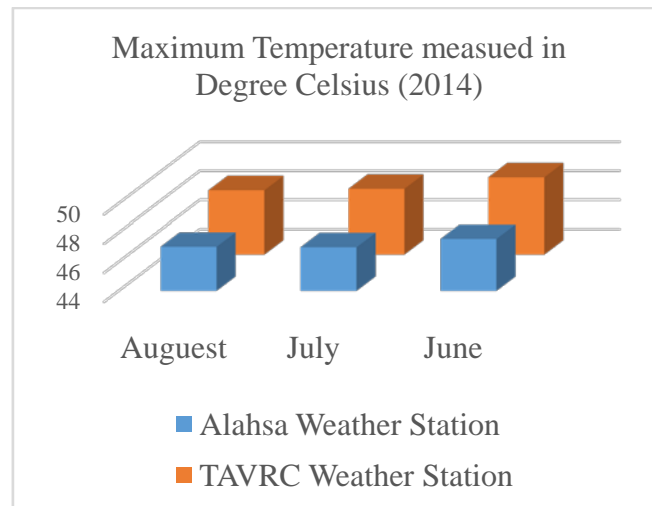


Chart 2. Maximum temperatures recorded at TAVRC and AMS, 2014

On the other hand, Chart 3. Below depicts the average maximum temperatures measured during June, July and August for 2004 and 2014. The difference in temperature between June 2004 and June 2014 is 2.3 °C while it is 1.5 °C for August.

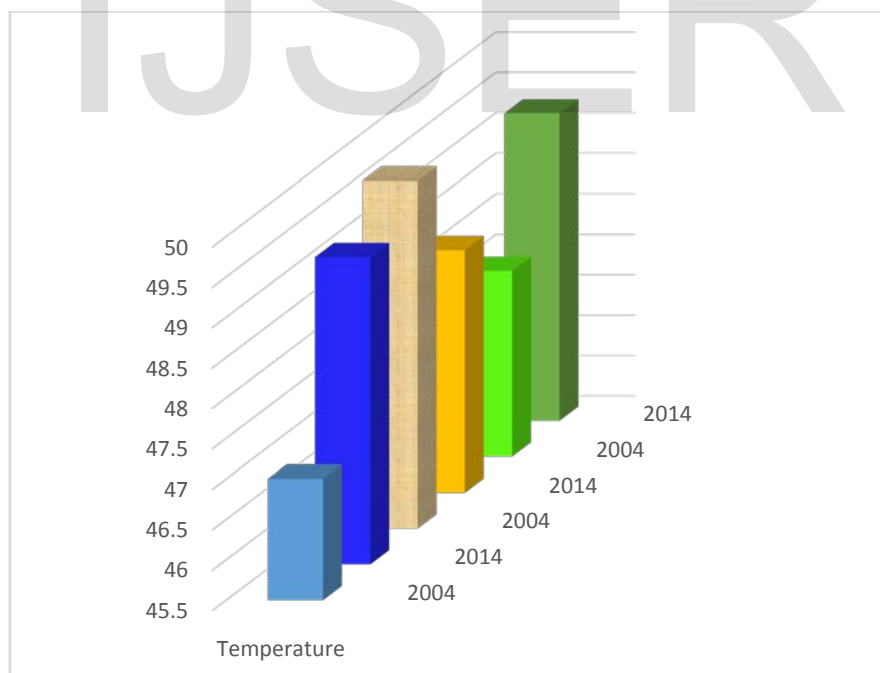


Chart 3. Maximum temperatures recorded in June, July and August for 2004 and 2014

The results confirm that, there is an increase of temperature counted for 2.3 °C for one decade from 2004 to 2014. Moreover, it shows that there is variation in the intensity of temperature between TAVRC and AMS counted for 2.0 °C difference.

3.3 EFFECTS OF LAND USE ON URBAN HEAT ISLAND

The urban growth of the governorate is obviously clear with expected urban growth reaching 19000 Acres by 2029. On the other hand, the intensity of the urban heat island of the governorate is counted for 2.0 degree reaching 2.3 degree. This increase is investigated during one decade difference from 2004 to 2014. Concerning land use during same period, there was an urban growth from 15706.9 Acres in 2004 to 24649.1 Acres in 2014, with an increase of almost 9000 Acres. Although the urban growth during this period is evidently clear, the direct effect of land use on the intensity of the urban heat island of the governorate is difficult to predict. Further in depth studies are needed to locate the nucleus of this urban heat island. In addition to the possibility of availability of more than one urban heat island within the region. Moreover, the land use pattern is not clearly specified during that decade. Nevertheless, the preliminary conclusion based on this research results confirms a direct relation between urban land use and the intensity of the urban heat island of the governorate. As the urban land increases, the intensity of the urban heat island increases.

4-CONCLUSION

Large cities have often been seen as an unstable form of development and less desirable than smaller cities, bringing with them both an intensification of existing urban problems and new problems [8]. City with its acres of concrete has a high thermal conductivity and heat capacity [10]. The results of the study confirm previous studies [2], [3], [7], and [8] that show that, urban growth has a negative consequences on climate. As urban areas are swelling rural areas a temperature increase is recorded. Results of this study confirms a direct relation between urban land use and the intensity of the urban heat island of the governorate. As the urban land increases, the intensity of the urban heat island increases.

Alahsa governorate is experience similar scenarios the mega cities went through. Unless decision makers and strategic planner are aware of the consequence of rapid, uncontrolled, unstudied

expansion of urban areas, unpleasant climate will result reflecting negatively in human comfort and health. So far the urban development of the governorate is recognized and evident. The governorate is experiencing high pace of urban development with considerable increasing levels of urbanization. More attention should be drawn to strategic planning of the governorate supported and enforced by decision makers, urban planner and relative authorized organizations.

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