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Research Article

Optimal Coverage Analysis of Existing Automated Teller Machines within Minna Metropolis, Nigeria using the Best-Fit Model

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Abstract

Owing to the fact that nearly all economic sector of a country has embraced technology in their mode of operation. The banking industry as a financial institution in its recent implementation of electronic banking and the use of Automated Teller Machine has not been left out. The location of this ATM's with respect to their users is a geospatial problem; the industry aim is to ensure that such facilities are optimally located. The location-allocation tools in Geographic Information System thus become useful. This study investigates and assesses the existing ATMs in the study area using location and service ability as a factor. Questionnaires were administered to assess the service ability of existing ATMs. For location evaluation the geographic coordinates of ATMs and Police stations were acquired using Garmin 78 Handheld Global Positioning System, the remotely sensed image of the study area was gotten from the Office of Surveyor General of the Federation, it was digitized and used along with the acquired coordinates to create a database using ArcGIS 10.3 software. The resulting map was used to create a network analysis. Various Location-Allocation models were then used to assess and fix new optimal locations for ATMs in the study area. The results show that with a travel distance of 1.5km used in the models, the maximum coverage model is the most suitable location-allocation models, for a banking system that seeks for equity among various banks, ATM centers can be sited using this model. The marginalization that occurs from other model make them unfit for the banking industry. One of the final results from this study is that the optimal area for locating new ATMs amongst potential sites in terms of compatibility with the chosen criteria was achieved. This study suggests that; decision making future siting of ATMs to serve customers within this distance zone could use this model.

Keywords: GIS, LAM, ATM site selection, marginalization, spatial analysis, Best-Fit Model

Introduction
Objectives, study area, Black Sea last lowstand time

Banking is money, credit and other financial transactions industry. Banking services are now made available via the use of computer due to the development in communication and information technology. Balance in a deposit type of account and other related information can now be known through computers. E-banking is referred to as transactions performed via computers and other communication means that are electronic in order to transact with money. Many of the e-banking services rendered by the banks today include Automated Teller Machines (ATM), net banking, credit card, phone banking, debit card, etc. Recently, in most banks, manual or human teller counter is being replaced by Automated Teller Machines (ATM) which is one of the improvements in banking sector that emerge due to advancement in technology.

In the banking industry, among the many facility services that are vital is the ATM. Since its invention more than 34 years ago in the banking industry, the face of banking has changed to this effect (Mansour et al., 2009). Just as the number of banks is growing, Nigeria has over 17000 ATMs as at 2016 and it has been on an increasing rate (EFInA, 2010). Upon siting of most of the ATMs at bank premises, there is still growing number of ATMs been sited off-premises like supermarkets, filling stations, and education centres, etc. A survey by the World Bank revealed that in 2018, Nigeria has an equivalence of 16.93 ATMs per 100,000 adults which is a reflection of how crowded ATM centres had always been (The World Bank, 2020).

ATMs are important banking facilities and it play a central role in our day-to-day activities. With most banks closing over weekends and holidays, ATMs ensure that consumers have access to their bank accounts 24 hours a day. But what happens when an urgent matter arises and there is no ATM nearby? One may be forced to travel many kilometers in search of an ATM. This is undesirable, as ATMs should be easily accessible. The Central Bank of Nigeria in their yearly report for 2020, report that ATM had the highest volume of usage with 968,433,479 after online mode of payment out of 11 modes of financial transaction, despite the COVID 19 pandemic and lockdown (CBN, 2020).

However, various researchers have identified different criteria that affect customer's satisfaction towards the use of ATM. This include; tangibility, assurance (Salami and Olannye, 2013), Security and privacy, reliability (Akinmayowa and Ogbeide, 2014), convenience, responsiveness (Ebere et al., 2015), unreliable network, waiting in line to use network ATM Machine (Amene and Buta, 2019) among others. Consumers are increasingly demanding the ability to conduct financial business at their convenience and at their preferred location. This calls for banks to locate ATMs for customers' convenience.

In addition, ATMs present a good opportunity to promote products and services. To take advantage of these benefits, an ATM must be placed in a location that is visible, secure and inviting. Location is thus an important aspect of retail development and in particular Automated teller machines (ATMs). The criteria identified in the field of behavioural science can be interpreted as a location factor in the field of geospatial science. It is therefore important to know the contribution of geospatial science in banking industries (Pieter et al., 2017). In other to balance the wheel between the banking system and customers, the development in technology has brought a huge improvement and global relevance of Surveying and Geoinformatics in all fields of profession (Thomas, 2014). The field of surveying is gradually transiting from its usual name and operation to the evolving regarding definition-Geomatics.

Geomatics is an integrated, multidisciplinary and systematic approach to instrument selection and appropriate techniques to collect, store, integrate, model, analyze, retrieve, transform, display and distribute georeferenced data from diverse sources with definite accuracy and continuity in digital format (Mario, 2010). These earlier notions establish the fact that the current trend of surveying and geoinformatics is presenting it relevant in all fields that deals with geospatial information. The relevance of the profession is not trivial in banking and other commercial sectors. Among many other areas of application of surveying and geoinformatics in banking is the location of banks and its facilities since in business the location or siting of the premises plays a significant duty in ensuring the success of the business (Halmi et al., 2016). The optimal location of ATMs does not only serve the bank users but also aid the banks in managing this facility (Thomas, 2014).The goal of the location-allocation problem's solution, is to find the best locations or location to fit one or more facilities which will make the highest utility value from criterion or multiple criteria (Snyder and Daskin, 2005; Mohammadı and Hosseınalı, 2019; Sulemana et al., 2020). Bad location of the facility has negative effect in terms of providing services to the beneficiary. Distance from the area of supply and the area of demand should be optimal. If location of the facility is far from area of demand, beneficiary may not be able or interested to take the service from the facility. Location of the facility should be well distributed such that capacity of the facilities can meet all the demands (Olusina and Adesina, 2015).

On the other hand, locating a facility is a function of the sector concerned: private or public sector. Private sector seeks location of sites that maximize a profit, while the public sector seeks facility sites that optimize the population's access to those facilities of the service (Marin et al, 2009). Since it is impossible to locate facilities at every demand point because of limited resources; there is need to assess and address inadequacies with available resources (NFPA, 2010). So, with optimal distance, capacity of the facility needs to be considered when taking decision. For any retail outlet to succeed it is important that it be located in a suitable area. However, getting the optimal location is a tricky process and is influenced by many factors. In essence, facility location should be done objectively with a view of meeting demand rather than allowing unethical and political will to prevail while taking such important decisions (Adesina et al., 2015).

On this note, Geographic Information System (GIS) is a digital technology that combines hardware and software for spatial data analysis, processing and mapping. It supports a wide variety of applications. The integration of GIS and location-allocation models provide a planning framework so as to monitor the effectiveness of the spatial location of any facilities (Ashraf, 2019). By incorporating them, the decision makers can pattern their findings for reformed and informed decisions. Besides, the advantages of making use of this tool involve aiding decision for successful selections via examination of different scenarios originated from various assumptions.

Thus, there are several postulations of models for facility location. These models include Maximize-Attendance Model or P-median model, Maximize-Capacitated-Coverage, Maximize-Coverage, Maximize-Market-Share, Minimize-Impedance, and Target-Market-Share, etc. (Schietzelt and Densham, 2003). Olusina and Adesina (2015) use P-median model to ensure that sum of all weighted travel time or distance from facilities and demand points and facilities locations are minimized. Maximize-Capacitated-Coverage works such a way that location of facilities ensures all or the maximum possible number of demands can be met without exceeding the capacity of any facility (Adesina et al., 2015; Adesina et al., 2017; Alan, 2010). Maximize Capacitated Coverage behaves like either the P-median or Maximize Coverage problem type but with the added constrain of capacity (Adesina et al., 2015). The Maximize-Coverage are implemented to ensure that facilities are located to as much demand point as possible; in this model, location of facilities are done to ensure that as many demands as possible are handled to solution facilities in the impedance range. In Maximize-Market-Share, choosing of a definite number of facilities are done in a way that demand allocated is maximized even in the existence of competitors.

Minna metropolis is fast developing urban centre in North-Central Nigeria. Businesses in Minna strive at its own pace and are pivotal for economic growth, all these involve transactions with money. Commercial activities in Minna continues week in week out without any break out even during the weekend or industrial actions. These factors make it mandatory that ATMs should be made available at all times and at reachable locations. Adepoju and Alhassan (2010) in a research identify various factors that lead to ineffectiveness in the use of ATM in Minna, the research shows that proximity to security post which is an implication of the location of such ATM has been a factor affecting the satisfaction that customer's derived from the use of the machine. They also identify concentration of ATM post in some area, where their effectiveness could not be maximized. For effective or optimal use of ATMs in any region like Minna metropolis, there is high need that the ATMs should be distributed to ensure convenience, security and safety of the users.

The review of various use of GIS in banking sectors, especially in relation to the use of ATMs include: Bank must minimize lost and maximize profit (Adepoju and Alhassan, 2010; Anne and Buta, 2019). Location is an important factor in modelling bank efficiency (Olusina and Adesina, 2015; Rudabeh et al., 2017). GIS is an effective tool in augmenting location and other factors for in depth analysis (Olusina and Adesina, 2015); Location-allocation model is an effective tool in GIS for the analysis (Mansour, 2009; Halmi, 2016; Adesina et al., 2017). Various factors have been modelled into location-allocation models such as convolution (Mansour, 2009), Responsiveness (Pieter et al., 2017), profitability (Mahmoud, 2018), Urban planning standard (Ashraf, 2019), customer's density and service area using weighted overlay tool in GIS (Aghade et al., 2015) The various researches make use of one allocation model to make decision considering the factors affecting location of ATM. This research work tends to enlarge the scope by applying the numerous allocation models and selecting the best fit model based in the criteria in question.

To this end, the goal of this research is to use location and service ability as a criterion to access the seven allocation models available in the ArcGIS, with the aim of choosing the most suitable models based on these two factors. The selected model will then be used to assess existing ATMs, project more locations and recommendations will be made for stakeholders in the banking sector.

Materials and methods

ArcGIS was used to map the existing ATMs locations and their demand points; along with other constraints and siting determinant factors (e.g. population, etc.). This thus served as a basis using the model builder for modelling the suitability or otherwise of the existing ATMs and the possible need for siting more ATMs at other locations.

Study Area

Minna is one of the towns in the Northern region of Nigeria and lies between latitude 9o38'N and 9o 40.02'N and within longitude 6o 33.005'E and 6o 37'E of the Greenwich meridian. According to 2007 population census, Minna has an approximate population of 304,000 and its population has been projected from 2006 to 2019 to reach 389,247 at 0.85% increases per rate. Figure 1 shows the map of the study area as extracted from composite map of Nigeria. Minna is used as a test bed with the aim of choosing the most suitable models based on these two factors (i.e. location and service ability) to access the seven allocation models available in the ArcGIS.

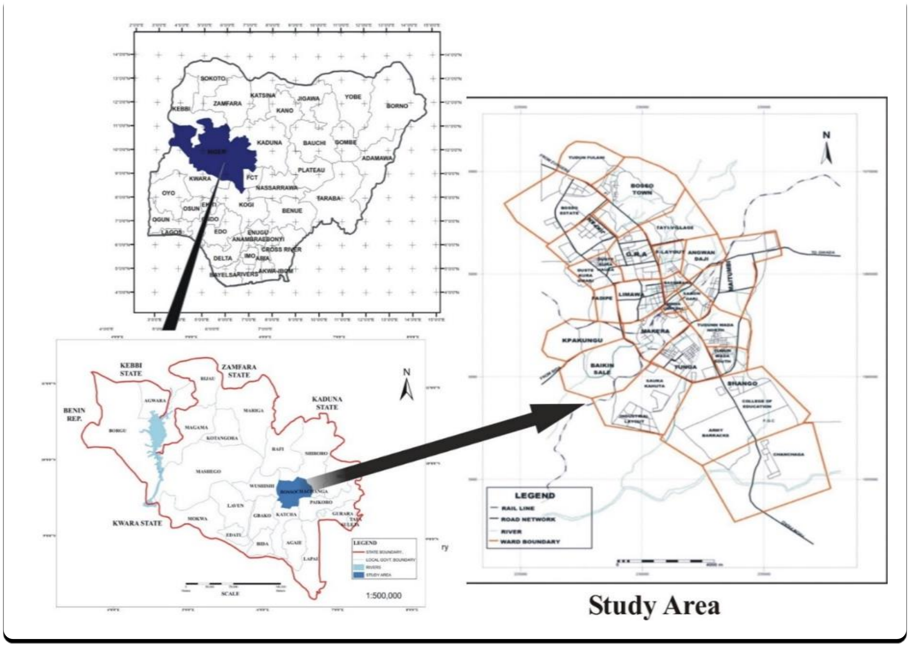

Fig. 1: Map of the study area

Data source and materials

In order to achieve the aim of the study, the following data and materials were used in the course of the study.
1. Coordinates of the existing ATMs and police stations in the study area were acquired using Garmin 78 handheld satellite receiver (handheld GPS).
2. ArcMap 10.3 was used to georeference, digitize, create database and carry out location-allocation queries in the study.
3. The questionnaire was designed and assigned to obtain information from users and providers of ATM services in the study area. The questions include investigation about the current locations of ATMs in the metropolis, if there is need for new ATMs to be sited, which of the banks is making move to plant a new ATM, among other questions. Figure 2 shows the methodology chart employed in this study from the data acquisition till the results obtained.

The data acquired was grouped into two categories, namely: primary and secondary data. The primary data acquired are point coordinates (X, Y) of the ATMs existing in the study area and also the questionnaires which were administered randomly in selected zones in the study area. Tables 1 and 2 show the position coordinates of the existing ATMs (labelled by the name of the bank owning them) and police stations respectively.

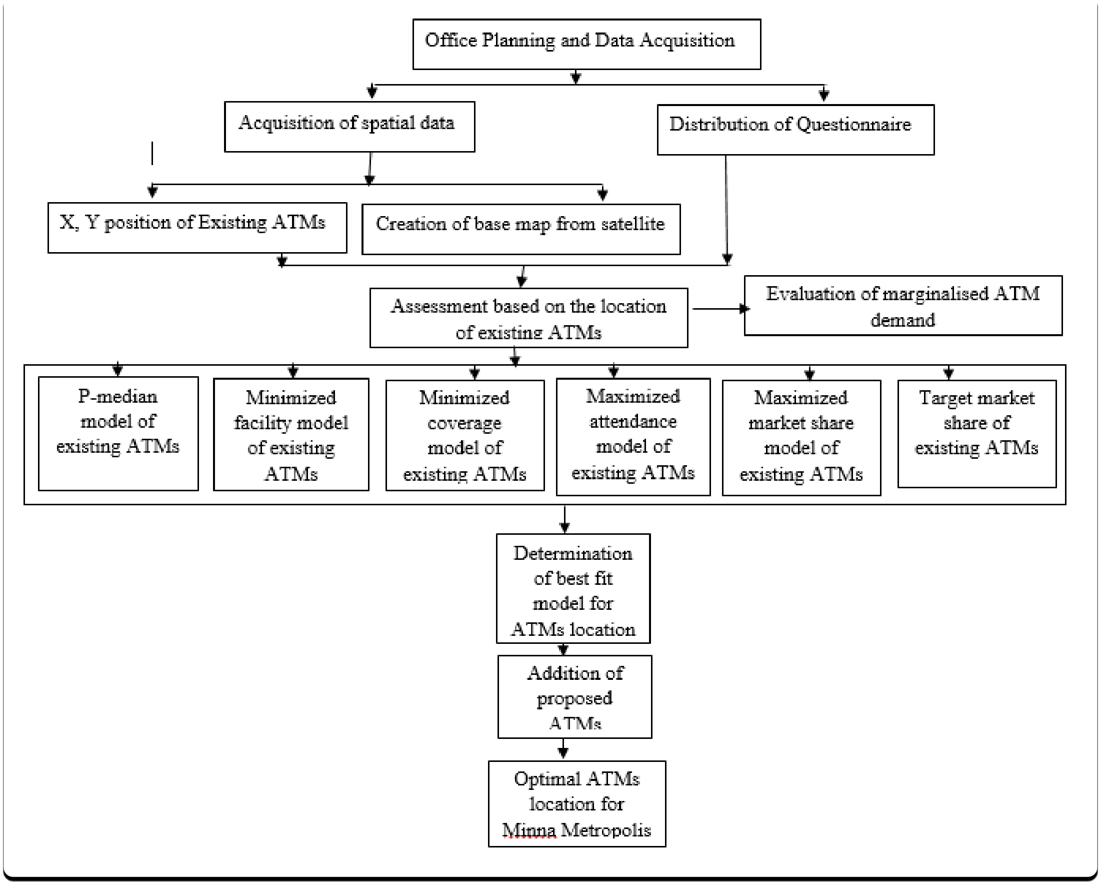

Fig. 2: Methodology chart used for the study.

In addition, the remotely sensed image of the study area was gotten from the Office of the Surveyor General of the Federation (OSGOF). Also, from this a database was created to include the information about ATMs in the study area and also their location data (Northings and Eastings) in order to foster further analysis. For the purpose of having a good road network system, the topology of the existing road network in the study area was created.

The remotely sensed imagery (satellite image) used for this study was georeferenced by using existing ground controls after the image has been reprojecting from WGS 84 to UTM. Digitizing was carried out using polygon, line and points to represent police station, roads and ATMs, and the shape files were created. The digitized road was used to create a network dataset using it tool in ArcGIS.

Selection of impedance cutoff

Impedance cutoff, this could imply travel time or distance. For some emergency facilities like fire station, health centers and so on, assessing the effectiveness of their locations, travel time is considered as impedance cutoff. Peculiar to this study, considering the nature of the facility under study, travel distance is considered as the impedance type using location-allocation models in ArcMap 10.3, in order to assess the usefulness of the current locations of the ATMs to meet the facility's demand, impedance cutoff distance of 1500m (Liusun, 2019)was chosen. This also served in assessing if there are any marginalized demand regions in the study area.

Table 1: Coordinates of ATMs existing within Minna metropolis

S/N	Banks name	Easting (m)	Northing (m)
1	Eco bank	230754	1063854
2	Wema bank	230747	1063891
3	Unity bank	230754	1064032
4	Polaris bank	230661	1064253
5	Access bank	230617	1064246
6	IBTC bank	230668	1064467
7	Polaris bank	236629	1064688
8	key stone bank	230624	1064908
9	zenith bank	230444	1065704
10	sterling bank	230488	1065774
11	union bank	231165	1063321
12	ASO bank	231121	1063270
13	first bank	231206	1063122
14	first bank	231226	1063082
15	Unity bank	231300	1063186
16	UBA bank	231342	1063214
17	UBA bank	231413	1063057
18	FCMB bank	231461	1063070
19	Zenith bank	231550	1062975
20	Fidelity bank	231611	1062825
21	Heritage bank	231873	1062713
22	Access bank	231841	1062661
23	GTB bank	231934	1062520
24	Diamond bank	232528	1061434
25	First bank	232606	1061275

Table 2: Coordinates of existing police station within Minna metropolis

S/N	Police station	Easting (m)	Northing (m)
1	Tundun Wada Police Station	231392.96	1061168.45
2	Paiko Division	231291.07	1063281.59
3	Kpakungu Police Station	228996.15	1061841.59
4	Nigeria Police Force HQ Minna	230177.96	1065670.55
5	Minna Police Head Quarters (HQ)	228611.11	1065372.94
6	Bosso Police Station	227733.92	1068077.99
7	Gidan Kwano Police Outpost	221990.45	1055117.25

Implementation of Location-Allocation Models

Seven location-allocation models are available in ArcGIS environment which are applicable for solving different types of location problems and these are Minimize Impedance, Maximize Attendance, Maximize Coverage, Maximize Market Share, Maximize Capacitated coverage, Minimize Facilities and Target Market Share. This study applied the seven models to identify and assess the coverage of the current ATM locations in order to find which part of the study area is within specified impedance. Because of the limitation of space, just two of the models are here explained. The database criteria used for the study includes road network, existing locations of ATM centers, security post, health centers and other facilities available in the area. Meanwhile, the outputs of the implementation of the seven models are discussed under the result in section 3The model that best fit according to the criteria selected was also discussed in the result section 3.

Minimize impedance problem

P-median is another and common name of this model. Minimize Impedance model is formulated in such a way that it tries to find the locations for a set of facilities which can minimize the sum of all weighted costs between all demands to be made used of by the nearest facilities.

In applying the p-median model in this study, existing ATMs stations were used as candidate locations and the population layer served as the demands. This location-allocation model was applied so as to minimize the total distance or total time traveled by users to reach demand points (ATMs locations). The equation was taken from Marianov and Serra (2002). *p*-median model is formulated thus:

$$\text{Minimize } \{Z = \sum_{s=1}^{m} \sum_{t=1}^{n} \propto_s d_{st} x_{st}\} \ldots \quad (4)$$

$$\text{Subject to: } \sum_{t=1}^{n} x_{st} = 1 \quad S = 1, \ldots, m \quad (5)$$

$$x_{st} \leq x_{tt} \quad s = 1, \ldots m; \quad t = 1, \ldots . n \quad (6)$$

$$\sum_{t=1}^{n} x_{tt} = p \quad (7)$$

where,
$x = 1$ if demand area i is assigned a facility at j, ij x 0 otherwise
s = nodes of demand index
m = number of demand points in the area of interest (study area)
t = potential location of facility index of potential facility sites
n= total number of potential facility location
d_{st}= distance between demand node s and potential facility site t
p= required number of facilities to be located

Thus, Equation (4) is meant to minimize the total demand-weighted distance between population (demands) and facilities. Equation (5) assigns every demand to a facility location while Equation (6) is a conditioning equation that constrains the number of facilities to be located.

Maximize coverage model

This model is an appropriate model for selecting the optimal location for ATM locations because such facilities are often needed to reach demand locations within a specified travel time or distance. Synonymous to *p*-median model, maximize coverage model has some checks that formulates how the demands are handled by it and these constrains are: (1) demands locations outside the facilities impedance cutoff are regarded as uncovered, (2) demands locations which fall within the impedance cutoff of one facility will have all other demands weight allocated to that facility, (3) For the condition that one demand is situated within the impedance cutoff exceeding one facility, it will be attached to the nearest. Maximize Coverage model was applied in this study to assess the existing ATMs stations for how well do they cover the population demands in the study area. Populations which are within the impedance cutoff of assigned facilities were considered covered. The equation below is from Marianov and Serra (2002). The Maximize Coverage model is formulated thus:

$$\text{Minimize } \{z = \sum_{i \in I} a_i \, y_i\} \quad (8)$$

$$\text{Subject to: } y_i \leq \sum_{j \in N_i} x_i \; \forall_i \in I \quad (9)$$

$$\sum_{j \in j} x_j \;\; = p \quad (10)$$

$$x_{j,} y_i \in 0{,}1 \qquad \forall j \;\in j, i \in I$$

where,
I = a set of demand locations
j = candidates facility locations in form of set
p = required number of facilities to be located
$x_i = 1$ (assign) if station is located at j, 0 if otherwise
y_i =1 if demand node i is covered, 0 otherwise
S= standard time or distance for coverage
N_i= the set of all candidate sites which can cover demand nodes i
a_i = the population or number of facilities at demand node i

Equation (8) is meant to maximize the number of demands covered. Equation (9) is a conditioning function that the demand at node *is* addressed covered when at least one facility is located within standard distance while Equation (10) is to give the total number of facilities that can be located.

Results and discussion of results

Minimize impedance model

Figure 3 shows the output from implementation of the minimize impedance model as used to decide on the number of demand points within the travel distance (1.5km) from demand to facility. From figure 3, it is seen that the model does not put redundant existing ATM locations along the road network into consideration in its implementation.

From the 412 demand points created based on the need of the population, only 81 could be reached according to the implemented minimum impedance model. This is approximately 20% of the total demand. Tundun Wadda, Kpakugun, Bosso, and populations along Gidan kwano-Kpakugun route are majorly not within the reach of the stipulated travel distance. ATM centers within the FUT Minna, Gidan-kwano campus, Minna were exempted from the implementation because these facilities in this vicinity is meant to meet ATM needs of the university populace. Also, the school management at her will may restrict outsiders from using this facility either directly or indirectly perhaps for security reason or any other causes that may authorized it to be done so. Recommendation of this model is that ATMs that are redundant should be distributed evenly within the study area instead of clustering them along Mobil-Tunga. Table 3 shows a list of the ATMs selected for implementation in this study.

Minimize facilities model

This model aims to reduce to the barest number of facilities that can be used in an area of interest, as the name implies. This model is exactly the same as the p-median and maximize coverage model (in figure 3) and disregards some redundant ATM machines along the network route as well. The output shows the selected effective facility in the study which selection is a function of which ATM is mostly accessible by the demands within the stated travel distance. Discussions under the *p*-median model are therefore relevant here. Figure 3 also serves the output of the minimize facilities model.

Maximize attendance

This model behaved in this study synonymously to the *p*-median, maximize coverage and minimize facilities model. Figure 3 is the representation of demands furnished by the selected ATMs according to this model. Other discussions and recommendations are the same with section 2.4.1 about the *p*-median model. Meanwhile, maximize attendance just like its semblance which is explained above, is useful for apportioning ATMs in a best economical way.

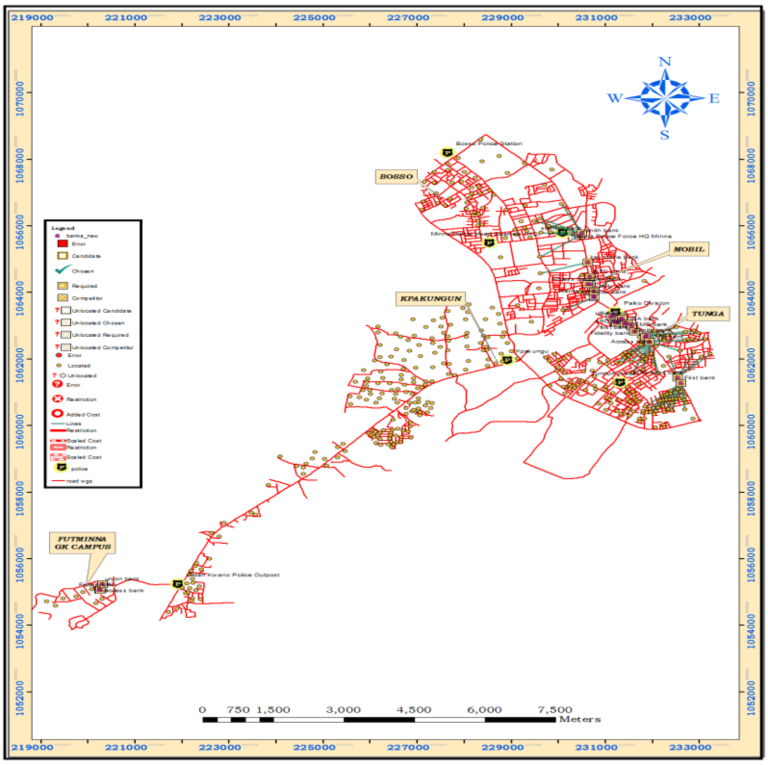

Fig. 3: Implementation result of minimum impedance and maximize coverage model

Table 3: Distribution of ATMs found useful by p-median model

S/No	ATMs	Number of demands met	%demand coverage
1	Key Stone Bank, Mobil	one	1.21
2	Sterilng Bank, Mobil	seven	8.59
3	Zenith Bank	four	4.88
4	Access Bank, Tunga	Twenty-seven	33.29
5	Diamond Bank	Four	4.88
6	First Bank, Tunga	Thirty	37.08
7	Ecobank, Mobil	One	1.19
8	Unity Bank, Mobil	One	1.19
9	Guaranty Trust Bank	Six	7.69
	Total	**81**	**100**

Maximize coverage model

The maximize coverage model was used to decide on the number of demands at the reach of the set 1.5 km of distance between demand and facility distance. In this study, the output of this model is similar to the *p*-median (figure 4) and disregards some redundant ATM along the road network as well. The result shows that the selection of an efficient facility in the area of study is based on which ATM is mostly accessed by the demands within the 1.5km threshold. A discussion under the p-median model is therefore relevant here. Figure 4 also serves as the output of the maximize coverage model.

Maximize capacitated coverage model

Maximize capacitated coverage model was also implemented so as to evaluate the number of demands within the 1.5km distance between demand and facility. Figure 4 show that this model has only 18 points of demand that can reach ATM in the specified distance when traveling along the built route wings. It can be seen from the output result that the model evenly distributes the total number of demands reachable to qualified or chosen banks. Table 4 shows the useful ATMs according to this model. From the 412 demand points created based on the need of the population, only 18 could be reached according to the implemented maximize capacitated coverage model. This is 4.4% of the total demand. Tundun Wadda, Kpakugun, Bosso, populations along Gidan kwano-Kpakgun route is majorly not covered under this travel distance.

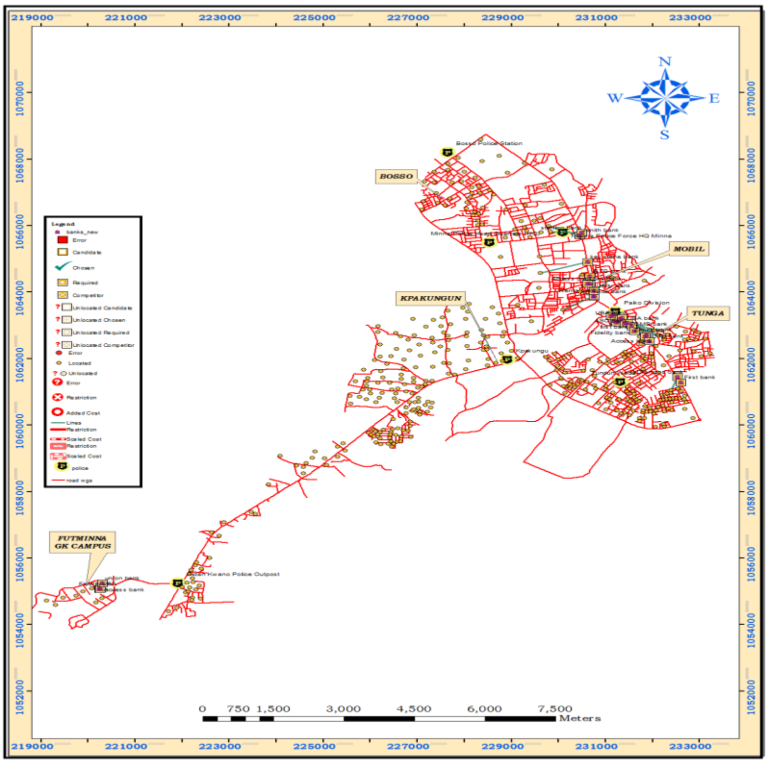

Fig. 4: Maximize capacitated coverage

Table 4: Useful ATMs according to maximize capacitated

S/No	ATMs	Number of demands met	%demand coverage
1	Keystone bank, Mobil	1	5.555
2	Zenith Bank, Mobil	1	5.555
3	Unity Bank, Mobil	1	5.555
4	Skye Bank, Mobil	1	5.555
5	Ecobank, Mobil	1	5.555
6	Unity Bank, Mobil	1	5.555
7	Guaranty Trust Bank	1	5.555
8	Heritage Bank, Mobil	1	5.555
9	UBA (1), Tunga	1	5.555
10	UBA (2), Tunga	1	5.555
11	ASO bank	1	5.555
12	FCMB	1	5.555
13	Wema Bank, Mobil	1	5.555
14	First Bank, Tunga	1	5.555
15	Zenith Bank, Tunga	1	5.555
16	Access Bank, Tunga	1	5.555
	Total	**18**	**100**

Maximize market share

By this model, which has result demand-facility resolutions (for 1.5km travel distance), shares all the demand reached for all banks. This model that creates a network not just between demand and facilities, but between demand and facilities (more than one facility) which is been depicted in figure 5 by the 'lines'. The amount of demands still met by this method remains 81 (19.7% of the total population) but facilitates location of nearest facility for a user in need of it by improving on the network. This model is perfect for evaluating the rate of existing competition among ATM service providers. Likewise, it is applicable for finding out the proximity between ATMs.

Target market share

This model gave the same output just as the maximize market share (as used in this study). The model (for a distance of 1.5km) shares the demand that is reached to all the banks. This model, establish a network both between facility and demand and also between facilities and demand (as displayed by the 'lines' in figure 5). The amount of demands still met by this method remains 81 (approximately 20% of the total population) but facilitates location of nearest facility for a user in need of it by improving on the network.

Best-fit location-allocation model

After implementing the models existing for the optimal location problems or models contained in the Arc-GIS software, it is necessary to determine among the models, which of them resolve location problem best and can achieve the goal of optimum location allocation. In order to evaluate the befitting model, the questionnaires filled by users of facility were analyzed.

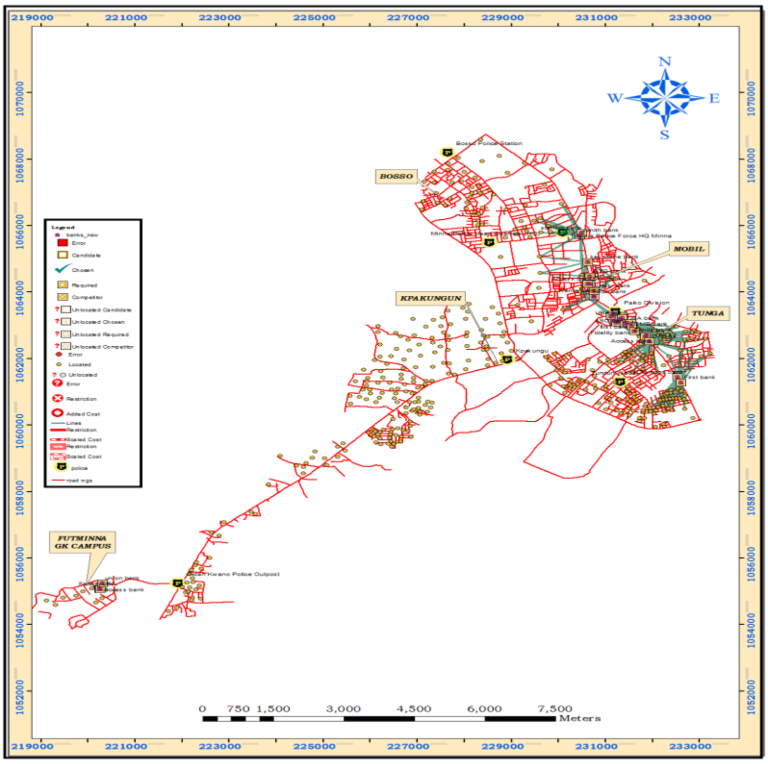

Figure 5: Implementation of Maximize market share model.

Analysis of the questionnaires

The questionnaires were designed and intended to obtain information from two categories of people: the ATM users and the service providers (banks). Unfortunately, due to the confidentiality of the questions in the bank's section of the questionnaire, upon all forms of persuasion, none of the banks owning ATM in the study area responded and hence, limited in a way the result of this study.

Occupational profile of interviewed users

ATMs in the study area draw its users from the students and working classes (from field survey). Eighty-one questionnaires were administered to the users (81) of which 49 were students. This constitute 60.50% of the total number of responders, and 33% of this category were from working class community, comprising 39.50% of the total responders.

Frequency of ATMs use

The rate of ATMs use in Minna were classified in this study as monthly, weekly and daily among the students conversed with. According to the responses, 14.3% of them visited ATMs daily, 36.6% visited ATMs weekly and 53.1% of the students visit ATMs monthly.

Geographical use of ATMs in the study area

Minna's geographical or spatial use of ATMs is expressed in terms of the whole responses rather than responders. The reason for this is that more ATM sites are used by the people. Therefore, for all responders, the number of ATMs visited was added and the total summed up. Though the responses of 81 (eighty-one) responders were analyzed. The maximum response from the respondent to the visit of the ATMs was 155. Figure 6 is therefore depicted as a function of the percentage of visited ATMs with respect to the responses in total.

In summary, the responders demand siting of new ATMs to ease their accessibility to ATMs. It is revealed that among these seven location-allocation models, maximum coverage is the best appropriate location models especially for a system of banking which desires to place the chances of all the banks on an equal pedestal, ATM centers can be best sited by making use of this model. It is also beneficial that users or customers of a particular bank within that range will travel within the defined distance in this study (1.5km) to use their own bank's ATM and hence minimize charges laid on them when ATM of other banks are used.

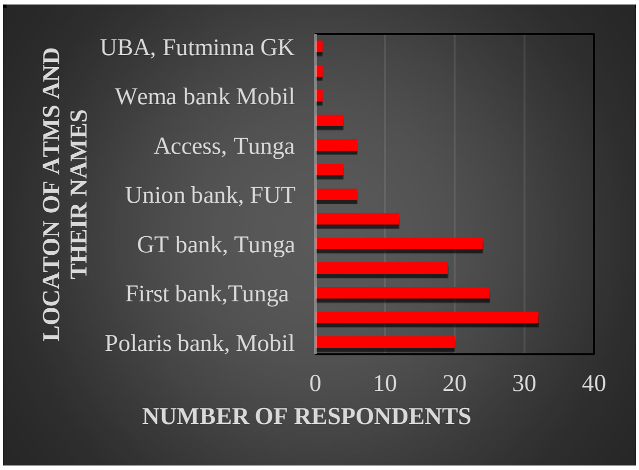

Fig. 6: Percentage of visited ATMs with respect to the responses in total

Proposed locations for new ATMs using maximum coverage

Buffering around police stations

From literatures reviewed and users view as analyzed above, the major factor considered by the banks in siting a new ATM station is proximity to police station or any other security agency. This factor was put into consideration here and a buffer operation performed to select optimal locations for the proposed ATM stations. A 1500m circular buffer operation was performed to map out demand points and police stations within this range. Figure 7 shows the output of the buffer operation performed with the police stations been the feature. Figures 8 and 9 show the proposed ATM locations optimally selected by considering proximity to police stations. 'Proposed' on the map indicates the new ATM stations selected to ensure demand points uncovered by the existing ATM locations are now covered within a travelling distance of 1.5km maximum.

Figure 8 shows that the maximum coverage model combined the existing ATM locations and also the proposed together and optimally selected the benefiting ones to the study area. It shows that some of the ATM centres along Tunga-Mobil route axis are outliers that should not be planted in their respective locations. UBA bank 1 and 2, FCMB and ASO bank are the identified outlying ATM for the purpose of this study. Meanwhile, these ATMs are located by the banks to ensure relevance and competition with other banks within their surroundings. This study recommends that these banks should form an integral part of the needed ATMs that will be planted at the new optimal locations.

From figure 9, most areas earlier marginalized are now covered within the selected travel distance. Figure 9 shows that Bosso, Kpakugun, Tundun Wada, etc. earlier marginalized as detected by the maximum coverage model are now covered using the same model with 187 demand points having access to an ATM at the 1.5km travel distance.

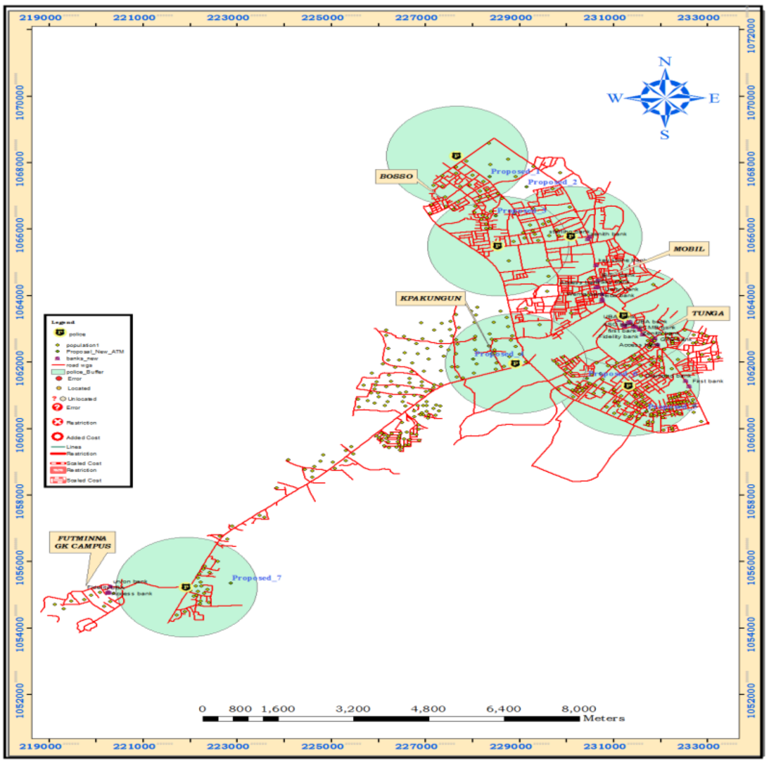

Fig. 7: Buffering around police stations

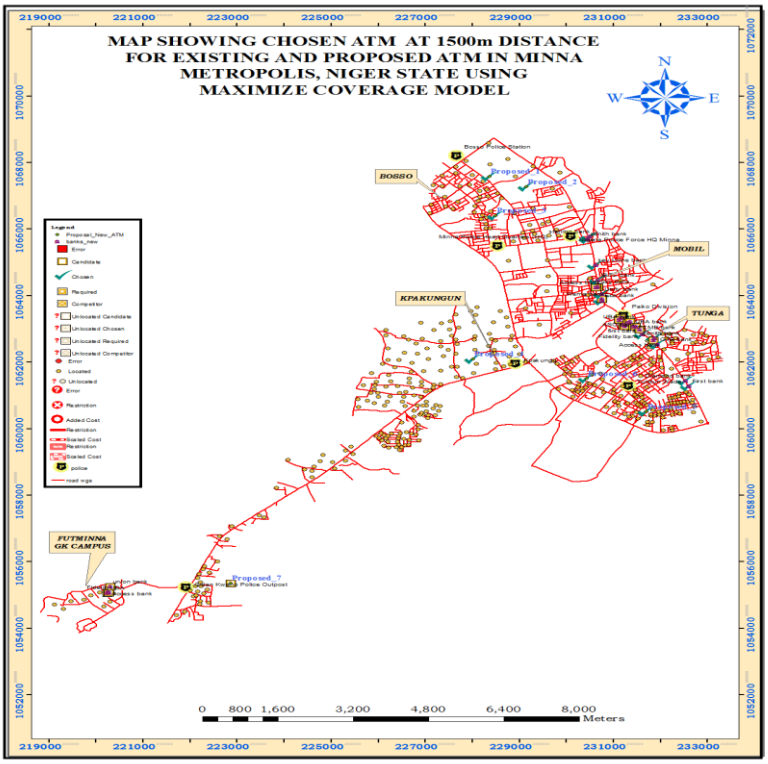

Fig. 8: Output of chosen ATMs using maximum coverage model

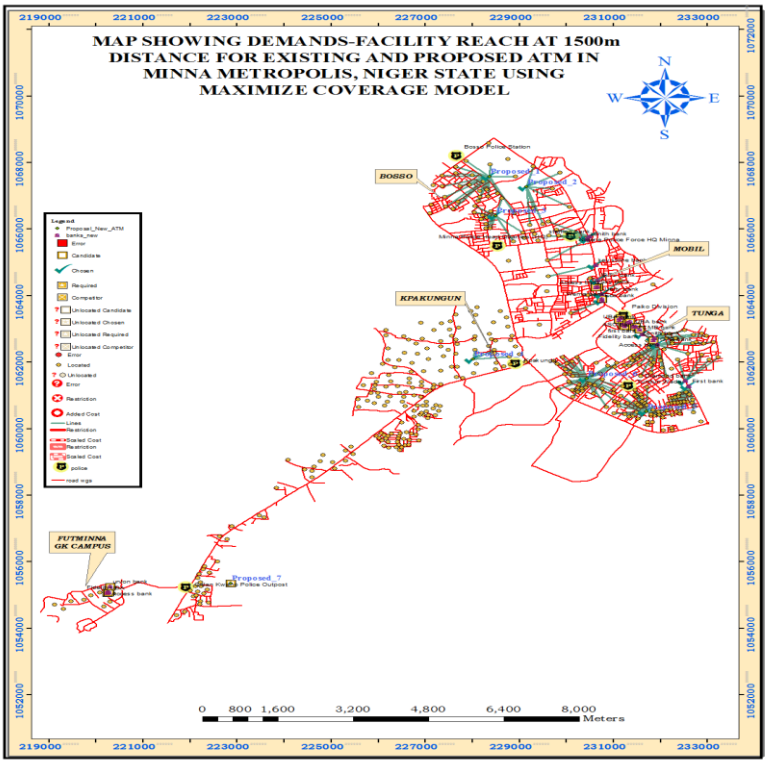

Fig. 9: Reach of demand to facility within 1500m for existing and proposed ATMs

Discussion and conclusion

From this study, ATM locations in Minna metropolis were found not to be measuring up with users or demands; this is to the effect of how wrongly these facilities have been located. Geographical Information System (GIS) is a paramount technique found very effective in solving location-allocation related problems. The study employed and examined various location models and estimated the best out of the models – Maximum coverage. However, the current situation in the study area shows that some central business districts like Kpakugun, Tundun Wadda, cannot access an ATM within the specified travel distance of 1.5km.

Based on capacity and demand information and queries generated in this work, it is evident that there is need for more ATMs. This work has proved that Banks industry in Minna Metropolis must quickly increase their developmental projects in establishing more ATMS in order to curb the upsurge in ATM inadequacy in the City and to avoid breading future hoodlums.

To this end, maximum coverage location-allocation model was employed in optimally locating the existing and proposed ATMs in the study area bearing in mind their proximity to police stations and other security agencies in the study area which is the major factor mostly considered by banks who manage this facility. This has reduced the number of marginalized demands for ATM usage and increased the efficiency of this facility in the study area hence, six new ATM centres has been proposed to ensure this is achieved.
This study further recommended the following: (i) Banks should look into those marginalized area for even distribution of ATMs facility, hence, this study can serve as a guide to ensure optimal locations (ii) Since security of ATM facility is major criteria to be considered in siting it, state government should pay attention to provision of enough security agencies at strategic locations so that more facilities can be allocated to areas that are marginalized (iii) This study should be further refined to ensure time impedance is considered and banks are made to be an integral part of the decision making.

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