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Physiographic hindrance in the development of mobile network frequency: A case study of Eritrea, Africa

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Abstract

Eritrea is one of the most geographically diverse countries characterised by a chain of mountains, rift valleys, escarpments, and coastal plain areas. In this country, the mobile network is being functioned through Base Transceiver Station (BTS). The mobile network affected by the geographically-diversified and technically poor mechanism of the country. That leads to the use of 2.5 mobile generation and frequency problems. Economically it is not viable for the country to connect the local connection through fibre optical or satellite. In this paper, an analysis has been made to show how the physiographic, climatic, and technical factors are negatively affecting customer`s satisfaction. It also analyses the percentage of users Zoba (province) wise and BTS Zoba wise over space and time. Consequently, suggestions have also been offered to overcome these problems. This is high time to think positively and make digitally advance by modifying the restricted rules of the country.

Key Words: *Mobile; frequency; BTS (Base Transceiver Station); digitally backward; Eritrea.*

Introduction

Mobile phone networks have been in operation for about 36 years. First introduced in Europe and Japan and in the U.S. in 1983, they have spread throughout the world in the past 10-15 years. Since May 2002, mobile (cellular) telephone started in this country is an example of a new product that has significantly affected how people live lives. At that time the effect of mobile networks was largely limited only to well-off countries. Penetration is now rapidly increasing even in quite poor countries.

This is an instrument that sends and receives voice messages and data. Telephones convert speech and data to electrical energy, which is sent great distances. Modern technology has made the telephone much more portable, convenient, and versatile. Lightweight, easily handheld cell phones make it possible to call and receive calls at any point of time and as well as any point of the place. Mobile now links with radio, Internet, and satellite services as part of global telecommunications (Adachi 2001).

Mobile has also been recognized for its expected ability to diminish the "digital divide." Defined as the division between those who have real access to and are effectively using information and communications technology (ICT), the digital divide is considered to separate countries into the "haves" (largely comprising developed nations) versus the "have nots" (mostly developing countries) (Bagchi 2005; Hill and Dhanda 2004).

Mobile plays a vital role in business and the economy, as well as in the personal and family lives of individuals. Mobiles also save lives and provide security by making it possible to summon help quickly in emergency and contact law enforcement or medical services. Mobile has other uses that do not involve one person talking to another. Instead, an automated menu can allow a caller to pay bills, obtain pre-recorded information, or retrieve messages from an answering machine.

Objectives of the study

1. To find out the problems faced by the people regarding the mobile frequency network.
2. To examine the geographical causes that affect the distributional pattern of the mobile network.
3. To analyze the geographical factors affecting mobile frequency regardless of time and space.
4. To measure how one Base Transceiver Station (BTS) is connected to other BTS station and being sparsely, and inclination problem of it creates gap leading to weaker mobile frequency.
5. To compare the level of governmental efforts toward customer satisfaction.

Database and methodology

Most of the resources that are helpful for my research were not directly available, In order to accomplish the task of this research, primary data have been collected through a field survey by making interviews with the officials of telecommunication service and also by interviewing the subscribers of the EriTel in order to know the satisfaction levels of customer and government efforts to facilitate the customers (telephone holders).

Secondary data have been gathered from the existing sources which have been undertaken by other researchers and published and unpublished documents. Data have also been gathered from different websites. In order to understand the emergence of mobile telephones worldwide; different magazines, journals, and pamphlets have also been studied. Further computer cartographic methods have been adopted to show the trend of mobile development. Zoba (Provinces) wise distributional pattern and percentage of mobile customers have been shown by bar diagrams. Phase wise development of Base Transceiver Station (BTS) has also been shown by the GIS map.

Area of the study

Eritrea is a small country in the east of Africa with diversified physical features and climatic conditions which vary from place to place with changing altitude (fig. 2). Its latitudinal extension is between 18º 02’ (Rasdumera) and 12º 02’ north (Ras keisar) and longitudinal position is between 36º 25’ 21’’ east to 43º 13’ east. It is bounded by the Red Sea in the east, the republican of Djibouti in the southeast, Ethiopia on the south, and Sudan on the west and north. This strategic position accords Eritrea a dominant position because it commands the sea route between the straits of Bab el Mendeb on the southern tip of the red sea which serves as a gateway to the Indian Ocean, and the Suez Canal in the north which leads to the Mediterranean Sea (fig. 1). Most commercial lines directed to Europe and the Mediterranean region from the Persian Gulf, East Africa, and Asia must pass through the Red sea. Thus, all kinds of commercial activities are intimately connected with the strategic utility of the Red Sea region, in which Eritrea plays a major role (Grove 1970).

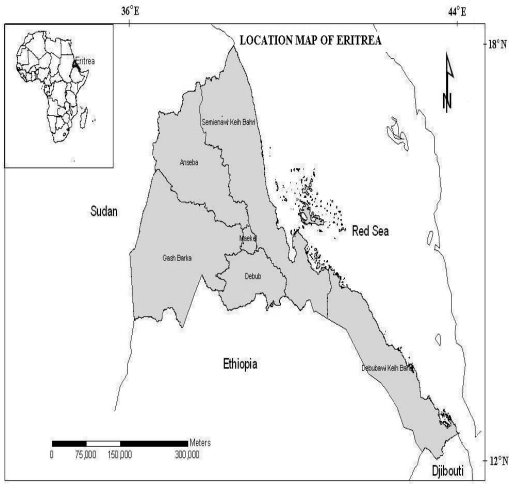

Fig. 1: Location Map of Eritrea

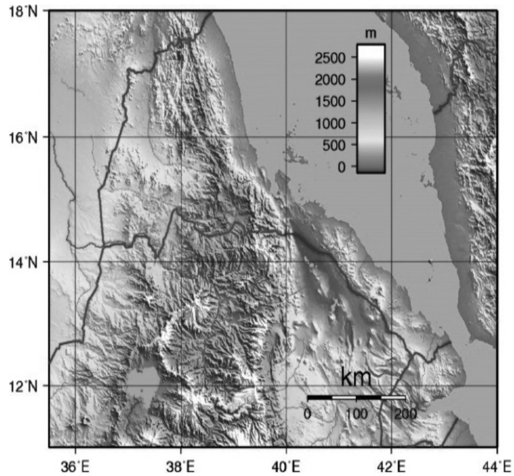

Fig. 2: Physiography of Eritrea

Mobile Network of Africa

The sharp growth in average subscriptions experienced across all African nations is now starting to cool off; it remains steady above 10 percent. As of 2012, 74 out of every 100 inhabitants on the continent have a mobile phone. But in the country of Eritrea and Somalia, the percentages of subscriptions are less than 20 percent. Continued political fragility in Somalia might have been the reason for poor performance in this measure, and with no political stability in sight, the low mobile penetration is expected to continue.

The growth of mobile phones across Africa has shown a strong positive correlation with population density, but other factors matter as well. The mobile phone coverage and geographic characteristics (Buys *et.al*, 2009) find that the probability of having a mobile phone tower in a particular location is strongly and positively associated with potential demand factors, such as population density and per capita income, as well as the competitiveness of the mobile phone sector within the country. In the country of Eritrea, reasons are to be found out as analysed in the succeeding paragraphs. The percentage of the mobile telephones to the total population reflects human development. Higher the percentage of customers having a mobile telephones, more developed is the economy and vice versa.

Mobile Phone Coverage in Africa

Figure 3 shows that mobile phone coverage in Africa has grown at staggering rates over the past decade. In 1999, only 10 percent of the African population had mobile phone coverage, primarily in North and South Africa (GSMA 2009). By 2008, 60 percent of the population (477 million people) had mobile phone coverage, and an area of 11.2 million square kilometers had mobile phone service-equivalent to the United States and Argentina combined. Only a handful of countries – Guinea Bissau, Ethiopia, Mali, Somalia, and Eritrea have relatively unconnected (GSMA 2008).

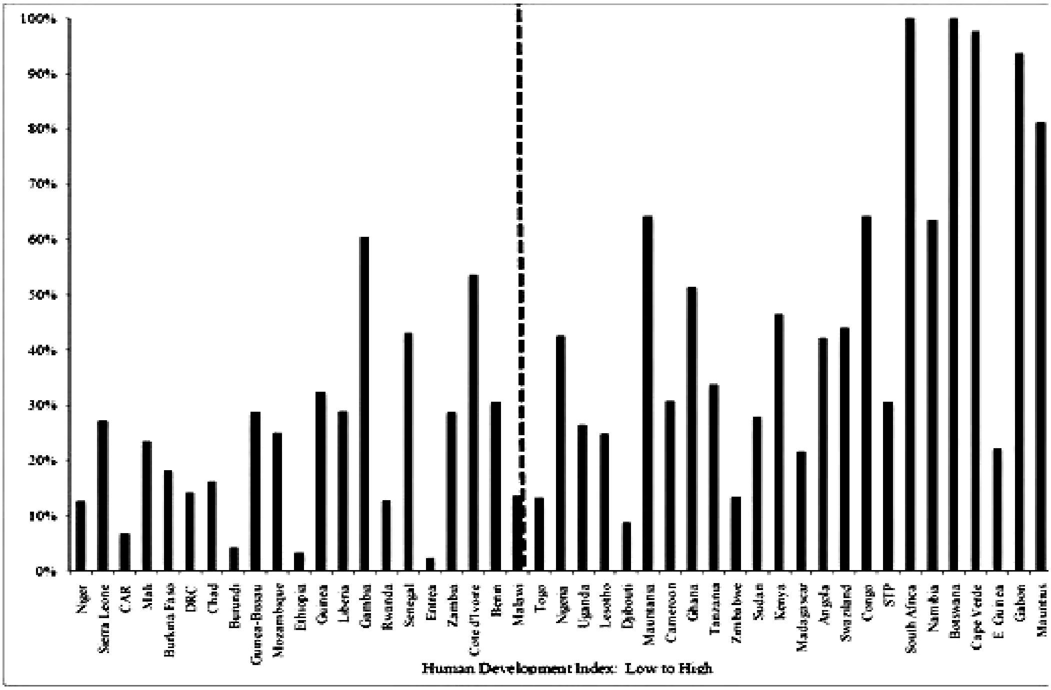

Fig. 3: Number of Mobile Phone Subscribers as a percentage of the Population 2008.

Note: Data on the number of Mobile Phone subscribers by country is provided by Wireless Intelligence. The graph reflects the percentage of Mobile Phone subscribers as a function of the total population in the countries in 2008. Countries are sorted by descending order by ranking on the UN's Human Development Index, from a high of 74 (Mauritius) to 179 (Sierra Leone).

Source: Human Development Index 2009

There have been huge disparities in the geographic rollout of this coverage, prompting concerns over an intra-African digital divide (International Telecommunication Union 2008). In 1999, most African countries had no mobile phone coverage, and only Egypt, Morocco, Senegal, and South Africa had coverage rates of over 40 per cent. By 2008, however, over 65 percent of the African population had access to mobile phone coverage, with 93 percent in North Africa (Algeria, Egypt, Libya, Morocco, and Tunisia) and 60 percent in sub-Saharan Africa. Overall, the expansion of mobile phone coverage has been the lowest in Ethiopia, Somalia, Eritrea and the landlocked countries of Central and West Africa.

Mobile Network of Eritrea

EriTel initiated GSM mobile service in Eritrea during the first week of November 2003. Subsequently, the (GSM) network became operational on March 22, 2004 with 18 BTS. Eritrea is the least developed nation in the sub- Saharan part of the African continent. Here mobile network connection is neither connected with fibre wires nor satellites. Satellite mobile connection is devoid due to the non-affordable economic condition of the country. Only for an international call, satellite connection is being exercised. Inside the country, a mobile network connection is connected through BTS. The BTS is facing physiographic problems.

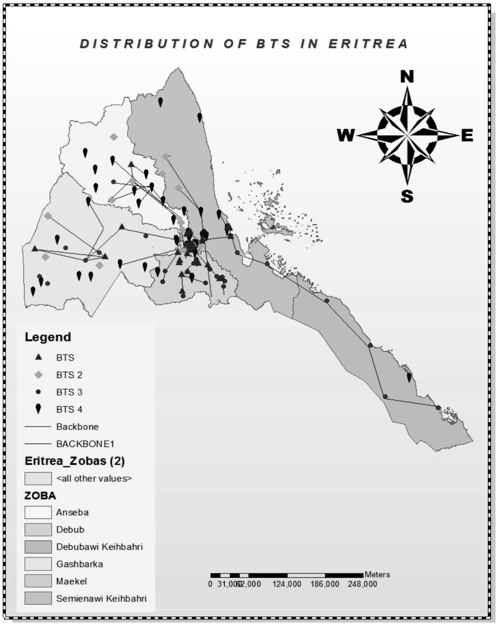

Fig.4: Distribution of BTS

BTS TOWERS

Fig.5: A View of BTS

Table.1 Phase Wise Distribution of BTS in each Zoba

Zoba	Phase 1 2004-2008	Phase 2 2008-2011	Phase 3 2011-2014	Phase 4 2015-onward	Total No. of BTS
Zoba Maekel	14	9	4	6	33
Zoba Northern Red Sea	6	4	4	9	23
Zoba Debub	9	0	10	2	21
Zoba Gash Barka	3	3	5	9	20
Anseba	1	4	1	12	18
Zoba Southern Red Sea	-	-	4	1	5
Zoba Total	33	20	28	39	120

Source: Eritel office 2015

Table 1 reveals that Zoba Maekel has the largest number of BTS because of a greater number of subscribers and urban land use having high rise buildings which act as obstacles to the frequency of mobile. Since the capital city is located in this Zoba, it is expected to have more mobile frequency. Lowest numbers of BTS have been noted in the Southern Red Sea. It is to be pointed out that the southern Red Sea Zoba is vulnerable to be attacked by outsiders that resulted to have less number of BTS. The second highest number of BTS has been noted in the Northern Red Sea followed by Debub (*i.e.*, 21), Gash Barka (*i.e.*, 20), Anseba (*i.e.*, 18).

Distribution of BTS (2004-2014)

At the beginning of the installation of BTS and its related equipment and technology, the capacity of the first switch had a limited capacity of 100,000 lines. It had outstanding shortage and drawbacks. To overcome all the shortfalls, the corporation (Eritel) replaced the existing switch with a new one having 400,000 lines upgradable to 1000,000 lines and with advanced features. Currently, the number of customers is close to 412,000. So there is still the possibility of adding more customers.

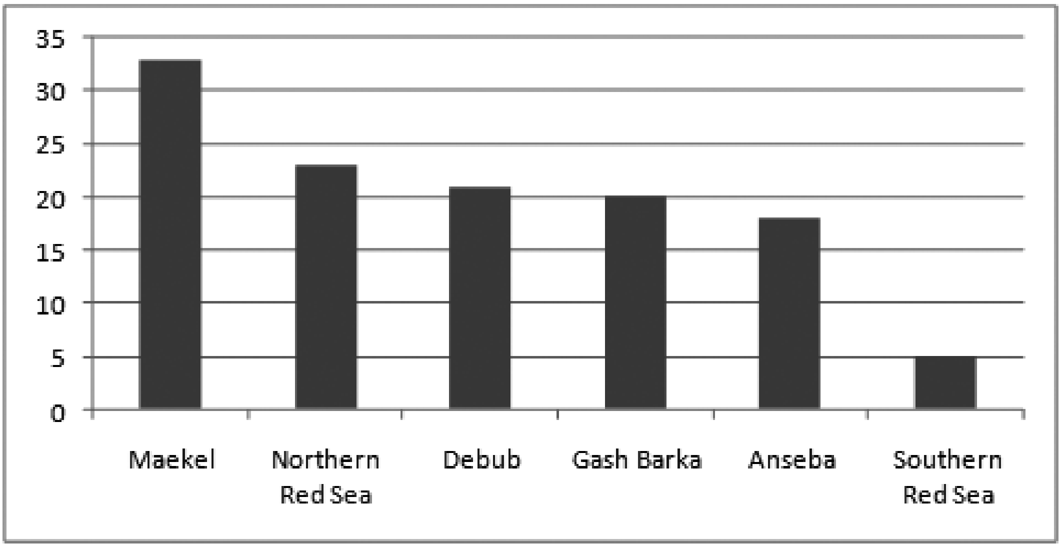

Fig.6: Distribution of BTS in All Zobas (2004-2014)

Generally, there is an increment of subscribers of mobile customers since 2004. Table 2 shows such an increment of subscribers every two years from 2004 till 2015 for different Zobas.

Table 2. Growth and Percentage of Subscribers from 2004–2015

Centre/ Region	2004-2006	2006-2008	2008-2010	2010-2012	2012-2014	2014-2015	Total no of subscribers	% of subscribers
Maekel	16,698	21,039	28,403	35,220	40,503	43,126	184,989	45
Debub	7250	9,425	12,726	17,816	26,724	33,672	107,613	26
Anseba	4,350	5,002	6,000	7,803	10,925	13,110	47,190	11
Gash Barka	3,502	4,200	5,250	6,825	9,213	10,595	39,583	10
Northern Red Sea	2,535	2,915	3,498	4,547	6,594	7,913	28,002	7
Southern Red Sea	_	_	1000	1200	1560	1794	5,554	1
Total	34,334	42,581	56,877	73,411	95,519	110,210	412,931	100

Source: Eritel Office 2015

The table illustrates that the number of subscribers widely differ from one Zoba to another in decreasing order. The highest percentage of mobile customers are found in Zoba Maekel (*i.e.,*45 %) with most BTS too. Zoba Debub is second in terms of percentage of customers (*i.e.*, 26 %), followed by Zoba Anseba (*i.e.*, 11 %), Zoba Gash Barka (*i.e.*, 10 %), northern Zoba Red Sea (*i.e.*, 7%). The least number of customers have been noticed in Zoba Southern Red Sea (*i.e.*, 1%). This Zoba has not only fewer subscribers, but also the least number of BTS. It is economically viable for the government to install more BTS in areas of the greater number of customers. So dense BTS installation match with dense population. Mobile customers are unsatisfied because of connection problems that also leads to irritation and anguish to the customers.

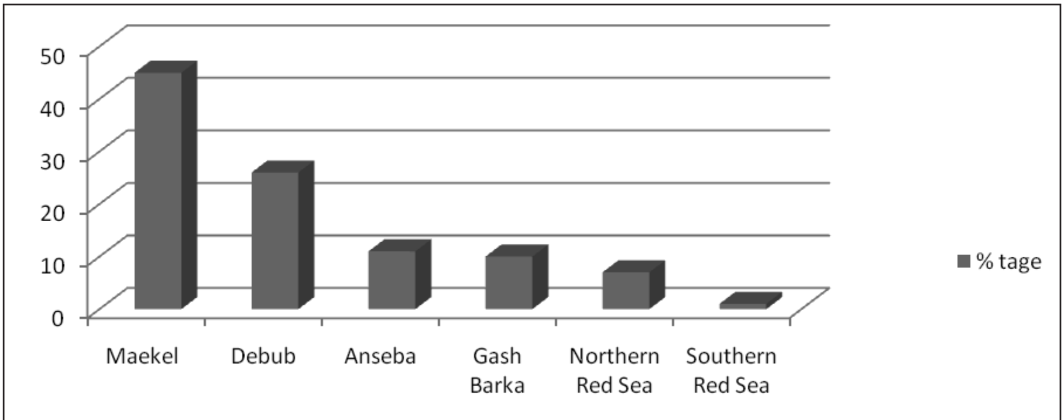

Fig.7: Total Percentage of Subscribers Zobawise

Currently, the mobile service in Eritrea has 70 percent of geographical area coverage and it can serve only 80 percent of the country`s population (Ministry of Information and Technology 2015). Remaining 30 percent of geographical area and 20 percent of the country`s population have no access to the mobile networks. And the long term plan of EriTel or the corporation is to give a full mobile service in all the habitable parts of Eritrea.

Factors that Influence the Efficiency of Mobile Network in Eritrea

The efficiency of a mobile network in Eritrea is affected by various factors such as physiography, climate, and technical. A brief description of these factors is given below.

(A) Physiographic features

Eritrea is a country having incredible diversity in its physiographic features; highlands, lowlands and the eastern escarpments are the main physiographic types of the country. This high land physiographic region is divided into six major physiographic parts. The lowland is divided into two parts, the eastern lowland that extends from the coast up to the foot of the highlands and the other is the western lowland which occurs from the extension of the western slope of the mountain to the border with Sudan. The eastern escarpment which is found from the foot of the mountains to the summit edge of the plateau is the most unique feature of the Eritrean physiography. This diversity in relief of the country not only affects the climate of the country but also the mobile network, often adversely (Abul 1960). These geographic conditions are affecting the movement of the network signals while proving a major hurdle to the installation of the BTS.

i) **Highlands and plateaus:** The area is a highland with an altitude of more than 1500 meters above sea level with the mild or cool climatic conditions and maximum rainfall. Its highlands include mountains, valleys, fault areas, gorges, plateau, and rugged land. In general, the maximum transmission distance between two stations is 50 km but when the signal propagates through the reflected surfaces such as rivers, oceans, lakes, sea, etc., then the maximum distance it can propagate is only about 35 km. The highland extends from the northern parts of the country (karora) which reach as far as Sudan’s border and up to Mereb trough in the south. And within this plateau highland, the land is highly uneven affecting the signals in their movements (Molnos 1969).

ii) **Fault/valley areas:** Fault and valley areas are common in Eritrea high altitude, which has low lying features from its surroundings (Buckle, C. 1978). Such landforms affect the transmission of signals from one BTS to another BTS because they become out of overshot (out of range). For example, (according to engineer Rustom 2015), the areas such as the Durfo depression have a problem in getting the access to mobile connection because of its lower altitude. So the Eritel Corporation tries to overcome these situations by making the poles of these BTS a little bit inclined in order to face the lower areas and they overcome such problems by planting repeaters in the fault/valley areas. And another problem created in places such as Asmara city, Dekemhare (City) is that there is a huge amount of mobile subscribers that create problems of congestion. One radio of a BTS can handle about 700 calls at a time but in the above-mentioned cities there are more than 700 users at any given time and this makes the usage of mobile network busy. As a consequence, the Eritel Company overcomes these problems by using more than one radio in one BTS site in order to satisfy the users.

iii) **Lowland:** The lowlands of Eritrea include all the places lower than 1500 meters above sea level. These are the coastal plains and the western plains. The red sea coastal plain extends between Ras Dumeira and Ras Keissar. It consists of the low, flat and narrow strip of land, where the western plains are found in the Gash Barka region which extends from the foothills of western escarpment up to the border with Sudan (Bridges, E. M. 1990). So, if we see the distribution of the BTS sites in both lowland parts of the country, they are very few in numbers and are spaced widely.

The lowlands of plains which are both sides (eastern and the western) flat and with little ups and downs. But, even though there are some uneven forms in the landscape, most of the time the BTS sites are going through in a little higher elevated area with a bit inclination in their poles. For example, the Barentu BTS site is located in front of the town and thus helps to cover the area in its totality. Also, in both the lowlands the intervals between the BTS sites are done in about 30 km, because in most of the lowlands there are no barriers such as high mountain ranges or any other obstacle which hinders the signals to travel for long-distance. Therefore, in most of the places, these BTS sites are planted in an interval of 25-29 km accordingly.

Other factors are also responsible for the low efficiency of the mobile networks that very few numbers of BTS sites are in the lowlands of the country due to less number of the population use the mobile network.

iv) **Eastern escarpment:** The eastern escarpment of the country is found in the eastern edge of the highland plateau up to the foot of the mountain. These are hollow areas which are difficult for the manipulation of the mobile network. It is to be pointed out that some of the villages are found in the deep bottom of the mountains even inclination of the poles cannot solve the problem of overshooting. Therefore, in these cases, the problem is solved by using a *repeater* device, which helps in the repetition of the signals somewhere planted on mid of the mountains. As the landscape along the escarpment is not uniform plants of BTSs are very difficult to install up to the foot of the escarpment.

(B) Climatic factors

i) **Rainfall** is one of the important sources of microwave attenuation. When the rain intensity is high, then the microwave signals get significantly attenuated. For example, it is observed that at high rain intensity (150mm/hr.) the fading of reflection of signals at 2.4 GHz (Giga Hertz) reached the value of 0.02 dB / km. So even if the transmission distance is near and transmitted power is large enough, the signals will be attenuated in the very significant amount due to higher rain fall. The link between two stations may be broken down. The attenuation becomes significant at higher frequencies and more precisely saying, at a frequency higher than 10 GHz. At higher frequencies, the signals can get attenuated 1dBm/km due to heavy rainfall. This country has a great experience of torrential rainfall at the time of summer, this time mobile frequency is affected by rainfall.

ii) **Waves** are factors that lead to a lowering in the density of network frequency, the capability of the signals to travel a longer distances. As a result, they get affected by the incoming wave and they reflect their direction while propagating over the surface of the sea. On the eastern side of the country touching the Red sea is affecting by this factor. So to protect such problems, the BTS stations must be put at a higher elevation from the sea level and the size of the antennas must be large enough to resist wave action.

iii) **Fogs, Mists, Winds, Snow, and Hurricane** are also factors that affect the signals. They reduce the frequency and the density of signals by deflecting the direction of signals, breaking down signals. Eritrea`s elevated areas are facing this problem by fogs, mists and high winds and hurricane. Sometimes strong wind or hurricanes also break antennas where signals totally stopped. But these effects are not much significant.

iv) V**egetation cover**: is also a factor that engenders the signal attenuation. The signal often has to propagate via the dense forest. The blocking and absorption of the signal are significant while propagating through the dense forest. Isolated trees are not the problem for microwave signals as their individual effect of attenuation is very small. In one experiment, it is observed that the trees having wet leaves can cause huge attenuation as compared to the trees bearing the dry leaves. It is observed that the signal can get attenuated up to 0.4 dB/m at3 GHz. Eritrea is having experience of such forest areas between two BTS. So there is a huge path loss if the signal passes through several hundred meters through the jungle.

(C) Other Factors

i) **The distance among the two BTS**: the maximum area that can be covered by one BTS is 50 km. This is an area where there is no obstacle. But in areas with natural and manmade barriers the coverage area reduces into 30 km, also sometimes below 30 km. If the distance is higher than the maximum limit becomes thinner, density reduces and the quality of voice is poor.

ii) **The number of customers:** the number of customers in an area is also affected the microwave signals. In areas like Asmara where there are high numbers of telephone users the problem of congestion significantly occurs. Because one Radio path can only hold 700 users at a given time if there is more than that of numbers, it says *Network busy* or *Radio path unavailable*. So in areas with the high number of mobile users, the area covered by BTS is very less, even less than 30kms. But in areas where the number of customers is very less the number of BTS is also very less. In such conditions the BTS can cover large areas, this specifically happening in the southern Red Sea region. The number of mobile users is few so there is no congestion, as a result, the number of BTS is also few.

iii) **Type of buildings**: types of the building also affect the quality of signals and the coverage area of the BTS. In cities and towns, most of the buildings are with high altitude with a high number of storied buildings, government offices, big industrial sectors…etc. they block the microwave signals from connecting from one to another station. For example in Asmara due to the presence of high altitude buildings the connection becomes blocked. This problem can be solved by locating the BTS at higher altitudes even over the roof of a high building.

iv) **Electricity supply:** all BTS stations in Eritrea have battery that saves power. Thus, when there is no electricity the BTS station continues its function by using the power from the battery. But if the electricity is not back within 6 hours then the battery starts to lose its power and after 7 hours the battery completely dies consequently is stoppage of connection.

Conclusion

The above determinants are dominantly hindering the mobile network frequency in Eritrea. Eritrea is having 2.5G (Generation) technology representing a state of development between 2G and 3G. This 2.5 generation technology has no voice message, video message and internet services. The country`s mobile network connections depend upon BTS. Existing BTS are facing physiographic, technical, electric and financial problems.

Physiographically this country has diverse features like mountainous areas, valleys, escarpments, below sea level areas and very limited plain areas in which installation of BTS is neither easy nor economically viable. Some of the areas have very less number of connections. In such situations, Eritel can solve the problem by multiplying the number of BTS and Radios for performing high-quality connection. The location of BTS should not be more than 30 to 35 km of range and the areas escarpments caves are needed to be installed of BTS. It may be considered that Eritrea is a digitally backward state. This is the high time to make the technology compatible with the pace of other nations.

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