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CREATING A GIS APPLICATION FOR RETAIL PLANNING IN SAUDI ARABIA

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ABSTRACT

Geographical Information Systems (GIS) are used today to provide advanced analysis tools and complete data packages for analyzing retail and demographic information. These tolls help retail planners in taking important retail planning decisions such as choosing retail locations, identifying and reaching potential customers, finding new markets, performing customer or store prospecting, defining customer-based or store trade areas, and identifying best retail locations. The aim of this paper is create a GIS application for retail planning in Saudi Arabia. Jeddah city has been selected as a case study representing a major commercial city in Saudi Arabia. The first part of the paper discusses recent world wide GIS applications in retail planning field. The second part of the paper focuses on the created GIS application and defines the created data base for all retail centers located in Jeddah city. The outputs of the application help retail planners in Jeddah city to evaluate the location and the spatial distribution of retail centers. In addition, the created application helps retail planners in analyzing the catchment area of retail centers. Several GIS functions are used in this paper including feature classification, address geo-coding, network and overlay analysis.

1. INTRODUCTION

Geographical Information Systems (GIS) are used today at several planning applications including land use planning, health care planning, and transportation planning. Retail planning is considered as one of the planning fields that could benefit from using this novel technology. Retail planners are faced today with many issues that can be better handled with GIS. These include constructing demographic, sales and competitive analysis, finding the best locations for new retail stores, creating effective marketing campaigns (Olson et al, 2005) , scheduling and route deliveries (Ganesh and Narendran, 2005), and providing better customer care information system (Razmi et al, 2006). The development of large-scale commercial formats also introduced some specific problems in the agenda of retailers, planners, and other important participants in the city development process (Spilkova and Sefrna, 2010). The most frequently discussed problems in connection with suburban shopping centers are the decline of city centers and the outflow of commercial functions to the outskirts of cities, traffic problems, particularly the problem of parking, liquidation of small retailers by strong international retail chains, the aesthetic aspect of newly constructed outlets and centers and also radical changes in the shopping behavior of customers (ibid).

GIS application in retail field is acknowledged and used by several international retailers. For example, Minute Man Company, uses GIS for products delivery at the USA. It uses GIS and Global Position Systems (GPS) to point out the location of delivery customers, select the most appropriate vehicle type located closest to the collection point and provides a displayed map to driver showing the most efficient path to delivery of pick up point (Grimshaw, 2000). Accordingly GIS is used to point out the location of delivery customers, select the most appropriate vehicle type located closest to the collection point and provides a display map to driver showing the most efficient path to delivery of pickup points (ibid), A second example is found in the application of Maps Guide software which is used in Germany to calculate optimum routes on defined rules. In addition, the Auto route software is used in the UK for defining routes between many retail locations (Dibb and Simkin, 1991).

Miracle supermarket in Ontario, Canada has used GIS software for assessment of new sites, and the processing of customer survey for existing stores. In this example, trade areas were defined based on distances from existing stores (ibid).

Based on the above discussion, GIS is considered as very useful technology in many retail applications. There are several studies that have discussed the advantages of using GIS in retail planning. For example, Murad (2003), and Murad (2009), has pointed that GIS functions such as Buffer and Thiessen can be used in retail planning field for catchment area definition. Birkin et al (2002), have presented the use of GIS for sales territory planning. In this example, GIS is used to identify business potentials for each postal sector at the UK, and then individual territories are created that include areas of 2000 business within a 15-minute drive time. Another GIS application is found in the study of identifying potential sites of discount stores across the UK. Using the average number of socio-economic group D and E households (the lowest socio-economic categories in the UK census), a potential demand map is created which shows the number of

postal sectors that have 500 or more D and E households within 5 minutes drive time of their centroids (ibid). Maatta-Juntunen et al (2010), have discussed a GIS application for measuring retail location accessibility in Finland and utilize GIS tools to assess store locations in terms of CO2 emissions from private cars used for consumer traffic. Birkin et al (1996), have used GIS to study changes in market penetrations for a new retail store and showed how GIS is used to find out the opportunities for locating new store at the South coast of England at the town of Hastings. This example indicates that the analysis of market penetration is one of the main retail analysis that can be made using GIS. Murad (2003) have presented similar GIS application that calculates market penetration for two retail centers at Jeddah - Saudi Arabia. The results of such study indicate that there are areas of good and poor performance and pointed that shopping developers can use those results to try to attract more customers from areas with low performance.

The use of GIS in modeling demand flows to retail location is another very important retail issue. Here, GIS is used together with spatial interaction models to calculate the interaction between retail location and residential areas. The interaction results are ruled by the size of demand, the attractiveness of retail location and the cost of travel between location j and area i. This approach is used by several studies (e.g. Suarez-Vaga et al, 2010, Murad, 2003, Birkin et al, 1996, Clarke & Clarke, 2001, and Bullas & Clarke 2000).

In a summary, It can be said that GIS is applied at several retail studies and these studies varies from defining retail territories and analyzing market penetrations up to modeling the flows of the retail demand. This paper will discuss how to use GIS for retail location assessment in Jeddah city, Saudi Arabia.

2. BACKGROUND

GIS technology is appropriate for a variety of usages including resource management, land surveying, and business planning. Businesses use GIS technology to solve problems, find solutions for marketing, delivering better services, and making good decisions. In addition, GIS technology has been implemented in service management for displaying large volumes of diverse data pertinent to various local and regional planning activities (Chen, 2007).

GIS is considered as a useful tool for retailers because it can help them in understanding their market, customers and competitors. This can be achieved through the analysis of market data such as sales data, demographics and competitors locations, census boundaries and sales territories. The main feature of GIS making it important for retail planners is related to its ability of providing answers to several retail location questions including: (a) evaluating the existing retail branch performance, (b) assessing the returns from an increase/decrease in store size, (c) presenting the best set of locations to target overseas market, (d) launching new product locations most likely to maximize sales, (e) finding the best geographical fit for possible retail margin, (f) optimizing the branch network of two or more retail organizations following merger/acquisition, (g) finding the spatial impacts of store closures or relocations, and (h) finding optimum store territories (Birkin et al, 2002).

A retailer can develop a map of its store using GIS software to calculate the actual Dimensions of a store. This can even handle multilevel stores and shelf depths. When a retailer has the store mapped, a consumer can view the map on a live website, and know the exact location of the item within the store. GIS might allow planners to create maps for specific use, while another GIS might be able to determine the size of wetlands necessary to be protected against damages and pollution from new district development (Cheng and Ling Yu, 2007). The diffusion of GIS in retail organizations can be traced to a number of factors relating to supply and demand of retail services. The demand factors include location of retail stores and maximizing profitability. Meanwhile, the supply factors are related to location of competitors and the visualization of consumer behavior. GIS are used by the vast majority of major retail chains across North America and Europe to provide decision support for a range of location-based decisions. The most common retail GIS applications include customer spotting, trade area analysis (e.g., demographic reporting for given trade areas), customer profiling, competitor analysis, hot-spotting, sales forecasting and consumer behaviour modeling. These can be applied to a number of decision events, from relatively low-risk store openings, renovations and merchandising decisions to major high-risk decisions, such as, corporate acquisition of competing chains or international expansion through merger activities (Hernandez, 2007). GIS could also be used to identify specific developmental sites based on a set of criteria using economic, social, environmental, and business-related data. In addition, GIS could be used to identify specific developmental sites based on a set of criteria using economic, social, environmental, and business-related data.

The simplest GIS tool that can be used at every retail GIS application is related to displaying and querying spatial and attribute data. For example, ArcGIS software has several functions that can be used for data

query and display. This software can display attributes in relation to points, lines or polygons, otherwise known as thematic mapping (Grimshaw, 2000). Retailers can use thematic mapping technique to present any collection of tabular data such as the size population within 30-min drive-time from a selected retail centre. Data query tools in GIS can be applied on a single attribute field such as the number of retail customers, or on a multiple attribute data field such as retail demand and retail supply. A number of studies have used GIS in order to examine spatial inequalities of services using accessibility measures (e.g., Langford, 2007, McLafferty & Grady, 2004; Phillips et al, 2000; Rushton, 1999). Such measures typically involve counting the number of services contained within census tract boundaries (e.g., Lin, 2004), or reporting the number of facilities inside a given Euclidean or travel-time distance of demand points. Previous techniques for measuring accessibility to retailing can be categorized by two primary approaches (Song and Sohn, 2007). The first approach calculates the distances from the housing unit to the relevant Central Business District (CBD), regional employment and commercial centers, or the nearest commercial store. The second approach measures accessibility as a function of the percentage of commercial land uses within each residential neighborhood. In this method, neighborhoods are defined by census tracts or blockgroup boundaries (ibid). GIS can be used for measuring accessibility to these two approaches. For example, Vandenbulcke et al (2009), focuses on the measurement of accessibility and limits the application to car accessibility and its spatial variation within Belgium and discussed two types of destinations (cities and railway stations) as well as two types of time periods (peak and off-peak).

3. METHODOLOGY

The purpose of the presented paper is to discuss a GIS application for retail centers at Jeddah city, Saudi Arabia. The created application covers macro and micro scale retail planning issues. In order to build this application, several data sets were captured and built using ArcGIS software. These are as following:

a- Points data One of the prime objectives of this application is to define retail market based on real demand locations. Accordingly, a survey was made on a sample of 500 retail customers which aimed at defining the spatial distribution of selected retail customers. Their locations were converted in the GIS as point features with a city district resolution. In addition, the exact location of retail centers are modeled in the GIS as points features.

b- Polygon and line data. In addition to making point features, the present application created polygon features showing city district boundaries as well as line features showing city road network. These two basic GIS features were used with point data to define and model the market area of retail centers at Jeddah city. For each of these features the relevant attributes were linked at the feature attribute table.

4. THE CITY SCALE ANALYSIS OUTPUTS

4.1 Classification of retail centers

In order to evaluate the location of retail centers in Jeddah city, GIS simple and advanced functions were used for defining the spatial distribution of retail centers and for defining the growth direction of retail centers in Jeddah city. Retail centers in Jeddah city can by classified based on different attribute data such as center name, land area, GLA, and parking size. These data were collected and saved in the geo-database and can be used for identifying the characteristics of retail centers in Jeddah city. Using the graduated symbol function of ArcGIS software, retail centers in Jeddah city were classified and the results of this type of analysis are shown in figures1 and 2. Looking at these figures retail planners can easily identify the location of large or small centers. Drawing quantities by graduated symbols is considered as an effective way to visually present a numeric attribute. This method is suitable for numeric data that represents a rank or progression of values. It draws larger symbols first and smaller symbols afterward. This is so that features with large values do not obscure features with smaller values. The graduated symbols method is used to map discrete locations or lines. Accordingly, graduated point symbols are drawn as the locations of individual features to show the magnitude of the data value. The presented study has applies the graduated symbol tool on the collected data and as a result of this function (figure 3) retail planners can easily identify the location of large or small retail centers in Jeddah city (eg. Red sea mall is one the large centers located north of the city with 500 retail shops, meanwhile, Sylaimania center is a small center located in the city center with 86 shops). Based on the results of this function, retail centers are classified at three groups called small centers (has less than 100 shops), medium centers (has 100-200 shops) and large centers (has more than 200 shops). This type of GIS classification tool can also be used with multiple attributes such as comparing retail center size with car parking area. This type of comparison can identify retail centers that has large amount of shops but not providing enough car parking area for retail demand.

4.2 Measuring orientation and direction of retail location

Measuring orientation and direction of retail centers help retail planners in abstracting the spatial trends in the distribution of retail centers. GIS spatial statistic functions can be used to measure whether-and to what extent- the distribution of features crates a pattern. The resulted direction of pattern can be used for several purposes. For example; one can calculate the degree to which student test scores in a city are clustered. Another example is found in the application of regional transportation network where planners need to identify the direction of manufacturing, retail and financial activities. In another example retail planner might want to use this function to see whether different types of businesses such as financial and manufacturing have similar trends or corridors in the city.

GIS spatial statistic tools can define the direction and orientation of points, polygons and lines features. For the presented application, points features showing retail centers location are selected and used within ArcGIS spatial statistical tools to define the orientation of retail centers in Jeddah city. The result of this type of analysis is presented in the form of an ellipse shape. It is produced by calculating standard distance in the x and y directions and by defining the axes of an ellipse encompassing the distribution of features. The ellipse is referred to as the standard deviation ellipse which allows the analyst to see if the distribution of features is elongated and hence has a particular orientation (ibid).

The standard deviation ellipse measures the standard deviation of the features from the mean center separately for the x-coordinates and the y-coordinates. The length of the ellipse axes are calculated in the east-west (x- axis) and north-south (y-axis) directions in distance unites (meters). Since the standard deviation is measured in each direction from the mean center, the total length of each axis is twice its standard deviation (ibid).

The presented study has calculated the standard deviation ellipse for every retail center group (large, medium and small). The resulted ellipse for every retail center group is shown in figures 4-6. Based on this result retail planner can easily identify the pattern and trends of all retail centers in Jeddah city. It is clear that orientation of retail growth in Jeddah city is toward the northern city districts and accordingly, any future retail development should follow this direction for the purpose of attracting large retail demand. Alshatee and Almohamdia are two districts located north of the city are considered to be the potential location for any future retail development in Jeddah city.

5. THE RETAIL CENTER MARKET AREA ANALYSIS OUTPUTS

5.1 Market area definition

Looking at the various types of GIS-based market area definition techniques, the presented paper has selected the simple ring method and then added to it a location of retail demand. Accordingly, the first step to produce this output was to plot and map the locations of retail customers that were interviewed in the course of this study. One of the useful GIS functions to be used for this purpose is known as Address Geocoding. It refers to the process of creating map features from addresses, place names, or similar information (Ormsby et al, 2004). In order to use this function, ArcGIS software requires that the user should have an address table containing a list of addresses stored as a data-base table or a text file as well as a set of reference data such as streets on which the addresses can be located. Using city-district shape file as a reference data and address table of retail customers, our application produced point features describing the spatial distribution of retail customers in Jeddah city (Fig.7).

This output shows the dissemination of the market area of the selected center. It is evident that there are some parts of the city (Al Bawadi, Al-Rabwah, and Al-Salamah) which produce remarkable retail customers to this center. These areas are actually falling within the 5-km ring defined around the selected center (Fig. 8). This output forms the primary market area of Al Hijaz Center and can be used by retail developers to define the parts of the city providing a larger amount of customers to this center. These parts should always be monitored and evaluated by retailers to make sure that these already attracted customers are regularly visiting this center.

5.2 Market area analysis

This part of the paper discusses how GIS can be applied to meet the objective of expanding the existing retail market. There are several GIS-based techniques to be used by retailers for preparing policies in this respect. One of them is based on drive-time analysis demonstrated by the present application. ArcGIS software is applied to create market areas based on drive-time bands. In order to make these drive bands (0-10, 10-20, 20-30, and 30-40 min.), data about road speed were captured into the road network attribute table and used to produce these drive time-based market areas. Customer locations' data were overlaid with the resulted drive-time bands to analyze these locations according to their nearness to the chosen center (Fig. 9). A key finding of this analysis is that there are different amounts of customers visiting Al-Hijaz center according to the drive-time bands. In order to classify these customers, GIS overlay functions

are used to subdivide each customer location according to its localization within the drive-time band. This type of GIS functions is defined as the process of comparing spatial features in two or more map layers (Grimshaw, 2000). GIS applied the input coverage and the overlay one to produce output coverage based on selected logic Boolean functions which can be used by different applications. They are the following: intersect, not intersect, union, all but A or B, union levels, and A not B (Davis, 1996). This part of the application deals with the intersect function demonstrating only the portion of the input coverage that falls inside the intersect one. Here an input coverage is the location of all the retail customers and an intersect coverage is the resulted drive-time band pattern. If the input coverage is a point one, as in our case, the intersect function will result in an output coverage of point feature, too (Chou, 1997). This output is useful for retail planners as it defines the extent of the retail market. Besides it can be applied to advise retail managers concerning the locations where no desired size of customers is produced, and, accordingly, to focus on these locations and try to expand the already existing retail market to cover such less attracted areas. For this retail center, city districts such as Al-Mohamadia, Al-Aziziayah, Al-Safa, and Al-Andalus are located within the less attracted bands. Therefore, retail managers should approach these districts more closely and introduce their center goods and services to people living in such areas so that they could be more attracted to this center.

The results of the created GIS application are considered as valuable tools for increasing the efficiency of retail center management and for evaluating the performance dynamics of retail center. The created application can be used by any retail center managers in Jeddah city for evaluating retail market and for identifying market segments that the retail center is under-serving. Large retail centers in Jeddah city such as Al-Tahlya mall or Hera center can apply the same created GIS models to evaluate their existing market sizes and to improve their performances.

6. CONCLUSION

GIS is considered as useful and important analytical tool in many retail planning applications such as market penetration, business forecast, consumer behavior/profile tracking and prediction. The current paper presents a GIS application for defining the spatial distribution of retail centers in Jeddah city. The application classify retail centers based on shopping sizes and produce three types of retail centers named as large, medium and small centers. For each of these three centers types, GIS spatial statistics are calculated. In addition, This paper discusses how GIS could be implemented as a tool for defining and analyzing the retail market of Al-Hijaz Center in Jeddah city based on customer location. Finally, a market area investigation has been performed based on GIS drive-time analysis technique and by using GIS overlay analysis function. This methodology could help retail planners in defining both strongly and less attracted parts of Jeddah city.

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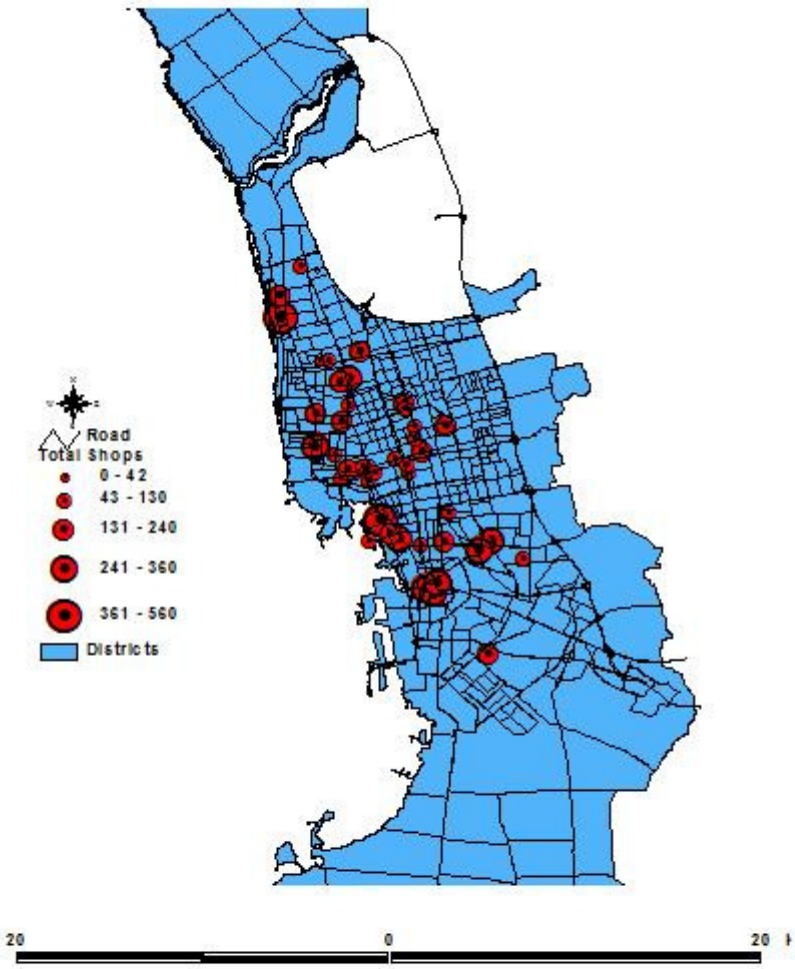

Figure 1 Classification of Retail centers based on number of shops in each center

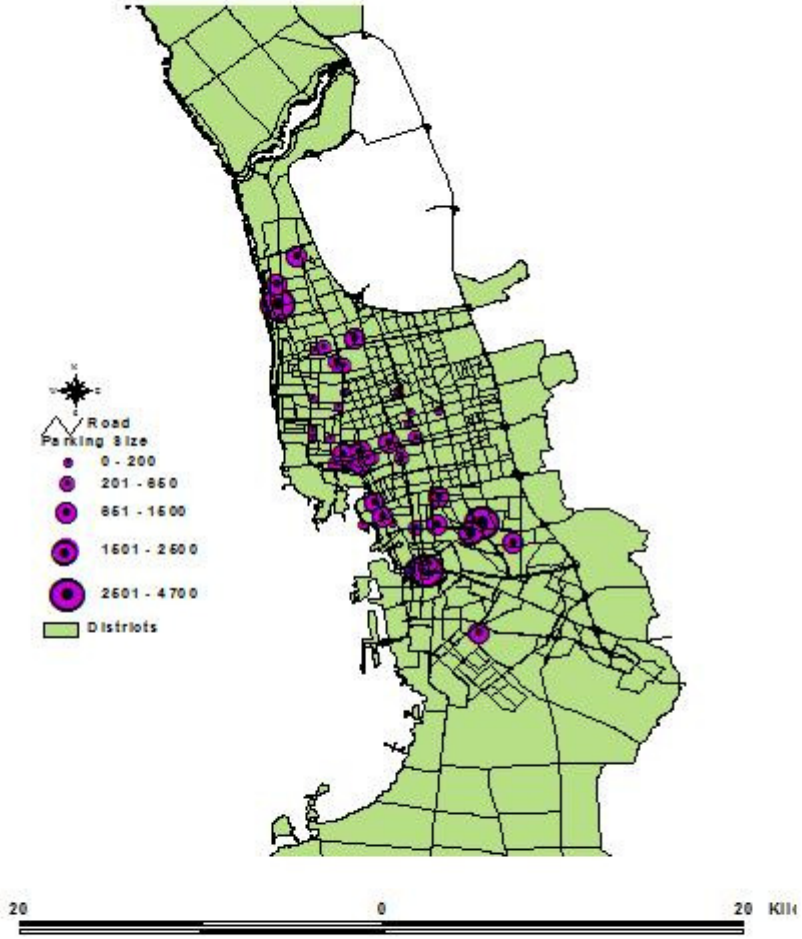

Figure 2Classification of Retail centers based on number of car parking in each center

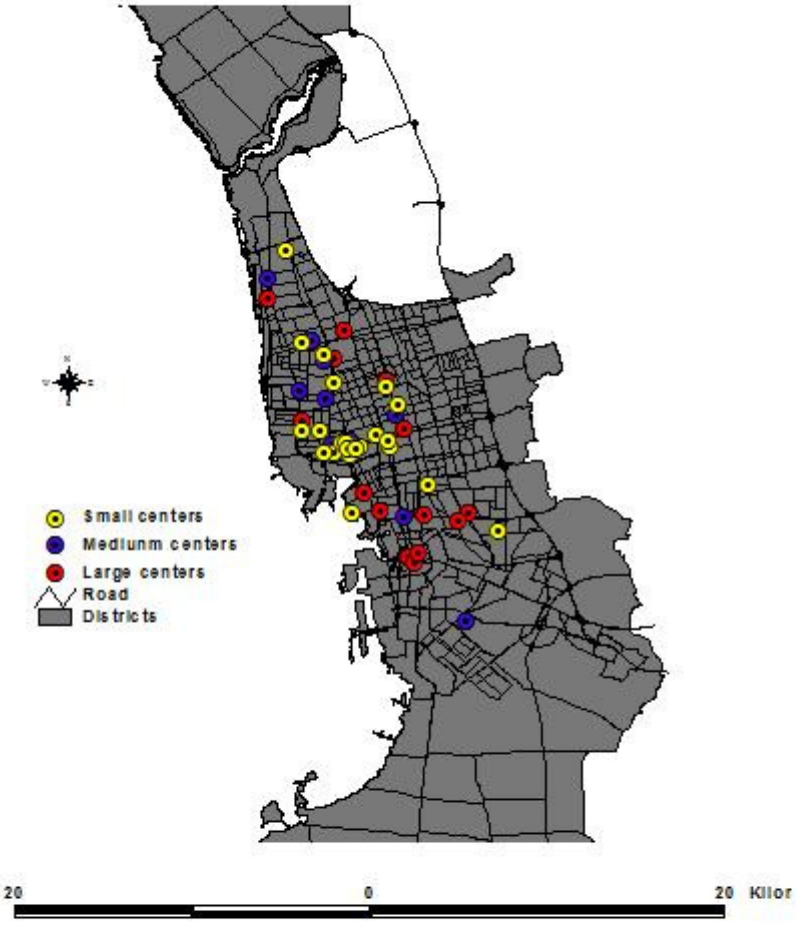

Figure 3 Classification of retail centers based on centers types

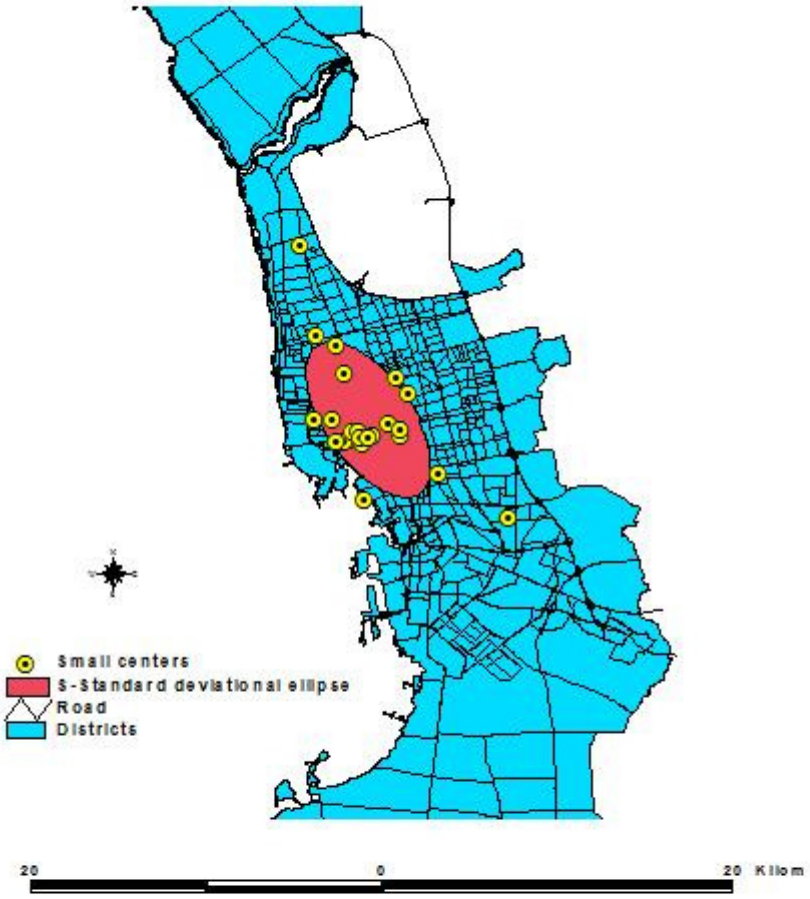

Figure 4 Standard deviational ellipse for small retail centers in Jeddah city

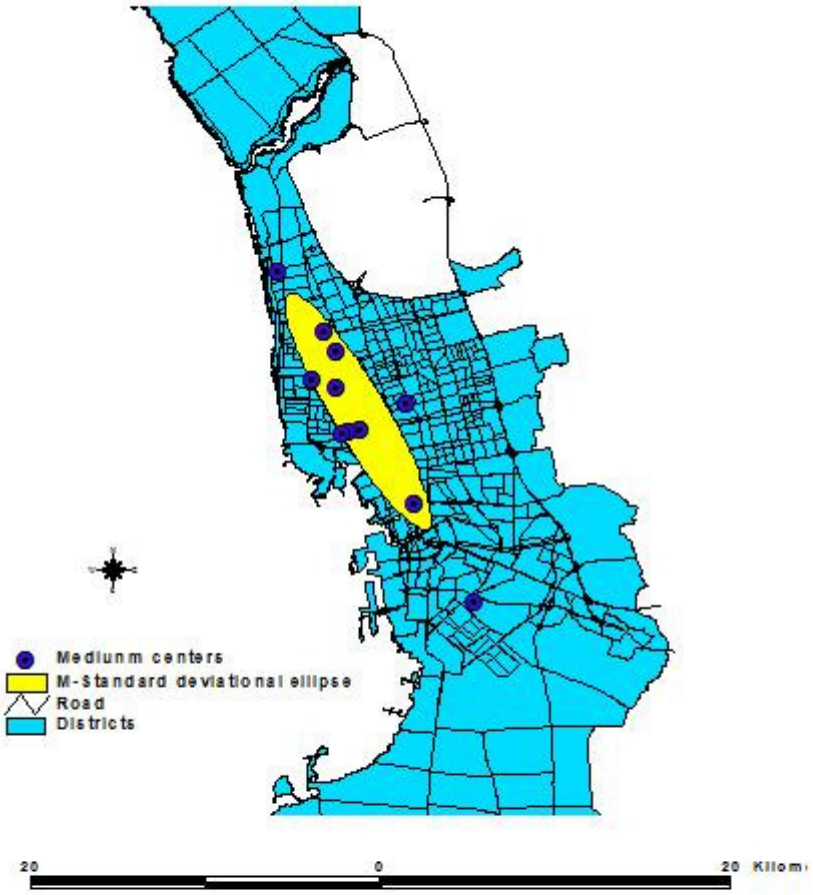

Figure 5 Standard deviational ellipse for medium retail centers in Jeddah city

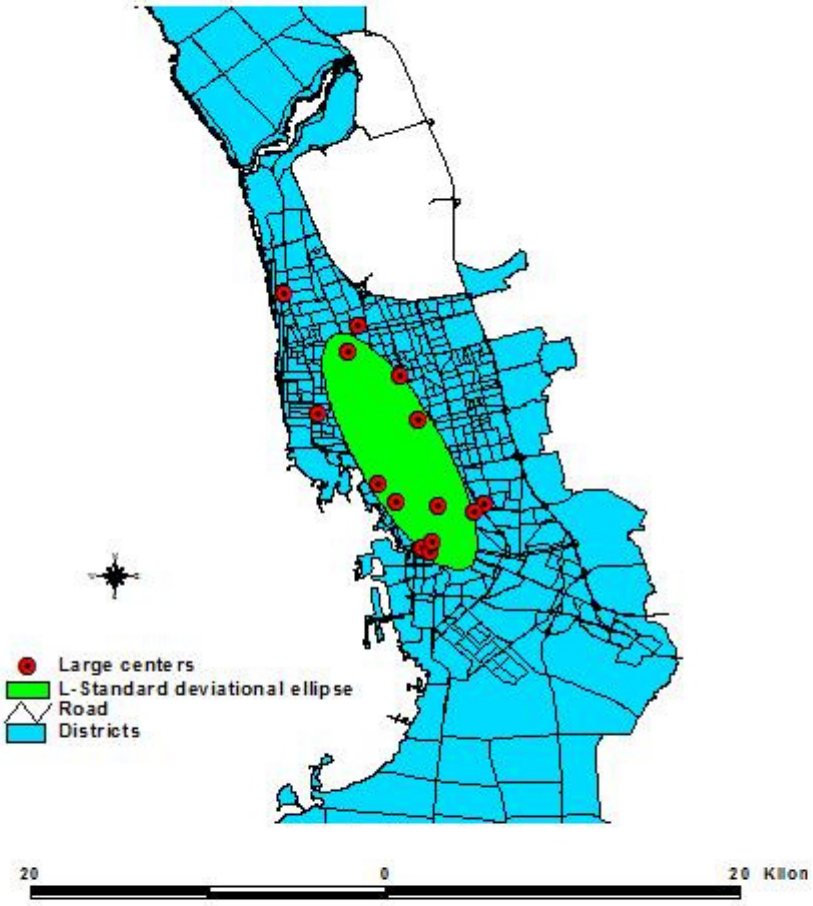

Figure 6 Standard deviational ellipse for large retail centers in Jeddah city

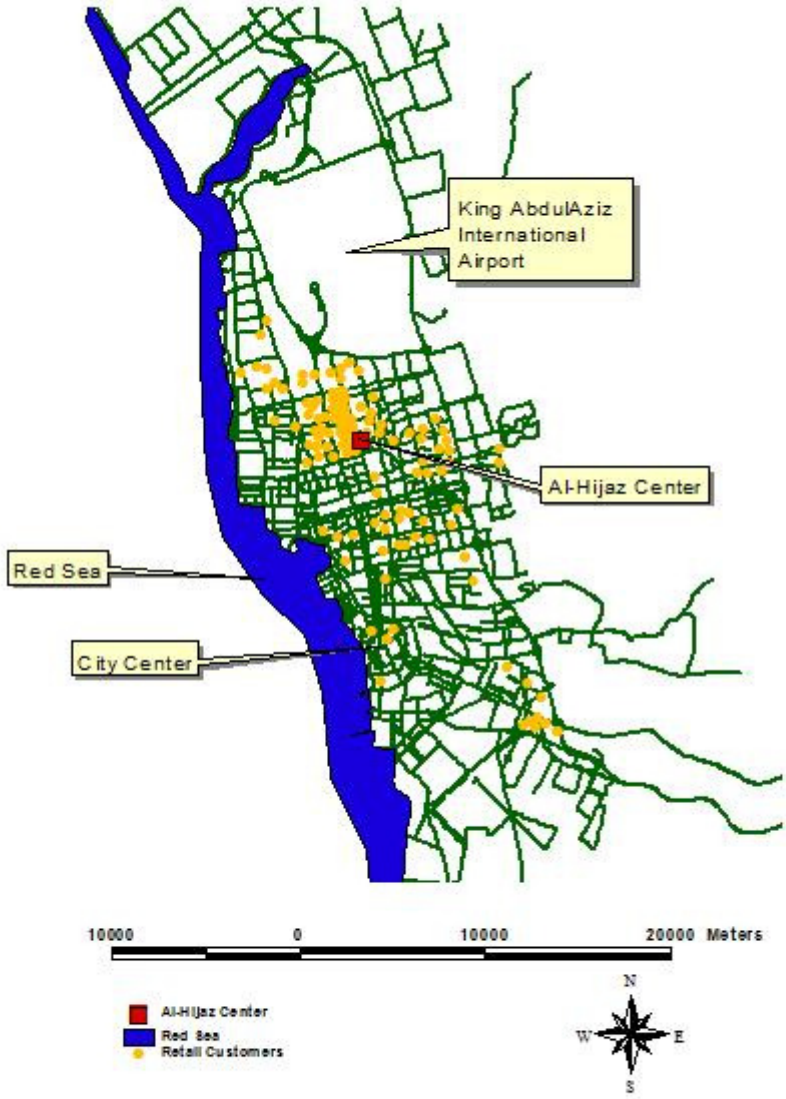

Fig 7 Distribution of Retail Customers

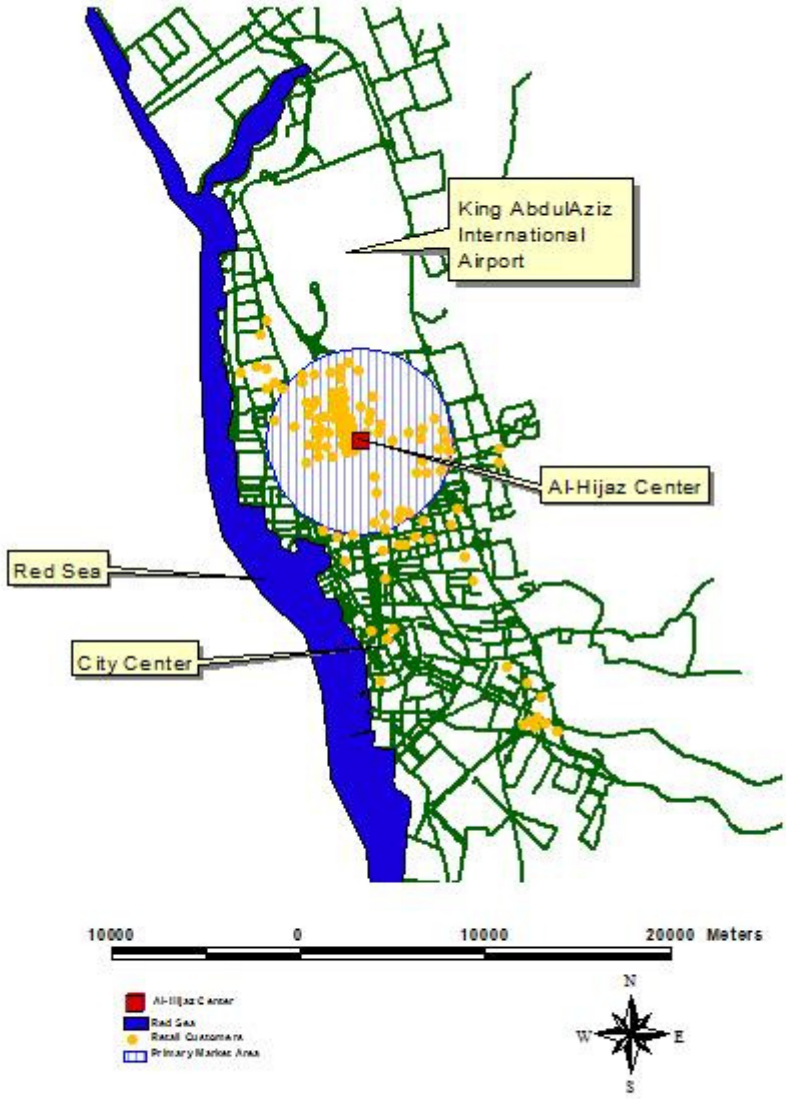

Fig. 8 Primary Market Areaof Al-Hijaz Retail Center

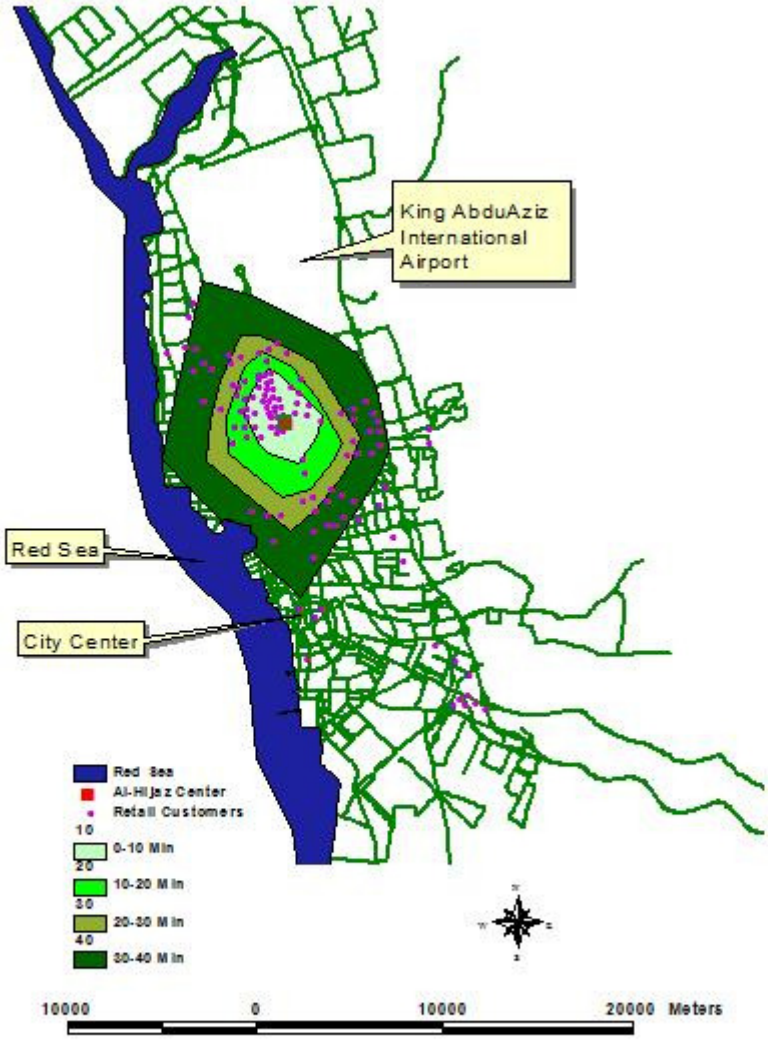

Fig.9. Drive Time Market Area