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SPECTRUM OCCUPANCY IN RURAL NIGERIA: A CASE FOR A LIGHTLY LICENSED SPECTRUM BAND FOR RURAL BROADBAND ENHANCEMENT

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ABSTRACT

A detailed report of the spectrum occupancy measurement drive conducted outdoors in three rural villages of Asong in Mkpat Enin, Ikot Akpabio in Etinan, and Afaha Offioing in Nsit Ibom Local Government Areas of Akwa Ibom state in Nigeria on the UHF and VHF broadcast frequency bands is here presented. The spectrum usage on a highly conservative noise floor, was high in the VHF band, thereby not having enough free bandwidth for secondary spectrum access while the UHF band percentage utilization for the three villages were found to be at 33%, 41% and 55% with available free cumulative bandwidths of 264MHz, 232MHz, and 176MHz respectively. From the findings, Nigeria can comfortably accommodate a lightly licensed spectrum band in the UHF band to enhancer rural broadband services.

KEYWORDS

Spectrum occupancy, Rural broadband enhancement, Secondary access

1. INTRODUCTION

The desire for efficient spectrum utilization has in the last decade spurred up many researches on ways to allow a mutually beneficial co-existence and opportunistic use of spectrum between the incumbent licensed users (known as the Primary Users (PUs) and the secondary unlicensed or lightly-licensed users (SUs). This interest became necessary as the methods of statistical and geographical allocation of frequency spectrum to licensees continue to encourage underutilization of spectrum. The earlier approach to solve the problem was the concept of refarming of spectrum from one type of service to another and/or the reallocation of spectrum when licensees failed to utilize them; both methods does not completely address the situation where operators have deployed the services but are not in operation at all times and in some areas (like the rural areas of less lucrative economic strength) do not deploy at all, leaving the spectrum scarce but not fully used and rendering the rural areas crossly underserved. A peculiar case in Nigeria is the issue of operators acquiring licenses for future use in case there is scarcity when it is required and in some cases the business plans changed after the spectrum has been acquired, completely tying-down the spectrum.

To tackle this problem, researchers, academia and products developers worldwide have been looking at the possibilities of sharing spectrum and allowing the use of fallow channels for the provisions of other services by other operators when the channels are not in use by the incumbent licensee [1], [2], [3], and [4]; but how much of these channels can actually be free and at what percentage of time? The research was therefore driven by this interest to determine the spectrum occupancy in rural Nigeria, using three villages in Mkpat Enin, Etinan and Nsit Ibom Local Government Areas of Akwa Ibom state to understand the relative spectrum usage in our rural areas and empirically deduce how the TV spectrum are used specifically in our rural environment. This will allow the characterization of spectral resources within the UHF and VHF bands presently underutilized in terms of frequency space and time space and as well help us to identify the most suitable bands for secondary access.

Several usage determination campaigns have been carried out in many countries in the world [5], [6], [7], [8], [9] [10] and [11] aimed at investigating the possibility of providing services on idle spectrum. In all spectrum occupancy drive, researchers attempted to quantify the spectral occupancy and help to identify possible free spectrum channels in their areas of interest, in this research we concentrated in the Ultra High Frequency (UHF) and Very High Frequency (VHF) spectrum bands within the rural areas of Nigeria, taking specific interest in inactive spectrum holes that may be appropriate for secondary access spectrum sharing broadband services in rural Nigeria. Driving secondary access on TVWS, trial projects have been initiated in some cities in US, Europe and Africa by Microsoft, Spectrum Alliance, Carlson Wireless, Shared Spectrum Company (SSC) and Google. Example is in [12] and [13]. Since we are interested in rural broadband enhancement, our concentration in this work is focused on the rural villages TV bands utilization only. The measurements were carried out in three villages in Akwa Ibom state, within the South – South geopolitical zone of Nigeria as prime studies.

2. METHOD USED IN EVALUATING SPECTRUM OCCUPANCY

This drive was carried out using energy detection method; since the sensitivity of the receiving system is ensured, the received signal strength was compared to noise threshold level in the environment within that frequency band called the decision threshold. Signals strengths detected above or equal to the threshold indicated an occupied channel while signal strengths below the threshold were considered as noise and channels said to be idle. The selection of these decision-thresholds based on noise floor is important to eliminate noise and to quantify the spectrum utilization accurately. The selection of a too-high threshold will definitely reduce the probability of detection of weak signals while a too-low threshold will produce a false-occupancy scenario [19]. Since the noise floor increases with frequency [11], to predict the best noise level, we followed [15], in this case, a known unused idle frequency channel was selected per band of interest and measured distinctively to determine the band-wise noise power. Sequel therefore the following noise floor decision thresholds were selected and using the M dB criterion [12] an additional 5dB was added to the actual noise level in each band of interest. These tests were repeated at each of the villages to ascertain the actual noise threshold suitable for each village in each band of interest as shown in the Pre-set Threshold in Table 1 below and values of signals equal to or above the threshold marked as occupied. Our choice to concentrate on the TV bands (VHF and UHF) bands was built from the fact that Cognitive Radios (CR) for the TV broadcasting bands are ready in the market following the release of IEEE 802.22 standard earlier predicted by [14]. Table 1 shows the determined noise threshold per broadcasting band of interest. Frequency selection for the measurements was informed by the Nigerian Communications Commission’s (NCC) National Frequency Allocation Table [15].

Table I: Calibrated noise floor for the four villages measured in Akwa Ibom State.

Frequency Bands for Broadcasting	Villages Pre-set Noise Thresholds in dBm		
	Asong	Ikot Akpabio	Afaha Offiong
174MHz – 230MHz (VHF)	-96.5	-96.5	-95
470MHz – 862MHz (UHF)	-96	-95	-92
Coordinates (lat- long)	N04.64661’ E007.82185^o	N04.89932’ E007.83600^o	N04.86788’ E007.91330^o

3. MEASUREMENT SETUP AND CHOICE OF LOCATIONS

The measurements were taken outdoors and where possible on the highest available platform in the three villages namely Asong in Mkpat Enin LGA, Ikot Akpabio in Etinan LGA and Afaha Offiong in Nsit Ibom LGA all of Akwa Ibom State of Nigeria. The choice was taken primarily to showcase the spectrum condition of typical rural communities in Akwa Ibom State which in turn represent the situation in many rural communities in Nigeria.

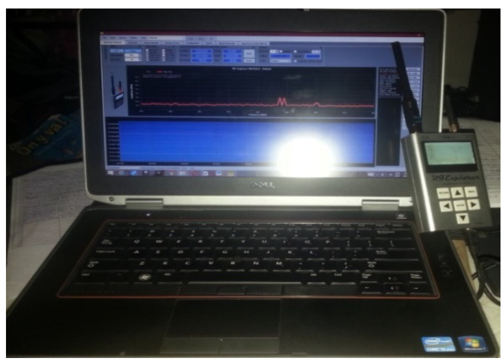

Fig 1: Picture of the Measurements setup.

The test apparatus comprises an affordable handheld device “RF-Explorer 3G Combo”, fitted with Nagoya NA-773 wide band telescopic antenna and a whip narrow band antenna capable of detecting a wide range of frequencies that satisfied the measurement drive. To capture and store the realtime data for future analysis, the RF-Explorer was connected to an RF-Explorer for Windows PC client software running on a Dell laptop through a USB cable. The RF-Explorer has already been proven to be efficient in spectrum use advocacy and measurements [16]. Picture of the experimental setup is shown in Fig.1. The energy detection test was carried out for a minimum of 5 minutes integration time per band and the average results presented herein.

4. SPECTRUM SURVEY FRAMEWORK

The measured received signal strength $r(t)$ is represented in the equation (1) as a function of the wanted signal and accumulated environmental noise.

$$r(t) = S(t) + N(t) \quad (1)$$

Where $S(t)$ represents the transmitted signal while $N(t)$ is the received noise within the environment. Hypothetically;

$$r(t) = \begin{cases} S(t) + N(t) & H_1 \\ N(t) & H_0 \end{cases} \quad \text{……………………………..……. (2)}$$

The signal strength measured was represented in dBm which is the power ratio in dB of the measured power referred to one milliWatt. H_1 Indicated the availability of signal on that channel and as such the channel is marked as occupied while condition H_0 indicated an unused channel and therefore considered available. From the hypothesis in (2), H_1 shows the received signal as a combination of the wanted signal and the noise within the measured environment, while H_0 constitute only the noise detected below the noise threshold of the band.

5. FREQUENCY CHANNEL OCCUPANCY MEASUREMENTS

The spectrum utilization can be quantified using the metric called "spectrum occupancy", which is the probability that a signal is detected above the measured threshold power level [12]. Measurements are carried out on channels within a certain band of interest to determine whether the channel is occupied or not. An integration time (IT) of 5, 15, and 30 minutes has been recommended by ITU [17]. In this work, 5-minutes measurements were used to monitor the channels within the UHF and the VHF bands distinctively to determine the actual frequency channel occupancy of each channel.

This evaluation can be done in two ways; one is to take into consideration the duty cycle (DC) of the signal thereby looking at the probability that a channel is occupied within a given period of time. Arithmetically:

$$DC = \frac{occupied\ period}{Total\ observation\ period} \times \frac{100}{1} \quad \text{………………………..…….. (3)}$$

Where the occupied period refers to the total time signal above the threshold was detected on the channel and the total observation period depicts the total time of measurements. The second consideration is called the Spectrum Resource Occupancy (SRO) which takes into consideration the total number of channels that are in use with respect to the total number of channels measured. It is sometimes referred to as band occupancy.

$$\text{…..} \quad SRO = \frac{No\ of\ Channels\ occupied}{Total\ No\ of\ channels\ measured} \times \frac{100}{1} \quad \text{………………..……..…… (4)}$$

We had chosen the spectrum resource occupancy method in this work as it provides information on all active channel irrespective of the time signal was alive or not. Measurement from multiple sweeps of iterations and data points were calculated and the maximum obtained used to identify utilization for all channels with signal strength above the predetermine noise threshold.

6. MEASUREMENT RESULTS AND ANALYSIS

Table 2 below gives the maximum received signal strengths filtered from the UHF sweeps taken during the spectrum occupancy measurements in three villages in Akwa Ibom State.

Table 2: Maximum Received Signal on the UHF band.

Frequency Point (UHF)	RSSS		
Freq Points	Asong	Afaha-offiong	Ikot Akpabio
470	-92.5	-94	-94
473.532	-91	-93	-93.5
477.063	-88.5	-91	-94
480.595	-88.5	-93.5	-94
484.126	-91	-93.5	-94
487.658	-96	-92.5	-94
491.189	-94.5	-91.5	-94.5
494.721	-95	-95.5	-96
498.252	-96	-96	-94.5
501.784	-94.5	-91	-93
505.315	-97	-92	-96.5
508.847	-89.5	-66	-94.5
512.378	-91	-61	-94
515.91	-95.5	-77.5	-87
519.441	-95.5	-84.5	-76.5
522.973	-96	-83.5	-78
526.504	-94	-85	-78.5
530.036	-96.5	-95	-93.5
533.568	-96	-81.5	-96
537.099	-94.5	-90	-95
540.631	-95	-92	-94.5
544.162	-95	-95	-95.5
547.694	-100	-76.5	-97
551.225	-94	-90.5	-96.5
554.757	-94	-95	-94.5
558.288	-99.5	-93	-96.5
561.82	-99	-95.5	-94.5
565.351	-99	-91.5	-96.5
568.883	-96	-96	-95.5
572.414	-99	-96	-98
575.946	-98	-98.5	-99
579.477	-98	-99.5	-98
583.009	-99.5	-98.5	-100
586.54	-99	-99	-98.5
590.072	-99	-99	-98.5
593.603	-83.5	-98.5	-98.5
597.135	-96.5	-96	-96
600.667	-98.5	-96.5	-94.5
604.198	-98	-96.5	-94

607.73	-98	-96.5	-79.5
611.261	-98	-98.5	-98
614.793	-98	-95	-96.5
618.324	-98	-93.5	-94.5
621.856	-97.5	-95.5	-97
625.387	-98	-97	-98.5
628.919	-98	-92	-96
632.45	-99.5	-90.5	-96.5
635.982	-99.5	-92	-97.5
639.513	-99	-97.5	-98.5
643.045	-100	-98	-99
646.576	-99	-94.5	-98
650.108	-99.5	-98.5	-99.5
653.639	-99.5	-96	-98
657.171	-96.5	-87.5	-96.5
660.703	-98.5	-96.5	-95
664.234	-98.5	-97	-97.5
667.766	-99	-98	-96
671.297	-98.5	-96.5	-97
674.829	-99	-97.5	-98.5
678.36	-97.5	-88.5	-94
681.892	-97	-98	-97
685.423	-98	-98	-91.5
688.955	-97.5	-93	-97
692.486	-99	-97	-97.5
696.018	-97	-95	-96.5
699.549	-98	-75	-92.5
703.081	-95.5	-79	-99
706.612	-95.5	-92	-99.5
710.144	-99.5	-86	-99
713.675	-100.5	-94	-99
717.207	-98.5	-87.5	-97
720.738	-98.5	-98.5	-99.5
724.27	-99	-92.5	-100.5
727.802	-100.5	-99	-98
731.333	-99	-98	-99
734.865	-99	-97.5	-99.5
738.396	-97.5	-95.5	-99
741.928	-94.5	-97.5	-99
745.459	-95	-97.5	-99.5
748.991	-92.5	-98.5	-97
752.522	-98.5	-92	-100
756.054	-99.5	-91	-100

759.585	-99	-82.5	-98.5
763.117	-99	-85.5	-98
766.648	-98.5	-89.5	-97
770.18	-99.5	-87.5	-99
773.711	-97.5	-86	-98
777.243	-97	-89.5	-95
780.774	-97	-91.5	-97.5
784.306	-98	-89	-90.5
787.838	-97.5	-95.5	-97.5
791.369	-97.5	-98	-97
794.901	-98	-96.5	-98
798.432	-98.5	-96.5	-97.5
801.964	-97.5	-97.5	-97.5
805.495	-96.5	-97	-98
809.027	-98	-98	-97
812.558	-98.5	-96	-99
816.09	-98.5	-95	-99
819.621	-96.5	-87	-98
823.153	-98	-97	-97
826.684	-98.5	-97	-97
830.216	-97.5	-93	-98.5
833.747	-98.5	-98	-98
837.279	-97.5	-94	-97.5
840.81	-97.5	-96.5	-97.5
844.342	-98.5	-92	-97
847.873	-99.5	-97	-90.5
851.405	-98	-96	-90.5
854.937	-99	-95.5	-99
858.468	-99.5	-94.5	-99
862	-99	-92	-98

Similarly the Table 3 below gives the maximum received signal strength filtered from the VHF frequency sweep measurements for the three villages in Akwa Ibom State Nigeria.

Table 3. Maximum Received Signal on the VHF band.

Frequency Points (VHF)	RSSS		
Freq Points	Asong	Afaha-offiong	Ikot Akpabio
174	-99	-83	-98.5
174.505	-99	-84.5	-99
175.009	-99.5	-88.5	-98.5
175.514	-99	-94.5	-97.5

176.018	-98	-94	-99
176.523	-99	-90	-99
177.027	-98	-95.5	-99
177.532	-99	-96.5	-99
178.036	-98.5	-94.5	-98
178.541	-98	-95.5	-98
179.045	-99.5	-97	-98.5
179.55	-99	-96.5	-98.5
180.054	-94.5	-93.5	-94
180.559	-98.5	-96.5	-98.5
181.063	-98.5	-97.5	-98
181.568	-98.5	-93	-98.5
182.072	-98.5	-93.5	-98.5
182.577	-98	-97.5	-98.5
183.081	-99	-97	-97.5
183.586	-99	-92.5	-98
184.09	-98.5	-95	-99
184.595	-99	-75	-98.5
185.099	-98.5	-91	-99
185.604	-97.5	-90.5	-97
186.108	-99	-97	-97
186.613	-99	-76	-98.5
187.117	-98.5	-77.5	-97
187.622	-99	-91	-98.5
188.126	-97.5	-88.5	-97
188.631	-97	-95.5	-97.5
189.135	-98	-89	-98
189.64	-98.5	-93.5	-98
190.144	-98	-92.5	-98
190.649	-99	-88	-99
191.153	-98.5	-89	-97.5
191.658	-97	-98	-98.5
192.162	-96.5	-96	-96
192.667	-98.5	-95	-97
193.171	-98.5	-97.5	-98.5
193.676	-98.5	-98	-99
194.18	-98	-98	-98
194.685	-98	-97	-98.5
195.189	-98	-97	-98
195.694	-99	-95.5	-98
196.198	-97.5	-98.5	-99

196.703	-97	-97.5	-98
197.207	-98.5	-97	-97
197.712	-98	-97.5	-98.5
198.216	-98.5	-96.5	-98
198.721	-98.5	-98.5	-81.5
199.225	-99	-99	-98.5
199.73	-98	-98.5	-99
200.234	-98.5	-96	-99
200.739	-99.5	-97	-97.5
201.243	-97.5	-98.5	-99
201.748	-98	-98.5	-98.5
202.252	-99	-96	-99
202.757	-98.5	-97	-98.5
203.261	-98.5	-97.5	-98.5
203.766	-98.5	-98	-99
204.27	-98.5	-96.5	-98.5
204.775	-98.5	-98.5	-98
205.279	-97	-98	-98.5
205.784	-98	-97.5	-99.5
206.288	-99	-98	-98.5
206.793	-99	-97	-97.5
207.297	-97.5	-98	-97.5
207.802	-98.5	-95.5	-99
208.306	-98	-98.5	-97.5
208.811	-98.5	-98	-99
209.315	-98.5	-98	-99
209.82	-95.5	-96.5	-96.5
210.324	-98.5	-97.5	-98
210.829	-99	-97	-98.5
211.333	-98.5	-97.5	-98.5
211.838	-98	-97	-96.5
212.342	-98.5	-97	-98
212.847	-98.5	-97.5	-98
213.351	-99	-97.5	-98.5
213.856	-98	-98	-98
214.36	-99	-97	-98
214.865	-99	-98.5	-98.5
215.369	-98.5	-98	-97.5
215.874	-98.5	-97	-98.5
216.378	-99.5	-96.5	-98.5
216.883	-97.5	-97.5	-99

217.387	-98	-98.5	-97.5
217.892	-98.5	-97	-99
218.396	-98.5	-98	-98
218.901	-98.5	-97.5	-97.5
219.405	-99	-98	-98
219.91	-98	-98.5	-98
220.414	-98.5	-99	-98.5
220.919	-98.5	-98.5	-97.5
221.423	-98.5	-97	-98
221.928	-97.5	-97	-96.5
222.432	-98	-97	-97
222.937	-98.5	-96.5	-97
223.441	-98.5	-97.5	-97.5
223.946	-96.5	-96	-90.5
224.45	-98.5	-96	-98
224.955	-99	-97.5	-98
225.459	-98.5	-98	-98.5
225.964	-99	-95.5	-97.5
226.468	-97.5	-95	-97.5
226.973	-99	-96.5	-97
227.477	-98	-94	-97
227.982	-99	-95.5	-98
228.486	-98.5	-95.5	-98.5
228.991	-98.5	-95.5	-96.5
229.495	-94.5	-91	-94
230	-96.5	-92	-97

Fig 2 and Fig 3 depicts the RSS versus frequency plot for the UHF and VHF bands covering the three villages presented in the tables 3 and 4 above..

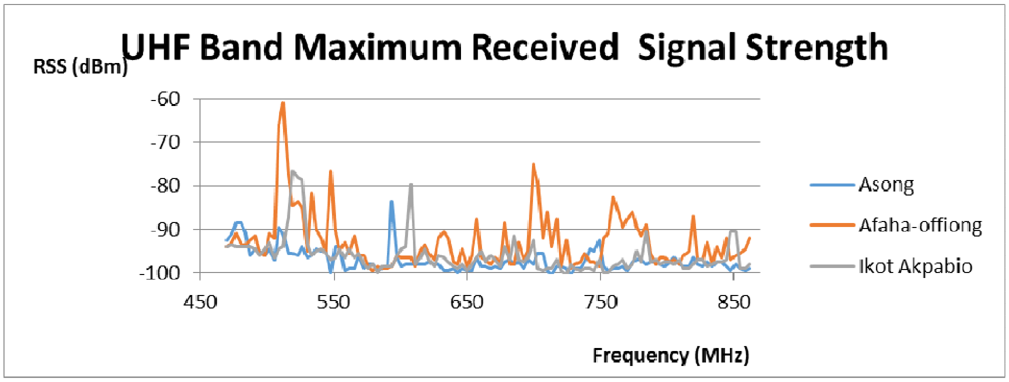

Fig 2 Maximum Received Signal Strength on the UHF Band

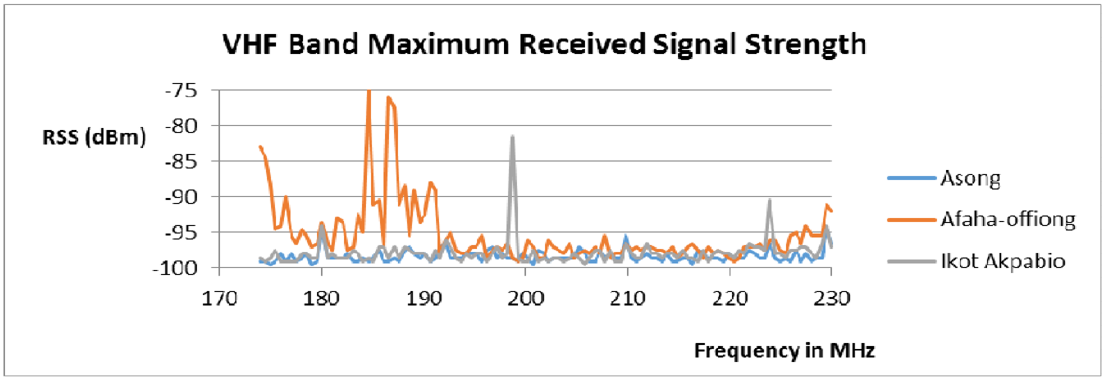

Fig 3 Maximum Received Signal strength on the VHF Band

6.1 Asong Village – Mkpat Enin LGA Data Analysis and Presentations.

Below is the plot (Fig 4) of the RSS Amplitude against measured Frequency point in the VHF band at Asong in Mkpat Enin LGA of Akwa Ibom State. Following in fig 5 is the waterfall image relating the RSS to the frequency and time of measurements.

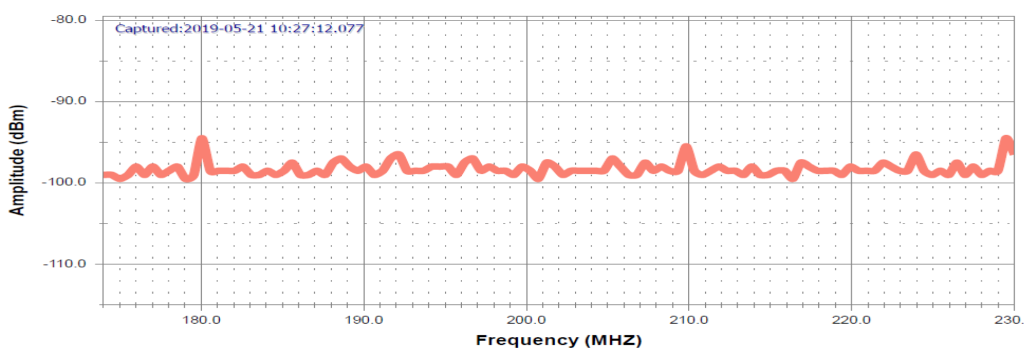

Fig 4: RSS amplitude against measured frequency points in the VHF band at Asong.

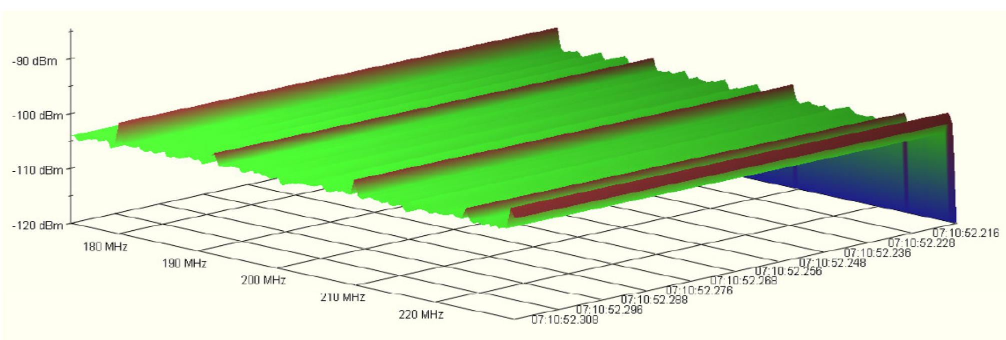

Fig 5: Waterfall of VHF band plot of RSS to frequency and time of measurements for Asong.

In calculating the SRO of the VHF band, a total of seven channels were measured in line with NCC frequency allocation table [15]. Using the threshold in table 1, we had four occupied throughout the measurements.

Total number of channel measured = 7
Number of busy channels = 4
Number of unused channels = 3
Available bandwidth = 3 x 8 = 24MHz
Spectrum occupancy of VHF channels at Asong = $\frac{4}{7} x \frac{100}{1} = 57.1 \equiv 57\%$

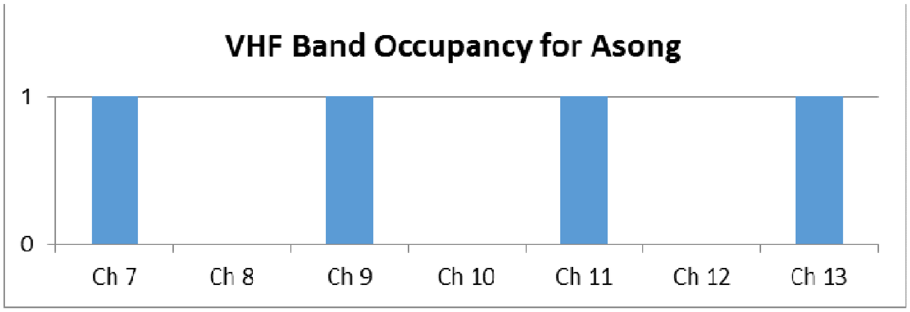

Fig 6: The VHF band occupancy for Asong.

Similarly, the UHF band was also monitored and the plots Fig 7 showing the individual RSS against the frequency is shown below, the waterfall and spectrum resource occupancy follows in Fig 8 and Fig 9 respectively

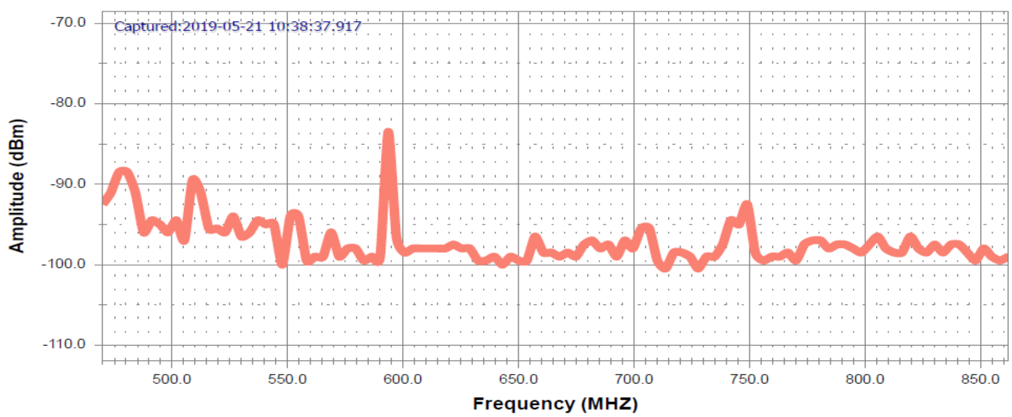

Fig 7: UHF RSS amplitude against frequency.

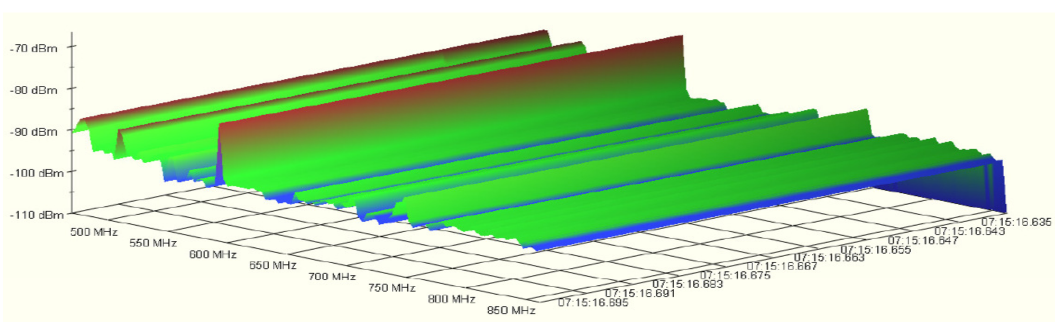

Fig 8: Waterfall imaging showing the RSS per frequency and time measured.

A total of 49 UHF channels were measured at Asong in Mkapat Enin LGA using the threshold in table 1 and 16 channels were found to have signal on them.

Total channels measured = 49
Total channels used = 16
Total unused channels = 49 – 16 = 33
Total available bandwidth = 33x8MHz = 264MHz

The spectrum resource occupancy for the UHF channels at Asong, in Mkpat Enin LGA is given using equation 1 as $SRO = \frac{used\ channels}{measured\ channels} x \frac{100}{1}$, $that\ is\ \frac{16}{49} x \frac{100}{1} = 32.7 \equiv 33\%$

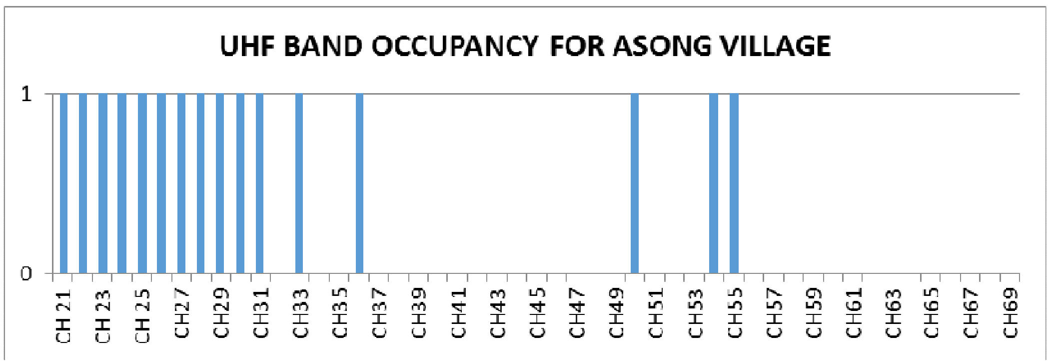

Fig 9: UHF frequency band occupancy for Asong village.

6.2 Ikot Akpabio - Etinan LGA Data Presentation

Below is the Ikot Akpabio VHF data plots and waterfall.

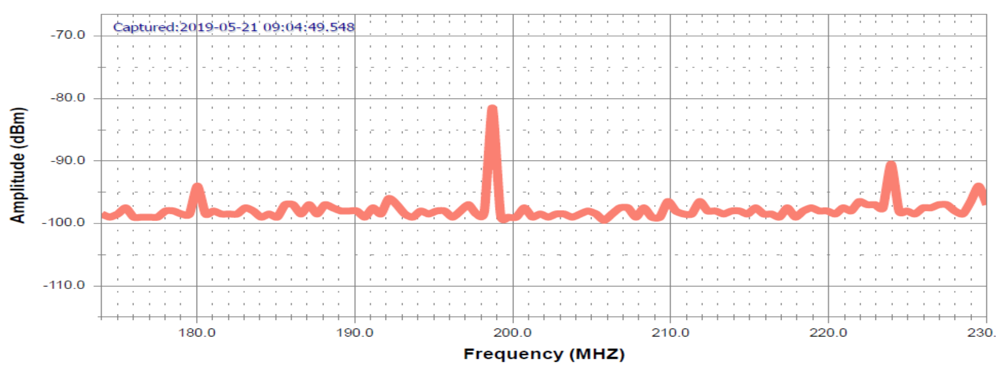

Fig 10: Shows the plot of RSS against frequency for Ikot Akpabio only in the VHF band.

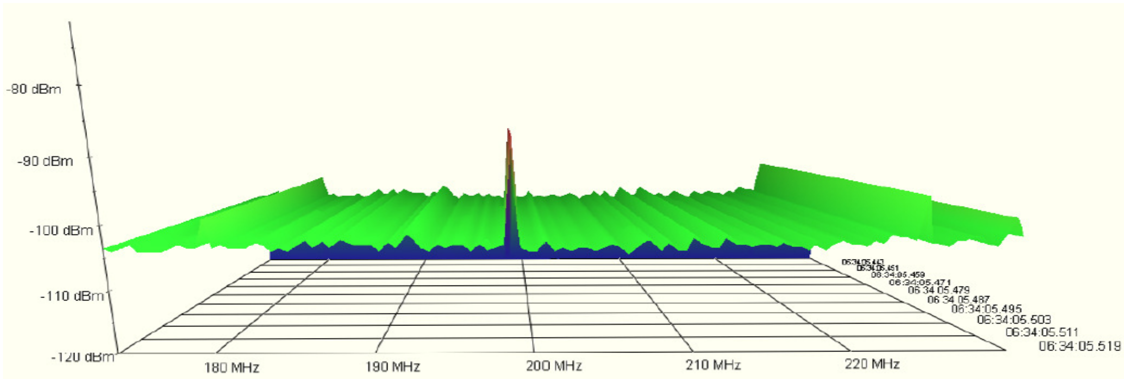

Fig 11: Waterfall image of Ikot Akpabio VHF band measurements.

Ikot Akpabio VHF band occupancy, a total of seven channels were measured as stated in [15], using the threshold in table 1, we had

Total number of channel measured	= 7
Number of busy channels	= 5
Number of unused channels	= 2
Available bandwidth	= 2 x 8 = 16MHz

Spectrum occupancy of VHF channels at Ikot Akpabio = $\frac{5}{7} x \frac{100}{1} = 71.4 = 71\%$

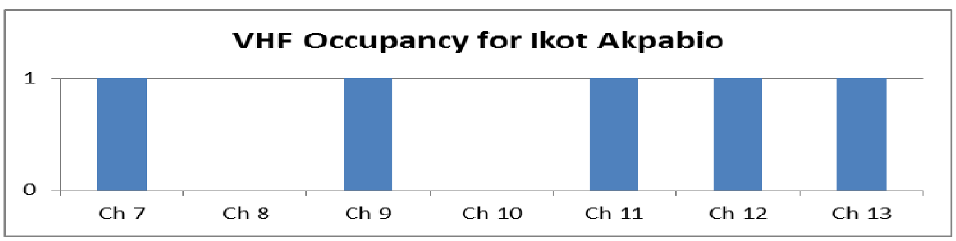

Fig 12 VHF occupancy for Ikot Akpabio – Etinan.

Fig 10, Fig 11 and Fig 12 depicts the RSS plot against frequency, the waterfall image and the channel occupancy of the VHF band respectively. Similarly Fig 13, Fig 14 and Fig 15 displays the behaviour of signals at the UHF band in the same to village of Ikot Akpabio in Etinan LGA.

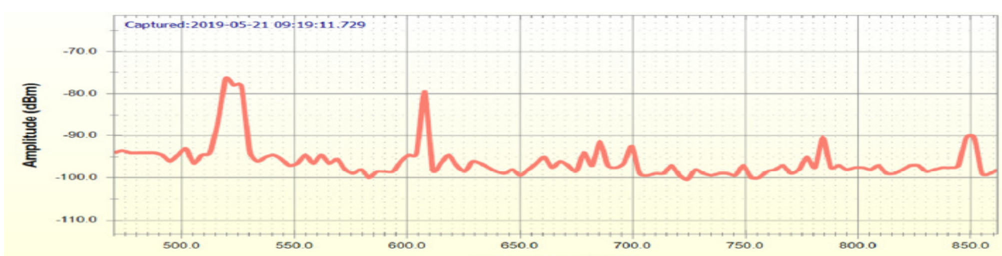

Fig 13: Amplitude versus frequency at the UHF band at Ikot Akpabio in Etinan LGA.

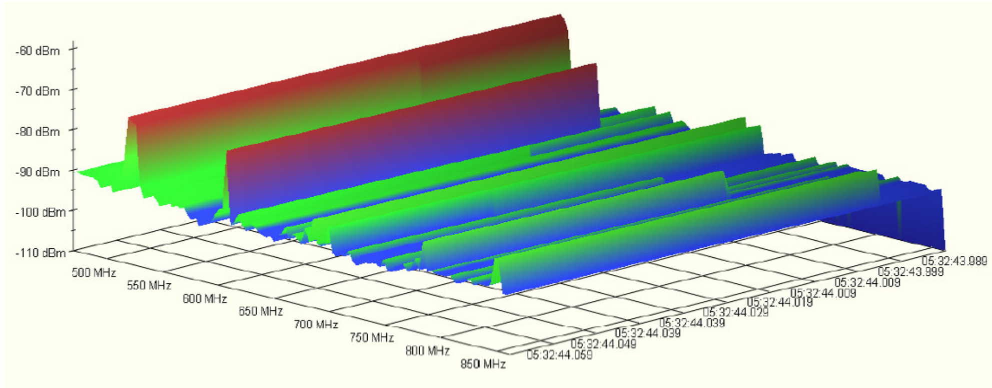

Fig 14: Waterfall diagram of amplitude versus frequency at the UHF band at Ikot Akpabio in Etinan LGA.

For Ikot Akpabio, we also apply the same method
Total channels measured = 49
Total channels used = 20
Total unused channels = 49 – 20 = 29
Total available bandwidth = 29x8MHz = 232MHz

The spectrum resource occupancy for the UHF channels at Ikot Akpabio, Etinan is given using equation 4.1 as $SRO = \frac{used\ channels}{measured\ channels} x \frac{100}{1}$, $that\ is\ \frac{20}{49} x \frac{100}{1} = 40.8 \equiv 41\%$

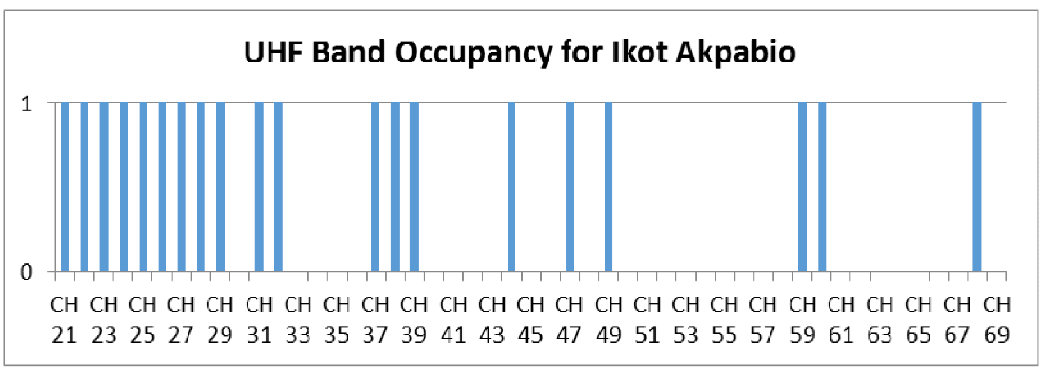

Fig 15: UHF band spectrum occupancy for Ikot Akpabio

6.3 Afaha Offiong Village – Nsit Ibom LGA Data Analysis and Presentations.

Afaha Offiong VHF plot, whitespace waterfall and VHF occupancy is presented below by Fig 16, Fig 17 and Fig 18 respectively.

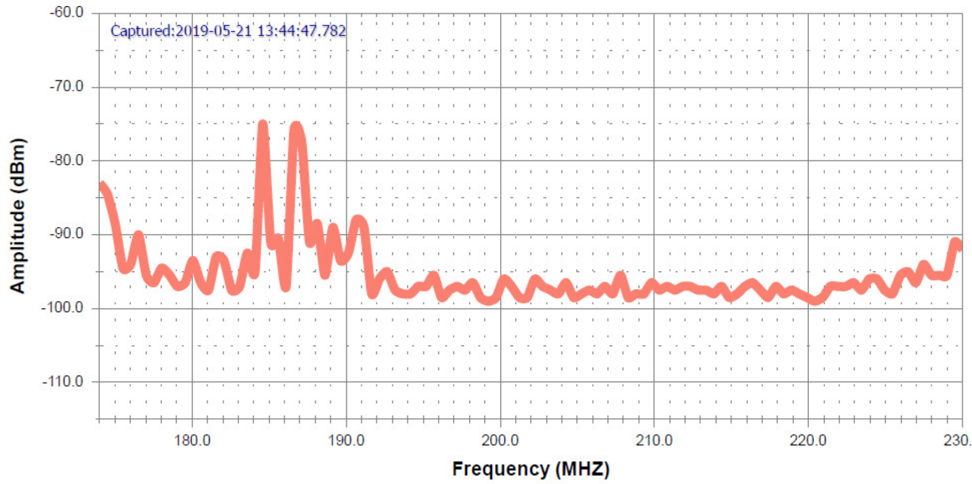

Fig 16: Power density against frequency in VHF band at Afaha-Offiong village in Nsit Ibom LGA.

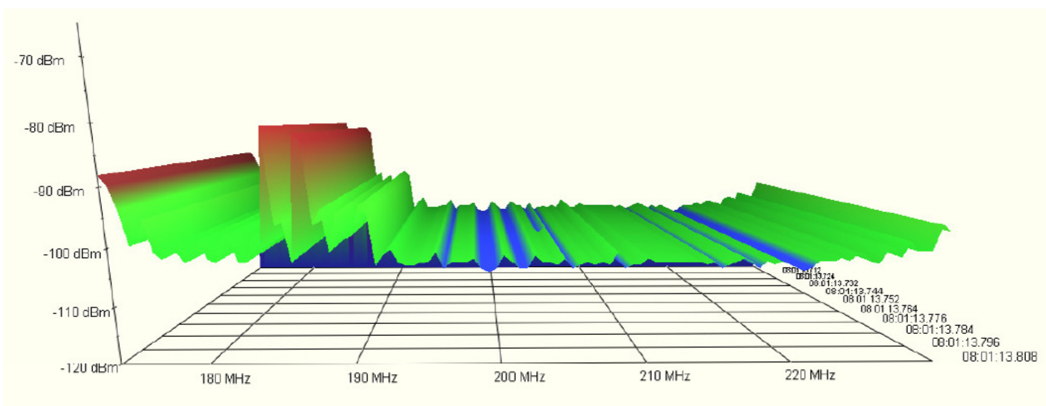

Fig 17: Waterfall display for Afaha-Offiong VHF band

Also for Afaha-Offiong, the VHF's occupancy was calculated as follows;

Total number of channel measured = 7

Number of busy channels = 4

Number of unused channels = 3

Available bandwidth = 3 x 8 = 24MHz

Spectrum occupancy of VHF channels at Asong = $\frac{4}{7} x \frac{100}{1} = 57.1 \equiv 57\%$

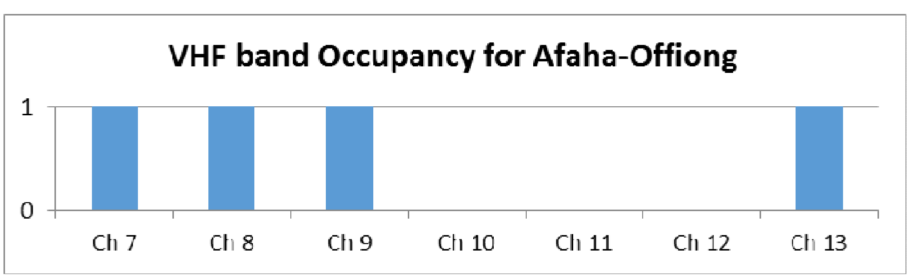

Fig 18: VHF band occupancy measurement for Afaha-Offiong.

Similarly Figure 19 to Figure 21 show the Afaha-Offiong UHF energy plot, waterfall display as well as the UHF occupancy measurements.

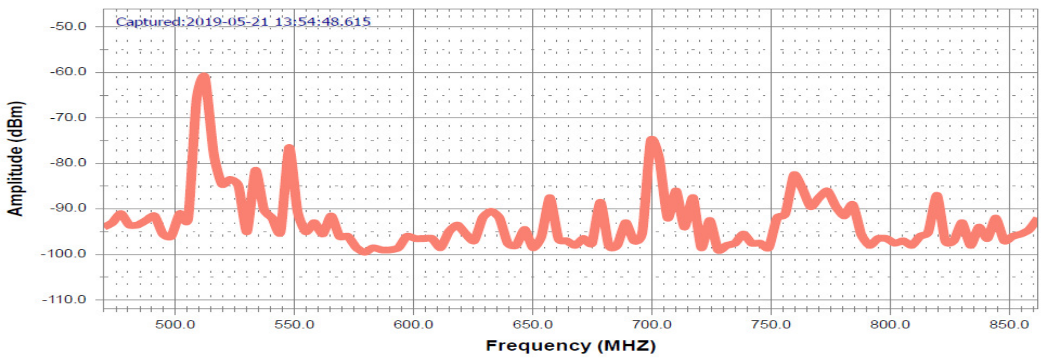

Fig 19: Signal Strength versus frequency

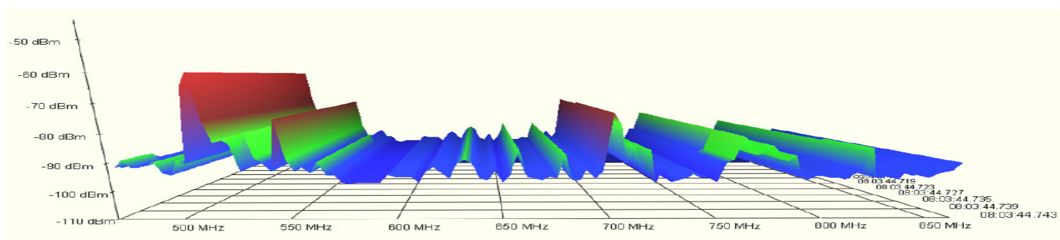

Fig 20: Waterfall image for UHF signal measured at Afaha-Offiong

For Afaha Offiong, we also apply the same method

Total channels measured = 49

Total channels used = 27

Total unused channels = 49 – 27 = 22

Total available bandwidth = 22x8MHz = 176MHz

The spectrum resource occupancy for the UHF channels at Afaha Offiong, Nsit Ibom LGA is given using equation 4.1 as $SRO = \frac{used\ channels}{measured\ channels} x \frac{100}{1}$, that is $\frac{27}{49} x \frac{100}{1} = 55.1 \equiv 55\%$

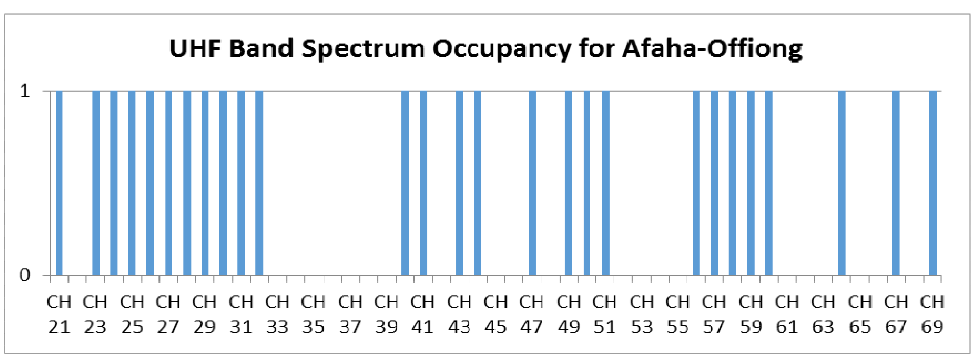

Fig 21: UHF band occupancy for Afaha-Offiong in Nsit Ibom LGA

7. CONCLUSION

This work investigated the VHF and UHF spectrum utilization in typical rural areas of Nigeria by taking empirical usage measurements of the spectrum bands in three villages in Akwa Ibom State. The target was to investigate the possibility of available channels for use by secondary rural broadband services providers in Nigeria. The results from the three villages show that the spectrum usage was high in the VHF band, thereby not having enough bandwidth for secondary spectrum access. The UHF band utilization for the three villages were; Asong 33%, Ikot Akpabio 41% and Afaha-Offiong 55% with available free cumulative bandwidth of 264MHz, 232MHz, and 176MHz respectively that can comfortably accommodate a lightly licensed spectrum band that can be put to use to enhance broadband penetration in the state. That is to say, that we can comfortably enhance the data access capability of our rural dwellers by use of TV-whitespaces as can be seen in this work.

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