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Assessment of Radio Frequency Signals Availability in Bida

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Abstract
This study investigates the availability and intensity of radio frequency (RF) signals in Bida, a town in southwestern Niger State, Nigeria (9.0800° N, 6.0030° E). Signal strength measurements for Amplitude Modulation (AM), Frequency Modulation (FM), Television (TV), and Global System for Mobile Communications (GSM) signals were conducted at sixty-nine locations using a spectrum analyzer (100 kHz–7.0 GHz). TV signals were captured with a Yagi antenna, while dipole antennas were used for AM and FM. GSM signals were measured using the Network Cell Info Lite app on an Android smartphone. The Epicollect5 mobile application facilitated accurate data collection and geotagging, with cloud-based synchronization enhancing field efficiency and data reliability. Kriging interpolation was employed for spatial analysis due to its high predictive accuracy. All four signal types were available across all locations but varied in intensity. Results showed that GSM signals had the lowest strength at -116 dB, followed by TV (-98.62 dB), FM (-94.09 dB), and AM with the highest strength at -87.00 dB. These findings provide critical insights for designing RF energy harvesting systems, offering a sustainable solution for powering low-energy devices in resource-constrained environments.

Keywords: *Radio waves, Signal strength, spectrum Analyzer, Antenna, Kinging interpolation.*

1.0 Introduction

Electromagnetic waves are a type of transverse wave, where the electric and magnetic fields are oriented at right angles to each other and to the direction the wave travels. These waves carry both electric and magnetic energy (Akinbolati *et al.*, 2016). Radio signals emitted by an antenna consist of both electric and magnetic waves (Adenodi, 2019). These waves are generated when electric and magnetic fields interact, leading to the formation of electromagnetic radiation. In simpler terms, electromagnetic radiation results from the oscillation of these fields (Seybold, 2005). According to classical physics, it represents the flow of energy through either a material medium or free space. Moving at the speed of light, the combination of these fields creates electromagnetic (EM) waves. Examples include radio waves, gamma rays, and visible light, all of which adhere to the equation $c = \lambda f$, where c is the speed of light, λ is the wavelength, and f is the frequency (Seybold, 2005). The various types of electromagnetic waves and their applications are in the following paragraphs:

The electromagnetic spectrum encompasses a broad range of wave frequencies and wavelengths, each associated with distinct properties and applications. At the lowest end of this spectrum are radio waves, which possess the lowest frequency and longest wavelength. These waves are fundamental to communication technologies, particularly in the transmission of radio and television signals. Radio waves are emitted by both natural sources, such as celestial bodies, and artificial sources like broadcasting antennas (Shinohara, 2014).

Occupying the next position in the spectrum are microwaves, which have higher frequencies than radio waves. Their ability to penetrate through various materials makes them highly suitable for diverse technological applications, including radar systems, wireless data transmission, and landline communication systems. Microwaves are also employed in microwave ovens and certain medical treatments due to their heat-generating capabilities (Shinohara, 2014).

Infrared waves follow microwaves on the spectrum and exist between microwaves and visible light. These waves vary in wavelength, with longer wavelengths associated with thermal radiation and shorter wavelengths commonly used in remote control devices and infrared imaging. Infrared technology is particularly advantageous for visualizing objects in low-visibility conditions such as fog, smoke, or mist, making it useful in both military and civilian applications (Shinohara, 2014).

Visible light constitutes the only portion of the electromagnetic spectrum perceptible to the human eye. It is emitted by both natural sources, like the sun, and artificial sources, including light bulbs and electronic displays. Objects appear visible when they absorb specific wavelengths of visible light and reflect others, allowing the human eye to perceive different colours and forms (Shinohara, 2014).

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Beyond visible light lie ultraviolet (UV) waves, which are characterized by shorter wavelengths and higher energy. Ultraviolet radiation is instrumental in scientific research, particularly in the analysis of molecular structures. Additionally, UV waves are employed in astronomy, enabling scientists to study the composition and behavior of galaxies and other celestial entities (Shinohara, 2014).

X-rays, with even shorter wavelengths and higher energy than UV waves, are most commonly associated with medical imaging. They allow for detailed visualization of internal structures, such as bones and are also utilized in therapeutic contexts, such as in the treatment of certain cancers. Their ability to penetrate tissues and materials makes them indispensable in both healthcare and security screening (Shinohara, 2014).

At the extreme high-frequency end of the spectrum are gamma rays, which possess the shortest wavelengths and the highest energy. These waves have a range of critical applications, particularly in the medical field, where they are used in cancer radiotherapy and the sterilization of medical equipment. In industrial settings, gamma rays are employed to detect internal flaws in metals and other materials, such as cracks and voids, due to their powerful penetrating abilities (Shinohara, 2014).

The increasing demand for sustainable and renewable energy sources has led to growing interest in radio frequency (RF) energy harvesting, a technique that captures and converts ambient electromagnetic energy from communication signals into usable electrical power. However, the efficiency and feasibility of RF energy harvesting systems greatly depend on the availability, strength, and stability of ambient RF signals in a given location. In a city like Bida, where wireless communication networks, broadcasting stations, and other RF-emitting devices operate within various frequency bands, assessing the actual level of RF signal availability is crucial for determining how much ambient energy can be harvested. Despite the potential for using ambient RF energy to power low-power sensors, IoT devices, or communication nodes, there is currently limited data on the strength and distribution of RF signals across Bida. Therefore, conducting a systematic assessment of RF signal availability will provide valuable insights into the viability of RF energy harvesting in the area. The results will help in identifying frequency bands with the highest power density, evaluating temporal and spatial variations in signal strength, and guiding the design and deployment of efficient energy-harvesting circuits and devices for sustainable wireless applications.

The structure of this paper is as follows: Section 2 explores the sources of radio frequency energy, Section 3 presents a literature review, Section 4 describes the materials and methods, Section 5 discusses the results, and Section 6 concludes the study.

2.0 Sources of Radio Frequency Energy

RF energy sources refer to the surplus energy transmitted by different communication signals that can be captured for harvesting (Sidhu *et al.*, 2021). RF energy harvesting is adaptable, durable, and self-sustaining (Obayiuwana *et al.*, 2024). The Radio Frequency Energy Harvesting (RF-EH) technique enables a communication node to collect RF energy from surrounding RF transmitters or designated RF sources, including television (TV) and digital television (DTV) signals, FM/AM radio broadcasts, mobile network base stations, and mobile devices (Obayiuwana *et al.*, 2024; Sidhu *et al.*, 2021).

2.1 *Wireless Fidelity*

Wireless Fidelity (Wi-Fi) is a short-range wireless communication technology that facilitates the connection of devices such as personal computers, laptops, smartphones, and personal digital assistants (PDAs) (Nechibvute *et al.*, 2017). It operates based on IEEE 802.11 standards, which define wireless local area networking (WLAN) protocols, ensuring seamless interoperability among various wireless networking devices (Nechibvute *et al.*, 2017). Wi-Fi functions within the unlicensed ISM frequency bands, typically between 2.4 GHz and 5 GHz. Originally developed for indoor use, Wi-Fi networks are optimized to cover distances of up to 100 meters (Nechibvute *et al.*, 2017).

A notable advancement in this field is the extensive deployment of Wi-Fi in high-traffic public areas, commonly referred to as hotspots. These hotspots provide internet access in locations such as coffee shops, restaurants, hotels, university campuses, airports, and other spaces where demand for wireless connectivity is high (Nechibvute *et al.*, 2017).

2.2 *Mobile Base Stations and Cellular Networks*

Over the last two decades, mobile communication technology has seen exponential growth, with global mobile phone subscriptions exceeding 7.3 billion (Nechibvute *et al.*, 2017). This expansion has led to an increase in the number of mobile network base stations, as cellular infrastructure must expand to support rising demand. Since mobile phones and base stations function as two-way radio systems, they rely on RF radiation for signal transmission. These systems operate within specific frequency ranges, allowing base stations and mobile devices to communicate effectively.

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In the Global System for Mobile Communications (GSM) network, two primary frequency bands are utilized: 900 MHz (GSM 900) and 1800 MHz (GSM 1800). Among these, the GSM 900 band is particularly suitable for RF energy harvesting, as it enables more efficient energy transmission over longer distances with lower signal degradation compared to higher-frequency bands such as those used in 3G and Wi-Fi (Nechibvute *et al.*, 2017).

2.3 *A.M Signal*

Amplitude Modulation (AM) is an analog modulation technique where the message signal's information is encoded in the amplitude of a carrier wave. AM radio operates within a frequency range of 540 kHz to 1700 kHz, corresponding to wavelengths between 565 m and 187 m. Since these wavelengths are significantly larger than typical antenna sizes, the antenna is often modelled as a short dipole. One advantage of this is the lack of strict size constraints, making it easier to design antennas for energy harvesting. AM transmitters are crucial for long-distance communication, utilizing amplitude modulation to encode low-frequency message signals onto high-frequency carrier waves. This method enables the efficient transmission of audio signals, which is widely used in radio broadcasting, navigation, and wireless communication (Xie *et al.*, 2011).

2.4 F.M. Signal

Radio Frequency (RF) energy harvesting can also be applied within the FM band, which spans from 88 MHz to 108 MHz. An FM transmitter is an electronic device that generates frequency-modulated signals using an antenna. Unlike AM, FM transmission varies the carrier wave's frequency to encode audio signals. Since FM transmitters operate at lower power, they are mainly used for communication and broadcasting. The ability to modulate sound through frequency variations makes FM transmission highly effective for various applications, including radio broadcasting and wireless communication (Tooki *et al.*, 2022)

2.5 *TV and DTV Signals*

RF energy harvesting is also feasible within the Digital Television (DTV) broadcasting spectrum, which ranges from 470 MHz to 860 MHz. Unlike solar energy, TV and DTV signals are not significantly affected by weather conditions, making them a more reliable energy source. Additionally, since these signals are continuously broadcast 24/7, they provide a consistent source of ambient energy that can be harnessed for various applications (Keyrouz *et al.*, 2012).

3.0 Literature Review

Spatial interpolation is a widely used method for estimating values at unsampled locations based on observed data from surrounding points. It plays a vital role in fields such as geography, environmental science, engineering, meteorology, and geology, where spatial data like maps, grids, or geographic coordinates are commonly analysed. Some commonly used spatial interpolation methods are Inverse Distance Weighting (IDW), Kriging, Contour, Spline Interpolation, and Nearest Neighbour (Li & Heap, 2008).

Previous studies on signal strength have often employed spline techniques. For instance, Akpaneno *et al.* (2024) utilized spline interpolation to map signal strength based on sample points and coordinates. However, this method has notable limitations. It relies heavily on visualizing sample points and coordinates without providing robust estimates for unsampled locations, leading to significant spatial gaps. This drawback hampers the comprehensive understanding and prediction of signal strength across study areas. Similarly, contour representation, another commonly used technique, assumes uniform changes between sample points, oversimplifying spatial variability. As demonstrated by Adeniran & Olusegun (2020), such oversimplifications often result in inaccuracies, particularly in complex environments.

Wong *et al.* (2004) conducted a comparative study evaluating the effectiveness of four spatial interpolation techniques: Spatial Averaging, Nearest Neighbour, Inverse Distance Weighting, and Kriging for estimating air quality data. The study evaluated accuracy using regression coefficients and coefficients of determination. Among these techniques, Kriging interpolation technique emerged as the most reliable, achieving values closest to unity for both metrics, thereby demonstrating its superior accuracy and predictive capabilities. Supporting this, Mohammed & Sulyman (2019) highlighted that Kriging is not only more accurate but also more flexible, as it accounts for both global trends and local variations.

Kriging spatial interpolation technique was adopted for this study due to its demonstrated ability to deliver precise and reliable predictions in complex spatial environments. Unlike other methods, Kriging offers a mathematical foundation that combines spatial autocorrelation and statistical modelling, allowing it to provide accurate estimates even in areas with sparse data. Its flexibility in capturing both global patterns and local variations makes it particularly effective for analysing spatial phenomena like signal strength. Furthermore, the method's proven success in previous studies, such as its superior performance in air quality estimation (Wong *et al.*, 2004), underscores its reliability and robustness. By choosing Kriging, this study aims

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to achieve more comprehensive and accurate mapping of signal strength, addressing the limitations observed in earlier techniques.

4.0 Materials and Methods

The materials and methods employed were carefully selected to ensure precise measurement, systematic data collection, and comprehensive analysis of signal strength for AM, FM, TV, and GSM signals. The materials included a spectrum analyzer, dipole antenna, Yagi antenna, Android mobile phones, and supporting tools like a laptop and vehicle for mobility. The data collection process utilized advanced mapping software, including ArcGIS Desktop and Avenza Map, to establish systematic sample points across the study area. Field assistants were guided by a street map loaded onto mobile applications, and signal measurements were conducted using standardized procedures for each signal type. Additionally, Epicollect5 mobile application was utilized for real-time data entry and storage.

4.1 *Overview of the study area*

Niger State, situated in Nigeria's north-central region, is one of the country's largest states by landmass. It shares borders with several states: Kogi and Kwara to the south, Zamfara to the northwest, Kebbi to the northeast, Kaduna to the north, and the Federal Capital Territory to the southeast. Bida, located in the southwestern part of Niger State, lies at approximately 9.0800° N latitude and 6.0030° E longitude. Positioned within Nigeria's Middle Belt, the town is predominantly inhabited by the Nupe people and is renowned for its rich cultural heritage, which includes traditional music, festivals, and craftsmanship. Figure 1 displays a map of the study area, marking the designated data collection sites.

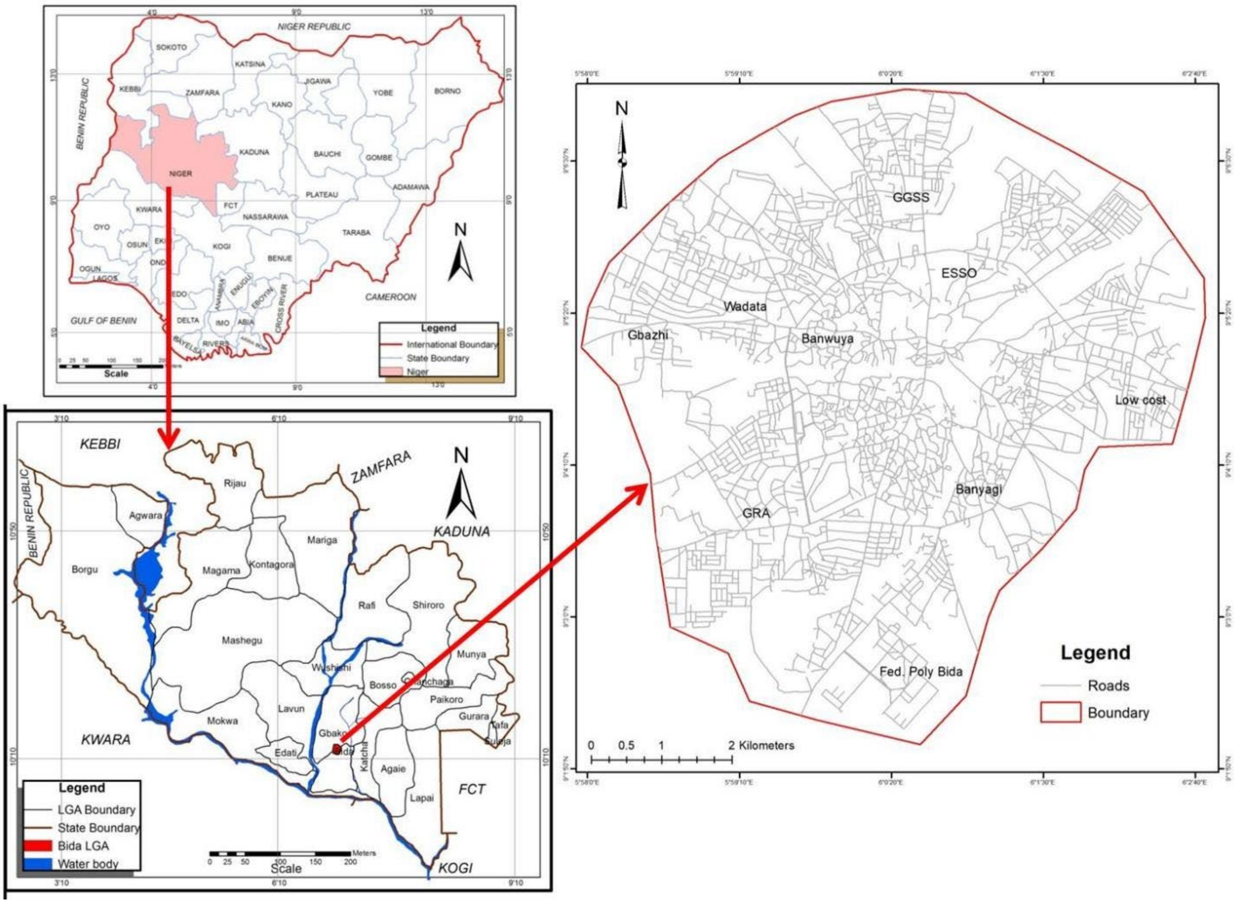

Figure 1: Map of the study region showing the designated data collection sites

4.2 *Method of Data Collection*

ArcGIS Desktop software was used to generate random points automatically at 300m intervals, indicating sample locations across the study area. Avenza Map mobile application software was installed on Android mobile phones to guide users on where data was collected. A street guide map of Bida indicating sample locations, was produced and loaded into the Azenza Map application in PDF format in order to guide field assistants to the sample locations.

As illustrated in Plate 1, a 50-ohm coaxial cable was used at each location, with one end connected to the dipole antenna and the other end attached to the spectrum analyzer via a cable connector. This setup

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facilitated the measurement of AM and FM signals. The frequencies were configured accordingly: for AM signals, the start frequency was set to 540 kHz and the stop frequency to 1700 kHz, while for FM signals, the range was set from 88 MHz to 108 MHz. For the measurement of the TV signal, the same procedures were followed for the AM and FM, except that the Yagi antenna was used and the start frequency was set at 470 MHz and the stop frequency at 860 MHz. The spectrum was then put on by pressing the on/off button and the peak marker was then put on by the spectrum analyzer and the signal strength in dB was shown on the screen of the device. An app called Network Cell Info Lite was installed on an Android phone and was used to measure the strength of the GSM signal.

Plate 1: A photograph showing the placement of the Yagi antenna and the Spectrum Analyzer for the measurement of RF at one of the study locations

The Epicollect5 mobile application was used for data collection. A form was designed for data collection in the Epicollect5 cloud platform, which allows access via the mobile application software. The Epicollect5 mobile application software was used for entering signal strength readings from the field through the Android phone and saved directly to the cloud, which was later downloaded in the form of a spreadsheet for analysis.

4.3 ***Method of Data Analysis***

The kriging spatial interpolation technique was used to analyse the signal strength of all four Radio frequency signals measured. Kriging was conducted using ArcGIS 10.8 Desktop software. Kriging allows spatial visualization of signal strength across the study area, indicating a level of signal strength across the space.

All spatial interpolation methods can be expressed as weighted averages of sampled data. They follow a common estimation formula, which is given as:

$$\hat{Z}(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i) \quad (1)$$

$\hat{Z}$ represents the predicted value of a specific attribute at the target location x_0 while z denotes the measured value at a sampled location x_i. The coefficient λ_i signifies the weight allocated to each sampled point, and n corresponds to the total number of sampled points considered in the estimation process (Li & Heap, 2008; Liu *et al.*, 2014). In geostatistics, this attribute is commonly referred to as the primary variable. A key concept in

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geostatistics is semivariance (γ), which quantifies the spatial variation between two data points and is mathematically expressed as:

$$\Upsilon(h) = \frac{1}{2} Var\{F(x_i) - F(x_{i+h})\} \quad (2)$$

In this study, $\Upsilon(h)$ represents the approximated variance between a pair of observed data points. The estimated variance between two observed data points, where h denotes the distance separating them, and $F(x)$ corresponds to the semivariogram function. The center of each grid is taken as location i, where the observed value is recorded, while all other areas are treated as locations requiring estimation (Li & Heap, 2008; Liu *et al.*, 2014).

5.0 Results and Discussion

Table 1 displays the results collected from sixty-nine locations, detailing the measured and recorded signal strengths for AM, FM, TV, and GSM frequencies.

Table 1: Result of Radio frequency Signal Strength measurement carried out in Bida (TV, FM, AM and GSM)

S/N	Latitude	Longitude	Place	TV Signal Strength (dBm)	FM Signal Strength (dBm)	AM Signal Strength (dBm)	GSM Signal Strength (dBm)
1	9.088417	5.988102	Emir palace	-74.41	-67.69	-55.54	-102
2	9.088734	5.984826	Gbazhi	-68.28	-64.43	-34.96	-112
3	9.093887	5.982821	Stadium	-61.12	-74.15	-34.08	-101
4	9.092547	5.989595	Ndayako Secondary School	-90.11	-73.05	-34.7	-106
5	9.10386	5.983312	Area 3	-63.34	-72.1	-34.79	-102
6	9.103286	5.992184	Edokota road	-66.52	-70.31	-34.72	-116
7	9.095793	5.998037	Area one	-78.21	-60.31	-54.89	-106
8	9.093171	6.002337	Banma Area Bida	-72.01	-94.09	-35.07	-95
9	9.093908	5.999992	Banma	-73.24	-74.44	-87.73	-90
10	9.107044	6.006907	Arahman	-75.98	-78.32	-35.22	-91
11	9.106144	6.010645	Lemu road	-68.42	-76.31	-35.29	-100
12	9.096617	6.010103	Esso junction	-54.75	-77.21	-34.78	-92
13	9.098197	6.019585	Ndazako	-74.16	-75.45	-34.06	-96
14	9.09643	6.027335	General Hospital	-71.22	-75.63	-34.73	-91
15	9.094316	6.027144	Kuchitagi	-73.42	-77.36	-35.1	-85
16	9.090644	6.032558	Kusodugboya	-99.4	-75.11	-34.14	-97
17	9.086887	6.028755	Project Quarters	-71.11	-80.28	-34.67	-93
18	9.086465	6.038865	FM area	-61.58	-83.48	-34.68	-104
19	9.073133	6.020905	Nasarafu	-70.14	-78.05	-35.58	-95
20	9.066502	6.020008	Eyagi Technical	-77.64	-73.33	-35.55	-80
21	9.063293	6.010046	Sima	-91.13	-75.41	-34.56	-97
22	9.061779	5.991245	Gowan lodge Gra	-71.33	-80.17	-34.57	-97
23	9.067508	5.991143	Rabahroad GRA	-58.03	-76.4	-34.88	-85
24	9.069131	5.999204	Govt college	-71.57	-77.97	-34.92	-87
25	9.07226	6.001394	Sabon Gida	-71.21	-72.06	-35.93	-94
26	9.072985	6.004289	Gudu Ndasa	-76.38	-83.15	-34.81	-98
27	9.067182	6.004029	Gbangbara	-61	-75.99	-34.72	-100

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S/N	Latitude	Longitude	Place	TV Signal Strength (dBm)	FM Signal Strength (dBm)	AM Signal Strength (dBm)	GSM Signal Strength (dBm)
28	9.060797	6.002784	Poly junction	-62.88	-83.1	-34.75	-95
29	9.054104	6.001194	Makama	-69.79	-71.56	-34.05	-90
30	9.046728	6.000445	Big Gate	-77.68	-81.26	-34.96	-82
31	9.039696	6.000066	Staff Quarters	-77.24	-78.64	-34.57	-84
32	9.040997	6.002458	Staff Sch FPB	-67.21	-82.41	-35.72	-105
33	9.03645	6.008344	QS Fpb	-45.2	-70.1	-35.02	-98
34	9.038455	6.005126	Admin FPB	-46.61	-72.49	-34.41	-93
36	9.081297	5.992412	Dokodza	-90.11	-72.05	-55.47	-101
37	9.073989	5.986594	Pichi road	-61.34	-71.1	-34.89	-111
38	9.079452	6.000714	Efu Mayaki Ndajiya	-66.32	-71.31	-34.01	-100
39	9.085625	6.000643	Banwuya	-77.21	-63.31	-34.63	-105
40	9.086903	6.010009	Lalemi	-73.01	-91.07	-34.72	-101
41	9.089883	6.004332	Kotaworo	-73.45	-72.44	-34.65	-115
42	9.072854	6.011144	Umaru Majigi	-54.45	-65.61	-54.82	-105
43	9.08896	6.017104	Masaga	-61.21	-62.41	-35	-94
44	9.09343	6.014053	Esso	-71.24	-72.15	-87.66	-89
45	9.080871	6.019091	Darachita	-54.75	-76.15	-35.15	-90
46	9.081936	6.023915	Bangaie	-74.16	-71.35	-35.22	-99
47	9.080588	6.024625	Darachita	-98.4	-77.43	-34.71	-91
48	9.083497	6.005822	Tswata Mukun	-66.52	-81.11	-33.99	-95
49	9.066525	5.983436	GRA Golf Extension	-58.03	-73.41	-34.66	-90
50	9.086915	6.023768	Bangaie	-63.34	-81.14	-35.03	-84
51	9.085574	6.018224	Bangaie	-68.28	-73.42	-34.07	-96
52	9.065721	6.016882	Banyagi	-61	-72.91	-34.6	-92
53	9.08933	5.99846	Banma	-72.1	-73.31	-34.61	-103
54	9.083159	6.032353	Bangaie	-69.79	-78.33	-35.51	-94
55	9.08307	6.027614	Bangaie	-62.8	-72.23	-35.48	-79
56	9.09085	5.974761	Gbazhi	-69.49	-70.29	-34.49	-96
57	9.102001	6.033634	Aliyu Makama Housing Estate	-77.6	-81.08	-34.5	-96
58	9.103905	6.022592	Ndazabo	-56.03	-80.26	-34.81	-84
59	9.112939	6.010354	Lafiagi	-77.57	-70.61	-34.85	-86
60	9.098541	5.993631	Edokota road	-74.21	-81.4	-35.86	-93
61	9.084702	5.976971	Gbazhi	-71.58	-70.15	-34.74	-97
62	9.053918	6.011858	Area 8	-61.68	-84.29	-34.65	-99
63	9.056538	5.985004	GRA Extension	-66.71	-74.4	-34.68	-94
64	9.053291	5.983056	GRA Extension	-72.58	-73.31	-33.98	-89
65	9.058377	5.995934	Area 7	-75.34	-70.33	-34.89	-81
66	9.056213	5.990739	Kangi	-62.25	-82.41	-34.5	-83
67	9.110774	6.003187	Behind GGSS	-47.21	-76.65	-35.65	-104
68	9.100611	6.002214	Makuku	-56.64	-71.39	-34.95	-97
69	9.089044	5.980592	Gbazhi	-73.22	-73.42	-34.34	-92

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The analysis reveals that GSM signal strength was the weakest across all sampled locations, whereas AM signal strength was the strongest. However, in some locations, the TV signal strength was weaker than the FM signal strength and vice versa in another location. Figure 2 shows the spatial distribution of AM signal strength over the entire study area. GGSS, Banwuya, and Wadata have the lowest signal strength, while Low Cost, GRA, Banygi, and Federal Polytechnic have the highest signal strength. Figure 3 illustrates the spatial distribution of FM signal strength across the study area. Esso, Banyagi, Low Cost, Federal Polytechnic Bida, and GRA exhibit the weakest signal strength, followed by Gbazhi and Banwuya, while Wadata has the strongest signal strength. Figure 4 shows the spatial distribution of TV signal strength throughout the study area. The areas of Wadata, Banwuya, and Low Cost have the weakest signals, followed by Banyagi, Gbazhi, GGSS, and GRA, with Federal Polytechnic Bida having the strongest signal strength. Figure 5 shows the distribution of GSM signal strength throughout the study area. The region with the weakest signal is followed by Wadata, Gbahi, GGSS, Esso, Banyahi, and Banwuya, whereas GRA, Low Cost, and Fed Poly experience the strongest signal strength.

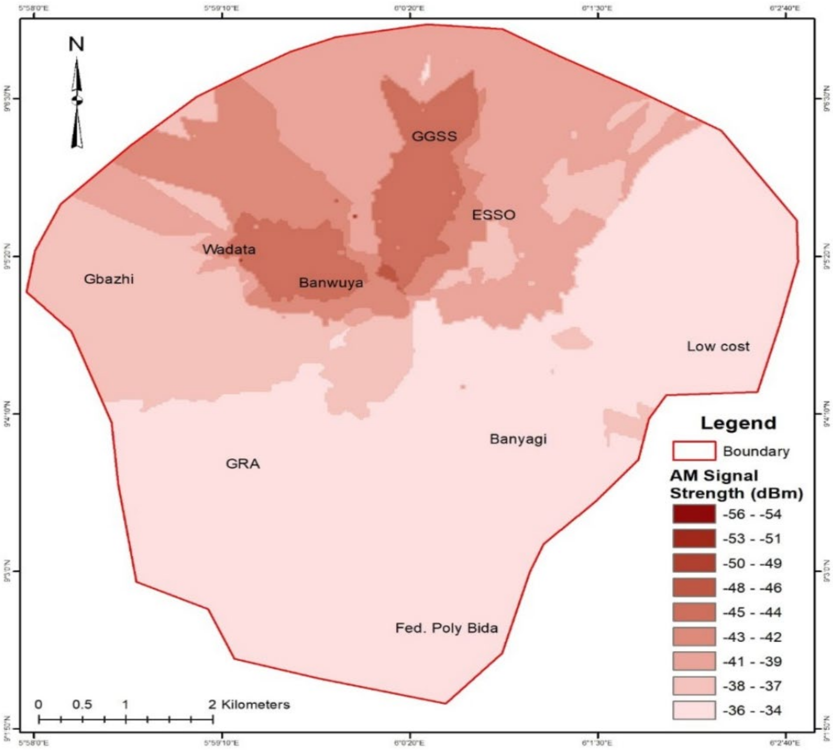

Figure 2: Spatial AM signal strength

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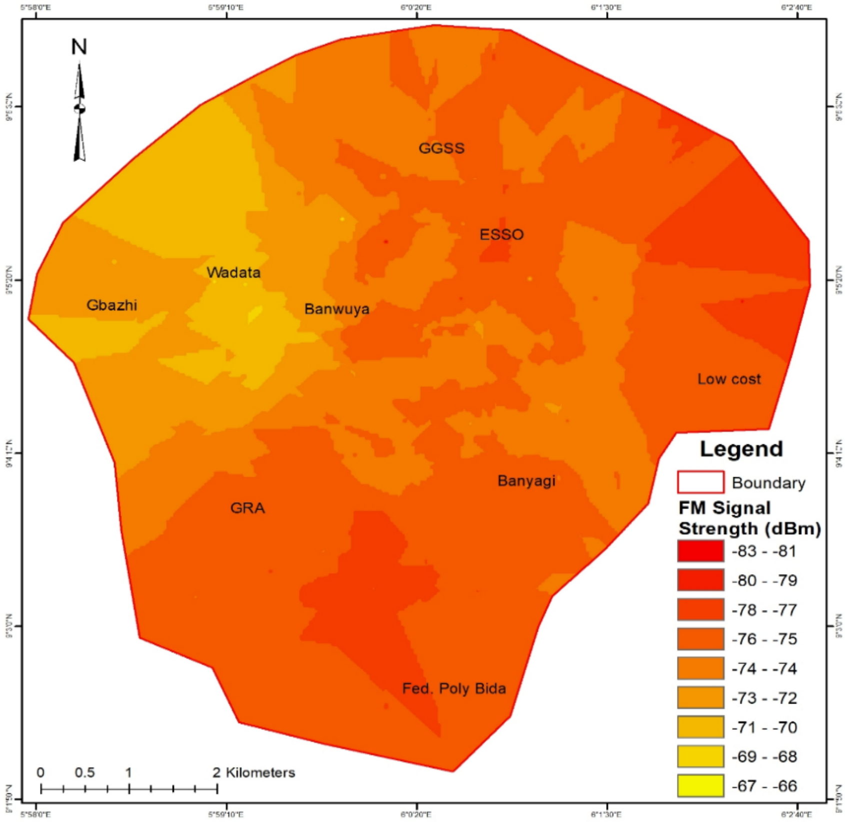

Figure 3: Spatial FM signal strength

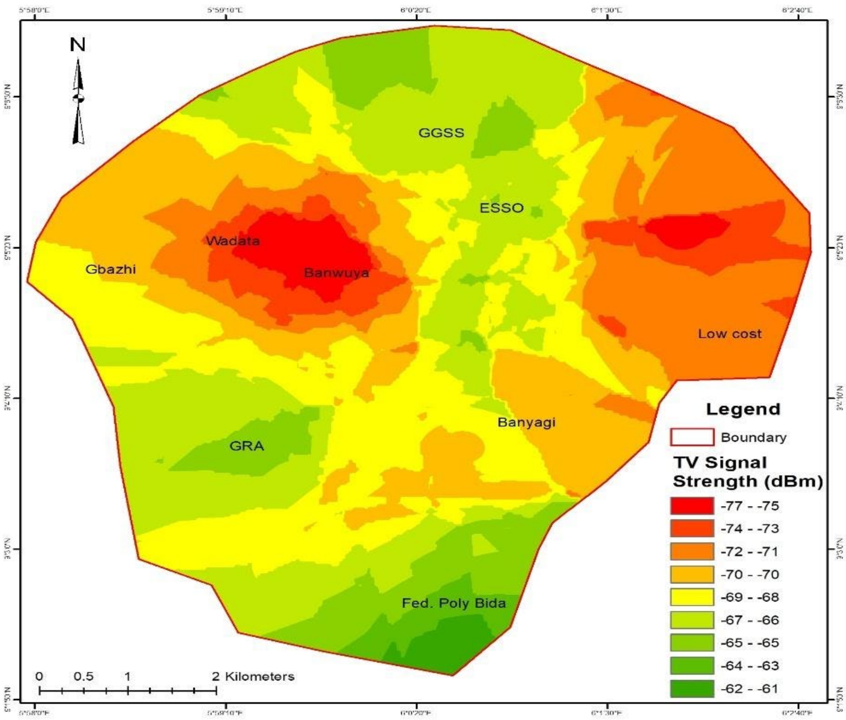

Figure 4: Spatial TV signal strength

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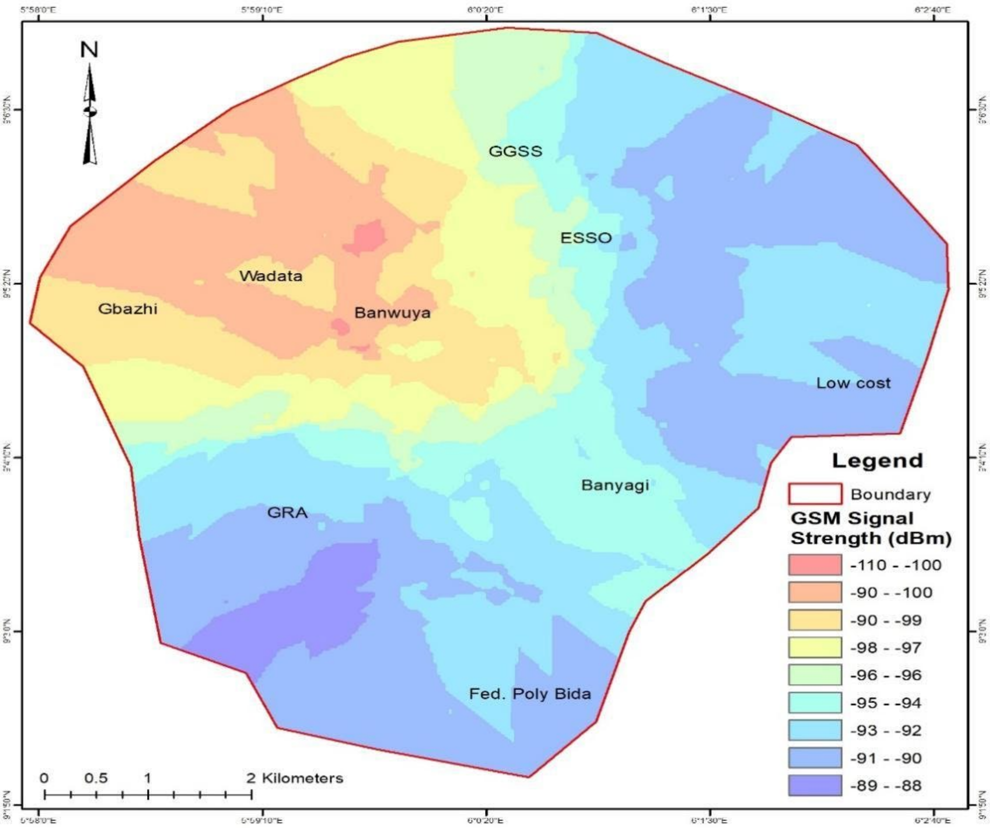

Figure 5: Spatial GSM signal strength

6.0 Conclusion

The spatial distribution of AM, FM, TV, and GSM signal strengths across Bida town was investigated at sixty-nine locations. The results revealed that GSM signals exhibited the lowest strength overall, followed by FM signals in some locations, while in other areas, TV signals were weaker than FM signals. AM signals consistently showed the highest strength across all locations. All four radio frequency signals were found to be available throughout the study area. These findings provide valuable insights into the availability and distribution of AM, FM, TV, and GSM signals in Bida, Niger State. The overall results will be useful for designing radio frequency energy harvesting systems. Implementing RF energy harvesters to power mobile devices and LED lights could play a significant role in addressing the energy crisis in developing countries such as Nigeria.

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