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Land Use Land Cover of an Urban Area using Remote Sensing (Texture Analysis Applications) and GIS - A Case Study of Central Region of Almadinah Almunawarah, Saudi Arabia

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Abstract In this study IKONOS images with high spatial resolution have been used for urban planning classification. This research explores approaches to improve urban planning and build up the data base for types of patterns area within the urban scheme in central of Almadinah Almunawarah using remote sensing based on Texture Analysis Applications and Geospatial Information System (GIS softwares). It has been compared with Traditional method (Field Survey) of urban planning classification in Almadinah Almunawarah. The activities of central Almadinah was divided into commercial area, investment area, industrial area, health services building, religious building, garden, infrastructure, government services building, and agricultural area. The results of this study showed the commercial and investments area was the largest area 6.5 km, and it is followed by religious services 3.2 km, while the third ring area the largest area was the agricultural housing area 16 km and then followed by commercial and investments area 5.3 km of the total area. This study recommends to use remote sensing data to classify the urban planning due to significantly improve land cover classification performance compare to traditional survey.
Keywords *classification; commercial area; IKONOS; image processing; geography; geospatial information; remote sensing; land cover*

1. Introduction

Recent advancements made in the development of satellite sensors, image processing techniques, urban classes' data collection techniques and GIS modeling have provided in combination a powerful tool for urban classification analysis and monitoring. A sensor orbiting the Earth on board the NASA's IKONOS satellites with high spatial resolution is now collecting the most detailed measurements ever made on the urban planning and classes. Like a sophisticated thermometer in space, the IKONOS can detect with high spatial resolution the details and changing of urban classes every 14 day over the entire globe through five spectral bands, or channels [4, 10, 22]. Urban area covers - Commercial area and investment area, industrial area, health services building, religious building, garden, infrastructure, government services building, agricultural area were extracted and monitoring from Almadinah Almunwarah, Saudi Arabia using high spatial IKONOS data sets, which have provided scientists with

improved measurement and monitoring capabilities over their predecessors. For instance, IKONOS can now better detect and mentoring the change of urban classes cover associated with signature value using information contained in the surface emissive and reflectance signatures. It also improves the accuracy in the measuring of classes' area.

In past the classification and planning organized in Almadinah city has been done based on traditional method of map digitizing of land cover classes and change detection were based in field survey [3, 6, 8]. This technique is useful for small area land cover classification but can't classify large area with many type of coverage classes and these methods are time consuming, it needs more effort and its low accuracy of land cover land use classification. Due to fast development and rapid urban expansion in Almadinah Almunwarah city and the need to update the map patterns of urban plans associated with data base build up to do proper urban planning and management of these areas a way that meets the growing work, housing, economic and investment activities need and distributed appropriately. It is appropriate considering the introduce of remote sensing (Texture analysis applications) and geographic information systems to monitoring this change with development of urban planning in the city of Medina and to update the databases of classes cover change. Due to previous studies related, many research done on land cover and land use classification using remote sensing data, urban planning and classification using pixel base classification [2, 23], land use land cover classification using land sat satellite image [5, 13, 16, 19], monitoring and change detecting of the urban scheme using quick bird satellite image [6, 21], IKNOS satellite data for urban planning [12, 15, 20]. Many works have been done on mapping and monitoring forest and vegetation, phytobiodiversity mapping using object oriented classification [18, 24]. However, mostly this work on pixel base classification without validation have been done between result extracted from satellite image and field work, also these work did not use the texture technique interpretation, which lead to low accuracy mapping land cover land use extraction.

In this research we have eliminated the Texture analysis applications technique and interpretation from IKONOS satellite image for more accurate land use land cover mapping and data base, which is a basic property, is an important technical to classify each feature and class cover. In other hand the research carry out with validation between result from satellite image and field work.

1.1. Study Area

The study area is Al-Madinah Almunawarah located at Eastern Part of Al Hijaz Region in the Kingdom of Saudi Arabia at latitude 24.28 06°E and longitude 39.36 6°N, as appeared in Figure 1. It is located in hot tropical region where it is subject to effect by the Mediterranean region in the north, and tropical season region in the south. Madinah is surrounded mostly by mountains, and it's height above sea level between (590-620 meters), where it's far from water bodies (240 km far from the Red Sea). Medina area is about 589 square kilometers and 99 square kilometers occupied by the urban area [14].

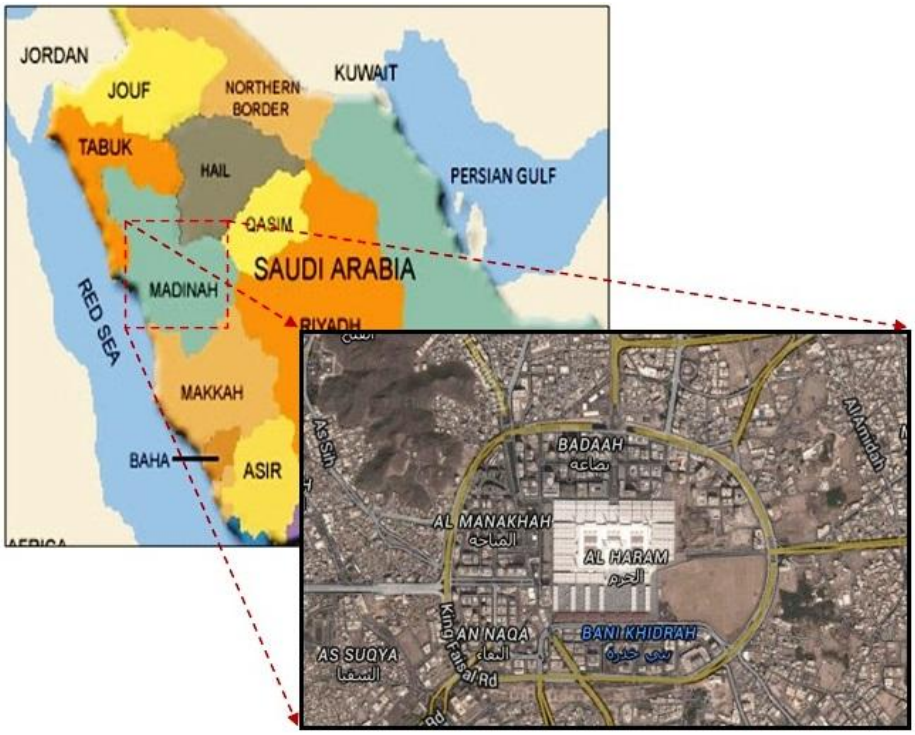

Figure 1: *Study area Al-Madinah Almunawarah, Saudi Arabia*

2. Data and Method

2.1. Data

The data have been used in this research acquired by Madinah development authority and downloading from the Global Land Cover Facility, www.landcover.org. The IKONOS datasets provide temporal and reliable information for extraction and monitoring of urban classes features. Obtaining the same information through traditional methods and field surveys would time consuming and use considerable human resources. Table 1 shows the details of IKONOS spectral band and spatial resolution.

Table 1: *Details of IKONOS spectral band and spatial resolution*

Satellite	Sensor	Band(s)	Spectral Range	Scene size	Pixel resolution
IKONOS-2	Multi-spectral	1 = Blue	455 - 520 µm	11× 11km	4 Meter
		2 = Green	510 - 600 µm		
		3 = Red	630 - 700 µm		
	panchromatic	4 = NIR	760 - 850 µm		
		Pan	760 - 850 µm		1 Meter

2.2. Image Registration

The IKONOS data sets were geo-referenced to the Universal Transverse Mercator (UTM) Projection using the “Georeference IKONOS” function in the ENVI software 4.2 version, which has provided automatic geometric correction of the IKONOS imageries including correction for orbit overlap and swath distortion (the bow-tie effect). This correction was done to enable checking the image coordinates with those of texture analysis class detection. The urban classes feature vector data was overlaid on the corrected images and an accuracy of < 0.6 pixel was obtained.

2.3. Texture analysis application

The Texture analysis applications is based on a methods that involve of six steps of processing: Magnetic resonance imaging (MRI) acquisition, region of interest (ROI) definition, region of interest ROI preprocessing, feature extraction and detections, feature selection process, and classification of each feature as shown the texture model and analysis in Figure 2. In texture analysis model none of these steps is working specific, and the process have to be done according to the methods and application. The texture analysis result can be more affected base on the process used throughout the methods. In this research, we provide description of each processing step of the texture analysis methods focusing on applications that explain many different methods.

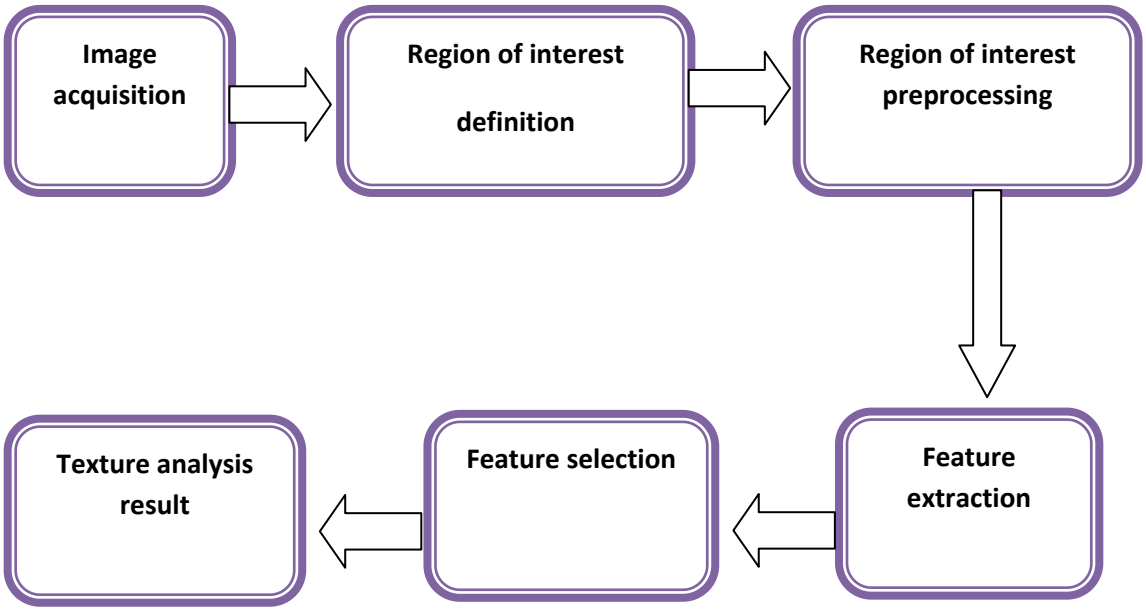

Figure 2: *Steps for MRI classification by means of texture analysis. ROI: region of interest. Resource (Larroza)*

The texture analysis and method were generally have distinction by high value accurate output for Built-up LULC specially when use for different features such as infrastructures, street grids, buildings and urban corridors, but it's have high commission error especially in low built-up in homogenous areas which have little to no textural variation, for this case we have used the modified texture analysis methods. In light of this reason, the processing of modified texture analysis which is used for correction based on textural analysis was only used for the low-built-up in homogenous areas to avoid increasing the omission error.

Because of this, in the high-built-up area the function of area of interest (AOI) was drawn around, and using the logic rule as shown in Figure 2. In other hand all Built-up pixels of MLC were retained as such used in the process of post-classification corrected (PCC) map. Then all the rest MLC Built-up patches of the research zone were process using modified texture role proposed by Feng [17]. Finally will reclassify the remainder of the MLC Built-up patches based on their NDVI threshold values. These threshold values were determined by detailed inspection of the textural images and NDVI images derived from the respective Landsat imageries corresponding to the LULC categories of interest which was guided with the use of orthorectified aerial photograph of the nearby period.

The texture analysis result can be more affected base on the process used throughout the methods. In this research, we provide description of each processing step of the texture analysis methods focusing on applications that explain many different methods. The texture analysis proposed by [7] ERDAS imagine software of the IKONOS spectral band was performed using a 5 × 3 moving window and the variance Equation (1):

$$V = \sum \frac{(X_{IJ} M)^2}{N-1} \qquad (1)$$

Where x_{ij} = DN pixel value (i, j), n =pixel number in the window and M definition is the mean of the moving window which is defined in drive Equation (2) [9]:

$$V = \sum \frac{X_{IJ}}{N} \qquad (2)$$

Satellite technology has been proven suitable for mapping environmental factors. In fact, the technology has been extensively used for large area vegetation monitoring. The spectral bands used for this purpose are visible and near infrared bands, as they provide useful information on chlorophyll absorption, which is also an indicator for healthy vegetation. Various mathematical combinations of these bands have been used for the computation of normalize different vegetation index (NDVI), which is an indicator of the presence and condition of green vegetation [9]. NDVI (Normalized Difference Vegetation Index) [11] which is the most widely used for vegetation index to interpretation and distinguish healthy vegetation from others classes feature in the satellite image or from non-vegetated areas. NDVI was derived using the expression given in Equation (3):

$$NDVI = \frac{(NIR - R)}{(NIR - R)} \qquad (3)$$

As shown in Table 1 the details of IKONOS spectral band and spatial resolution where NIR = Near Infra-Red (band 4 for IKONOS spectral band); R = Red (band 3 IKONOS spectral band).

3. Results and Discussion

The texture analysis methods have been applied into the extraction process in order to identify the feature and classes from the satellite image. Automatically apply the classification rules in the satellite image analysis and visualization software to determine land cover land use features. The image processing and enhancement for feature extraction was done using IKONOS imageries acquired 2012. The texture analysis algorithm was applied in this research. It is a part of the multi-process of six steps of processing. Individual features are perceived as the initial texture. These features are then sequentially merged pair-wise into larger ones with the purpose of minimizing the heterogeneity of the resulting features. The texture is based on various scales determined by properties of texture of each feature. The overall accuracies as well as Kappa index of agreement were computed for each class. Besides this, classification accuracy and stability within texture analysis methods were also assessed. The overall accuracies in texture analysis model and classification achieved were 88.023.

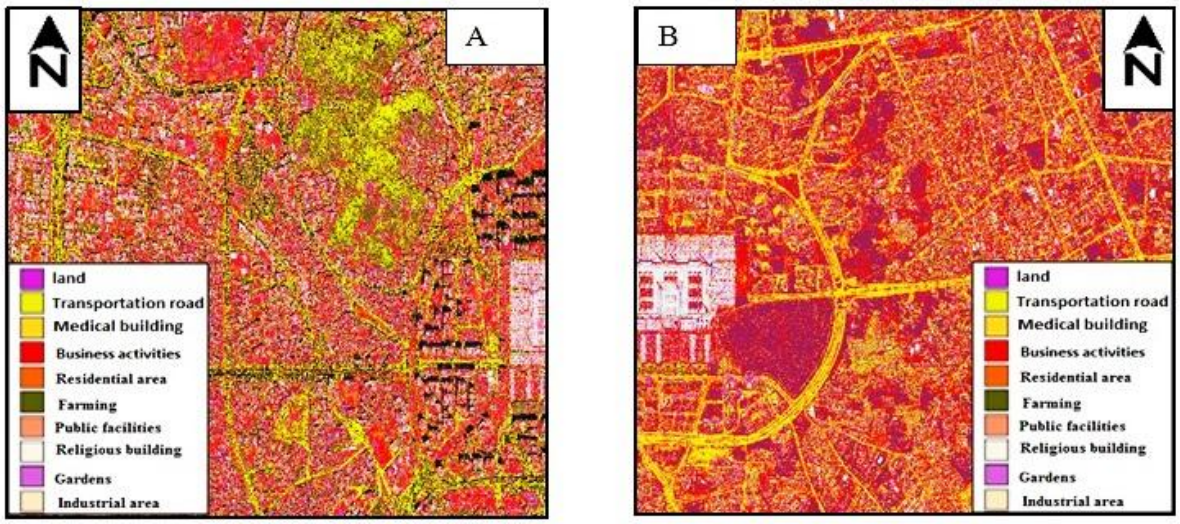

Figure 2: *(A and B) Feature and classes map of the central region Madinah Munanwarah in 2012*

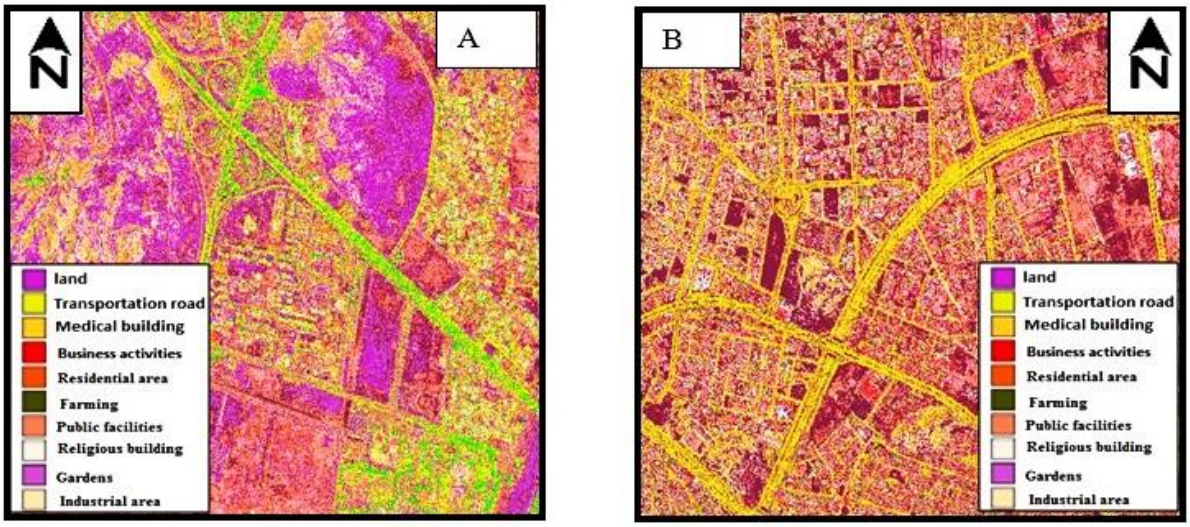

Figure 3: *(A and B) Feature and classes map of the third ring Madinah Munanwarah in 2012*

As shown in Figure 2 and 3, results of the texture analysis and process of Urban scheme from IKONOS 2012 satellite imagery the classification of percentage coverage within the urban area in the central region. It is cleared that the commercial activities occupies the highest percentage 4.5 km from the types of activities in the central area of the scheme while in the third ring area the residential and farming was the largest coverage 19 km from the total area.

The Central region of Almadinah Almunawarah were classified and divided using texture analysis and NDVI model into eight categories as show in Table 2. Business activities and investments, Industrial Area, Residential area and farming, Public facilities, Medical building, Religious building, Government building, Entertainment services and Gardens. In 2012 image classification, the Business activities and investments was found to have the largest coverage 4.5km in the total area of Central region - 58.43 %, and the second largest coverage into central region was found the religious building 4km; 28% of the total area in central region.

Table 2: *The investigated feature and classes extracted from IKONOS satellite image*

N	Urban planned patterns	N	Urban planned pattern
1	Business activities and investments	5	Medical building
2	Industrial Area	6	Religious building
3	Residential area and farming	7	Government building
4	Public facilities	8	Entertainment services and Gardens

As mention before the commercial activities occupies the highest percentage 6 km. It is attributed to that most population activities in central region of Almadinah Almunawarah and services are limited to the surrounding campus area in central region, and also because the Madinah city's considered as the second religious center for Muslims after Mecca. The increasing number of hotels requirement in the region because the number of visitors is estimated approximately 2 million visitors per year and all of them gather in the central area next to the Haram al-Sharif and in need of services. The facilities were so crowded in central area of commercial activities, but the third ring area increase the proportion of housing because the city's residents are turning to get away from traffic areas and population-enrollment.

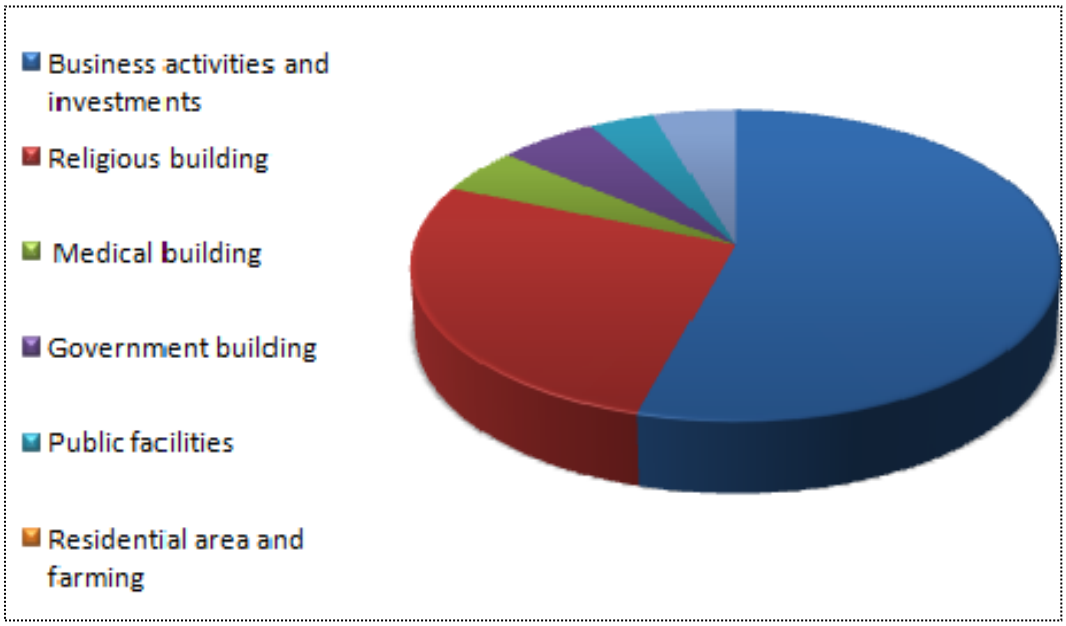

Figure 4: *Percentage of coverage area for each type activities in Al Madinah central region*

As shown in Figure 4 religious building come in second place of the activities in the central region Al Madinah Almunawarah. The coverage percentage almost 28% of the total area of central region, the government services and building was 6%, medical building 5%. The garden was 4%, while the public facilities coverage in central region 3%, residential area and farming was the smallest pattern within limited areas 0% from the total area of the central region due to the number of visitors which's more than 2 million and they are staying in central region near to Al-Ahram – Al-Sharief and they use the hotels in the central area.

In the third ring residential area and farming was dominate the rest of the patterns of the third ring with an total area 19 kilometers which is about 60% from the total area, and commercial activities coverage about 5.5 km 23%, and then comes government building 9%. The medical building was 6%, and the garden was 5%, while the industrial area in was the smallest area which cover less than 1% of the total area in the study area.

3.1. Validation & Comparison of Texture Analysis- Result and Field Survey Data (Field Work)

In order to checked the accuracy assessment of texture analysis result, the comparison has been done between field data and result detected by texture analysis from satellite image to check the validity of use the texture analysis. Table 3 show the result of texture analysis: percentage of coverage area for each class extracted from satellite image. Table 4 show the result of field survey data: percentage of coverage area for each class extracted from field work. The comparison has been done by applying linear regression coefficient and the ratio of validation in most classifications. The result of this comparison show high matching almost 89.5% between the two results in the central region.

Table 3: *Percentage of coverage area for each class extracted from satellite image*

Urban planned patterns	Area km^2	Urban planned patterns	Area km^2
Business activities and investments	5.8	Medical building	0.93
Industrial Area	0	Religious building	3.2
Residential area and farming	0	Government building	0.65
Public facilities	0.437	Entertainment services and Gardens	0.434

Table 4: *Percentage of coverage area for each class extracted from Field Survey*

Urban planned patterns	Area km^2	Urban planned patterns	Area km^2
Business activities and investments	6	Medical building	0.94
Industrial Area	0	Religious building	3
Residential area and farming	0	Government building	0.62
Public facilities	0.450	Entertainment services and Gardens	0.443

4. Conclusion

Remote sensing technology and GIS with texture analysis and methods have been tested and compared, the validation done with field survey. The accuracy assessment of texture analysis output was 92.7% for detection and identify of feature distribution coverage. IKONOS satellite image with high spatial resolution 1m significantly use and it is also enable the analysis to classifying central region of Almadinah Almunawarh. There are other factors contributed to the accuracy of classification in the central region and third ring in Almadinah Almunwarah, including radiometric correction and geometric correction as preprocessing of satellite image before start the process of classification. The matching between satellite image result and field survey data was almost 89.5%. Both results field survey and texture analysis results show the Business activities have the largest coverage area in central region. It is about 6km from the total coverage area, then the religious building with total area 3.2km, but the residential area and farming have the smallest coverage area 0% from the total area, while in the third ring the residential area have the largest coverage area with 19km. The research result shows that the distribution of feature and activities within the urban regions in the study area is affected tremendously by human activities. So the economic activities and investment in the central region constitute more than 60% of all other activities as a result of the large number of religious tourism in the Medina area.

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