Journal of Arabic and Human Sciences
Qassim University, Vol. 13.No.3. PP 27-43. (February 2020/ Rajab 1441)

ATMs Geographical Distribution Using Suitability Modeling Analysis in Khartoum - Sudan

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Abstract: Banking and banking services in major cities are one of the most important GIS applications in service sector. Khartoum has expanded in breadth and mass of urban and stretched in its edges. However, the accessibility of the services to its residents around the residential areas seems to be in demand. The present study aimed to evaluate the reality of the distribution of ATM machines in Khartoum locality and the extent to which criteria are followed in selecting the appropriate location for the service in accordance with the request of the citizens. The researcher used GIS techniques to evaluate ATMs distribution and identify areas suitable for the establishment of new ATMs in Khartoum. ArcMap 10.2 was used in this study to produce maps and to create inputs layers for model processing. The available thematic maps for Khartoum locality, Google Maps and the GPS points (coordinates of ATM sites) were presented the data for this paper. In Khartoum State there are 367 ATMs operating 24 hours a day.

The results of the study showed that more than 77% of the residential areas in the Khartoum locality are suitable for the establishment of bank ATMs, when testing the standard population density criterion to determine the suitability. The areas actually need these services in light of the difficulty of day-to-day traffic, indicating that the accessibility to exist ATM sites is a limiting factor with the time-limited issue. The study proved that the use of GIS models analysis to determine the proper location of services is an effective tool. The study's recommendation is related to usage of international and regional criteria and standards to achieve the high accessibility satisfaction and competition between banks.

Keywords:
ATMs - banking services - GIS applications - ArcMap 10.2

1- Introduction:

Banking industry is changing at a very rapid pace especially in the recent years, as significant advancements in communication and information technology accelerated. Due to these changes and open market policy, banking sector is facing strong competitions to overcome this challenge through many strategies that implemented. One of these is creating a vast network of financial and transactions center Automated Teller Machine (ATM) centers at appropriate locations so as to reach maximum customers (Priyanka Dandekar, 2014). Some of the most dramatic changes are being seen in (ATM) and debit card industry (Fumiko, et al, 2003). Automated Teller Machines (ATMs) can be considered among one of the most important electronic facilities in the banking industry (Genevois, et al , 2015).

ATMs appropriate site selection is considered to be one of the top requirements as ranked by the customers in a competitive manner. The bank with an accessible ATMs location ranked to be optimally deployed. So, the good strategic plan for locating ATM, the more the bank wins customers.

ATM bank facility is one of the low-order facilities that is utilized by a single or a limited number of residential communities. Tompkin et al (2010) stated that the ATM location problem is a part of facility location problems. In Khartoum State all facilities are faced the same fate, i.e. not properly located in their right place to meet the community's' needs easily. The most basic issues concerning the location decision are profitability and potential of the location. The potential of locations for the organizations with productive sales staff, the right marketing strategies and customer communication provides profitability inherently (1EKREM et al, 2017).

The soci-economic significance of the ATMs becomes crucial and all developed countries draw special attention about its distribution as one of the top society's requirements. One strike example indicates the importance of the ATM in the banks directional strategy is in the United States ATMs growing levels from only 25,000 in 1981 to more than 150,000 in 1999 (Wilson,1999). One important fact to be noted is that commercial banks compete not only on the dimension of price but also on the dimension of location (OU, et al, 2006; Swinyard et al, 1987). The developed countries are outstanding in the ATMs facilities as average distance to financial service points like an ATM or bank branch is an indicator, at access (Kübra, 2015).

The recent trend among banks is to satisfy customer's demands and plan to increase number of ATM and extend their networks to reach residential areas (Mehdi, 2013).

There are many factors affecting customer's usage of ATM in Khartoum State, which are more or less shared the same spatial characteristics. The most are, accessibility to ATM closet location, distributional inequality, low transaction management, long waiting hours either due to machine out service (technical fault) as there is no specific ATM down time for repair, and sometimes waiting for cash supplying service.

All banks in Sudan have consortia to win ATMs, with certain procedure coordinating by bank of Sudan general assembly as an authorized body. Banks shall deploy ATMs within their premise. ATMs outside banks' premise should be arranged by the bank of the Sudan (Central Bank). All banks carry one objective that ATMs locations should be satisfied to permit access at reasonable times.

The problem of ATM deployment in Khartoum is seen to be strategic and managerial national obvious problem. It is lacking a scientific guidelines criteria and standard requirements. In order to solve this problem, new spatial technologies GIS related function are available such as Multi Criteria Evaluation (MCE), which used for the purpose of this study.

Therefore, the problem of this study presents in choosing the best site for ATMs following standard workflow according to certain criteria to provide modern banks services.

2. Previous Studies:

Many researchers add community criteria for ATMS locations seeking better accessibility. Convenience is added as pivotal factor for the most customers to increase accessibility of the ATM (Adams, 1991). Seeking location solutions are more acceptable spatial analysis applications such as bank services, health care centers, car wash units, gas stations, fire stations. The aim of solving these types of problems from distance or accessibility point of view is to decide the minimum cost of locations of a set of facilities to cover all customer demand (Aldajani, 2009). Automated teller machines (ATMs) are an important aspect of our lives and their location can influence how often or not we use the ATMs. Location is often considered as one of the most important factors leading to the success of a business venture. Businesses derive profits from a good location (Jacquelynen (2001).

Ekrem et al (2017) studied ATM location optimization approaching a Heuristic solution. In their research they focused on the new mathematical model to locate the bank ATM network. They established a three phase solution framework that helps the planners to determine the best locations for a number of ATMs to be added to existing options (Swapnil Awaghade, et al 2014). Berman (1995) classified ATMs, gasoline stations and convenience stores in the same group which they called "discretionary service facilities". They emphasize that these kinds of facilities should be located along paths of customer flow due to preplanned trips rather than in an area where the residences and work places exist. Boufounou (1995) classified the relevant factors of decision making with respect to branch location into four categories. These categories are; location features, trade area characteristics, competitive situation features and internal branch characteristics. Banks are trying to provide a variety of self-service channels such as Automated Teller Machines (ATM,) Internet banking and Mobile Banking (m-banking) in order to increase customer convenience, reduce costs and maintain profitability (Rasha et al, 2014).

3. Methodology:

3.1 Study Area:

Khartoum State hosts the capital of Sudan (Khartoum City). It lies between longitudes 31.5° to 34° E and latitudes 15° to 16° N. The State is located in the center of the Sudan where the two main rivers (Blue and White Niles) meet and form the Nile River. The area of the State is 22 736 sq. kilometers and the population is Estimated at 6.6 million (2014 census). The State consists of three main towns (Khartoum, Omdurman and Khartoum North), in addition to some semi-urban areas in the peripheries, Fig (1).

In Khartoum city, there are 37 banks offered ATMs facilities. There are 367 ATMS used by customers of various banks. Cash withdrawal is the main functional service commonly needs by the customers. As far as the number of ATMs per bank is concerned, we can classify the banks according to ATMs they own. Banks have (1 to 5 ATMs), have (6 to 10 ATMS) and have (11 + ATMs). In the first category we find 19 banks have 49 ATMs constitute 13.35% of the total ATMs. There are 7 banks having only one ATM for each. Second category involves 8 banks having 59 ATMs constitutes 16.08% of the total ATMs. The bulk of the ATMS found in the third category where 259 ATMs that were distributed over the state belong to the 10 greater banks constitute 70.57% of the total banks' ATMs. The 3 greater banks (Khartoum, Faisal Islamic and Omdurman National Banks) have 162 ATMs equal 44.14% of the total ATMs in Khartoum State table (1). Still there are about 77% of the areas out of the down town suitable for installing ATMs.

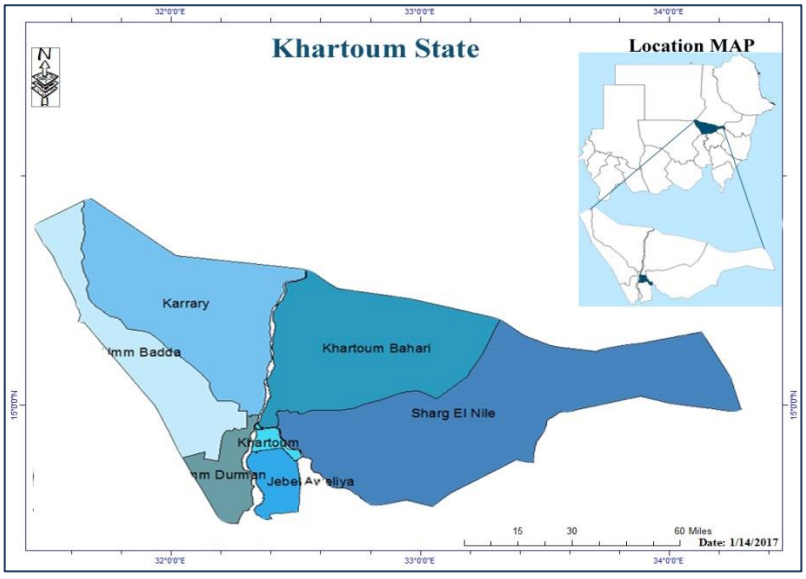


Figure 1: Study Area-Khartoum State

Fig (1): location of Khartoum Locality

3.2 Data used:

In this research data are acquired in form of shape files and KML files which represent vector data model. On the other hands, Google Earth as a geo-browser available on the web for free, had been used for getting allocation coordinates of the ATMs, which validated with help of the GPS ground truth. Eight different data layers were incorporated. Table (2) Shows datasets and criteria used.

Data preparation tasks which was performed includes projecting data, reducing the spatial extent to the area of interest, deleting unneeded attributes, creating new attributes and cleaning up attribute value.

Table (1): Sudan Banks and their ATMs in Khartoum State 2018

Level -1 (1 – 5) ATMs		Level -2 (3 – 10) ATMs		Level -3 (11 +) ATMs	
Bank name	No	Bank name	No	Bank name	No
Industrial Development	1	AlSalam Bank	9	Khartoum bank	69
Financial investment	1	Animal Resources bank	9	Faisal Islamic Bank	58
Workers National	4	Byblos Bank	8	Omdurman National	35
Agricultural bank	3	Real Estate Commercial	8	Saudi Sudanese Bank	21
National bank of Egypt	1	ElNile Bank	7	Tadamon Bank	15
Sahel-Saharan investment	4	Sudanese French	6	AlBaraka bank	14
Sudanese Egyptian	5	Saving and Social Devel.	6	Blue Nile Mashreg	14
AlShamal Islamic	4	National Bank of Abudbai	6	Sudanese Islamic	12
Ivory bank	1			ElNelian Bank	11
Farmers Commercial	4			Aljazeera Sudanese	10
Qatar National	4				
United Capital	3				
Export Development	4				
Family bank	2				
Abu Dubai Islamic	1				
Arab Sudanese bank	3				
National bank of Sudan	1				
Qatar Islamic Bank	1				
AlKhaleej bank	2				
Total	49		59		259

Source: Bank of Sudan (2018) – raw data

3.3 Methods of Data Analysis:

The basic premise of suitability analysis is that each aspect of the landscape has intrinsic characteristics that are in some degree either suitable or unsuitable for the activities being planned (Murphy, et al, 2005; Briney, and Amanda 2016).Suitability analysis can be performed using either vector or raster data. The

results are often displayed on a map that is used to highlight areas from high to low suitability (LaGro, James A, 2017).

Software used for analysis is Arc Map version 10.2 as a powerful tools used for developing spatial analysis.

Table (2): Description of Dataset Used

No	Data Set	Criteria	Influence Weight %	Tools
1	Land Use	Accepted Commercial, Educational and Recreational lands	10	Multiple Ring Buffer, Feature to Raster, Select ,Reclassify, Weighted Overlay
2	Main Roads	Accepted Area must be within Buffer distance 100 m	15	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay
3	Universities	Accepted Area with Buffer distance > 50 m	5	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay
4	Hospitals	Accepted Area with Buffer distance > 100 m	5	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay
5	Safety	Accepted Area with Buffer distance > 1000 m	5	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay
6	Main Markets	Accepted Area must be within Buffer distance	35	Multiple Ring Buffer, Identity, Feature to

No	Data Set	Criteria	Influence Weight %	Tools
		100 m		Raster, Reclassify, Weighted Overlay
7	Population Density	Accepted area with high population density and high Income	20	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay
8	Existing ATMs	Accepted Area with Buffer distance > 500 m	5	Multiple Ring Buffer, Identity, Feature to Raster, Reclassify, Weighted Overlay

Suitability analysis in a GIS context is a GIS-based process used to determine the appropriateness of a given area for a particular use. Suitability is determined through systematic, multi-factor analysis. Model inputs include a variety of physical, cultural, and economic factors. Eight data sets used including ATMs datsets, universities, hospitals, police centers, main markets, population density, landuse and roads. Table (2) and figure (2) present the thematic layers used.

The applied criteria consider the active option of ATMs, 500 m distance was considered far away from each other. Standard criteria for ATM location should be considered are the distance from road, facility, hospital and university, which were applied within 100, 200, 100, 300, and 200 to 400 meters respectively as maximum distances. Population density is considered to get an idea about the remote areas that customers are not accessing ATMs facility. The commercial and educational land use patterns were involved. All outputs were reclassified to bring same weighted values, which is essential and required latter for the weighted overlay analysis. Weighted overlay analysis is used for locating the potential sites for new ATMs.

After performing multi-criteria analysis using above criteria and weighted overlay descriptions, the potential sites for locating ATMs centers were identified within the urban extent of study area.

3.4 Model Builder:

Model builder is an application used to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input; Figure (3) shows final model. The model process is a Sequential Spatial Processing (SSP). Each data input criteria have an output that serve as input for the next process. There are many tools and

functions that are used in modeling site selection with different application methods. For this research, Multiple Ring Buffer, Identity, Merge, conversion, select, point feature, reclassify and weighted overlay were the applied tools for building the ATM suitability model.

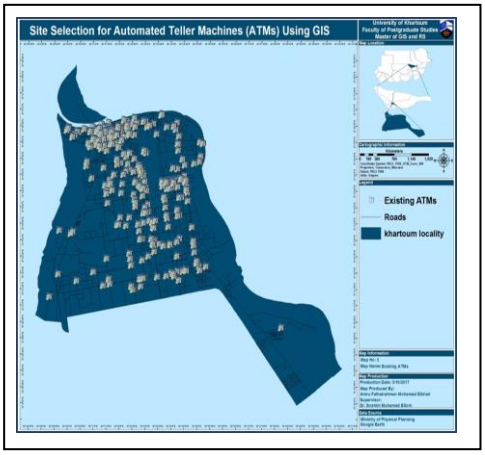


Fig (2/a): Existing ATMs layer

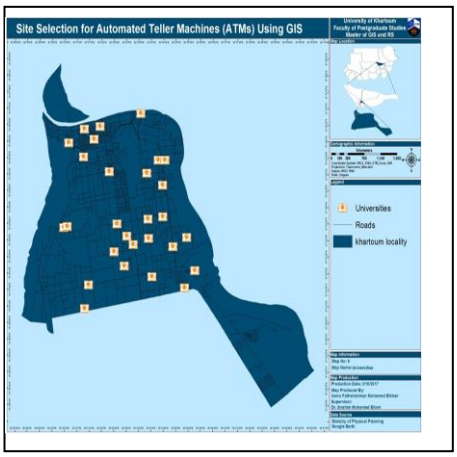


Fig (2/b): Universities

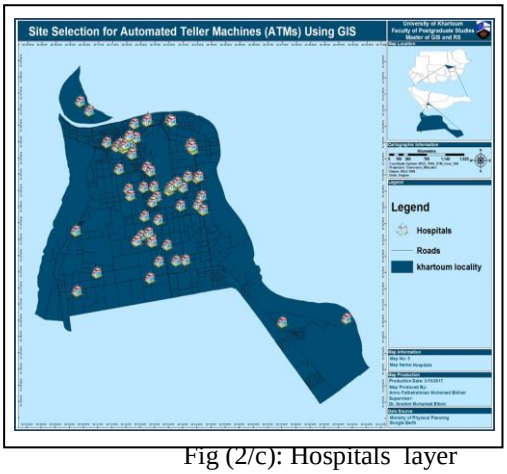


Fig (2/c): Hospitals layer

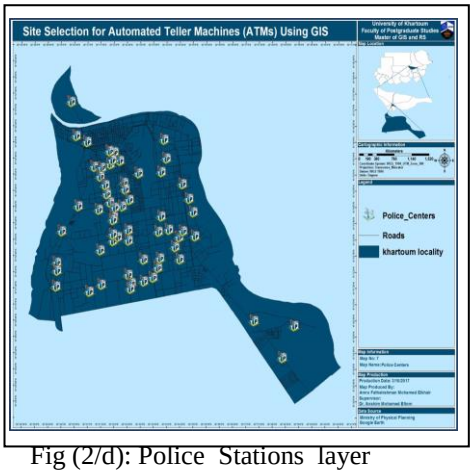


Fig (2/d): Police Stations layer

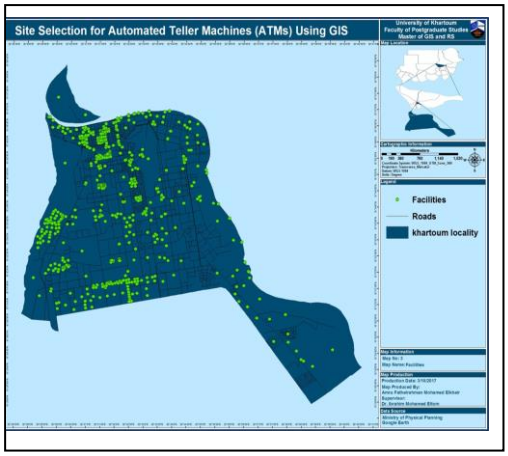


Fig (2/e): Facilities layer

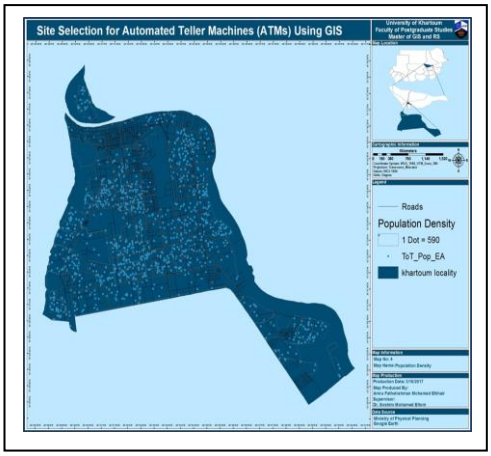


Fig (2/f): Population Density layer

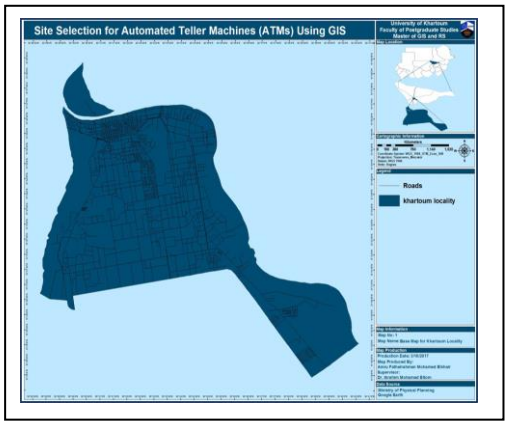


Fig (2/i): Roads layer

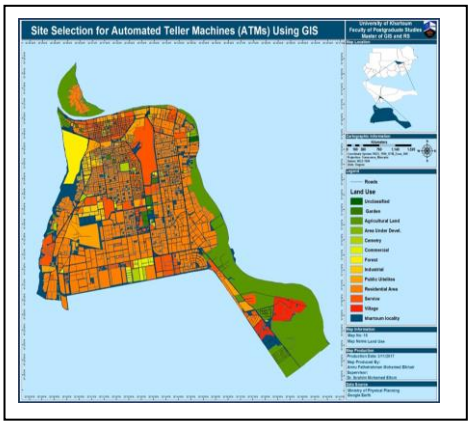


Fig (2/h): Land use layer

Fig (2): Main thematic layers used for executing ATMs suitability Mode

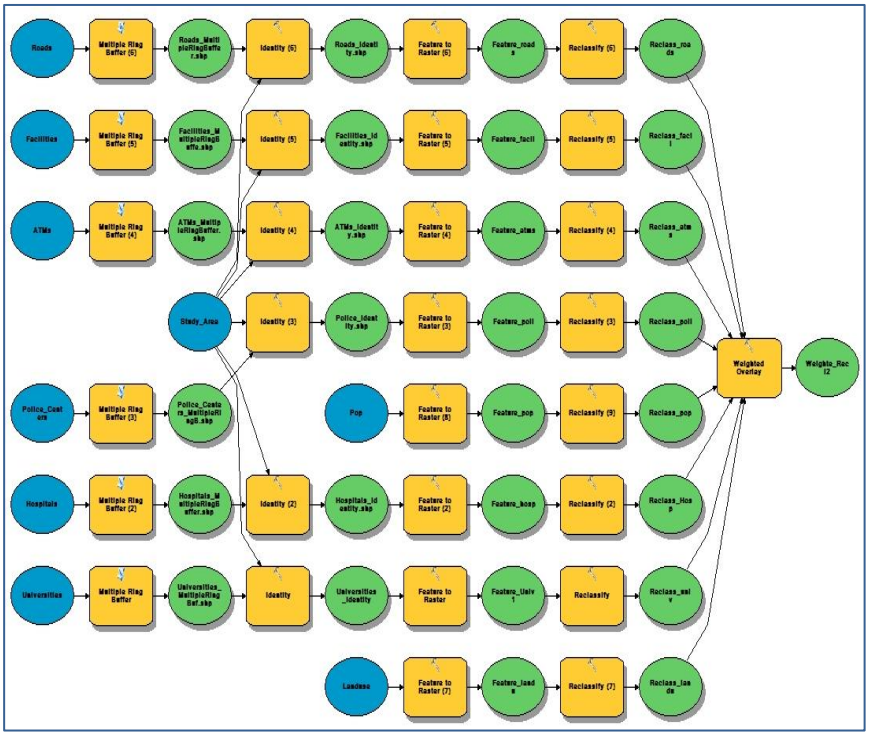


Figure (3): The complete model Structural Presentation

4-Results and Discussion:

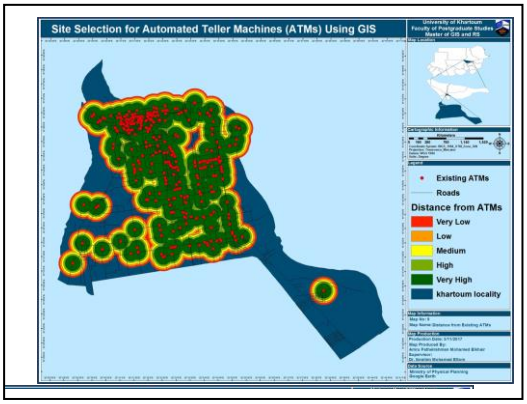
Weighted overlay analysis is used for locating the potential sites for new ATMs. This technique is used to compare eight diverse factors on a common scale and weigh them according to their importance. In this analysis population density is given a highest weightage because the location of ATM should be in close proximity to the customers. Roads, hospitals, universities, safety are assigned the minimum weightage and land use assigned a medium weighted percentage.

The ATMs appropriate location problem is modeled and prescribed mathematically as the researchers used GIS Suitability Analysis. There are three suitability level analysis, which are level-1 (high) considered suitable criteria affected the decision of ATM location; level-2 (less in significance) for ATM decision location, but not ignored while processing weighted overlay for final suitability); and level -3 (insignificant) criteria or have lesser consideration have a least value in ranking significance of criteria.

The criteria for level-1 are (roads, population density, facilities and universities) as analyzed separately with ATMs options relationships for final

interpretation. Fig (4/a-b-c-d) presents the overall analysis of the level-1 criteria with association with the existing ATMs options. Fig (5) showed the high and very high suitable sites depending on the criteria used. Most of these areas are in dense populated areas where actually no ATMs. Customers to get their service, they should be transported to the centre of the town where most of the ATMs are installed.

Roads automatically have an important priority to name the ATMs' locations in Khartoum State. Roads in Khartoum are characterized by their bad design for parking and always are congested by walkers mainly in markets that evaluated to be considered with some kind of preservation.



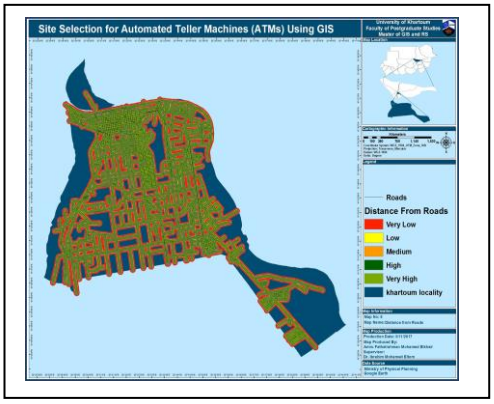
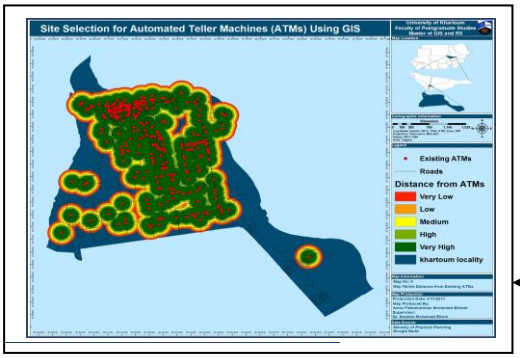


Fig (4/a): Exist ATMs Fig (4/b): Suitability with Roads



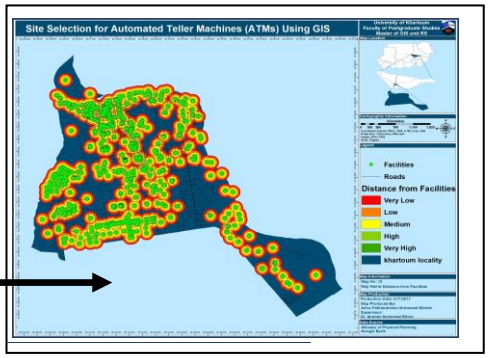


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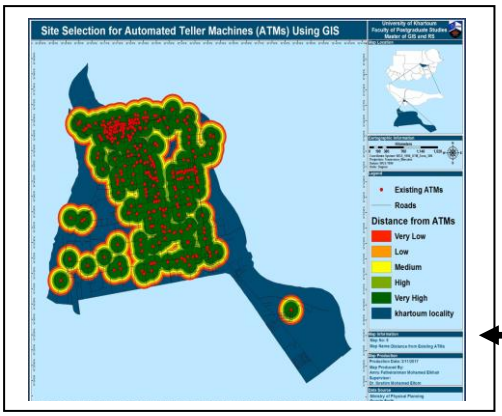
Fig (4/a): Exist ATMs Fig (4/c): Suitability with facilities distribution



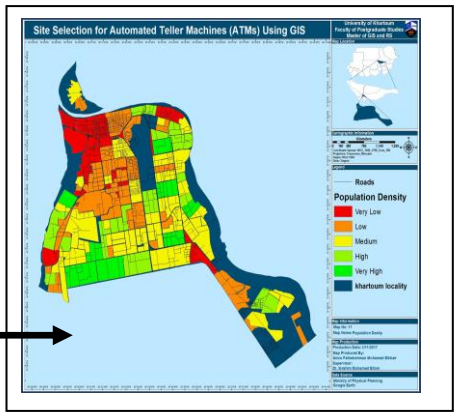
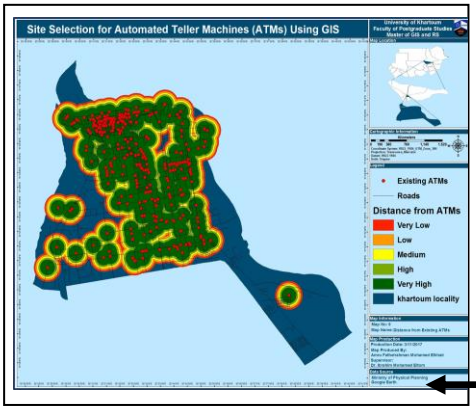


Fig (4/a): Exist ATMs Fig (4/d):): Land use



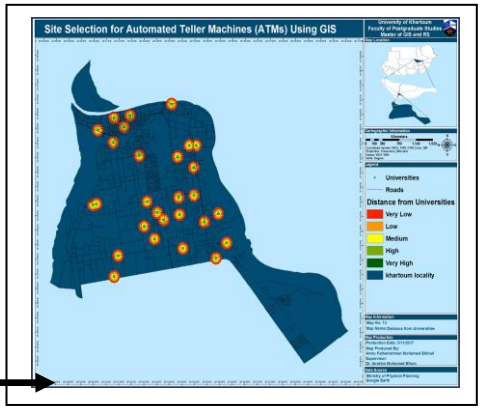


Fig (5/a): Exist ATMs Fig (4/h): Suitability with Universities

Fig (4/a): Exist ATMs

Fig (4/e): Suitability with Population Density

Fig (4-a-b-c-d) the overall analysis of level-1 criteria with associations with the existing ATMs options

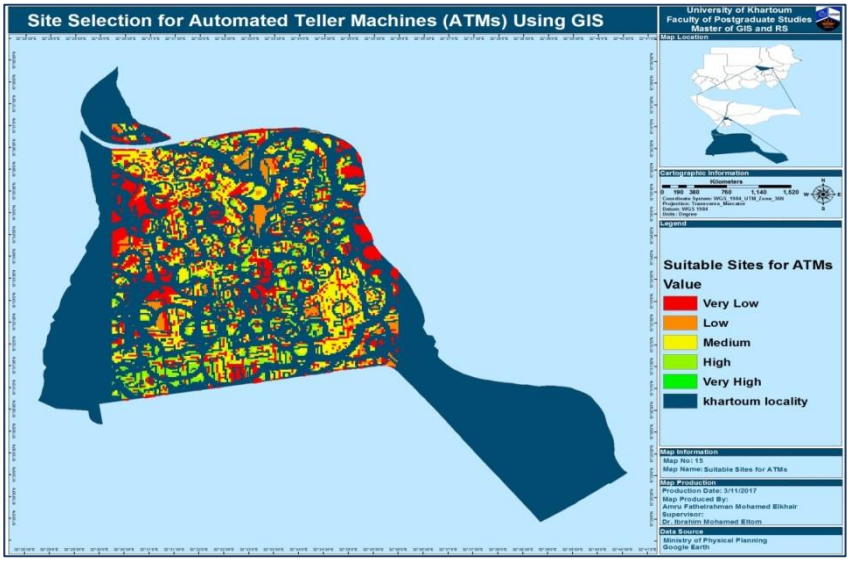


Figure (5): Final Suitability Map for Locating ATM in Khartoum

From the suitability map we can interpret the spatial homogeneity of the ATMs distribution. For the benefit of the customers the ATMs utility should be transferred into residential areas.

5. Conclusion:

The research results agreed with Khan (2010) that excellence in quality has become imperative for organizations sustainability. So the 21 years gap between the first ATM installed in Khartoum in 1997 by the Nieleen bank and now, needs to assess the banks facilities quantitatively as well as qualitatively for better customer's satisfaction.

The overall analysis showed, areas that not covered by ATMs services are amble over the Khartoum locality and state as well. The exits ATMs numbers are distributed unevenly and don't consider high level criteria or standard and this attributed to the banks own philosophy in locating ATMs. The real services provided by the existing ATMs are during the day times from 7:00 AM to 5:00 P.M.

The spatial distribution of the exiting ATMs is to some extent optimum for serving the central of the Khartoum at the main familiar streets where most of the business activities are allocated, but not to satisfy the people wishes.

The assessment showed that one ATM has received high frequency of customers from different areas at the same time. ATMs accessibility is associated with the transportation networks that pass across these locations.

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التوزيع الجغرافي لأجهزة الصراف الآلي باستخدام تحليل نمذجة الملائمة في مدينة الخرطوم – السودان

د. إبراهيم محمد التوم

أستاذ البيئة وتطبيقات نظم المعلومات الجغرافية المشارك

بقسم الجغرافيا بكلية اللغة العربية والدراسات الاجتماعية بجامعة القصيم/ وجامعة الخرطوم.

ملخص البحث: تعتبر الخدمات المصرفية في المدن الكبرى من أهم مجالات تطبيقات نظم المعلومات الجغرافية في قطاع الخدمات في الخرطوم. هدفت الدراسة الحالية إلى تقييم واقع توزيع أجهزة الصراف الآلي في محلية الخرطوم ومدى اتباع المعايير في اختيار الموقع المناسب للخدمة حسب طلب المواطنين. الأساليب: استخدم الباحث تقنيات نظم المعلومات الجغرافية لتقييم توزيع أجهزة الصراف الآلي وتحديد المناطق المناسبة لإنشاء أجهزة صراف آلي جديدة في الخرطوم. تم استخدام ArcMap 10.2 في هذه الدراسة لإنتاج الخرائط وإنشاء الطبقات المستخدمة كمدخلات لمعالجة النموذج. تم استخدام الخرائط الموضوعية المتاحة لمحلية الخرطوم وخرائط جوجل ونقاط إحداثيات مواقع الصرافات الآلية للبيانات المستخدمة بهذه الورقة. يوجد في ولاية الخرطوم ٣٦٧ جهاز صراف آلي تعمل خلال ساعات اليوم. النتائج: أظهرت نتائج الدراسة أن أكثر من ٧٧٪ من المناطق السكنية في محلية الخرطوم تصلح لإنشاء ماكينات الصرف الآلي للبنوك عند اختبار معيار الكثافة السكانية لتحديد مدى ملاءمتها. تحتاج المناطق فعليًا إلى هذه الخدمات في ضوء صعوبة حركة المرور اليومية، مما يشير إلى أن إمكانية الوصول إلى مواقع أجهزة الصراف الآلي الموجودة يعد عاملاً مقيدًا للمشكلة محدودية الوقت. الخاتمة: أثبتت الدراسة أن استخدام تحليل النمذجة في بيئة نظم المعلومات الجغرافية لتحديد الموقع الملائم للخدمات أداة فعالة. وتتعلق توصية الدراسة باستخدام المعايير الدولية والإقليمية لتحقيق وتقييم الرضا عن سهولة الوصول والمنافسة بين البنوك.

الكلمات المفتاحية: الصراف الآلي / نظم المعلومات الجغرافية / قطاع الخدمات/ ArcMap 10.2