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Co-Location Strategy for Mobile Telecommunication Masts of Telecommunication Companies in the Cape Coast Metropolitan Area

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Abstract

Locating a set of facilities (resources) in order to minimize the cost of satisfying some set of demands (of customers) with respect to some constraints has been under study for a long time. Several location problems have been solved using a number of mathematical models and methods. The proliferation of masts across our landscapes nowadays has been in direct response to increased desire for mobile (wireless) communication services by the public. In order to prevent chaotic building of masts or towers all over the metropolis and to placate the citizenry who are nervous about possible health and environmental impact of these masts, co-location has been widely recommended by industry experts. A number of Facility location strategies under operations research can be used to solve this problem. Factor Rating method was adopted in this paper. The goal of Factor Rating is for a mobile service provider to be able achieve its objectives by considering all relevant factors involved in deciding to site a mast. Such factors may be physical, political, environmental economical, and social. Following the strict implementation of factor rating method on mast locations in the Cape Coast metropolitan area by five mobile service providers, five optimal locations were discovered.

Keywords: Factor Rating, Location, Mast, Optimal, Telecommunication

1. Introduction

The location of any facility may have a tendency of posing both desirable and undesirable effects. There are many factors that are taking into consideration when locating a facility which may have direct or indirect effect on the settlement where it is located. Location is a branch in operation research which deals with determining the most appropriate site to locate a facility. Amponsah and Darkwa (2007) noted that, in locating a facility, one need to optimize one or more factors and it has to be accurately and mathematically measured. This will serve as scientific basis for a site to be used to locate that facility. One facility that the paper looks at is Mobile Telecommunication Masts. With the ever increasing need for broadcasting and telecommunications in this day and age, it has brought in some development in technological innovation and newness in industrial transformations. The Ministry of Communication Policy Document (2004) pointed out that Ghana has been among the leading countries in Africa in promoting telecommunication developments. According to the document, it has been so because Ghana first opened its basic telecommunications industry to private competition more than a decade ago, and it continues to be a leader among African nations in the expansion of market entry, the development of new services and business arrangements, and the growth of the telecommunications sector generally. Støttrup-Andersen (2009) observed that, in most recent times, especially within the last decades, the need for tall structures has accelerated with the requirements for effective communication especially the advent of radio, radar and television. Latest the exponential growth in the use of cellular phones has meant a new era for towers and masts, however smaller in height but larger in number. Støttrup-Andersen (2009) acknowledged that in several places where masts are sited, a number of factors are taken into consideration. He pointed out that the overall layout of telecommunication masts and towers is governed by the requirements of transmission and receiving conditions. This requirement often leads to the design of relatively tall structures or in mountainous areas or a smaller structure on the top of hills or mountains.

However there have been concerns about erection of mast in an unrestrained manner by mobile telecommunication companies. Burkson (2011), an expert in Business and Telecommunication wrote in his article that “a sure sign of maturity in the telecom sector is the rush to outsource tower management and ownership to third parties as a means of diversifying revenue and focusing on core activities. A number of countries where mobile telecommunication infrastructure has boomed have advocated sharing. These advocacies have been crafted in their telecommunication policy documents. Burkson (2011) discussed in his piece the tower business model in India and United States. He noted that In India, mobile companies invest massively in tower infrastructure. But in order to prevent chaotic building of towers all over the country and to appease the citizenry who are nervous about the radiation effects of these towers, the government has licensed one private basic

services operator (BSO) in each state to set up an independent telecom networking the state As noted by Jhunjhunwalaet al. (1998), the inter-state network and international links in India are being operated by the government-owned monopoly operator (Department of Telecommunications, DOT). Burkson (2011) indicated that in the United States also, towers are built by third parties, with American Towers and Crown Towers being the biggest players in the sector. National Communication Authority of Ghana(NCA), have indicated that in the near future only licensed companies will be allowed to build and operate new towers, with the view that the mobile networks will buy space from the newly licensed operators rather than build their own towers

In Ghana, the fast pace of globalization has attracted development in infrastructure such as mobile telecommunication mast. According to Ghana Statistical Service, Ghana's population now stands at 24,223,431 and out of that number 19,000,000 constituting 70% of the total population owns mobile phones (Business Monitor International report 2010). This means that there should be an increase in siting of mobile phone towers across the country. Dowuona (2009) stated in his article and attributed to National Communication Authority (NCA), that currently there are 3,000 plus telecom towers serving over 13 million mobile phone subscribers and according to experts in the telecommunication industry, the number of towers is woefully inadequate to assure quality service. In as much as it is inadequate, however, the haphazard manner of mast proliferation is a cause for concern.

The Cape Coast Metropolis is bounded on the south by the Gulf of Guinea, west by the Komenda / Edina / Eguafo /Abrem Municipal, east by the Abura/Asebu/Kwamankese District and to the north by the Twifu/Hemang/Lower Denkyira District. The Metropolis covers an area of 122 square kilometers and is the smallest metropolis in the country. It is also the capital of the Central Region. Cape Coast metropolis has a population of 82,291 (2000 census). It is well known for its rich cultural history and tourist attractions, hence attracts a lot of tourists(CCMA, 2011).Because of its historic and tourist attractions, the central Government has established numerous infrastructures to enable it function as such. It has benefited from modern infrastructural developments such as good urban road networks, public schools, hospitals and a lot more (CCMA, 2011). Well known educational institutions in Ghana can be found in Cape Coast Metropolis. Due to the influx of people into the place, it has also attracted some investments in the Telecommunication sector. The six major mobile communication operators in Ghana namely MTN, Airtel, Vodafone, Expresso, Tigo and Glomobile have established their presence there. The private sector mobile telecommunication companies have contributed immensely to the growth of infrastructure in the town in order to enhance their business operations. Currently, a visitor to the Cape Coast Metropolitan area cannot escape the sight of huge tall metallic slender structures (mast or towers) going up as far as 50 meters in height, and serving a purpose of cell sites for telecommunication companies. New ones are emerging every passing moment.

Ofcom (2011) pointed out that, to provide seamless coverage across an area, mobile phone network operators must erect enough masts to be in range of mobile phones most of the time. Each mast can only handle a fixed number of calls, and so multiple masts will need to be clustered in built-up areas.

Operations Research is a branch of mathematics which represents the study of optimal resource allocation. The goal of Operations research is to provide rational bases for decision making by seeking to understand the structure of complex situations, and to utilize this understanding in any way possible, in order to study and improve system performance (Heger 2006). The paper looks at a branch of study under Operations Research which looks at location in general. Amponsah and Darkwa (2007) looked at location problem to be concerning the location of one or more facilities in some space, so as to optimize some specified criteria.

In as much as it is necessary for masts to be located in various places for the purposes of telecommunications, there are legal and policy frameworks that owners of masts must adhere to.

There are institutional bodies backed by law of the state to regulate on issues relation to telecommunication masts. These are Environmental Protection Agency, National Communication Authority, Radiation Protection Board, Inter-ministerial Committee on Communications, Ghana Civil Aviation Authority, and Metropolitan, Municipal and District Assemblies .According to the Environmental Protection Agency (EPA) in Ghana, to mount a mast, a telecom operator needs separate permit from Environmental Protection Agency (EPA), metropolitan, municipal and districts assemblies in addition to written neighborhood approval from people living close to the location, where the mast would be erected." (Daily Graphic, Feb1, 2010). The National Communications Authority (NCA) and the Environmental Protection Agency (EPA) have proposed co-location of telecom towers as a licensing requirement for operators as a way of solving the problem of proliferation. The government has, indeed, asked the regulators to get tough on operators to voluntarily co-locate; some operators

had actually initiated moves towards co-location long before the government's directive, but some are also yet to implement co-location solution.

The National Communications Authority (NCA) has licensed six mobile telecommunication companies to operate in Ghana. They operate under brand names Tigo, MTN, Vodafone, Expresso, Airtel and Glomobile (Source: www.moc.gov.gh). Out of the six, one is yet to start operation as of the time of this study. It is in the light of the of the forgoing discussions as regard proliferation and co-location of telecom masts that we present this paper to examine a co- location strategy for telecommunication masts of mobile telecommunication companies in the Cape Coast Metropolitan Area. The objectives of this study are to review and assess the growing impact of telecommunication industry in the Cape Coast Metropolitan Area and associated mounting of masts. Secondly, to adopt a facility location strategy to optimal location of a mast belonging to each of the five(5) mobile telecommunication networks and finally, use the findings to determine the suitability or otherwise of a co-location possibility. Finally, make recommendations based on findings for mobile telecommunication companies, mast owners, public authorities and regulators.

2. Methodology

2.1 Data Gathered and Analysis

Both primary and secondary data was captured for the study. However, secondary data was used data analysis.

The research covered masts belonging to five licensed mobile communication companies which have sited masts in the Cape Coast Metropolis. The companies are Vodafone, Airtel, Tigo, MTN, and Expresso. All site location of masts relevant for this project was visited and assessed. Factors which influenced location of masts were observed.

Coalition of all locations was also got from various Government Agencies. This included Municipal Assembly and Environmental Protection Agency and Mobile Communication Companies in the Cape Coast Metropolis. Added to that was verification of locations by the Mobile communication companies under the research. Information about the exact location of their mast and factor which were considered relevant for the site were quizzed by the researchers.

Pre-coded, open-ended questions and interviews to solicit the data from the respondents/target group were performed. Part of the questionnaire was meant for management/staff of Mobile Telecommunication Companies to rate locations of their masts based on factors outlined. They were to rate each locationona1to10pointbasis factor to reflect its relative importance in relation to the companies objectives.

The problem of facility location for Mobile Telecommunication Masts calls for use of various location models and methods in order to obtain a solution. A number of Location models such as Factor rating, Location Break-Even Analysis, and Center of Gravity Method an be used to solve this problem.

2.2 Review of Methods

In finding optimal location of Mobile telecommunication masts for Cape Coast Metropolitan area, we settled on Factor Rating method. Factor rating method was adopted since it considers all the necessary factors (physical, economic, social, environmental and political) needed for the location of a facility such as a mobile telecommunication mast. In addition, it considers all factors which help fulfill a mobile telecommunication company's objectives.

In adopting factor rating methodology, its algorithm was followed strictly and consistently. The algorithm is as follows:

Develop a list of relevant factors.

Assign a weight to each factor to reflect its relative importance in the company's objectives.

Develop a scale for each factor. (1 to 10)

Have management or related people score each relevant factor, using the scale developed in (iii) above.

Multiply the score by the weight assigned to each factor and total the score for each location.

Make a recommendation based on the maximum point score, considering the result of qualitative approaches as well.

When a decision is sensitive to minor changes, further analysis of either the weighting the point assigned may be appropriate.

Step 5 is written mathematically as:

$$A = \sum_{i=1}^{n} \frac{w_i}{w_T} S_i$$

$$M = \max\left\{\sum_{i=1}^{n} \frac{w_i}{w_T} S_i\right\}$$

where

w_i: weight assigned to each factor

w_T: total weight

S_i: score for each factor location

A: aggregate score for each location

M: maximum among factor rating scores

Table 1: Factors considered and their rated weights

Factor	Factor Name	Rating Weight
1	Community Consultation and Desirability	0.3
2	Utility(Electricity and Water Source) availability and cost	0.2
3	Co-location Feasibility	0.2
4	Population density and economic activity	0.3
5	Geological Nature of the Site	0.3
6	Directions for various directional antennas	0.3
7	Future maintenance and expansion	0.2
8	Available ground area and access to the site	0.2

Source: Field Data, November 2011

3. Results and Discussion

Mast locations of five mobile telecommunication operators in Cape Coast Metropolis as of the time of this study were noted. That is Airtel, Vodafone, Tigo, MTN, and Expresso. Tables below illustrates how data was analyzed using Factor Rating.

3.1 Mast Locations - Airtel Ghana, Cape Coast Metropolis

Mobile Phone Masts belonging to Airtel Ghana in the Cape Coast Metropolis have been sited in six (7) locations. These locations are presented in Table 2.Management/Staff of Airtel Ghana Ltd, Cape Coast branch was then given a questionnaire to rate each location on a 1 to 10 point basis. Perceive from Tables 3 and 4, the location ratings and the computations of the score ratings respectively.

Clearly from the respective aggregate scores, location E or site E has the highest aggregate. Hence that location may be recommended or sitting of additional telecommunication equipment and probable co-location consideration.

3.2 Mast Locations - Vodafone Ghana, Cape Coast Metropolis

Mobile Phone Masts belonging to Vodafone in the Cape Coast Metropolis were sited in six(6) locations. See the results in Table 5. Management of VODAFONE Ghana Ltd, Cape Coast branch was then given a questionnaire to rate each location on a 1 to 10 point basis (See Table 6).

It is very obvious from the respective aggregate scores as given in Table 7 that site C would be recommended since it has the highest aggregate. Hence that location may be recommended for sitting of additional telecommunication equipment and probable co-location consideration.

3.3 Mast Location- Tigo Ghana Ltd, Cape Coast

Mobile Phone Masts belonging to Tigo, Cape Coast Metropolis are in eleven (11) locations. However the 11th Mast location at Bakaano is yet to be completed as of the time of this study. We have summarized the results of these sites in Table 8. Management of TIGO Ghana Ltd, Cape Coast branch was then given a questionnaire to rate each location on a one (1) to ten (10) point basis as illustrated in Table 9.

It can be deduced from the respective aggregate scores, as shown by computations in Table 10 that location A is to be recommendable since it has the highest aggregate score rating. Hence that location may be recommended for sitting of additional telecommunication equipment and probable co-location consideration.

3.4 Mast Location- MTN Ghana Ltd, Cape Coast

Mobile Phone Masts belonging to MTN, Cape Coast Metropolis are in fourteen (14) locations. Observe these locations as presented in Table 11. Management and related people of MTN Ghana Ltd, Cape Coast branch was then given a questionnaire to rate each location on a 1 to 10 point basis. The results of these sites are summarized in Table 12. However, Table 13 demonstrates the results of the computations of the aggregate score ratings.

Infer from Table 13 that site M would be recommended since it has the highest aggregate. Hence that location may be recommended for sitting of additional telecommunication equipment and probable co-location consideration.

3.5 Mast Locations - Expresso Ghana, Cape Coast Metropolitan

Mobile Phone Masts belonging to Expresso in the Cape Coast Metropolis has been located in one(1) location. Table 14 summarizes the results of this site. Table 15 illustrates the results of the questionnaire given to Management or staff of Expresso at the Cape Coast branch to rate each location on a 1 to 10 point basis.

From the aggregate scores (infer from Table 16), location A, which is the only site would be recommended since it has the highest aggregate. Hence that location may be recommended for sitting of additional telecommunication equipment and probable co-location consideration.

4. CONCLUSION AND RECOMMENDATIONS

The results obtained indicate that location E as the optimum location for Airtel, for Vodafone, location C, for Tigo, location A, MTN and Expresso have locations M and A respectively as optimum (see Table 17).

The aim of factor rating method is for a firm to be able to achieve their objectives by taking a total view of all relevant factors which directly or indirectly affect their operations. By so doing a positive strategic decision is eventually arrived at in location a facility. The most technical or economically convenient reasons for mounting a mast at a particular location may not be ideal when juxtaposed or compared with possible environmental impact as well as other factors combined. For telecommunication masts, decisions that can be made include relocation of existing mast, mounting of additional telecommunication equipment on existing mast, sharing of telecommunication equipment, investment by third party telecommunication companies such as erection of mast and telecommunication services, and finally, consideration for co-location by telecom owners.

As customers need access to mobile telecommunication services, it will be most beneficial if telecommunication facilities that makes access to these services possible, that is, masts, are sited close to the customers. Investors willing to enter into the telecom sector can easily do so since they can utilize existing infrastructure instead of setting up new infrastructure from the scratch. New entrants in the sector will be relieved of huge initial startup cost in building new infrastructure.

Conclusively, our paper revealed optimal location of masts belonging to mobile telecommunication companies in the Cape Coast metropolis. By adopting a Facility location model, that is Factor rating, five mast locations were found to be optimally located. These locations are ideal candidates for implementation of a co-location strategy by stakeholders.

In view of the findings the paper recommends the following:

i. Independent of mobile telecommunication companies must be tasked to erect masts, so that the mobile

telecommunication companies can engage in core business, thereby maximizing revenue. National Communication Authority (NCA) must enforce that directive.

ii. New entrants wanting to operate as mobile telecommunication service providers must share already existing telecom infrastructure so as to reduce initial startup cost.

iii. Mast owners may adopt this approach in managing their mast locations, be it erecting of new masts which can house as many telecommunication equipment as possible or relocation of existing masts.

iv. Mobile telecommunication mast/tower design must have the capacity to accommodate at least three service providers.

v. In as much as the factors used in this study were carefully selected, additional factors may also be considered with weights base on relative objectivity of a researcher.

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Table 2: Mast Locations in the Cape Coast Metropolis, Airtel Ghana

NO	COMPANY	COMMUNITY	LOCATION	ALIAS
1	AIRTEL	KOKOADO	OPPOSITE THE SEA ADJACENT CAPE VARS	A
2	AIRTEL	SEIWIN –NANABA	SEIWIN NEAR CPOLY	B
3	AIRTEL	KWAPROW	NR ACHIMEDES SCH	C
4	AIRTEL	PEDU ESTATE	OPP. PRESBY CHURCH, ALONG REG. HOSPITAL RD.	D
5	AIRTEL	ASHANTI ROAD	SOC. WELFARE REG. OFFICE	E
6	AIRTEL	OLA	BESIDE WOODEX INT. HOSTEL /CNC	F
7	AIRTEL	AMAMOMA	NEAR METHODIST CHURCH BUILDING	G

Source: Field Data, November 2011

Table 3: Location rating by Management of on a 1-10 point basis, Airtel Ghana

			Locations						
Factor	Factor Name	Rating Weight	A	B	C	D	E	F	G
1	Comm. Cons/Desir.	0.3	9	9	10	8	10	7	10
2	Uitility and Cost	0.2	8	5	8	9	9	8	8
3	Co-location Feasibility	0.2	5	6	7	6	5	3	5
4	Pop. Density/ Activity	0.3	9	8	9	7	10	7	10
5	Geological Nature	0.3	7	8	8	7	7	10	8
6	Directions for Antenna	0.3	8	8	7	8	10	10	9
7	Future maint &Expan	0.2	7	7	10	6	8	9	7
8	Ground Area Avail.	0.2	8	7	8	10	9	6	8

Source: Field Data, November 2011

Table 4: Score rating and Computation of aggregate

				LOCATIONS						
Factor	Factor Name	Rating Weight	Ratio of Weight	A	B	C	D	E	F	G
1	Comm. Cons/Desir.	0.3	0.15	1.35	1.35	1.5	1.2	1.5	1.05	1.5
2	Uitility and Cost	0.2	0.1	0.8	0.5	0.8	0.9	0.9	0.8	0.8
3	Co-location Feasibility	0.2	0.1	0.5	0.6	0.7	0.6	0.5	0.3	0.5
4	Pop. Density/ Activity	0.3	0.15	1.35	1.2	1.35	1.05	1.5	1.05	1.5
5	Geological Nature	0.3	0.15	1.05	1.2	1.2	1.05	1.05	1.5	1.2
6	Directions for Antennas	0.3	0.15	1.2	1.2	1.05	1.2	1.5	1.5	1.35
7	Future maint &Expan	0.2	0.1	0.7	0.7	1	0.6	0.8	0.9	0.7
8	Ground Area Avail.	0.2	0.1	0.8	0.7	0.8	1	0.9	0.6	0.8
			Total Score	7.75	7.45	8.4	7.6	8.65	7.7	8.35

Source: Field Data, November 2011

Table 5: Mast Locations in the Cape Coast Metropolis, Vodafone.

No	COMPANY	COMMUNITY	LOCATION	ALIAS
1	VODAFONE	AYEKO AYEKOO	OPPOSITE DANCE P	A
2	VODAFONE	AYEKO AYEKOO	OPPOSITE DANCE P	B
3	VODAFONE	NANABAKROM	NR MOSQUE	C
4	VODAFONE	NANABAKROM	OPPOSITE MUSTARD SEED COMPANY CO. LTD	D
5	VODAFONE	AMAMOMA	NR STERNER STUDENTS HOSTEL	E
6	VODAFONE	EFUTU	OPPOSITE EFFUTU SEC. TEC. SCH	F

Source: Field Data, November 2011

Table 6: Location Rating by Management on a 1-10 point basis, VODAFONE Ghana

			Locations					
Factor	Factor Name	Rating Weight	A	B	C	D	E	F
1	Comm. Cons/Desir.	0.3	8	8	9	9	8	5
2	Utility and Cost	0.2	10	10	6	7	10	7
3	Co-location Feasibility	0.2	7	7	8	8	6	7
4	Pop. Density/Activity	0.3	10	10	9	7	10	8
5	Geological Nature	0.3	10	10	9	9	8	10
6	Directions for Antenna	0.3	9	9	10		9	9
7	Future maint &Expan	0.2	8	8	10	9	7	8
8	Ground Area Avail.	0.2	5	5	7	7	8	6

Source: Field Data, November 2011

Table 7: Score rating and computation of aggregate

				LOCATIONS-VODAFONE MASTS					
Factor	Factor Name	Rating Weight	Ratio of Weight	A	B	C	D	E	F
1	Comm. Cons/Desir.	0.3	0.15	1.2	1.2	1.35	1.35	1.2	0.75
2	Utility and Cost	0.2	0.1	1	1	0.6	0.7	1	0.7
3	Co-location Feasibility	0.2	0.1	0.7	0.7	0.8	0.8	0.6	0.7
4	Pop. Density/Activity	0.3	0.15	1.5	1.5	1.35	1.05	1.5	1.2
5	Geological Nature	0.3	0.15	1.5	1.5	1.35	1.35	1.2	1.5
6	Directions for Antenna	0.3	0.15	1.35	1.35	1.5	0	1.35	1.35
7	Future maint &Expan	0.2	0.1	0.8	0.8	1	0.9	0.7	0.8
8	Ground Area Avail.	0.2	0.1	0.5	0.5	0.7	0.7	0.8	0.6
			Total Score	8.55	8.55	8.65	6.85	8.35	7.6

Source: Field Data, November 2011

Table 8: Mast Locations in the Cape Coast Metropolis, Tigo.

No	COMPANY	COMMUNITY	LOCATION	ALIAS
1	TIGO	ASHANTI ROAD	COMM DEVT REG OFFICE,	A
2	TIGO	AKYIM	HOLY CHILD BUNGALOW	B
3	TIGO	EWIM	BEHIND GBC OFFICES	C
4	TIGO	4TH RIDGE	LAGOON VIEW HOSTEL	D
5	TIGO	ANTEM	KINGDOM HALL OF JAH. WITHNESSES	E
6	TIGO	AMISSANO	BESSAKROM	F
7	TIGO	UCC	BEHIND CASFORD HALL	G
8	TIGO	OLA	OLA TRAINING COLLEGE	H
9	TIGO	ESUEKYIR	BEHIND WINNERS CHAPEL	I
10	TIGO	AMAMOMA	NR FLORENCE HOSTEL	J
11*	TIGO	BAKAANO	NR PHILIP QUARQOE	K

Source: Field Data, November 2011

Table 9: Location Rating by Management on a 1-10 point basis, Tigo Ghana

			TIGO LOCATIONS										
Factor	Factor Name	Rating Weight	A	B	C	D	E	F	G	H	I	J	
1	Community Consultation and Desirability	0.3	9	7	8	6	10	5	8	6	9	10	6
2	Uitility availability and cost	0.2	8	9	6	8	7	7	6	7	7	6	7
3	Co-location Feasibility	0.2	10	10	7	8	5	7	5	5	10	8	8
4	Population density and economic activity	0.3	9	8	4	9	8	8	6	4	10	10	4
5	Geological Nature of the Site	0.3	10	5	8	6	8	10	7	5	5	6	9
6	Directions for various directional antennas	0.3	9	9	6	9	7	8	7	6	6	7	8
7	Future maintenace and expansion	0.2	8	8	8	9	6	8	8	5	9	5	5
8	Available ground area and access to the site	0.2	5	9	10	8	10	6	9	10	6	7	6

Table 4.9: Rated Weights (Source: Field Data; November 2011)

Table 10: Score rating and Computation of aggregate

Factor	Factor Name	Rating Weight	Ratio of Wt.	A	B	C	D	E	F	G	H	I	J	K
1	Comm. Consult. and Desirability	0.3	0.15	1.35	1.05	1.2	0.9	1.5	0.75	1.2	0.9	1.35	1.5	0.9
2	Uitili. and cost	0.2	0.1	0.8	0.9	0.6	0.8	0.7	0.7	0.6	0.7	0.7	0.6	0.7
3	Co-location Feasibility.	0.2	0.1	1	1	0.7	0.8	0.5	0.7	0.5	0.5	1	0.8	0.8
4	Pop.density and economic activity	0.3	0.15	1.35	1.2	0.6	1.35	1.2	1.2	0.9	0.6	1.5	1.5	0.6
5	Geological Nature of the Site	0.3	0.15	1.5	0.75	1.2	0.9	1.2	1.5	1.05	0.75	0.75	0.9	1.35
6	Directions for various directional antennas	0.3	0.15	1.35	1.35	0.9	1.35	1.05	1.2	1.05	0.9	0.9	1.05	1.2
7	Future maintenace and expansion	0.2	0.1	0.8	0.8	0.8	0.9	0.6	0.8	0.8	0.5	0.9	0.5	0.5
8	Available ground area and access to the site	0.2	0.1	0.5	0.9	1	0.8	1	0.6	0.9	1	0.6	0.7	0.6
			Total Score	**8.65**	**7.95**	**7**	**7.8**	**7.75**	**7.45**	**7**	**5.85**	**7.7**	**7.55**	**6.65**

Table 11: Mast Locations in Cape Coast, MTN Ghana

No	COMPANY	COMMUNITY	LOCATION	ALIAS
1	MTN	BAKAANO	PHILIP QUAICOE BASIC SCH	A
2	MTN	ASHANTI ROAD	COMM. DEVT REG. OFFICE	B
3	MTN	EWIM	BEHIND GBC OFFICES	C
4	MTN	4TH RIDGE	LAGOON VIEW HOSTEL	D
5	MTN	ADISADEL ESTATE	SHC OFFICE COMPOUND	E
6	MTN	PEDU NGUABADO	NEAR CAPE TECH	F
7	MTN	ABURA	NEAR OLD CEMETARY	G
8	MTN	EYIFUA	NEAR GNAT HALL	H
9	MTN	KAKOMDO	BEHIND EMPART GAS	I
10	MTN	UCC	BEHIND CASFORD HALL	J
11	MTN	AMAMOMA	OPP. AYENSU PLAZA HOSTEL	K
12	MTN	AMAMOMA	ROUND PALACE HOSTEL	L
13	MTN	AMAMOMA	AFEDZI HOUSE COMPOUND	M
14	MTN	EFUTU	OPP. FUEL STATION	N

Source: Field data, November 2011

Table 12: Location Rating by Management on a 1-10 point basis, MTN Ghana.

			MTN LOCATION													
Factor	Factor Name	Rating Weight	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Comm. Consult.& Desirability	0.3	4	10	9	5	10	10	7	9	8	10	6	10	7	9
2	Uitility and cost	0.2	8	8	10	8	7	7	9	8	7	6	7	5	10	8
3	Co-location Feasibility	0.2	10	6	7	6	5	8	8	5	10	8	8	5	8	9
4	Population densit and eco. activity	0.3	9	6	5	8	8	8	8	4	10	6	4	10	9	9
5	Geological Nature of the Site	0.3	5	8	8	9	8	10	5	5	5	6	9	10	10	9
6	Directions for various directional antennas	0.3	5	7	7	10	7	7	6	6	6	8	7	10	6	5
7	Future maintenace and expansion	0.2	10	8	9	5	6	7	8	5	9	9	10	5	9	9
8	Available ground area and access to the site	0.2	5	9	6	10	10	6	5	8	10	8	6	5	9	7

Table 13: Score rating and Computation of aggregate

				LOCATIONS- MTN MAST													
Factor	**Factor Name**	**Rating Weight**	**Ratio of Weight**	**A**	**B**	**C**	**D**	**E**	**F**	G	H	I	J	K	L	M	N
1	Community Consult.& and Desirability	0.3	0.15	0.6	1.5	1.35	0.75	1.5	1.5	1.05	1.35	1.2	1.5	0.9	1.5	1.05	1.35
2	Uitility and cost	0.2	0.1	0.8	0.8	1	0.8	0.7	0.7	0.9	0.8	0.7	0.6	0.7	0.5	1	0.8
3	Co-location Feasibility	0.2	0.1	1	0.6	0.7	0.6	0.5	0.8	0.8	0.5	1	0.8	0.8	0.5	0.8	0.9
4	Population density and economic activity	0.3	0.15	1.35	0.9	0.75	1.2	1.2	1.2	1.2	0.6	1.5	0.9	0.6	1.5	1.35	1.35
5	Geological Nature of the Site	0.3	0.15	0.75	1.2	1.2	1.35	1.2	1.5	0.75	0.75	0.75	0.9	1.35	1.5	1.5	1.35
6	Direct.for various directional antennas	0.3	0.15	0.75	1.05	1.05	1.5	1.05	1.05	0.9	0.9	0.9	1.2	1.05	1.5	0.9	0.75
7	Future maint. and expansion	0.2	0.1	1	0.8	0.9	0.5	0.6	0.7	0.8	0.5	0.9	0.9	1	0.5	0.9	0.9
8	Available ground area and access to the site	0.2	0.1	0.5	0.9	0.6	1	1	0.6	0.5	0.8	1	0.8	0.6	0.5	0.9	0.7
	Total Score			**6.75**	**7.75**	**7.55**	**7.7**	**7.75**	**8.05**	**6.9**	**6.2**	**7.95**	**7.6**	**7**	**8**	**8.4**	**8.1**

Table 14: Location of Masts belonging to Expresso In the Cape Coast Municipality.

No	COMPANY	COMMUNITY	LOCATION
1	EXPRESSO	IST RIDGE	BEHIND REGIONAL COORD RESIDENCE

Table 15: Rated Weights and 1 to 10 point table of Factors

Factor	Factor Name	Rating Weight	Location A
1	Community Consultation and Desirability	0.3	8
2	Uitility availability and cost	0.2	8
3	Co-location Feasibility	0.2	10
4	Population density and economic activity	0.3	9
5	Geological Nature of the Site	0.3	8
6	Directions for various directional antennas	0.3	6
7	Future maintenance and expansion	0.2	8
8	Available ground area and access to the site	0.2	9

Table 16: Score rating and Computation of aggregate rating Scores

Factor	**Factor Name**	**Rating Weight**	**Ratio of Weight**	**Location A**
1	Community Consultation and Desirability	0.3	0.15	1.2
2	Utility availability and cost	0.2	0.1	0.8
3	Co-location Feasibility	0.2	0.1	1
4	Population density and economic activity	0.3	0.15	1.35
5	Geological Nature of the Site	0.3	0.15	1.2
6	Directions for various directional antennas	0.3	0.15	0.9
7	Future maintenance and expansion	0.2	0.1	0.8
8	Available ground area and access to the site	0.2	0.1	0.9
			Total Score	**8.15**

Table 17: Optimal locations found using Factor Rating method

Telco	**Optimal site**	**Location Name**	**Community**
AIRTEL	E	SOC. WELFARE REG. OFFICE	ASHANTI ROAD
VODAFONE	C	NR MOSQUE	NANABAKROM
TIGO	A	COMM DEV'T REG OFFICE	ASHANTI ROAD
MTN	M	AFEDZI HOUSE COMPOUND	AMAMOMA
EXPRESSO	A	BEHIND REGIONAL COORD RESIDENCE	IST RIDGE