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Research Article

SPATIO-ENVIRONMENTAL ASSESSMENT OF MOBILE SIGNAL DISTRIBUTION IN ROCKY DUTSIN-MA

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Abstract

This study investigates the spatial distribution and variation in mobile phone network quality across Dutsin-Ma Town, a region characterized by irregular topography, inselbergs, and extensive rock outcrops. The objective was to assess how environmental and terrain-related factors influence mobile network performance. Using a systematic grid sampling technique, data were collected from fifty strategically selected locations using smartphones to measure Ultra-High Frequency (UHF) signal strength for four major network providers: MTN, GLOBACOM, AIRTEL, and ETISALAT. To validate the findings from a user perspective, 100 structured questionnaires were also administered to residents.

Results revealed that network quality in Dutsin-Ma is predominantly suboptimal, with 48% of the town experiencing average signal quality and 36% classified as poor. Only 16% of sampled locations demonstrated good network coverage. Questionnaire data showed that MTN is the most preferred provider among residents (43%), largely due to its relatively better performance in rocky and elevated areas. Areas such as Motel, Gidan Ruwa, and Hayin Gada—situated at moderate elevations between 512–578 meters—reported the strongest signal strength. In contrast, regions like Unguwar Alkali and Unguwar Wakaji recorded the poorest signal performance, attributed largely to challenging terrain features.

Interestingly, the study also noted some exceptions to the general trend, where network quality for providers like GLOBACOM and AIRTEL improved with elevation in specific locations such as Kadangaru and Makarantar Gabas. Furthermore, rugged terrain and rocky outcrops were found to hinder the installation and optimization of network infrastructure, particularly masts, thereby exacerbating connectivity issues in the affected areas.

The research concludes that elevation, terrain ruggedness, and landscape features significantly influence mobile network distribution in Dutsin-Ma. It recommends improved land use and town planning policies that facilitate equitable placement of network infrastructure, ensuring enhanced signal quality across all parts of the town.

Keywords: Elevation, Landscape, Network, Environment, Determinism, Possibilism

INTRODUCTION

From time immemorial, information and communication have fashioned the basis of human existence. People want to communicate with their family and friends and to be communicated with. This desire has been a driving force, inspiring people to continuously seek for a new and effective means of dissemination of information to one another on real time basis irrespective of distance. Network communications worldwide have experienced rapid growth in the past two decades with modern phones allowing people to make and receive calls from almost every place. Cellular communication is supported by an infrastructure called a cellular network, which integrates cellular phones into the Public Switched Telephone Network-PSTN (Zhang and Stojmenovic, 2005.) Apart from voice service, cellular telephony provides other services to the users like short messages services (SMS), Instant messaging (IM), multimedia messaging service (MMS), wireless internet, etc (Pashtan, 2006).

Rappaport (1996) defined the quality of signals as set of technologies that work on a network to guarantee its ability to dependably run high priority applications and traffic under limited network capacity. Quality of service for network is an industry-wide set of standard and mechanism for ensuring high-quality performance for critical applications. It also refers to the performance of various communication services rendered which defines efficiency as determined by the level of users' satisfaction. Zhang and Stojmonvic (2005) gave some Tanzanian regulations clearly recommending measurement of the mobile network quality from time to time and comparing them with the norms so as to assess the level of performance.

While the threat to network quality is mainly perceived to be technical, the physical environment plays a critical role in that regard (Abdulazeez *et.al.,* 2021). For example, communication system installations often take place over irregular terrains that can greatly affect and distort the expected network performances. Therefore, the terrain profile of a particular area needs to be taken into account when estimating the path loss since the transmission path between the transmitter and the receiver can vary from simple line-of-sight to one that is obstructed by buildings, rocks, hillsides or foliage (Sridhar, 2004) typically characteristic of the study area. Radio waves require direct line of sight from Base Station to Base Station (BS to BS).

Around Dutsin-Ma Town, there are hills and mountains which can create obstacles and prevent signal of one BS from reaching another BS or Base Station Controller (BSC). This problem potentially degrades quality of service and affects both network coverage and capacity. Secondly, there are apparent challenges to infrastructural network strength from service providers in Dutsin-Ma. It was understood that network infrastructure is available mainly in the center of most towns and urban areas, but not in the peripheries where communication is also key (Mishra, 2007). This research was carried out to analyze the spatial network quality in Dutsin-Ma Town to assess the impact of geographic factors on the network quality in the town.

1.1 MATERIALS AND METHODS

1.1.1 Study Area Description

The study area is Dutsin-Ma Town in Dutsin-Ma Local Government Katsina State. Dutsin-Ma is located between latitude 12°09'18''N to 12°30'44''N and longitudes 7°20'48''E to 7°3'18''E. It is one of the oldest towns in central parts of Katsina State. Dutsin-Ma Local Government, its bordered by Kankia, Charanci and Matazu LGAs to the East, Safana LGA to the West, Danmusa LGA to the South and Kurfi LGA to the north (Fig 1.1a). The area is part of the tropical continental wet and dry Sahelian climate region (Koppens *Aw*) with total annual rainfall ranging from 700-800mm. The areas vegetation is *sudano-sahelian* types with predominantly grass and few scattered trees. (Ministry of land and survey Katsina, 2008; Abdulazeez et.al., 2018).

1.1.2 Methodology

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The study area (Fig 1a) was divided into 50 spatially distributed parts by imposing a grid on its map. The coordinates of the center of each grid were recorded and identified in the ground as a sample. Data collected include the Ultra High Frequency (UHF) for each point, Absolute (latitude and longitude) location, elevation, and inventory of physical features (Table A). User information on network quality was collected through questionnaire administration from at least two respondents which were selected using availability sampling technique.
The UHF is the International Telecommunication Union (ITU) designation for radio frequency ranging from 300-3000 Mhz denoting signal strength. Statistical Analysis was used to obtain average results of recorded UHF values taken for three different times of the day. Results of the data analyze were presented on graphs, charts, and

frequency tables. Network quality maps for the four major telecommunication networks were processed in ArcGIS 10.1 and presented.

Before conducting sampling for the research, topography and elevation (Fig 1b) were considered to ensure comprehensive data collection. The varied terrain, characterized by rocky outcrops and undulating landscapes, required a stratified sampling approach to capture diverse network quality experiences. Elevation differences,

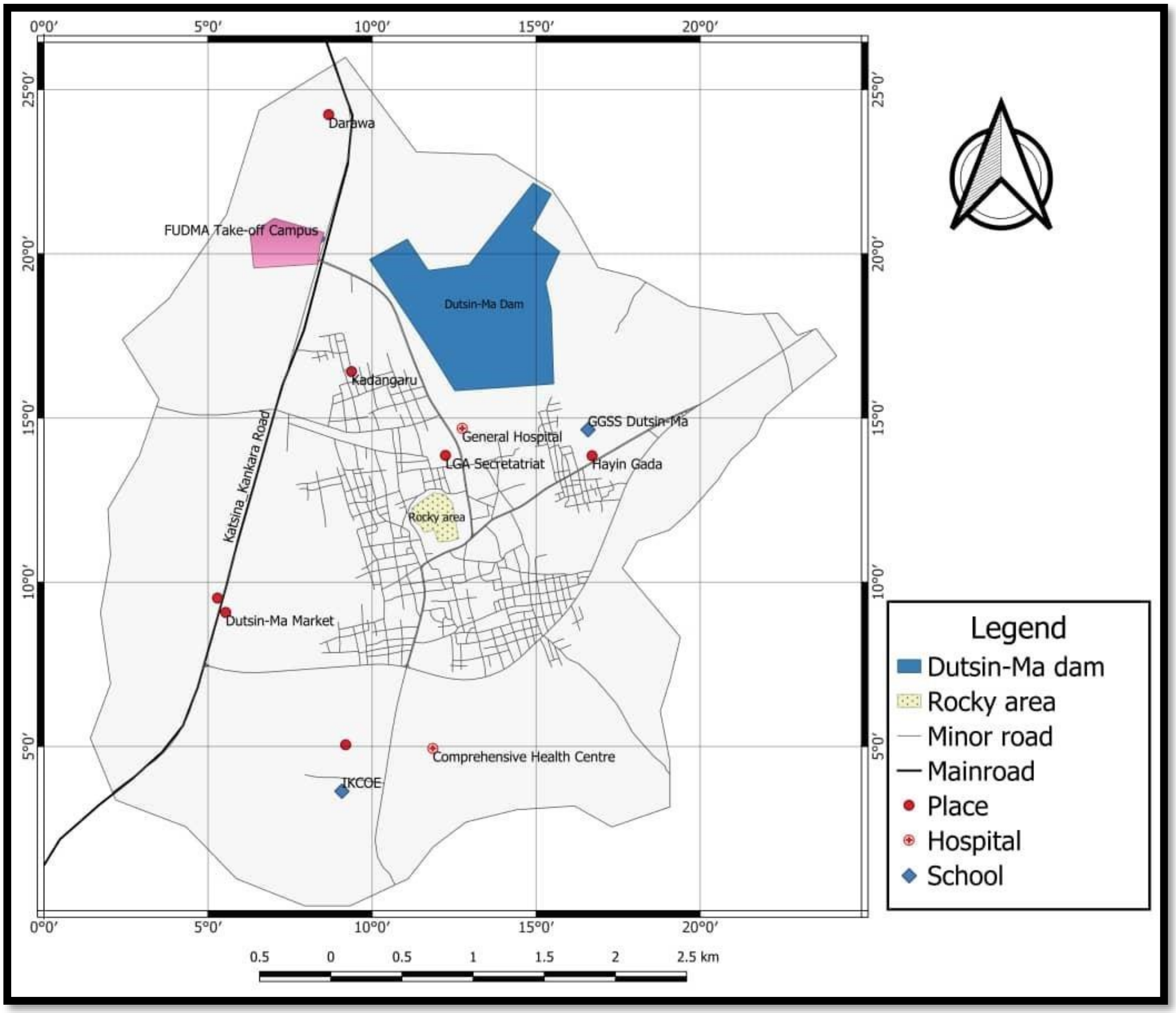

Fig 1a: Map of Dutsin-Ma Town, the Study Area

impacting signal strength and propagation, were mapped and included in the sampling framework, ensuring that both high and low elevation areas were adequately represented. This approach enabled a thorough analysis of how the physical geography of Dutsin-Ma influences mobile network performance.

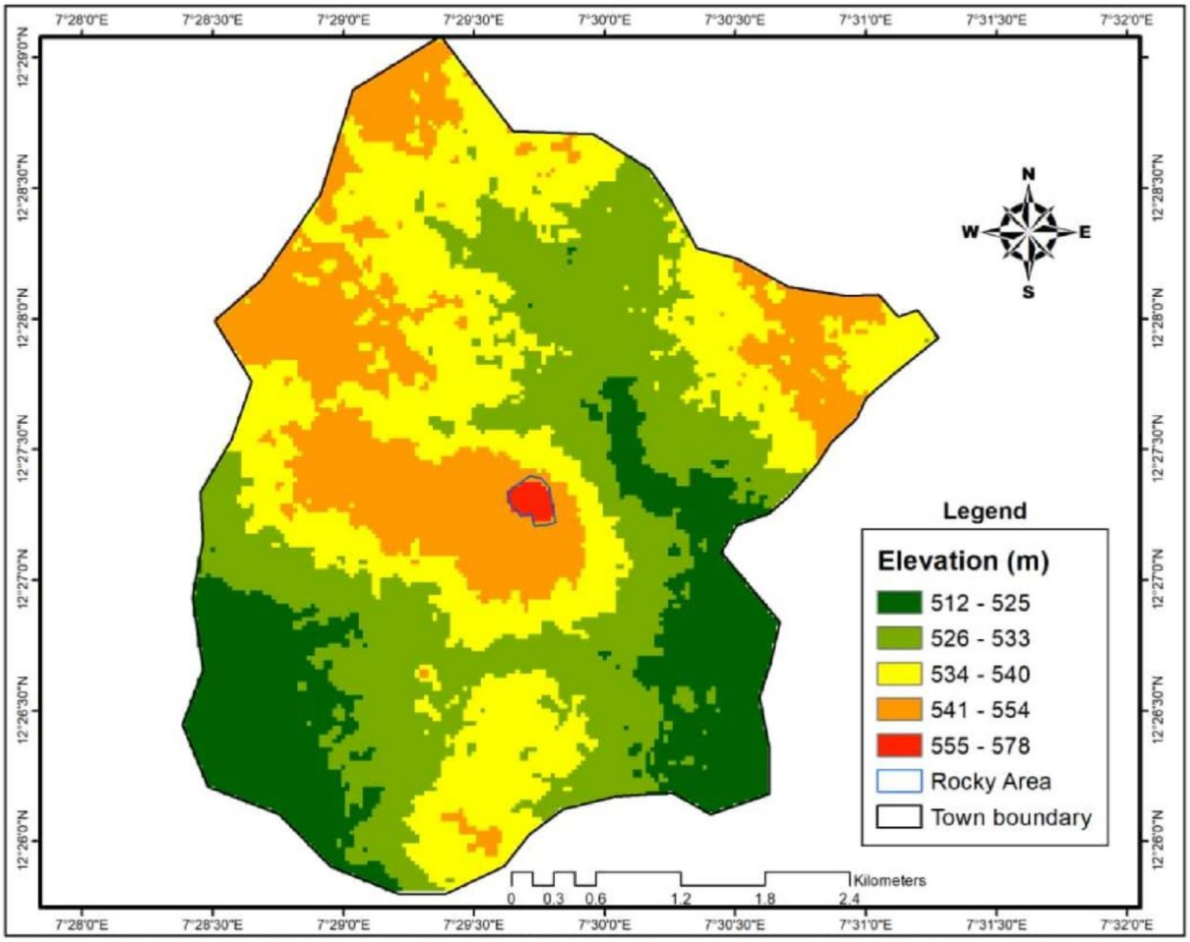

Fig 1b: Map of Dutsin-Ma, the Study Area with elevation

1.2 RESULTS AND DISCUSSION OF FINDINGS

From table A, it can be analyzed that generally Dustisn-Ma is a not a town with good network as average (48%) and poor (36%) network quality dominates the area; only 16% of the areas have good network quality. While the elevation range of the town is 512-578m (Figure 1b), the average is about 535m above sea level. Most cellphone masts transmit their signals horizontally not vertically, with the exception of a few that transmit signals sporadically in all directions, therefore, network quality in many cases is likely to decrease with altitude (Colpaert, 2018). Furthermore, at high altitudes, atmospheric conditions may cause signal delays due to the earth's curvy shape (Karanja *et.al.*, 2023).

Table A: Average Mobile Network Quality Across 50 Sampled Location in Dutsin-Ma Town.

SN	LOCATIONS	LATITUDE	LONGITUDE	ELEV	MTN	GLO	ETISALAT	AIRTEL	REMARKS			
1	FUDMA	12°28' 21.1"	07°29' 12.5"	535m	-89dBm 12Asu	-89dBm 12Asu	-91dBm 11Asu	-91dBm 11Asu	Average	Average	Poor	Poor
2	Hayin Wakaji	12°26' 51.1"	07°30' 08.0"	525m	-76dBm 14Asu	-77dBm 18Asu	-79dBm 11Asu	-75dBm 14Asu	Average	Average	Average	Average
3	Comprehensive	12°26' 23.0"	07°29' 50.1"	531m	-75dBm 17Asu	-93dBm 10Asu	-81dBm 16Asu	-73dBm 25Asu	Average	Poor	Average	Average
4	Kadangaru	12°28' 04.7"	07°29' 17.5"	536m	-89dBm 10Asu	-67dBm 23Asu	-63dBm 23Asu	-93dBm 11Asu	Average	Good	Good	Poor
5	Darawa	12°28' 34.1"	07°29' 21.2"	535m	-103dBm 14Asu	-95dBm 9Asu	-85dBm 14Asu	-90dBm 11Asu	Poor	Poor	Average	Poor
6	UBA	12°26' 42.5"	07°29' 08.4"	525m	-92dBm 21Asu	-87dBm 13Asu	-71dBm 21Asu	-91dBm 11Asu	Poor	Average	Average	Poor
7	Shema Quarters	12°26' 59.5"	07°28' 52.1"	531m	-91dBm 11Asu	-83dBm 15Asu	-91dBm 11Asu	-97dBm 08Asu	Poor	Average	Poor	Poor
8	Maria moh Ajiri	12°27' 43.1"	07°29' 01.5"	540m	-93dBm 11Asu	-91dBm 11Asu	-75dBm 19Asu	-93dBm 11Asu	Poor	Poor	Average	Poor
9	Makabartar Gabas	12°27' 10.9"	07°30' 22.1"	520m	-63dBm 24Asu	-51dBm 31Asu	-53dBm 30Asu	-91dBm 14Asu	Good	Good	Good	Poor
10	GRA	12°27' 33.4"	07°30' 39.5"	532m	-76dBm 14Asu	-79dBm 17Asu	-65dBm 24Asu	-81dBm 14Asu	Average	Average	Good	Average
11	CDSS	12°27' 54.4"	07°31' 01.4"	529m	-98dBm 11Asu	-78dBm 17Asu	-75dBm 24Asu	-99dBm 11Asu	Poor	Average	Average	Poor

12	Hayin Gada	12°27' 28.2"	07°30' 15.7"	522m	-57dBm 46Asu	-65dBm 24Asu	-73dBm 22Asu	-69dBm 26Asu	Good	Good	Average	Good
13	Bakin Dam	12°27' 47.8"	07°29' 58.2"	528m	-79dBm 30Asu	-60dBm 23Asu	-77dBm 22Asu	-53dBm 16Asu	Average	Good	Average	Good
14	Kadangaru Kuka	12°27' 46.0"	07°29' 40.7"	527m	-63dBm 20Asu	-79dBm 17Asu	-79dBm 17Asu	-71dBm 22Asu	Good	Average	Average	Average
15	Kanti	12°27' 26.1"	07°29' 26.1"	532m	-70dBm 20Asu	-80dBm 16Asu	-59dBm 27Asu	-51dBm 30Asu	Average	Average	Good	Good
16	Dan Rimi	12°27' 14.1"	07°29' 51.6"	538m	-59dBm 25Asu	-75dBm 19Asu	-63dBm 25Asu	-65dBm 22Asu	Good	Average	Good	Good
17	Masallacin Yarabawa	12°27' 33.1"	07°29' 35.9"	530m	-92dBm 11Asu	-65dBm 25Asu	-55dBm 29Asu	-92dBm 11Asu	Poor	Good	Good	Poor
18	Barga	12°27' 23.1"	07°29' 35.2"	542m	-98dBm 11Asu	-85dBm 14Asu	-81dBm 16Asu	-100dBm 8Asu	Poor	Average	Average	Poor
19	Karambanin Dan Abba	12°27' 26.7"	07°29' 22.7"	536m	-99dBm 11Asu	-107dBm 07Asu	-81dBm 16Asu	-91dBm 11Asu	Poor	Poor	Average	Poor
20	Dan Kauye	12°27' 23.3"	07°29' 16.6"	542m	-99dBm 9Asu	-103dBm 05Asu	-79dBm 16Asu	-11dBm 07Asu	Poor	Poor	Average	Good
21	Gidan Buredi	12°27' 26.6"	07°29' 31.2"	542m	-98dBm 11Asu	-61dBm 26Asu	-97dBm 08Asu	-100dBm 11Asu	Poor	Good	Poor	Poor
22	Tudun Alkali	12°27' 13.8"	07°29' 33.4"	541m	-75dBm 17Asu	-93dBm 10Asu	-95dBm 11Asu	-73dBm 20Asu	Average	Poor	Poor	Average

23	Unguwar Tsamiya	12°27' 07.2"	07°29' 39.5"	539m	-83dBm 14Asu	-79dBm 17Asu	-75dBm 19Asu	-81dBm 14Asu	Average	Average	Average	Average
24	Abuja Road	12°27' 17.6"	07°29' 56.9"	534m	-73dBm 14Asu	-77dBm 18Asu	-69dBm 22Asu	-54dBm 22Asu	Average	Average	Good	Good
25	Tsohuwar Kasuwa	12°27' 14.4"	07°30' 07.6"	524m	-76dBm 14Asu	-53dBm 30Asu	-83dBm 15Asu	-79dBm 14Asu	Average	Good	Average	Average
26	Unguwar Yandaka	12°27' 08.0"	07°29' 58.0"	529m	-77dBm 14Asu	-60dBm 22Asu	-71dBm 21Asu	-76dBm 14Asu	Average	Good	Average	Average
27	Unguwar Mai Saje	12°27' 04.3"	07°29' 46.1"	540m	-85dBm 14Asu	-97dBm 08Asu	-67dBm 23Asu	-89dBm 11Asu	Average	Poor	Good	Average
28	Unguwar Alkali	12°26' 47.5"	07°29' 35.3"	527m	-93dBm 11Asu	-101dBm 11Asu	-75dBm 19Asu	-96dBm 11Asu	Poor	Poor	Average	Poor
29	IKCOE	12°26' 15.1"	07°29' 01.5"	530m	-94dBm 11Asu	-87dBm 13Asu	-83dBm 15Asu	-59dBm 27Asu	Poor	Average	Average	Good
30	Asibitin Campus	12°26' 28.7"	07°29' 10.5"	526m	-81dBm 14Asu	-67dBm 23Asu	-77dBm 18Asu	-82dBm 14Asu	Average	Good	Average	Good
31	Makara Huta	12°26' 52.1"	07°29' 20.6"	531m	-104dBm 11Asu	-81dBm 16Asu	-83dBm 15Asu	-81dBm 16Asu	Poor	Average	Average	Average
32	Yarima Primary	12°26' 46.5"	07°29' 47.9"	525m	-98dBm 11Asu	-93dBm 10Asu	-99dBm 07Asu	-92dBm 11Asu	Poor	Poor	Poor	Average

33	Mega Station	12°26' 43.0"	07°28' 50.6"	516m	-87dBm 14Asu	-77dBm 18Asu	-95dBm 09Asu	-90dBm 11Asu	Average	Average	Poor	Poor
34	Sokoto Rima	12°26' 05.0"	07°28' 16.8"	513m	-96dBm 11Asu	-93dBm 10Asu	-91dBm 11Asu	-89dBm 12Asu	Poor	Poor	Poor	Average
35	Pilot	12°26' 20.5"	07°28' 37.3"	517m	-88dBm 14Asu	-77dBm 18Asu	-85dBm 14Asu	-86dBm 14Asu	Average	Average	Average	Average
36	Unguwar Dangaje	12°27' 07.6"	07°28' 43.4"	530m	-91dBm 11Asu	-73dBm 20Asu	-77dBm 18Asu	-87dBm 12Asu	Poor	Average	Average	Average
37	Kashe Naira	12°27' 20.6"	07°29' 06.6"	546m	-63dBm 25Asu	-98dBm 19Asu	-81dBm 16Asu	-67dBm 23Asu	Good	Poor	Average	Good
38	Bayan Gudan Radio	12°27' 55.9"	07°29' 04.5"	542m	-103dBm 11Asu	-79dBm 17Asu	-87dBm 13Asu	-97dBm 11Asu	Poor	Average	Average	Poor
39	Motel	12°28' 00.0"	07°29' 35.8"	534m	-54dBm 27Asu	-91dBm 11Asu	-89dBm 12Asu	-62dBm 26Asu	Good	Poor	Average	Good
40	Gidan Ruwa	12°27' 37.6"	07°30' 00.9"	521m	-83dBm 14Asu	-63dBm 25Asu	-59dBm 27Asu	-83dBm 14Asu	Good	Good	Good	Average
41	Kanya	12°27' 23.9"	07°29' 38.3"	531m	-69dBm 22Asu	-83dBm 15Asu	-79dBm 21Asu	-68dBm 26Asu	Good	Average	Average	Good
42	DTC	12°27' 23.4"	07°30' 07.6"	519m	-77dBm 18Asu	-63dBm 25Asu	-69dBm 22Asu	-75dBm 19Asu	Average	Good	Good	Average
43	Hayin Gada Unguwar Kudu	12°27' 21.5"	07°30' 18.0"	532m	-78dBm 14Asu	-53dBm 30Asu	-51dBm 28Asu	-75dBm 14Asu	Average	Good	Good	Average

44	Unguwar Kudu	12°26' 58.2"	07°30' 09.0"	527m	-73dBm 20Asu	-71dBm 21Asu	-75dBm 19Asu	-74dBm 11Asu	Average	Average	Average	Average
45	Unguwar Dabino	12°26' 56.9"	07°29' 59.8"	531m	-80dBm 14Asu	-85dBm 14Asu	-73dBm 20Asu	-77dBm 14Asu	Average	Average	Average	Average
46	Gangaren Wakaji	12°26' 44.2"	07°30' 16.6"	517m	-93dBm 11Asu	-89dBm 12Asu	-83dBm 15Asu	-90dBm 11Asu	Poor	Average	Average	Poor
47	Shagari Quarters	12°26' 34.0"	07°30' 10.1"	525m	-82dBm 14Asu	-73dBm 20Asu	-79dBm 17Asu	-79dBm 14Asu	Average	Average	Average	Average
48	Sabuwar Wakaji	12°26' 55.3"	07°30' 21.0"	522m	-83dBm 14Asu	-61dBm 26Asu	-81dBm 16Asu	-81dBm 14Asu	Average	Good	Average	Average
49	Gigiyu Quarters	12°26' 49.9"	07°30' 31.3"	517m	-85dBm 14Asu	-71dBm 21Asu	-77dBm 18Asu	-83dBm 14Asu	Average	Average	Average	Average
50	Low Cost	12°26' 36.0"	07°29' 45.3"	532m	-79dBm 16Asu	-75dBm 19Asu	-71dBm 21Asu	-77dBm 14Asu	Average	Average	Average	Average

Source: Fieldwork, 2022

1.2.1 Demography of Network Users

The age distribution shows that 34% of the users fall within the age of less than 25 years old; 36% falls within the age range 25-34; 20% falls within the age range of 35-44, 4% falls within the age range of 45-54; 2% falls within the age range of 55-64 and 15% falls within the age of 64 years to above. This shows that the population of network users is dominated by the youth which are very active with communication.

The sex distribution of the respondent reveals that 64% are male while 36% are female. From the questionnaire survey, 57 % of network users have a qualification beyond secondary school meaning they are at least educated enough to understand the dynamics of network quality.

1.2.2 Major Networks Used in Dutsin-Ma Town

Table 1 shows the major, primary or first choice network used by the respondents indicating a clear preference for MTN (43%) and Airtel (36%). Globacom users (9%) and Etisalat (12%) following by a distance. This implies that majority of the network users of Dutsin-Ma Town are using MTN as their preferred network.

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Table 1: Primary Network of residents

SN	NETWORK	FREQUENCY	PERCENTAGE %
1.	MTN	43	43
2.	GLO	09	9
3.	AIRTEL	36	36
4.	ETISALAT	12	12
	Total	**100**	**100**

Source: Fieldwork, 2022 Table 2 shows the results for respondents' second choice network. MTN is the most popular secondary network of users as well with 41% followed by Airtel with 30%. This indicates that MTN and Airtel Networks relatively have the best spatial coverage in the town.

Table 2: Secondary (Other) Network(s) used by the Respondents

SN	NETWORK	FR EQUENCY	P ERCENTAGE %
1.	MTN	36	36
2.	GLO	16	16
3.	AIRTEL	28	28
4.	ETISALAT	10	10
	Total	**100**	**100**

Source: Fieldwork, 2022.

1.2.3 Location-Based Network Quality According to Users

The detail of network quality in specific areas of Dutsin-Ma Town (Table A) is being presented in maps and tables based on recorded UHF values and customer satisfaction which varied across different telecommunication networks. Data collected from Network users returned a result of 71% for Danrimi as the best location to make calls in the town; 20% preferred Unguwar Tsamiya and 9% opted for Abuja Road. Incidentally, all three locations are within the center of the town which has a relatively flat terrain and favourable topography. Although, close to them is located the largest inselberg (highest elevation) in the town. It was however observed that there is a high concentration of masts in the area, without which the quality of the network may have been very poor.

The quality of major primary Network shows that MTN is of good quality in some areas like Kashe Naira, Kanya and Danrimi; the Network is average in areas like Asibitin campus, Pilot and Hayin Gada whereas Isa Kaita College of Education, Unguwar Alkali and Unguwar Dangaje had poor connections (Fig 2). These are relatively flat areas.

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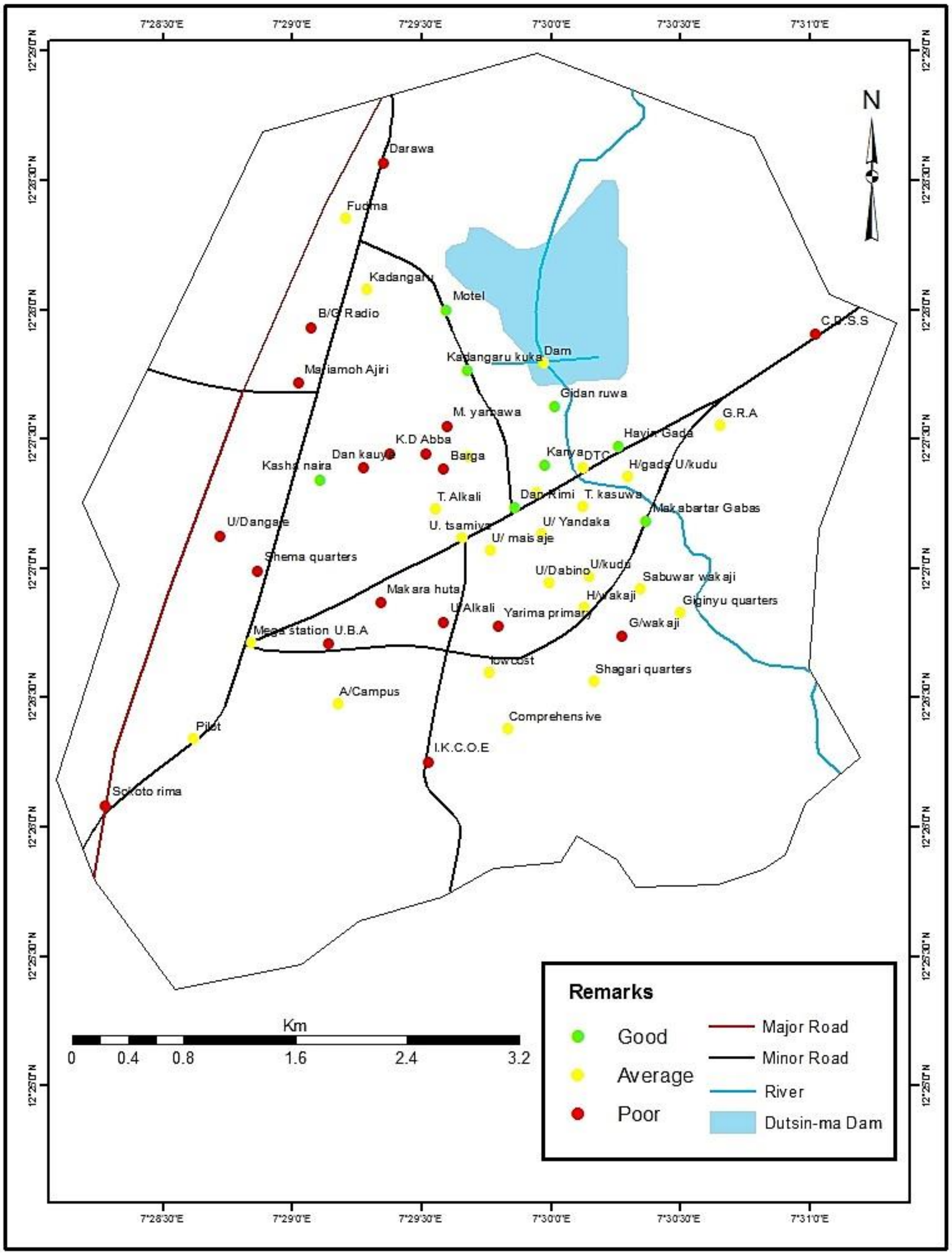

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Figure 2: Spatial Quality of MTN Network in Dutsin-Ma Town

Airtel Network is good in some areas like Dan Kauye, Motel and Danrimi. It is Average in areas like Comprehensive, Lowcost and Unguwar Dabino and poor in UBA, Bayan Gidan Radio and Darawa areas (Fig 3). Most of the areas where the Airtel network is poor are located to the Western part of the town which have ab elevation of between 500-550m above sea level.

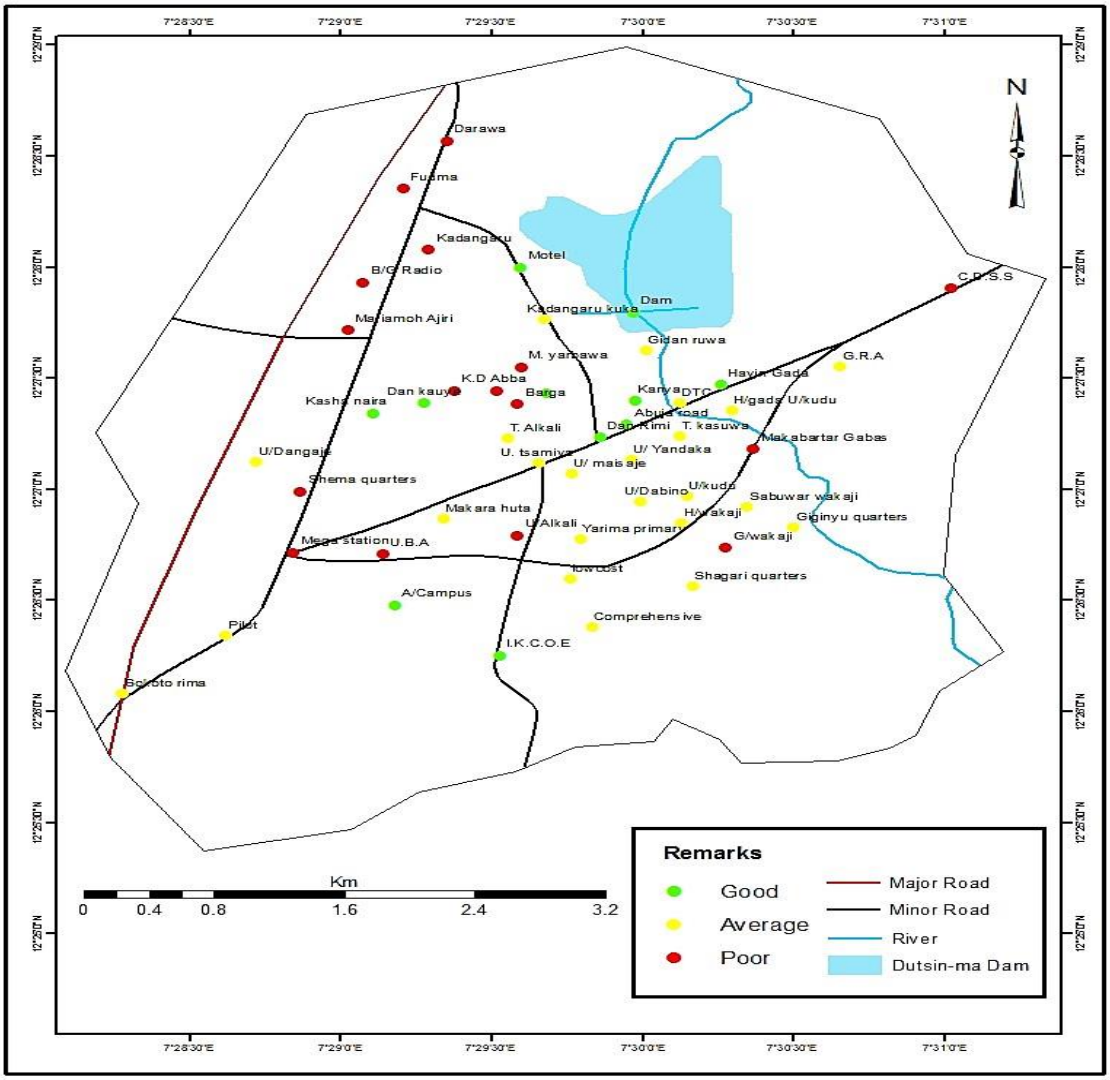

Figure 3: Spatial Quality of Airtel Network in Dutsin-Ma Town

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The Quality of Glo Network is good in Masallacin Yarabawa, Asibitin Campus (Dogon Karfe) and Karambanin DanAbba and Average in Danrimi, Unguwar Tsamiya and Giginyu quarters. Airtel network is poor in some areas like Yarima Primary School, Dan Kauye and Unguwar Alkali areas of Dutsin-Ma Town (Fig 4). Influence of topography was not much significant.

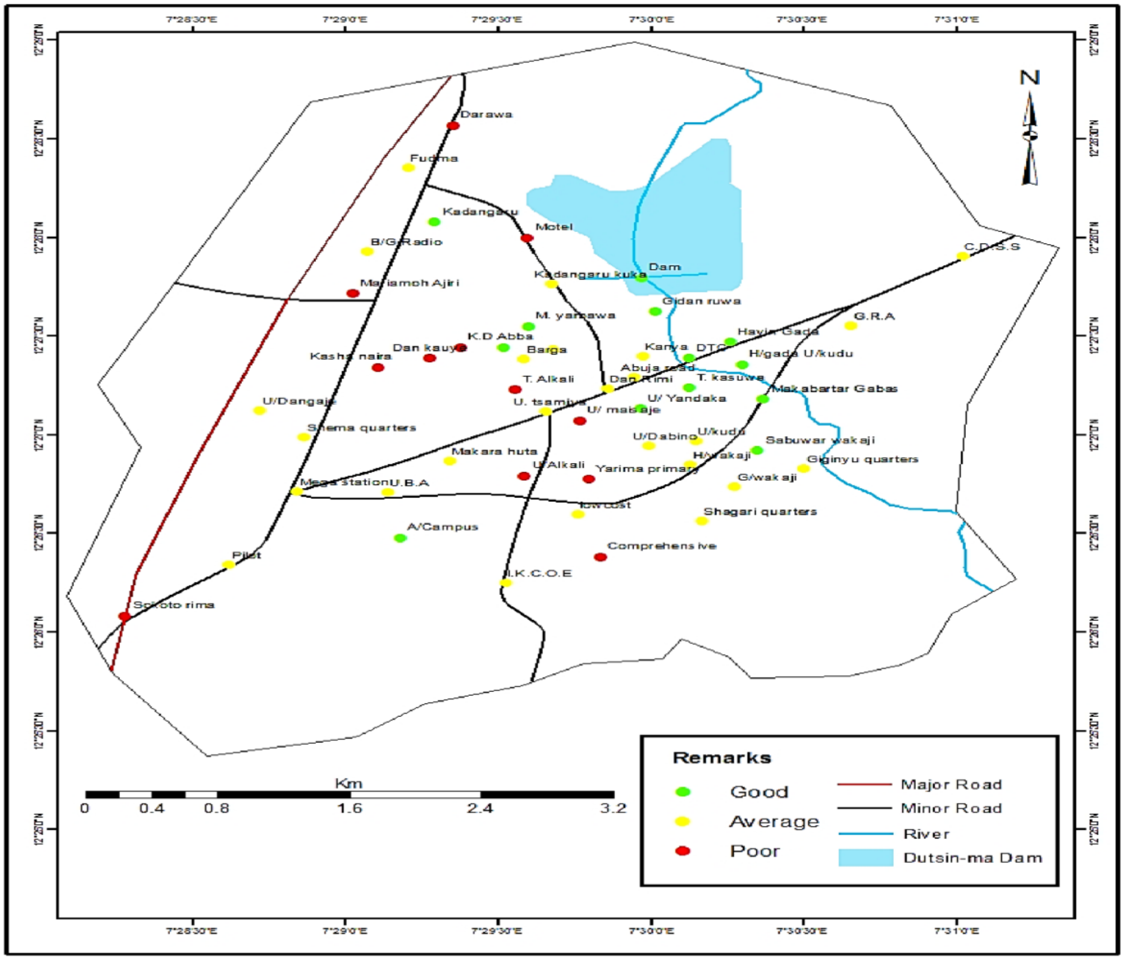

Figure 4: Spatial Quality of Glo Network in Dutsin-Ma Town

The Quality of Etisalat Network in Dutsin-Ma Town is good in Danrimi, Gidan Ruwa and Makabartar Gabas, it is average in IKCOE, Makara-Huta and Low cost. The network is poor in Sokoto Rima, Mega Station and Tudun Alkali areas of Dutsin-Ma Town (Fig 5). The eastern side of the town with relatively flat terrain has better Etisalat network quality.

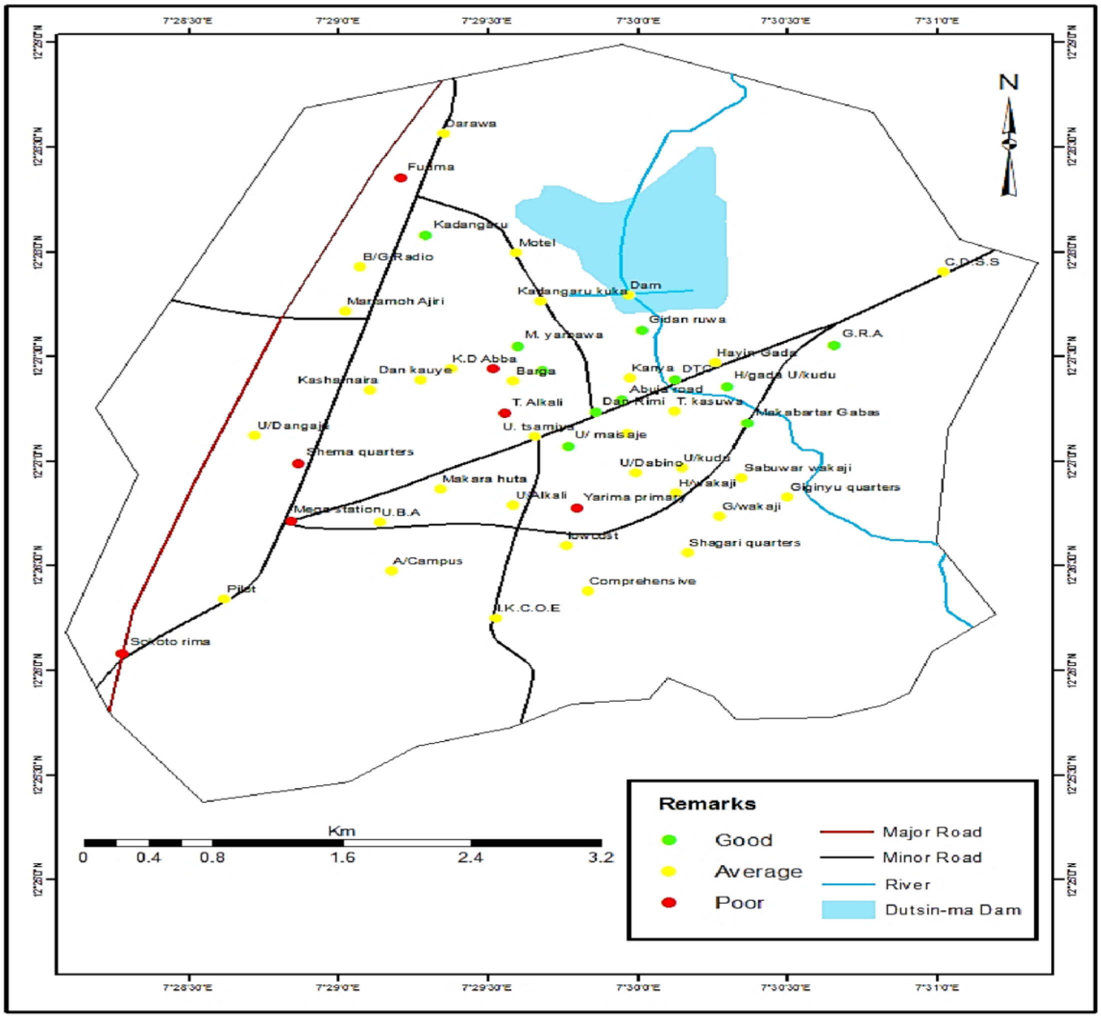

Figure 5: Spatial Quality of Etisalat Network in Dutsin-Ma Town

1.2.3 Geographical Impediments to Network Quality According to Users

Table 3 shows the percentage of the major physical impediment to network quality in Dutsin-Ma Town. Rocks and boulders constitute 73% while weather conditions go with 19% of the physical impediment toward network quality. This clearly shows that the nature of terrain or landscape of Dutsin-Ma Town has significant influence the network strength of the study area.

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Table 3: Physical impediments to Network Quality in *Dutsin-Ma Town*.

SN	PHYSICAL IMPEDIMENT	FREQUENCY	PERCENTAGE %
1.	Rocks	73	73
2.	Weather	19	19
3.	Vegetation	8	8
4.	Others (specify)	00	00
	Total	**100**	**100**

Source: Fieldwork, 2022.

Table 4 shows some human impediments to network quality in Dutsin-Ma Town. Inadequate masts constitute 81%, large population goes with 8% and remoteness goes with 3%. This implies that apart from elevation and terrain, inadequate masts contribute to the poor network quality of some places in Dutsin-Ma Town.

Table 4: Human Geographical Impediments to Network Quality

SN	HUMAN IMPEDIMENT	FREQUENCY	PERCENTAGE %
1.	Large population	08	8
2.	Inadequate masts	81	81
3.	Remoteness	03	03
5.	Buildings	8	8
6.	Other(s) specify	00	00
	Total	**100**	**100**

Source: Fieldwork, 2022.

Table 5 shows the best time to which network is at its best to Network users. About 80 % of the respondents reveal that the network is at its best in the night while 26% prefer morning. This shows that the network users prefer to use network at night because of its stability and less congestion.

Table 5: Temporal Dimension of Network Quality

SN	TIME	FREQUENCY	PERCENTAGE%
1.	Morning	24	24
2.	Afternoon	4	4

3.	Evening	4	4
4.	Night	68	68
	Total	**100**	**100**

Source: Fieldwork, 2022.

From those interviewed, 97% of the respondents believe that rugged terrains and rocky landscape has effect on the network quality of Dutsin-Ma Town, while 3% of the respondents do not share this belief. Meanwhile, 26% of the respondent believe rocky landscapes constitute barriers to the erection of telecommunication mast, whereas 74% think the rocky landscape blocks free distribution of signals. About 12% of the respondents observed that increase in population has resulted in more pressure of network quality and 88% of the respondents suggest that it is the same increase in population that has attracted the installation of more masts in the area instead.

Table 6 shows the most significant types of network problems in Dutsin-Ma Town. The main problem according to the respondents is poor connectivity with 55%, unclear sound while making calls goes with 17%, poor internet service has 17%, complete shut down and breakage goes with 2% and 1% respectively. This shows that poor connectivity is the worst problem affecting network quality of Dutsin-Ma Town.

Table 6: Major Network problem in Dutsin-Ma Town.

SN -	NETWORK PROBLEM	FREQUENCY	PERCENTAGE%
1.	Poor connectivity	55	55
2.	Unclear sound	17	17 3. Poor
	internet service	17	17
4	Complete shutdown	02	02
5.	Breakage	01	01
	Total	**100**	**100**

Source: Fieldwork, 2022

1.3 FURTHER DISCUSSION OF FINDINGS

Apart from other socio-economic factors, the quality or strength variation of Network quality is partly due to the nature of rugged terrain and rocky landscape of Dutsin-Ma Town. The research shows that some of the samples that are close to the rocky areas have poor Network quality. This factor is clearly similar to the research work of Mtaho and Ishengoma (2011) in the Analysis of quality service in Tanzania cellular Network which identifies the geographical terrain as one of the main factors that led to the Network quality variability in a particular area. This is also partly due to differences in quality of network infrastructure between MTN, AIRTEL, GLO and ETISALAT.

The spatial network quality can be seen in the maps of Dutsin-Ma Town of MTN, Airtel, Glo and Etisalat Network shown in Figures 2, 3, 4 and 5 respectively. This was supported by the result of network quality across Dutsin-Ma Town which was gotten from respondents through questionnaires.

Finally, it was observed that the elevation or the nature of landscape in Dutsin-Ma Town have great influence on network quality across Dutsin-Ma Town, this is because the areas surrounded with high elevated lands tends to be poor in all the networks, while the areas surrounded by moderate elevated lands tend to be average and lastly the areas surrounded- by low elevation tend to be good in term of network quality for MTN, GLO, AIRTEL, and Etisalat.

1.4 CONCLUSION

Geography is a critical factor in physical and human development. Communication is an important aspect of human development which requires not only the right infrastructure but careful environmental planning to achieve the maximum results. Based on the study carried out, it is therefore recommended that the GSM operators be advised to consider geographical factors in making any efforts to improve their quality of service to enhance mobile communication performance within and outside the study area.

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