NATIONAL COMMUNICATIONS AUTHORITY

Quality of Service (QoS) Monitoring of Cellular Mobile Voice Services- Northern Region

[February 2016]

[Communications for Development]

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Background

In pursuance of Annexure D1 and D2 of the Cellular Mobile Licence of Telecommunication Operators, the user perspective of the quality of voice services are tested to ensure the compliance of Operators to the obligations on service quality to the user.

The report is based on findings on quality of service in Northern Region from 10th February to 4th March 2016 for all Operators except for Expresso due to technical challenges. The voice service of Expresso is not available in the entire Northern region and Glo voice service is available at parts of Tamale Metropolitan area.

What we measure

As per the Cellular Mobile licence obligations, the QoS indicators and their respective threshold for compliance under assessment considering the user's perspective are;

- **Stand-alone Dedicated Control Channel (SDCCH) Congestion Rate**

- **Call Setup Time (CST)**

- **Call Congestion Rate**

- **Call Drop Rate (CDR)**

- **Call Completion Rate (CCR)**

- **Voice Call Audio Quality**

- **Coverage**

Findings

The results for the district capitals within Northern Region tested during the period are as below:

a) Stand-alone Dedicated Control Channel (SDCCH) Congestion Rate

SDCCH Congestion is defined as the probability of failure of accessing a stand-alone dedicated control channel during call set up.

For analysis and calculations,

$$SDCCH\,Congestion[\%] = \frac{Number\,of\,connect\,fails\,due\,to\,Immediate\,Assignment\,Failures}{MOC\,call\,attempts} \times 100\%$$

SDCCH Congestion Rate should be equal or less than one per cent (1%).

The results for the cities and towns tested in February are as below:

Table 1 Signalling Congestion Rate Cellular Mobile Voice Service, February 2016

Month	Town	MTN	Vodafone	Tigo	Airtel	GLO
February	Bimbilla	0%	0%	No Network	0%	No Network
February	Bole	0%	0%	0%	0%	No Network
February	Bupe	0%	0%	0%	0%	No Network
February	Daboya	0%	0%	0%	No Network	No Network
February	Damongo	0%	0%	0%	0%	No Network
February	Gushegu	0%	0%	0%	0%	No Network
February	Karaga	0%	0%	0%	No Network	No Network
February	Kpandai	0%	0%	0%	0%	No Network
February	Kumbungu	0%	0%	0%	0%	No Network
February	Saboba	0%	0%	0%	0%	No Network
February	Sagnerigu	0%	0%	0%	0%	No Network
February	Salaga	0%	0%	0%	0%	No Network
February	Sang	0%	0%	0%	0%	No Network
February	Savelugu	0%	0%	0%	0%	No Network
February	Sawla	0%	0%	0%	0%	No Network
February	Tamale	0.23%	0%	0%	1.28%	1.44%
February	Tatale	0%	0%	0%	0%	No Network
February	Tolon	0%	0%	0%	0%	No Network
February	Wulensi	0%	0%	0%	0%	No Network
February	Yendi	0%	0%	0%	0%	No Network
February	Zabzugu	1.72%	0%	0%	0%	No Network

REMARKS:

❖ Vodafone and Tigo were in compliance in all tested cities and towns with the Signalling Congestion threshold of less than 1 percent (1%) .

❖ MTN failed the Signalling Congestion threshold in Zabzugu.

❖ Airtel and Glo failed the Signalling Congestion threshold in Tamale.

b) Call Setup Time (CST)

Call Setup Time is the period of time elapsing from the sending of a complete destination address (target telephone number) to the setting up of a call to the receiving terminal;

$$\text{Call set - up time } [s] = t_{alerting-signal} - t_{address-sending}$$

$t_{alerting\ signal}$ – Moment when an alerting signal is sent to the called terminal

$t_{address\ sending}$ – Moment user presses the SEND button on the calling terminal

CST should be less than ten seconds (<10secs) in 95% of cases.

Table 2 Call Setup Time of Cellular Mobile Voice Service, February 2016

Month	Town	MTN	Vodafone	Tigo	Airtel	GLO
February	BIMBILLA	6.18sec	3.77sec	N/A	6.21sec	N/A
February	BOLE	6.11sec	4.74sec	5.49sec	12.14sec	N/A
February	BUIPE	6.12sec	5.27sec	8.18sec	5.56sec	N/A
February	DABOYA	5.52sec	6.06sec	N/A	7.54sec	N/A
February	DAMONGO	8.45sec	5.19sec	12.498sec	9.63sec	N/A
February	GUSHEGU	7.33sec	3.36sec	13.14sec	7.52sec	N/A
February	KARAGA	9.74sec	7.44sec	13.81sec	N/A	N/A
February	KPANDAI	4.59sec	5.79sec	14.78sec	5.35sec	N/A
February	KUMBUNGU	6.93sec	6.84sec	9.27sec	11.82sec	N/A
February	SABOBA	4.27sec	3.14sec	7.1sec	7.11sec	N/A
February	SAGNARIGU	8.55sec	7.86sec	12.56sec	12.298sec	N/A
February	SALAGA	6.96sec	4.49sec	13.19sec	16.82sec	N/A
February	SANG	5.79sec	6.13sec	6.72sec	5.81sec	N/A
February	SAVELUGU	10.42sec	3.04sec	9.498sec	7.54sec	N/A
February	SAWLA	5.898sec	4.92sec	5.03sec	6.32sec	N/A
February	TAMALE	9.26sec	9.83sec	14.93sec	13.29sec	7.35sec
February	TATALE	9.39sec	6.2sec	6.42sec	5.77sec	N/A
February	TOLON	4.044sec	7.27sec	6.98sec	5.92sec	N/A
February	WULENSI	4.38sec	4.34sec	9.55sec	6.53sec	N/A
February	YENDI	9.25sec	6.3sec	10.18sec	13.17sec	N/A
February	ZABZUGU	14.33sec	3.79sec	9.497sec	12.05sec	N/A

REMARKS:

❖ All Operators except Vodafone failed to meet the parameter threshold for Call Setup Time in certain localities.

   ❖ Airtel had high Call Setup Time of 12.35sec in the Northern region.

   ❖ MTN had Call Setup Time delays in Savelugu and Zabzugu.

   ❖ Tigo had Call Setup Time delays at Damongo, Gushegu, Karaga, Kpandai, Sagnarigu, Salaga, Tamale and Yendi.

   ❖ Airtel had Call Setup Time delays at Bole, Kumbungu, Sagnarigu, Salaga, Tamale, Yendi and Zabzugu.

c) Call Congestion Rate

Call Congestion Rate is the probability of failure of accessing a traffic channel during call setup;

$$\text{Call Congestion } [\%] = \frac{\text{Number of Connect failed calls}}{\text{Total number of call attempts}} \times 100\%$$

Traffic Channel Congestion should be equal or less than one per cent (1%).

Table 3 Call Congestion Rate Cellular Mobile Voice Service, February 2016

Month	Town	MTN	Vodafone	Tigo	Airtel	GLO
February	Bimbilla	0%	0%	No Network	0%	No Network
February	Bole	0%	0%	0%	0%	No Network
February	Bupe	0%	0%	0%	0%	No Network
February	Daboya	0%	0%	0%	No Network	No Network
February	Damongo	0%	0%	0%	0%	No Network
February	Gushegu	0%	0%	0%	0%	No Network
February	Karaga	0%	0%	0%	No Network	No Network
February	Kpandai	0%	0%	0%	0%	No Network
February	Kumbungu	0%	0%	0%	0%	No Network
February	Saboba	0%	0%	0%	0%	No Network
February	Sagnerigu	0%	0%	0%	0%	No Network
February	Salaga	0%	0%	0%	0%	No Network
February	Sang	0%	0%	0%	0%	No Network
February	Savelugu	0%	0%	0%	0%	No Network
February	Sawla	0%	0%	0%	0%	No Network
February	Tamale	0.47%	0%	0%	1.39%	0.72%
February	Tatale	0%	0%	0%	0%	No Network
February	Tolon	0%	0%	0%	0%	No Network
February	Wulensi	0%	0%	0%	0%	No Network
February	Yendi	0%	0%	0%	0%	No Network
February	Zabzugu	1.72%	0%	0%	0%	No Network

REMARKS:

- ❖ Vodafone,Tigo and Glo remained compliant with the licence threshold of less than one percent (1%) in all the tested locations

- ❖ MTN and Airtel recorded high traffic congestion at Zabzugu and Tamale respectively.

d) Call Drop Rate (CDR)

Voice Call Drop Rate is the probability of a call terminating without any of the users' will;

$$DropRate[\%] = \frac{Number\ of\ calls\ terminated\ unwillingly}{Total\ number\ of\ call\ attempts} \times 100\%$$

Call drop rate should be equal or less than three per cent (3%).

Table 4 Call Drop Rate Cellular Mobile Voice Service, February 2016

Month	Town	MTN	Vodafone	Tigo	Airtel	GLO
February	Bimbilla	0%	0%	No Network	0%	No Network
February	Bole	0%	0%	0%	0%	No Network
February	Bupe	0%	0%	0%	0%	No Network
February	Daboya	0%	0%	0%	No Network	No Network
February	Damongo	0%	0%	0%	0%	No Network
February	Gushegu	0%	0%	0%	0%	No Network
February	Karaga	0%	0%	0%	No Network	No Network
February	Kpandai	0%	0%	0%	0%	No Network
February	Kumbungu	0%	0%	0%	0%	No Network
February	Saboba	0%	0%	0%	0%	No Network
February	Sagnerigu	0%	0%	0%	0%	No Network
February	Salaga	0%	0%	0%	0%	No Network
February	Sang	0%	0%	0%	0%	No Network
February	Savelugu	0%	0%	0%	0%	No Network
February	Sawla	0%	0%	0%	0%	No Network
February	Tamale	0%	0%	0%	0%	0%
February	Tatale	0%	0%	0%	0%	No Network
February	Tolon	0%	0%	0%	0%	No Network
February	Wulensi	0%	0%	0%	0%	No Network
February	Yendi	0%	0%	0%	0%	No Network
February	Zabzugu	0%	0%	0%	0%	No Network

REMARK:

❖ All Operators were in compliance with the Call Drop Rate licence threshold of less than three percent (3%) in all localities tested.

e) Call Completion Rate (CCR)

Call Completion Rate is defined as the probability that a call has, after being successfully set up, be maintained during a period of time and ending normally.

$$\text{Call Completion } [\%] = \frac{\text{Number of normally ended calls}}{\text{Total number of call attempts}} \times 100\%$$

Call Completion Rate should be equal or better than seventy percent (70%).

Table 5 Call Completion Rate Cellular Mobile Voice Service, February 2016

Month	Town	MTN	Vodafone	Tigo	Airtel	GLO
February	Bimbilla	98.44%	98.65%	No Network	98.44%	No Network
February	Bole	100%	100%	100%	98.59%	No Network
February	Bupe	100%	96.63%	100%	100	No Network
February	Daboya	100%	100%	100%	No Network	No Network
February	Damongo	100%	82.31%	80.33%	99.14%	No Network
February	Gushegu	100%	100%	98.08%	100%	No Network
February	Karaga	93.48%	100%	80%	No Network	No Network
February	Kpandai	100%	100%	100%	71.93%	No Network
February	Kumbungu	100%	100%	100%	75.58%	No Network
February	Saboba	97.96%	100%	100%	100%	No Network
February	Sagnerigu	98.83%	97.41%	99.51%	96.72%	No Network
February	Salaga	98.92%	99.07%	100%	96.15%	No Network
February	Sang	100%	100%	100%	100%	No Network
February	Savelugu	94.69%	27.27%	100%	99.10%	No Network
February	Sawla	100%	100%	100%	100%	No Network
February	Tamale	95.33%	96.42%	99.64%	93.04%	94.96%
February	Tatale	100%	100%	100%	100%	No Network
February	Tolon	100%	100%	100%	100%	No Network
February	Wulensi	100%	100%	100%	100%	No Network
February	Yendi	100%	100%	100%	89.83%	No Network
February	Zabzugu	56.90%	100%	91.49%	100%	No Network

REMARKS:

❖ Airtel,Tigo and Glo were in compliance with the Call Completion Rate licence threshold of less than seventy percent (70%) in all localities tested.

❖ MTN and Vodafone recorded a low Call Completion Rate at Zabzugu and Savelugu respectively.

f) Voice Call Audio Quality

Voice Call Audio Quality is the perceptibility of the conversation during a call. Voice Call Audio Quality is measured by a parameter called the Mean Opinion Score (MOS) which categorizes speech samples in ranges from 0 to 5.

Range	Colour Code	Rating
[0 – 2.5)		Poor
[2.5 – 3.5)		Fair
[3.5 – 4)		Good
[4.1 – 5)		Excellent

Table 6 Speech Quality Mean Opinion Score Northern Region, February 2016

Greater Accra	MTN	Vodafone	Tigo	Airtel	Glo
MOS	3.53	3.69	3.72	3.44	3.67

REMARK:

❖ MTN, Vodafone, Tigo and Glo were assessed to give GOOD speech quality.

❖ Airtel was assessed to give FAIR speech quality.

REMEDIES

❖ The NCA has notified Operators of these findings and has directed all Operators to improve their coverage in some localities by June 2016.

❖ Airtel has been granted moratorium till May 2016 to resolve the persistent Call Setup Time delays which has been acute since 2015.

❖ Glo has also been sanctioned for failing in SDCCH Congestion Rate in the Northern Region.

APPENDICES

COVERAGE AND SPEECH MAPS

The Maps below show the coverage level and speech quality in the various towns where monitoring was performed. The coverage map is a combination of both 2G and 3G network signal strength. In each plot is a legend to indicate definitions of signal strength and quality range attained by Operators during measurement. Coverage levels in green falls in the rage of -85dBm and above, and are considered good. Those between -85 and -95dBm are considered average and are indicated in yellow. The red samples represent worse coverage in the range of -95 to -110dBm. The black samples represent areas with no coverage. The speech quality was assessed with Mean Opinion Score (MOS) which ranges from 5 to 1.

APPENDIX I

COVERAGE AT BIMBILLA

Fig. 1 - MTN Coverage Map, Bimbilla - February 2016
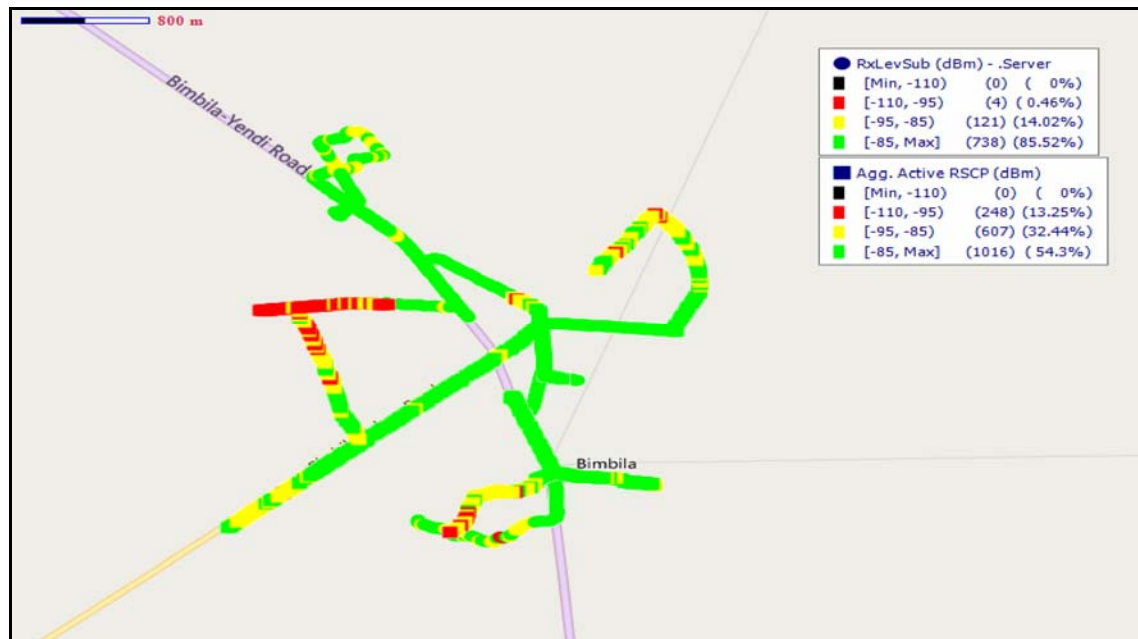
Remarks: Good network coverage with scattering fair spots on both 2G and 3G service in around Masaka, Our Lady of Peace Schools and Kunkunaa areas.

Fig. 2 - Vodafone Coverage Map, Bimbilla - February 2016
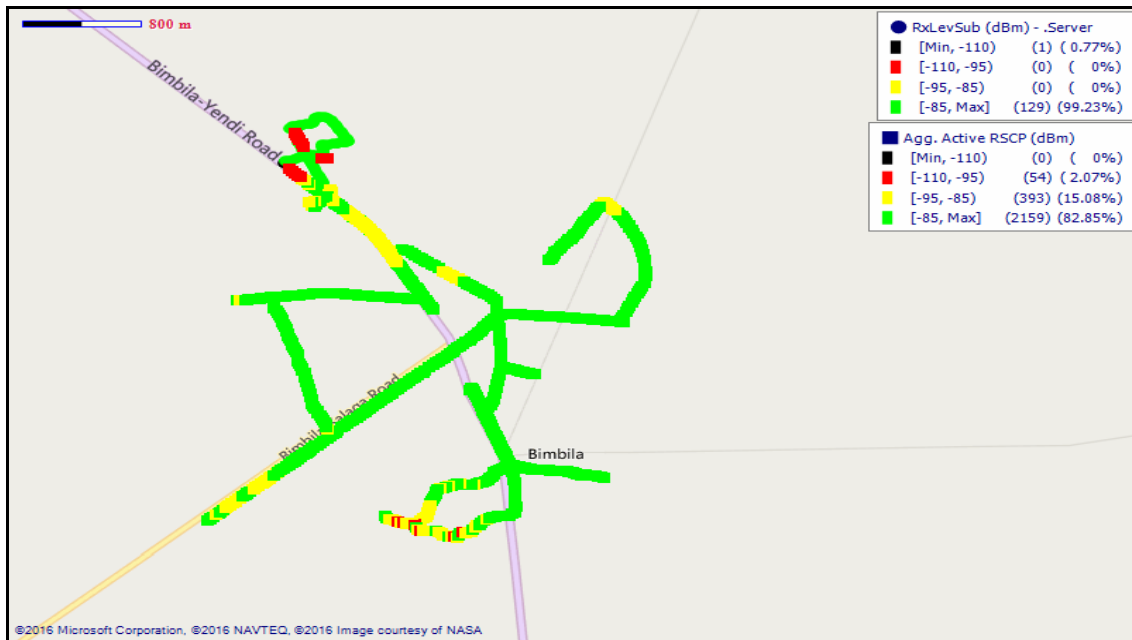
Remarks: Good network coverage in Bimbilla. Improvement is however needed at Bimbilla Training College, District Assembly and Kunkuna.

Fig. 3 - Airtel Coverage Map, Bimbilla - February 2016
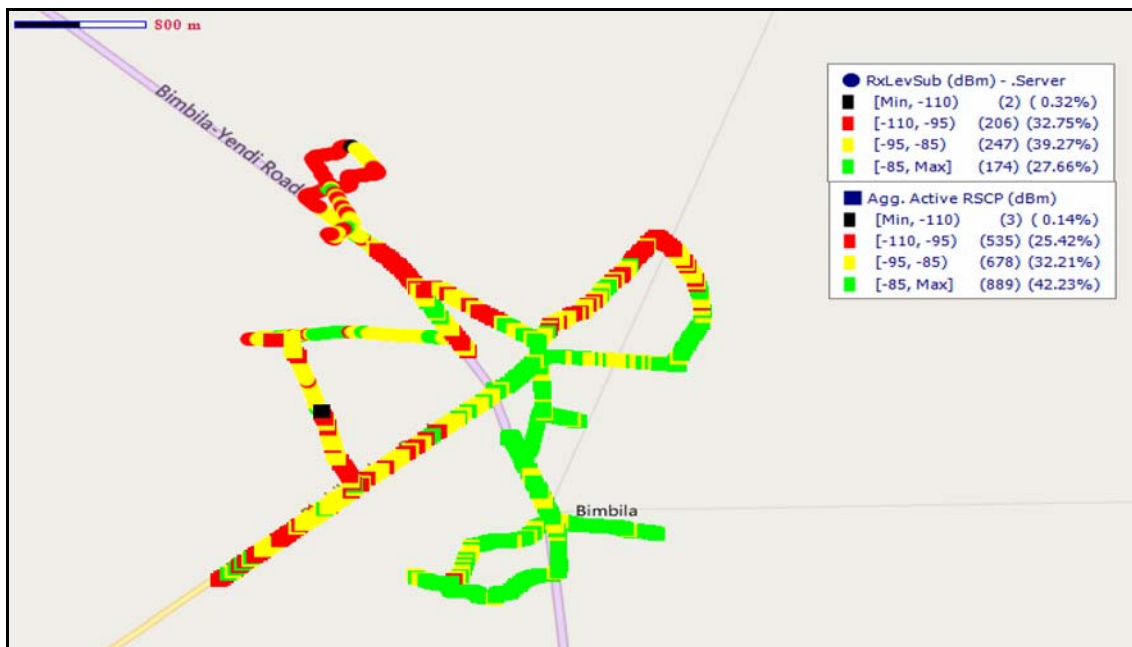
Remarks: Poor network coverage in Bimbilla. Major improvement is needed at Bimbilla Training College, Masako, District Hospital, District Assembly and Kunkuna.

COVERAGE AT BOLE

Fig. 4 - MTN Coverage Map, Bole - February 2016
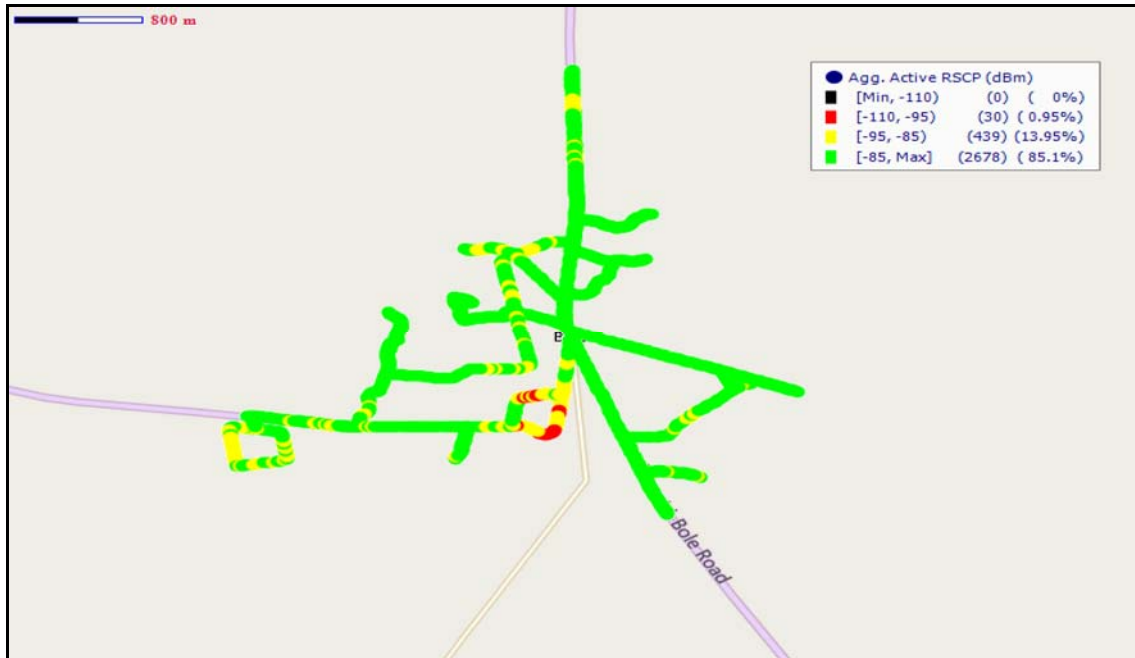
Remarks: Good 3G network coverage in Bole. Improvement is needed.

Fig. 5 - Vodafone Coverage Map, Bole - February 2016
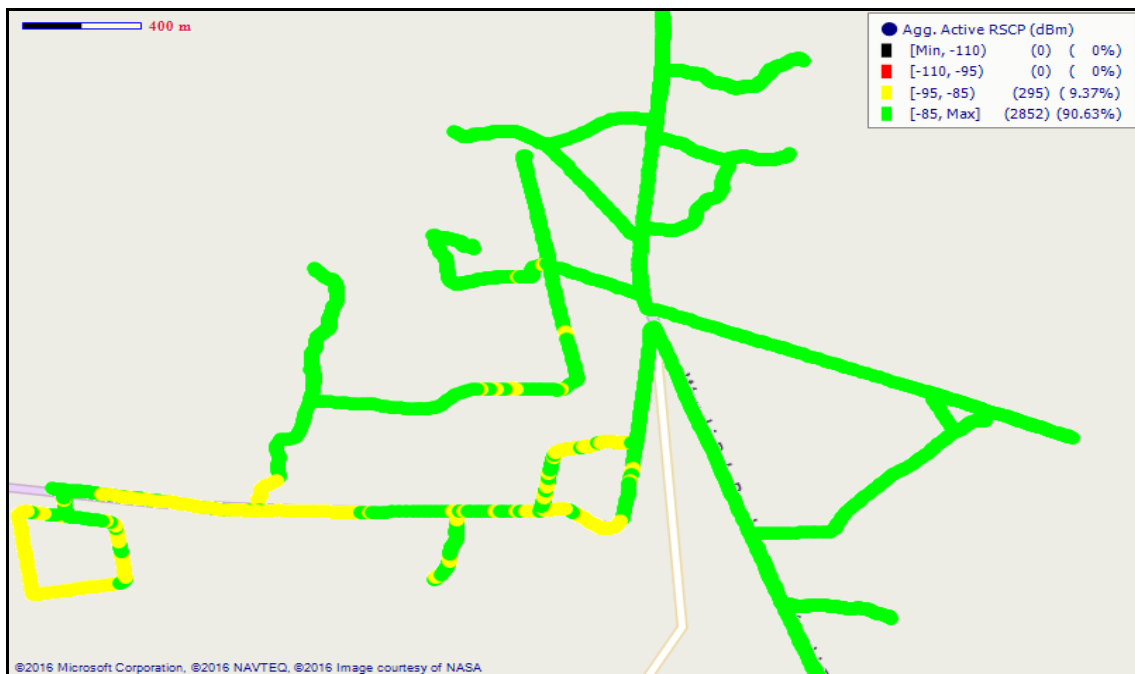
Remarks: Good 3G coverage in Bole

Fig. 6 - Tigo Coverage Map, Bole - February 2016
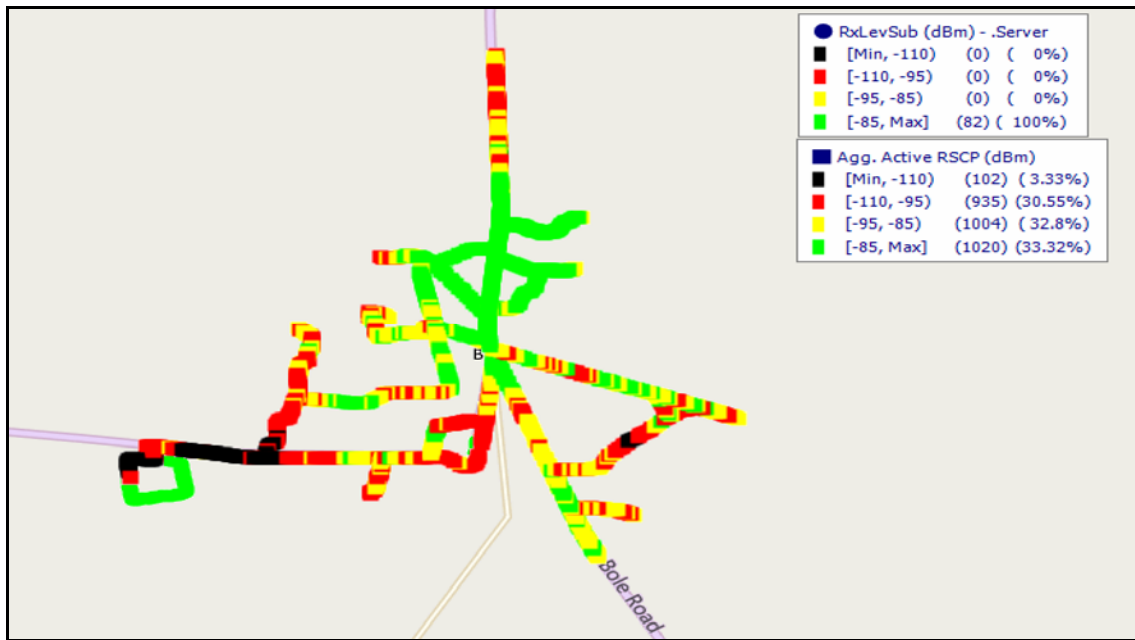
Remarks: Fair network coverage in Bole. Major improvement is needed at the District Hospital, COCOBOD Guest House, Bole SHS, Sawaba, Mango Line, District Assembly, Domeabra and District Police Office area.

Fig. 7 - Airtel Coverage Map, Bole - February 2016
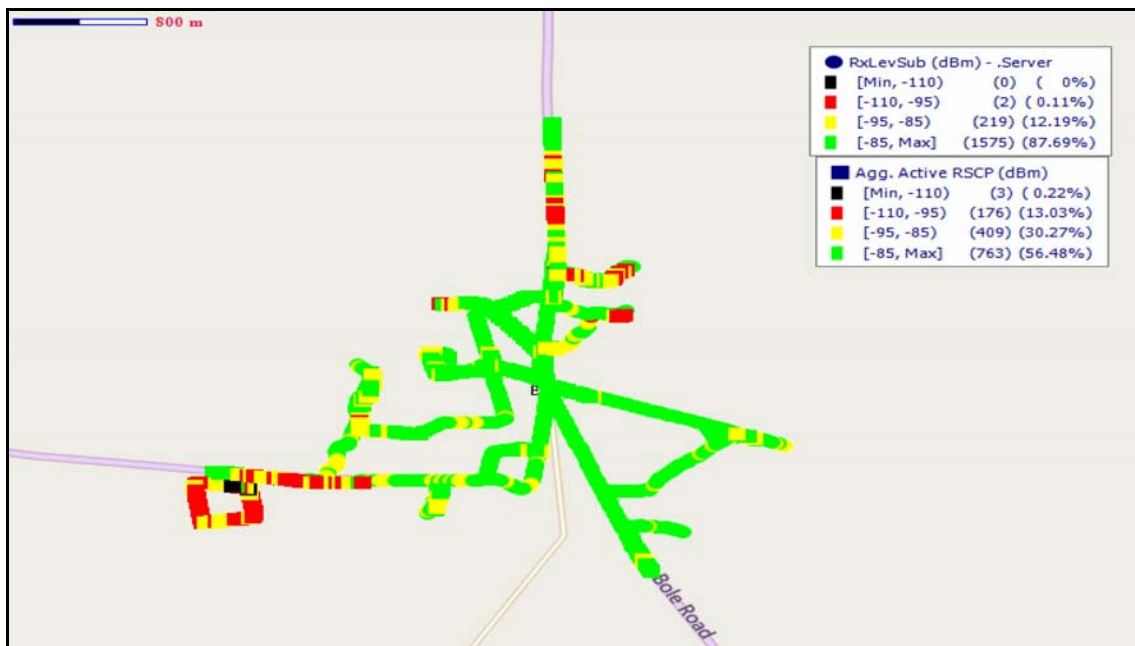
Remarks: Good network coverage in Bole however, 3G coverage needs improvement at COCOBOD Guest House, Bole District Hospital and Bilinsen.

COVERAGE AT BUIPE

Fig. 8 - MTN Coverage Map, Buipe - February 2016
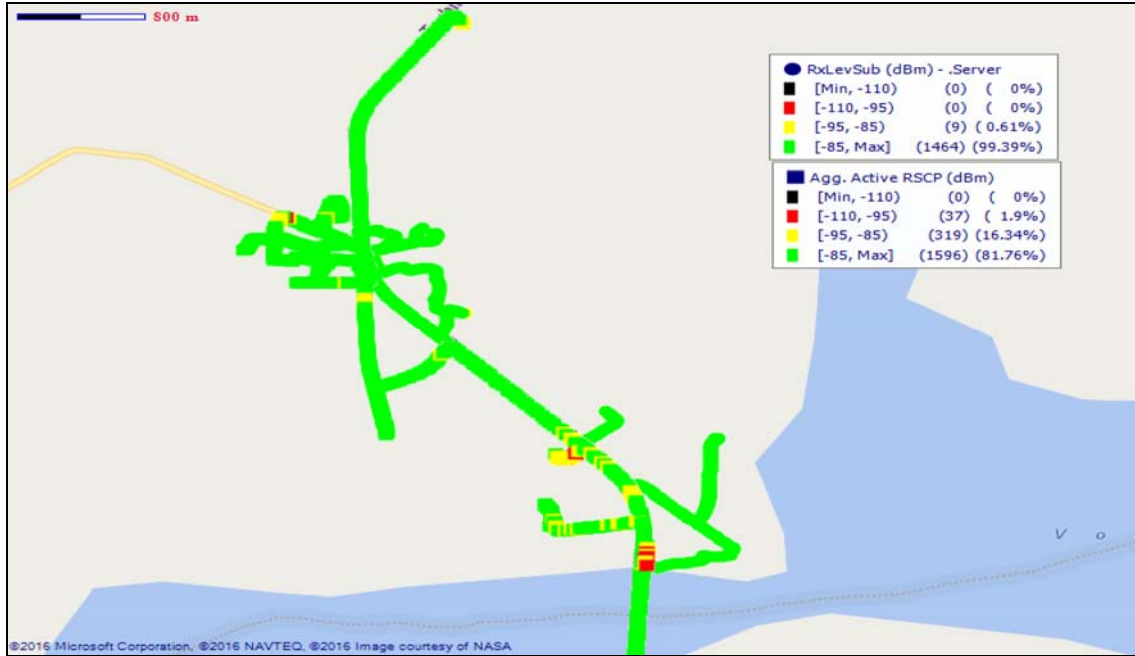
Remarks: Good network coverage in Buipe. Improvement is needed around the Bridge area.

Fig. 9 - Vodafone Coverage Map, Buipe –February 2016
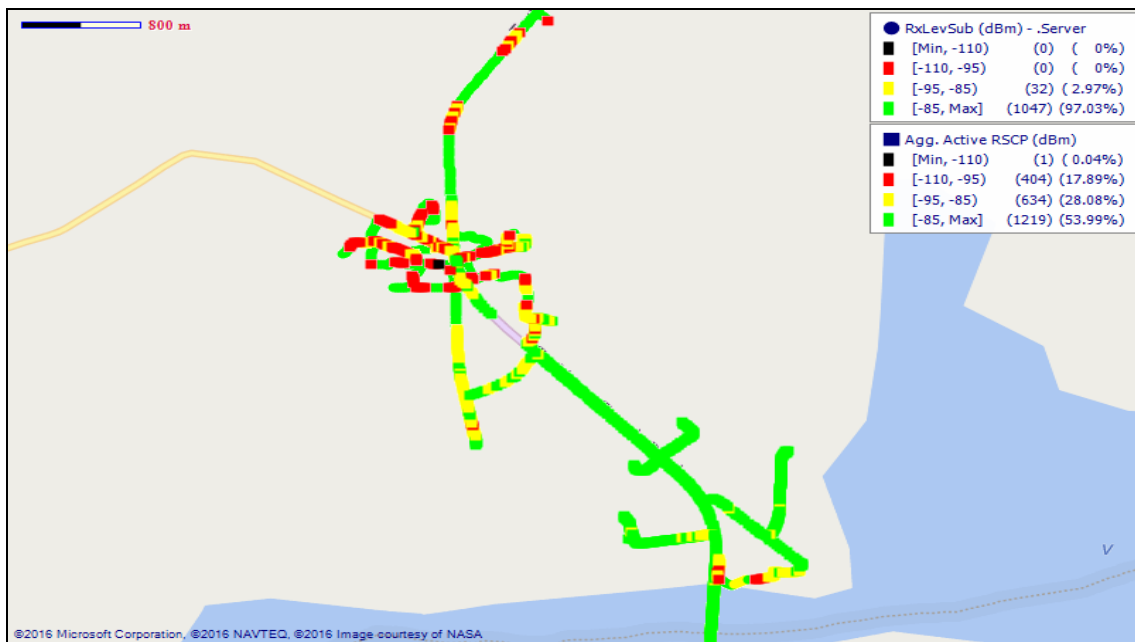
Remarks: Fair network coverage in Buipe. Improvement is still needed at Bridge, Wolonto, Boduwase, District Assembly, Jinapor Stadium, BOST Depot and Yipala.

Fig. 10 - Tigo Coverage Map, Buipe - February 2016
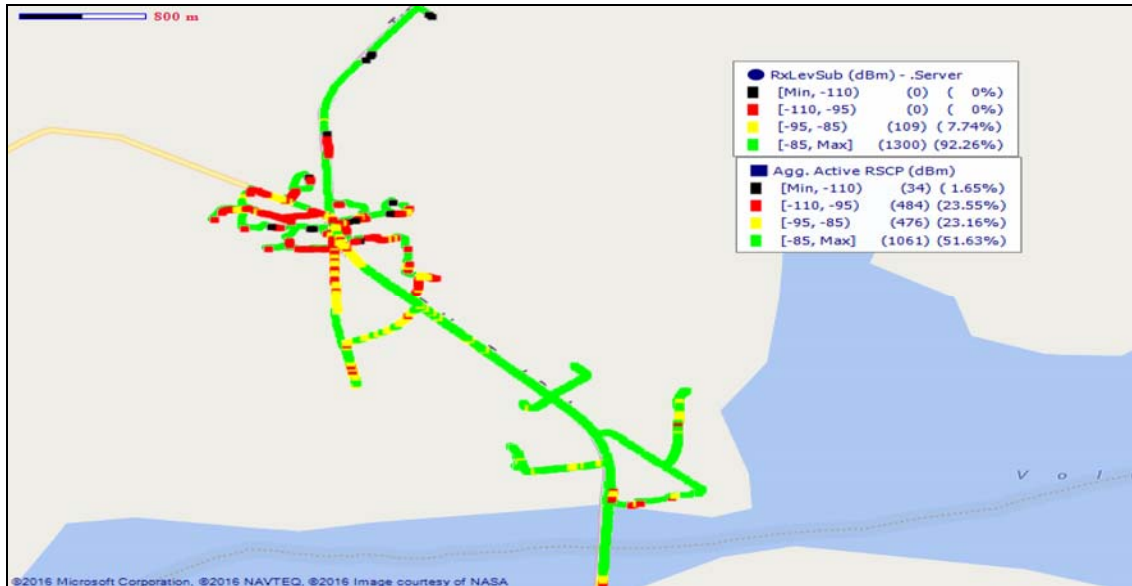
Remarks: Fair network coverage in Buipe. Improvement is still needed around the Bridge, Wolonto, Yipala, Boduwase, Jinapor Stadium and District Assembly.

Fig. 11 - Airtel Coverage Map, Buipe - February 2016
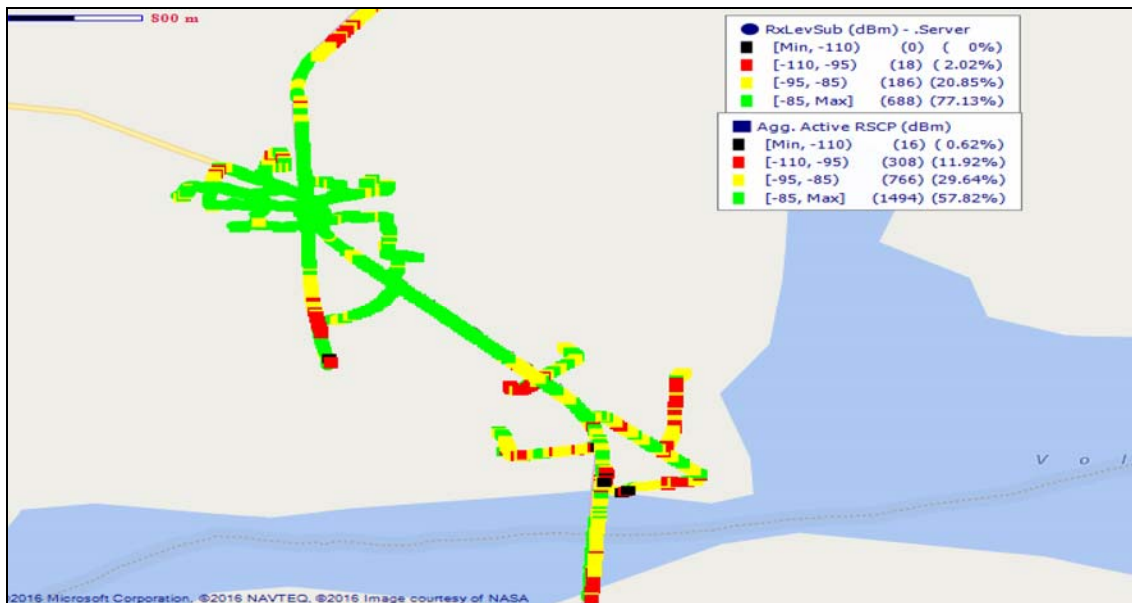
Remarks: Good network coverage in Buipe. Improvement is however needed at District Assembly, Boduwase, Bridge and Wolonto.

COVERAGE AT DABOYA

Fig. 12 - MTN Coverage Map, Daboya - February 2016
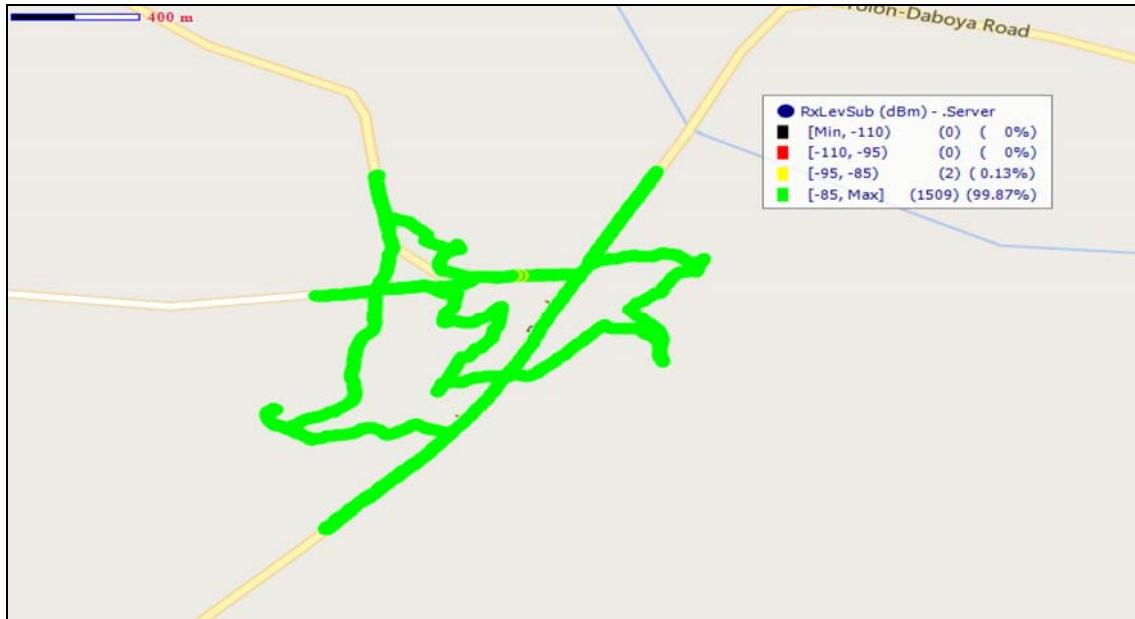
Remarks: Good 2G coverage in Daboya.

Fig. 13 - Vodafone Coverage Map, Daboya – February 2016
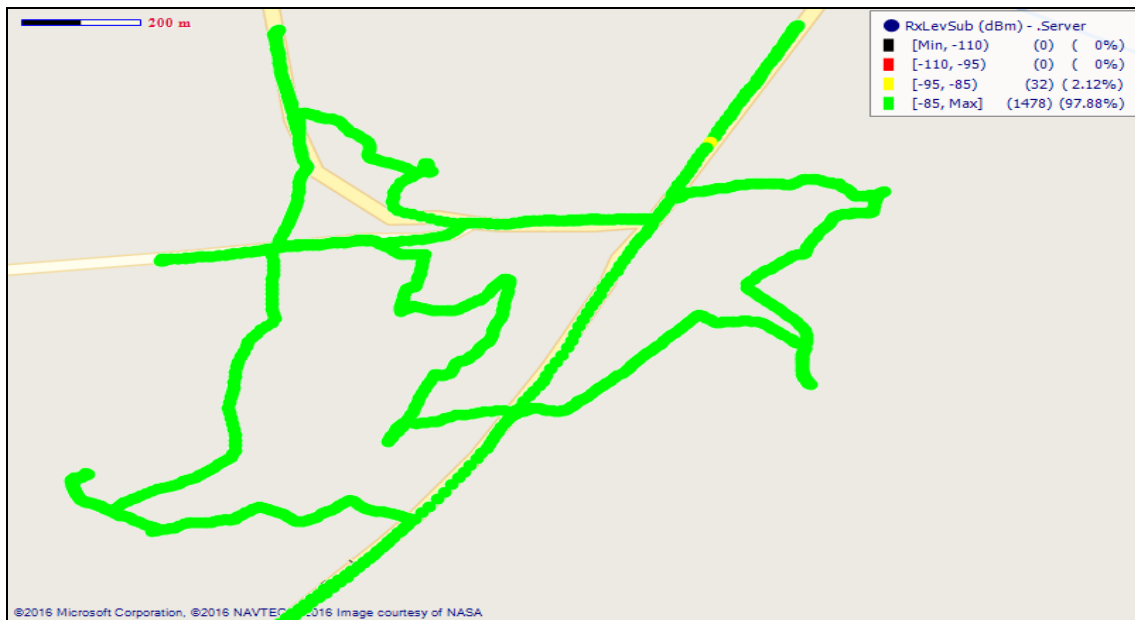
Remarks: Daboya Network Coverage Map

Fig. 14 - Tigo Coverage Map, Daboya - February 2016
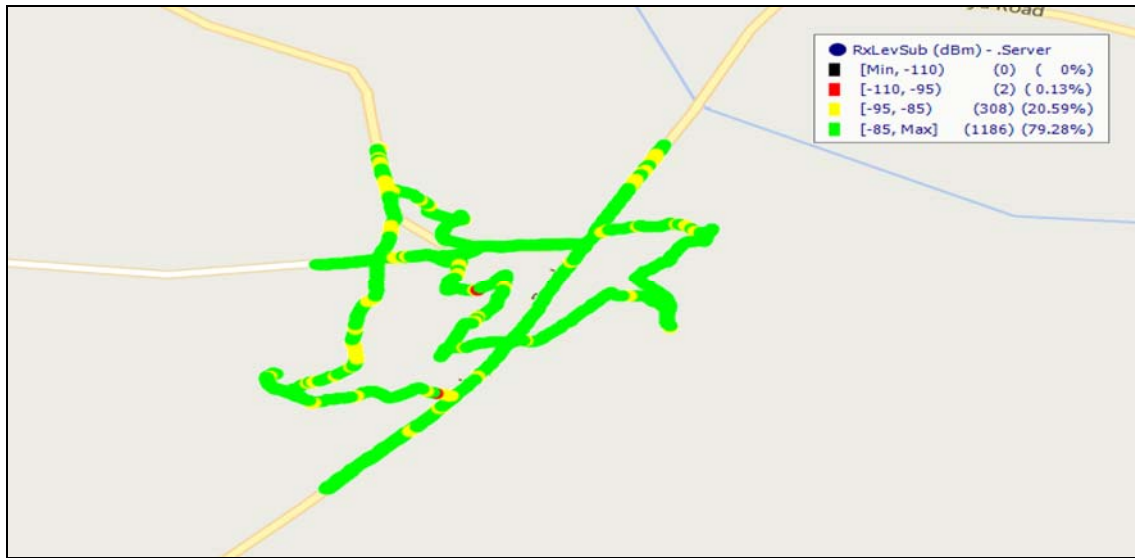
Remarks: Good 2G network coverage in Daboya.

COVERAGE AT DAMONGO

Fig. 15 - MTN Coverage Map, Damongo - February 2016
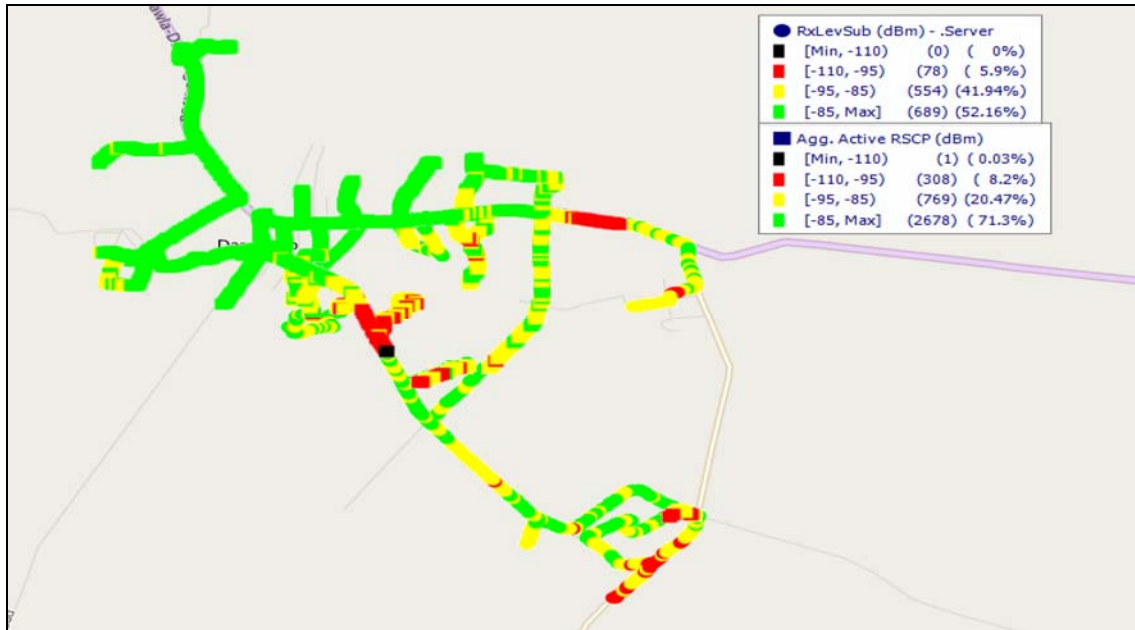
Remarks: Good network coverage in Damongo. However areas around Canteen, Catholic Guest House and Lanbanto need improvement.

Fig. 16 - Vodafone Coverage Map, Damongo - February 2016
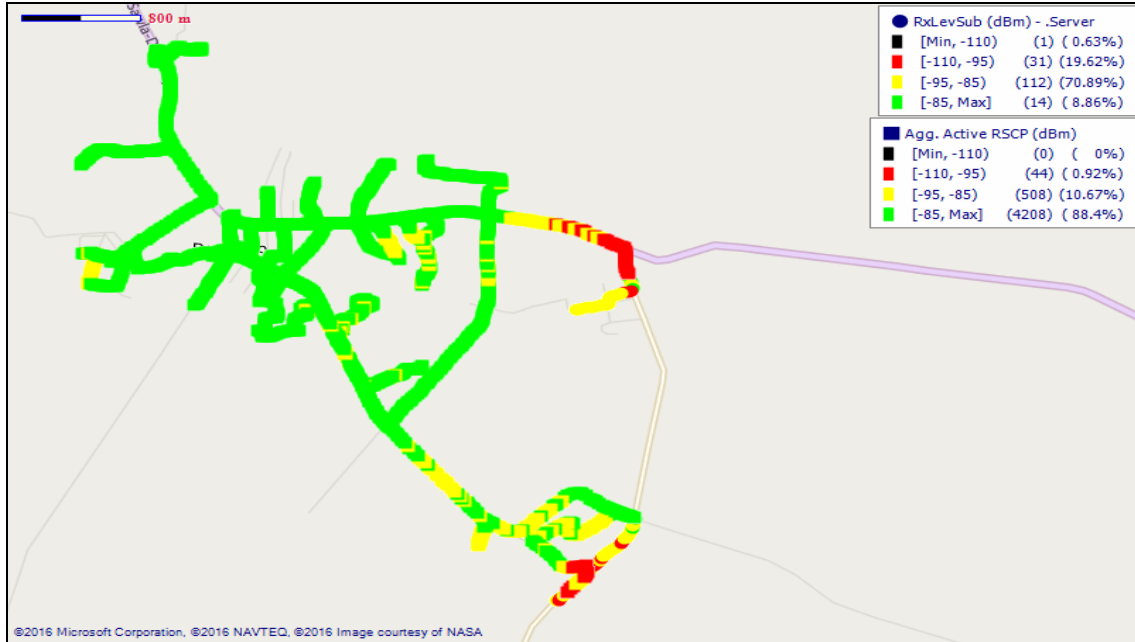
Remarks: Good 3G network coverage in Damongo. Improvement is needed on both 2G and 3G around Canteen and Damongo SHS.

Fig. 17 - Tigo Coverage Map, Damongo - February 2016
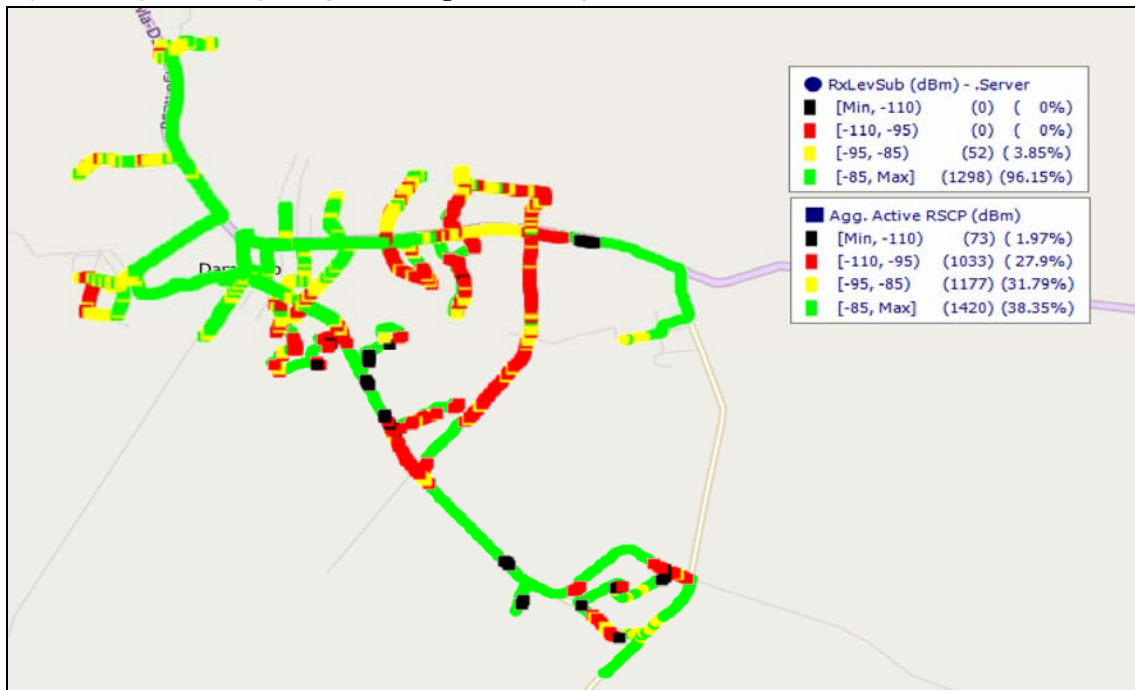
Remarks: Good 2G network coverage. However improvement is needed on the 3G network especially around the Canteen, Market, West Gonja Hospital, Hanga Line, Atributo, Damongo SHS and District Police Office.

Fig. 18 - Airtel Coverage Map, Damongo - February 2016
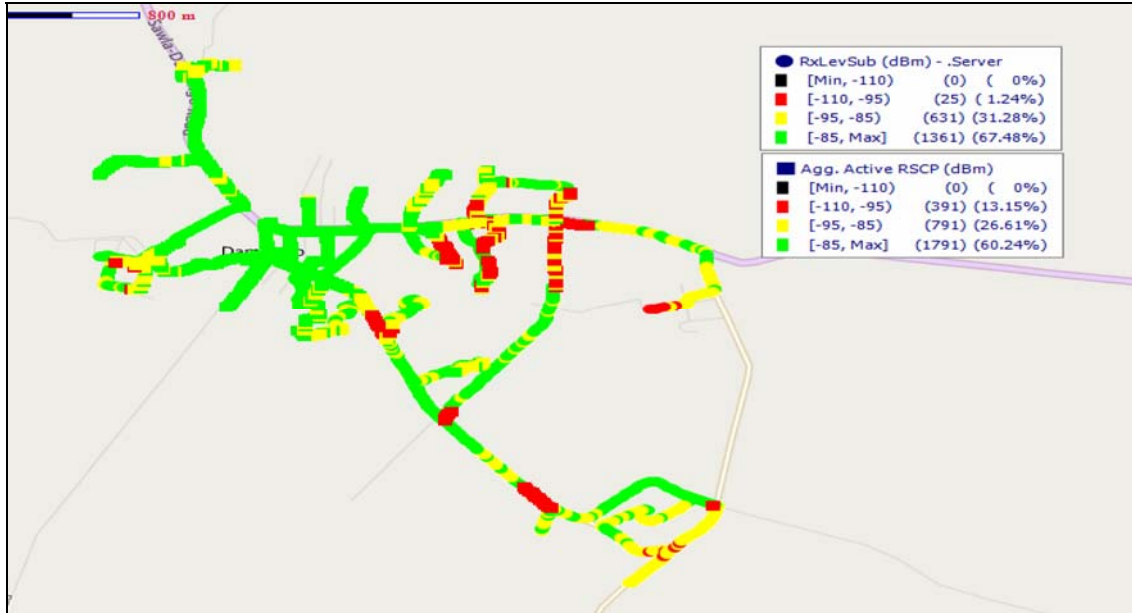
Remarks: Good network coverage. Improvement is however needed at Canteen, Catholic Guest House, Atributo and District Police Station.

COVERAGE AT GUSHEGU

Fig. 19 - MTN Coverage Map, Gushegu - February 2016
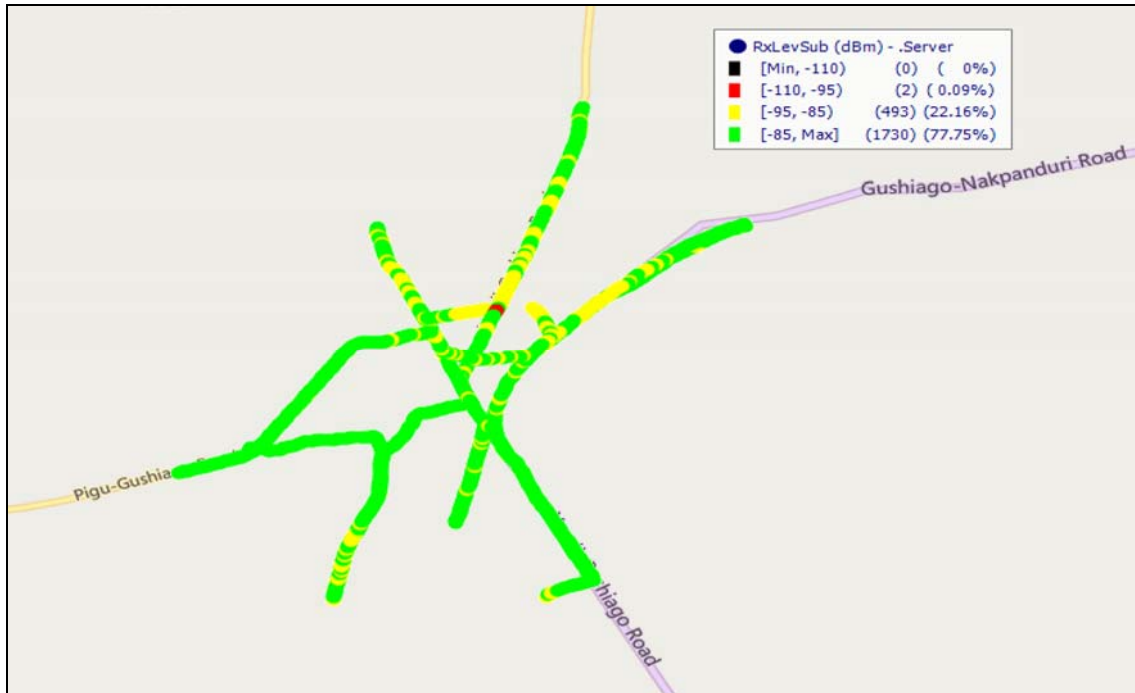
Remarks: Good 2G coverage in Gushegu.

Fig. 20 - Vodafone Coverage Map, Gushegu - February 2016
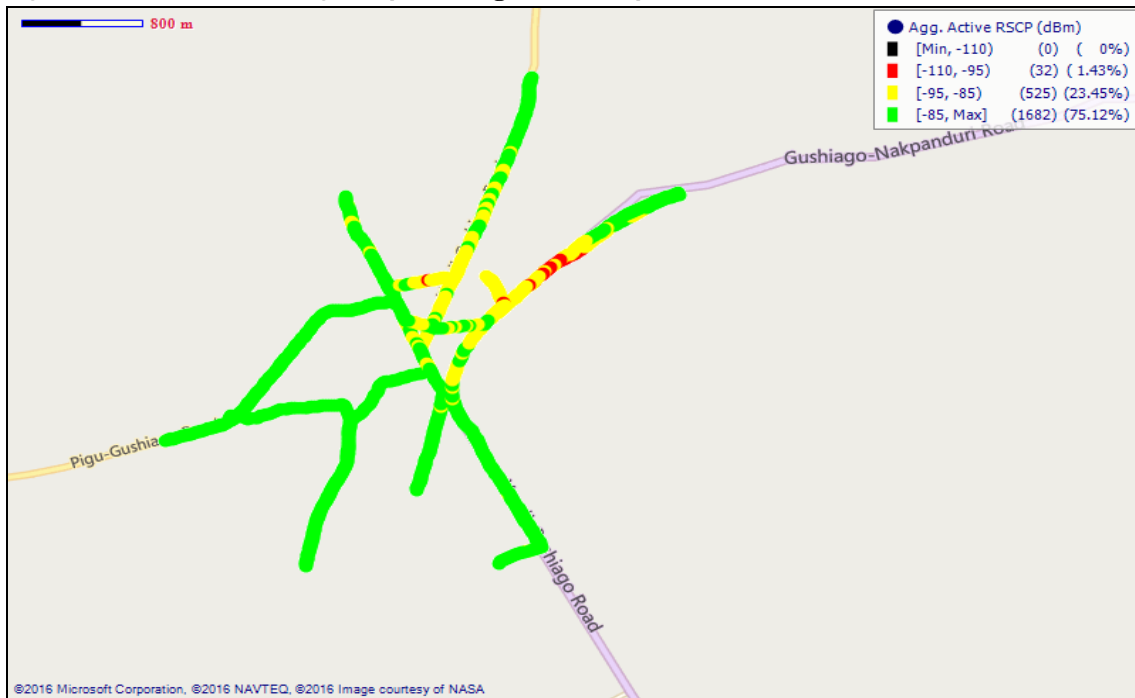
Remarks: Good 3G network coverage in Gushegu with no 2G coverage. Improvement is needed at Nayilifong, District Hospital and Christ the King Parish.

Fig. 21 - Tigo Coverage Map, Gushegu - February 2016
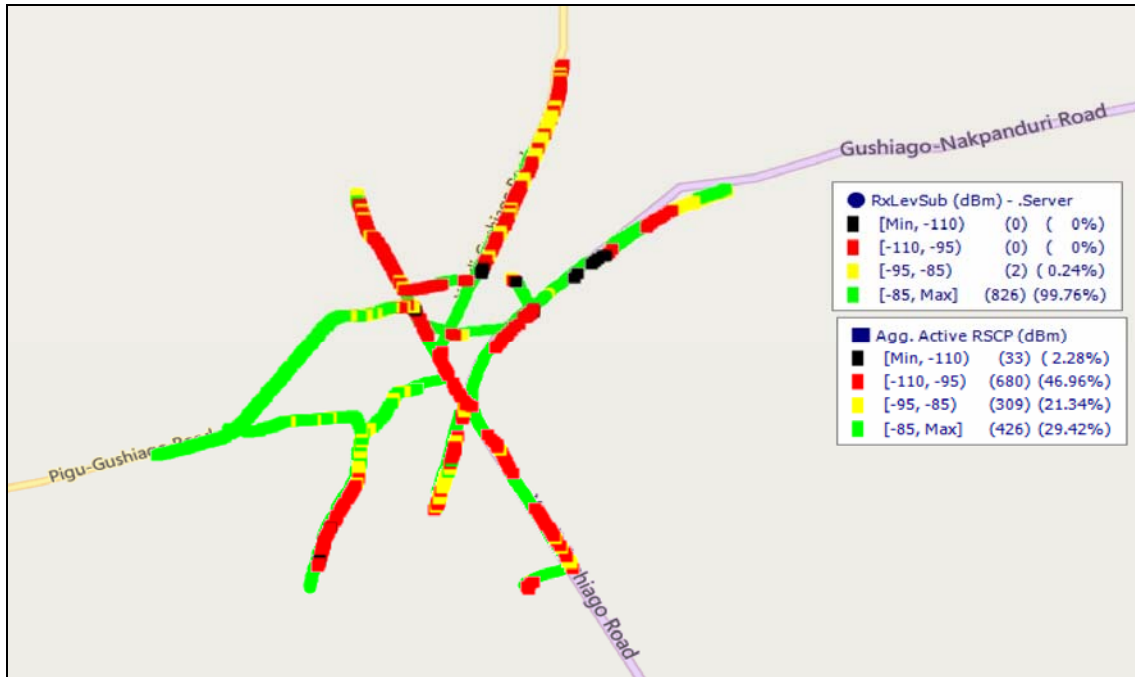
Remarks: Gushegu has a good 2G coverage with a poor 3G service. Major improvement needed.

Fig. 22 - Airtel Coverage Map, Gushegu - February 2016
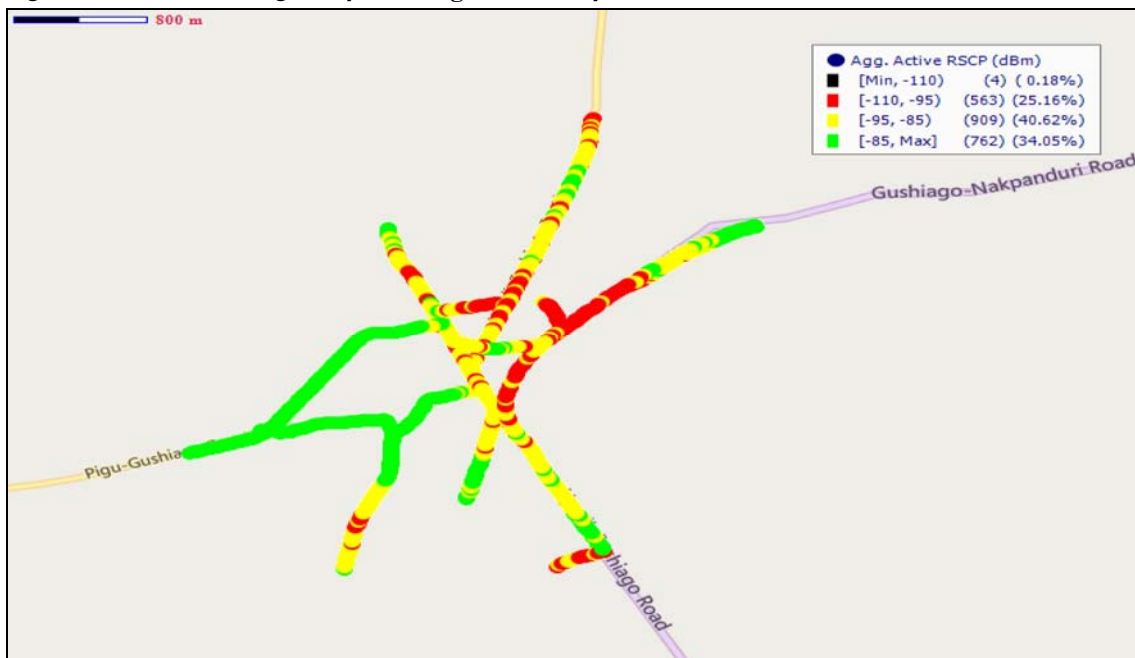
Remarks: Poor 3G coverage in Gushegu. Major improvement is needed around Christ the King Parish Area, District Hospital, Nayillifong, Market, Gushegu SHS and Soadufong.

COVERAGE AT KARAGA

Fig. 23 - MTN Coverage Map, Karaga - February 2016
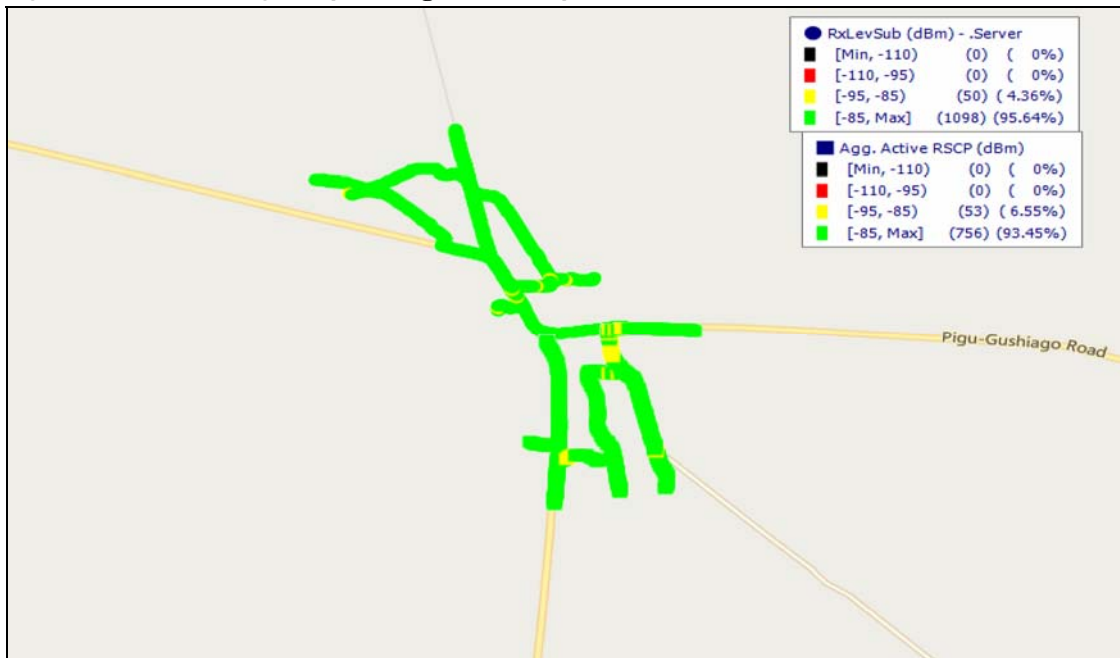
Remarks: Good network coverage on both 3G and 2G in Karaga.

Fig. 24 - Vodafone Coverage Map, Karaga - February 2016
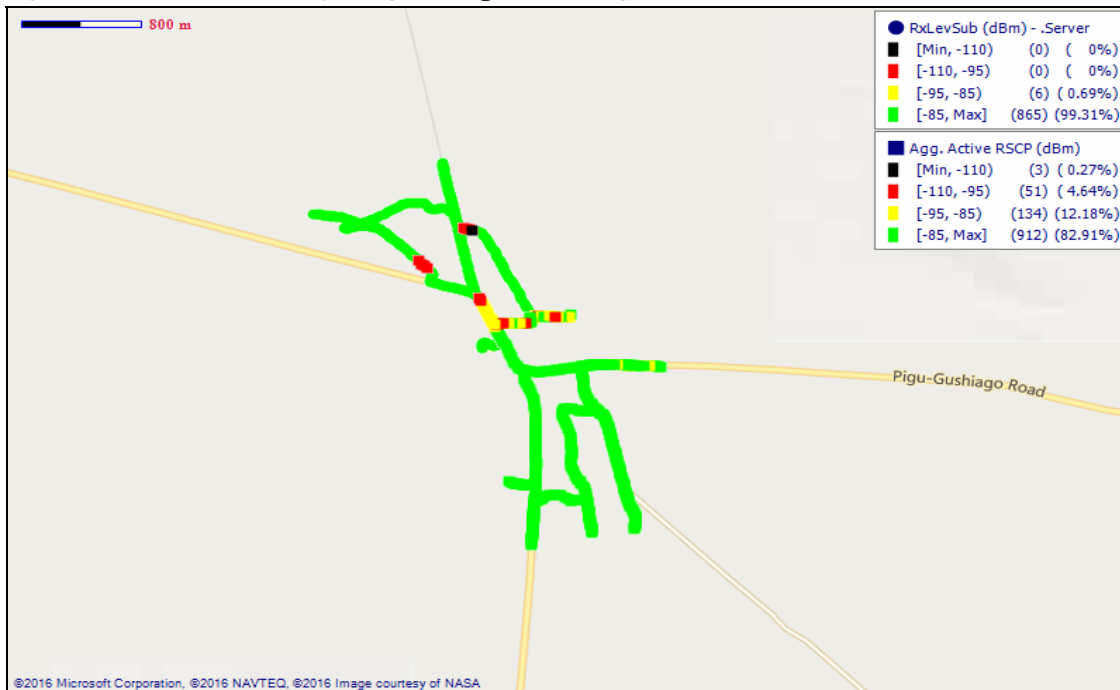
Remarks: Good network coverage in Karaga yet improvement is needed at Nayilifong No. 2.

Fig. 25 - Tigo Coverage Map, Karaga - February 2016
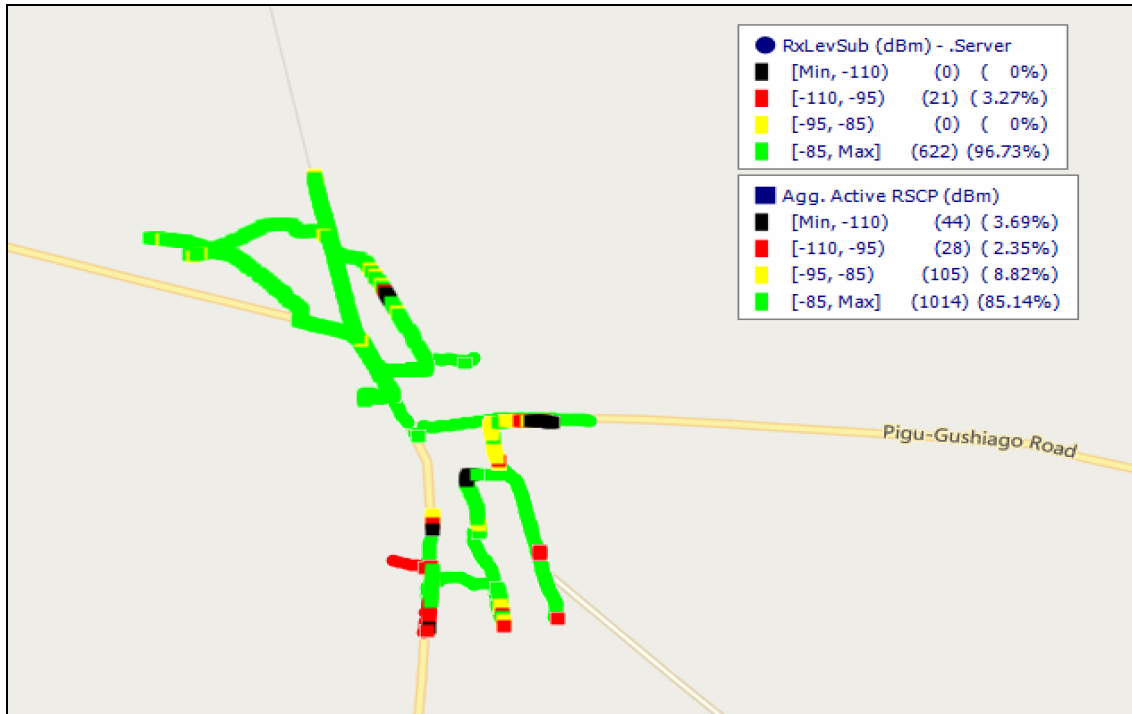
Remarks: Good 2G and 3G network coverage in Karaga. Improvement is however needed at Nayilifong 1 & 2, Yapalsi and Dagbonbilafong.

COVERAGE AT KPANDAE

Fig. 26 - MTN Coverage Map, Kpandae - February 2016
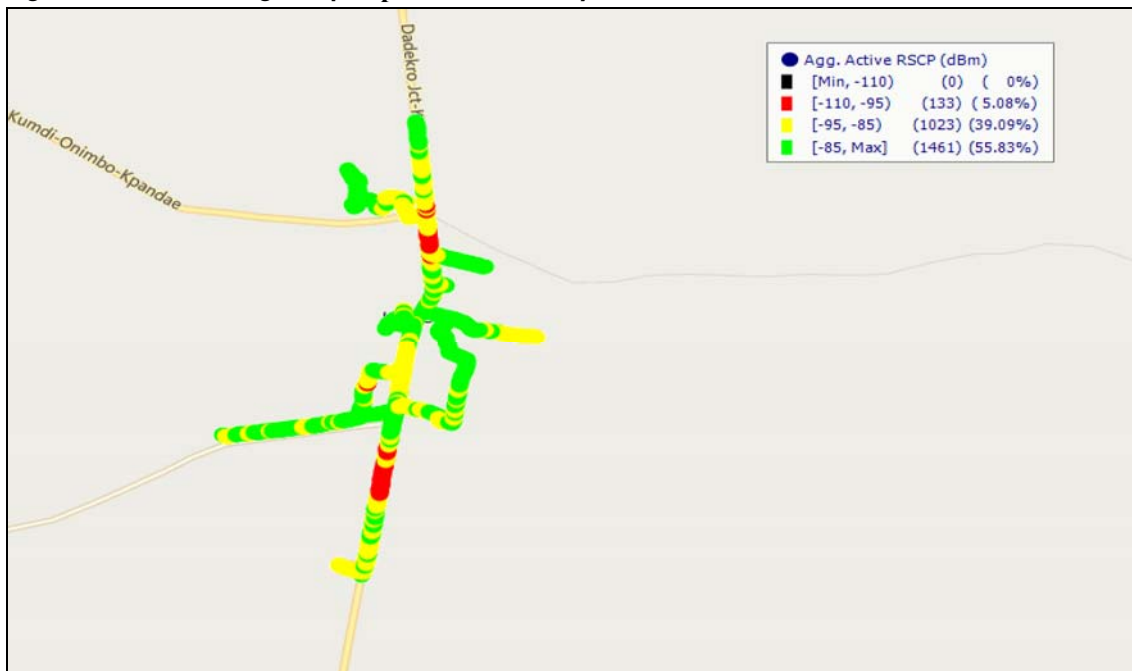
Remarks: Fair 3G network coverage in Kpandae with improvement needed around Madure, Market and District Assembly Bungalows.

Fig. 27 - Vodafone Coverage Map, Kpandae - February 2016
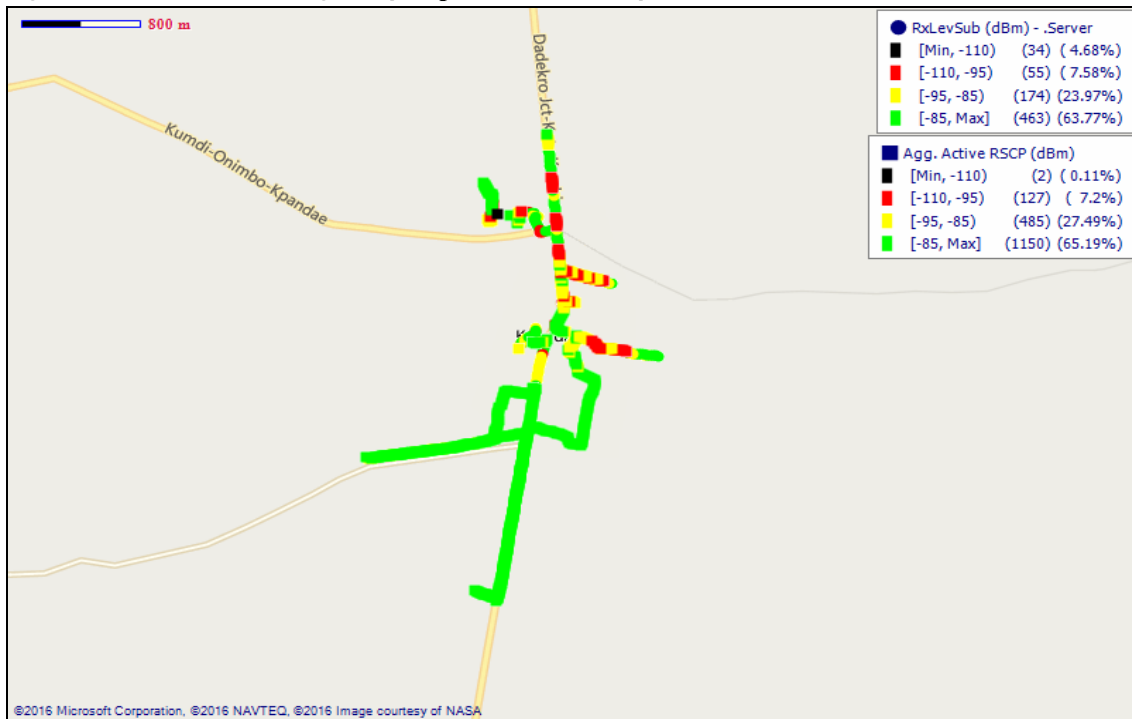
Remarks: Good network coverage in Kpandae however improvement is needed at Zongo, Basare Line, Madure and Market.

Fig. 28 - Tigo Coverage Map, Kpandae - February 2016
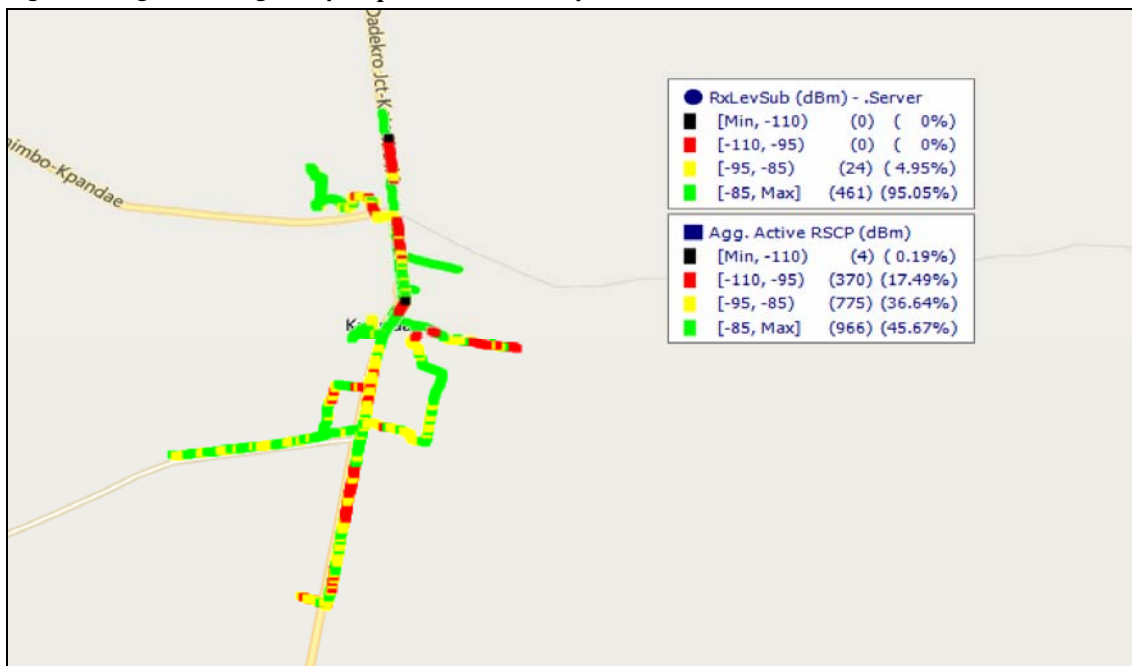
Remarks: Good 2G network with a fair 3G coverage. Major improvement is needed at areas around Zongo, Market, Madure, Catholic Guest House and Kpandae Polyclinic.

Fig. 29 - Airtel Coverage Map, Kpandae - February 2016
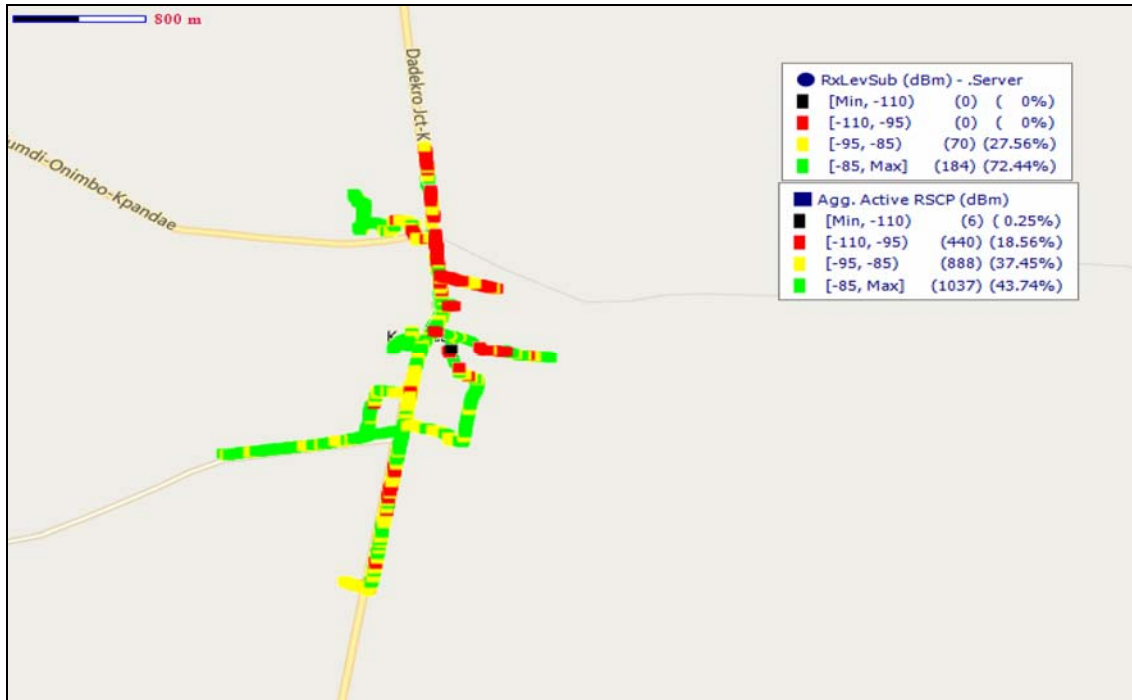
Remarks: Fair network coverage in Kpandae. Major improvement is needed around Zongo, Basare Line, Madure and Market.

COVERAGE AT KUMBUNGU

Fig. 30 - MTN Coverage Map, Kumbungu - February 2016
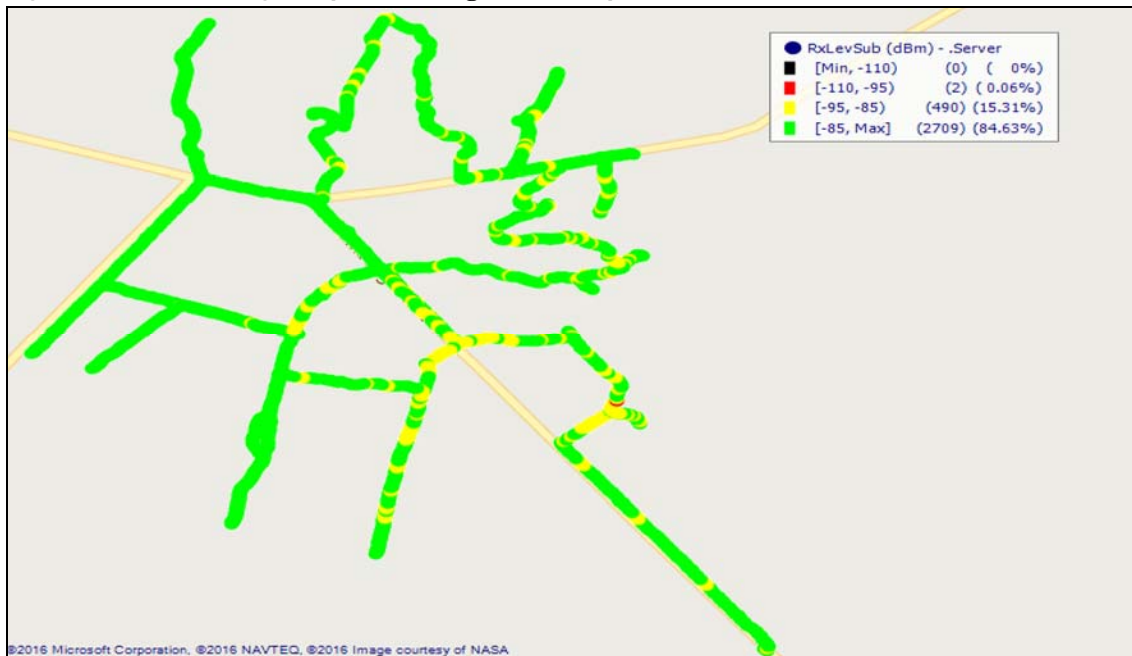
Remarks: Good 2G network coverage in Kumbungu.

Fig. 31 - Vodafone Coverage Map, Kumbungu - February 2016
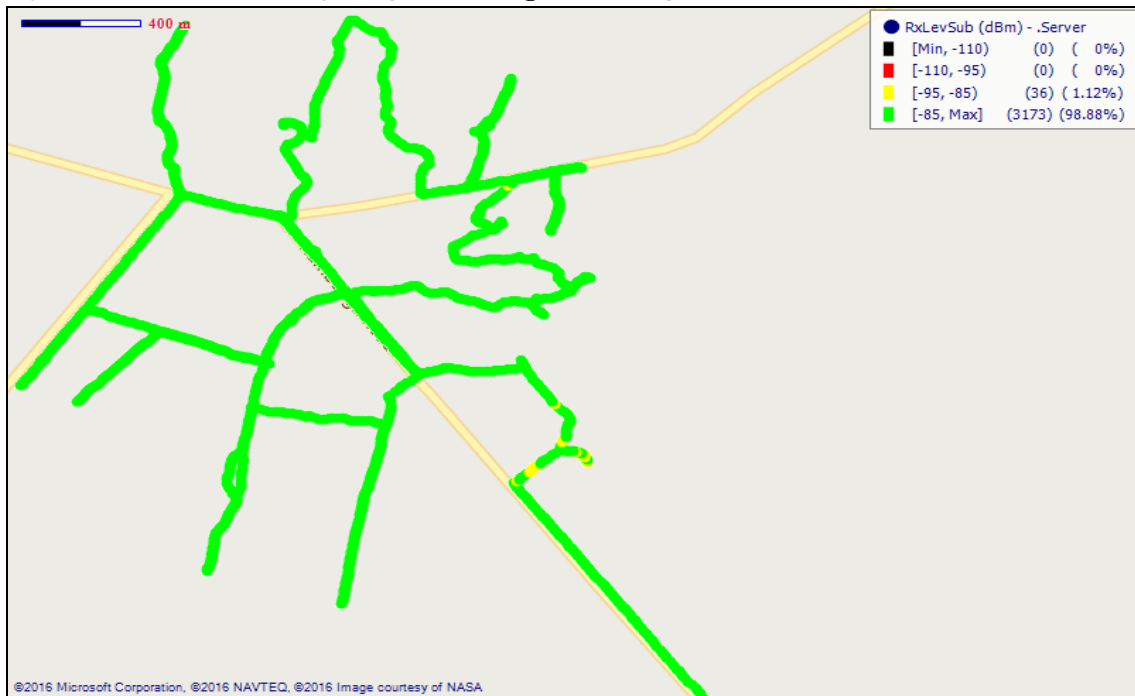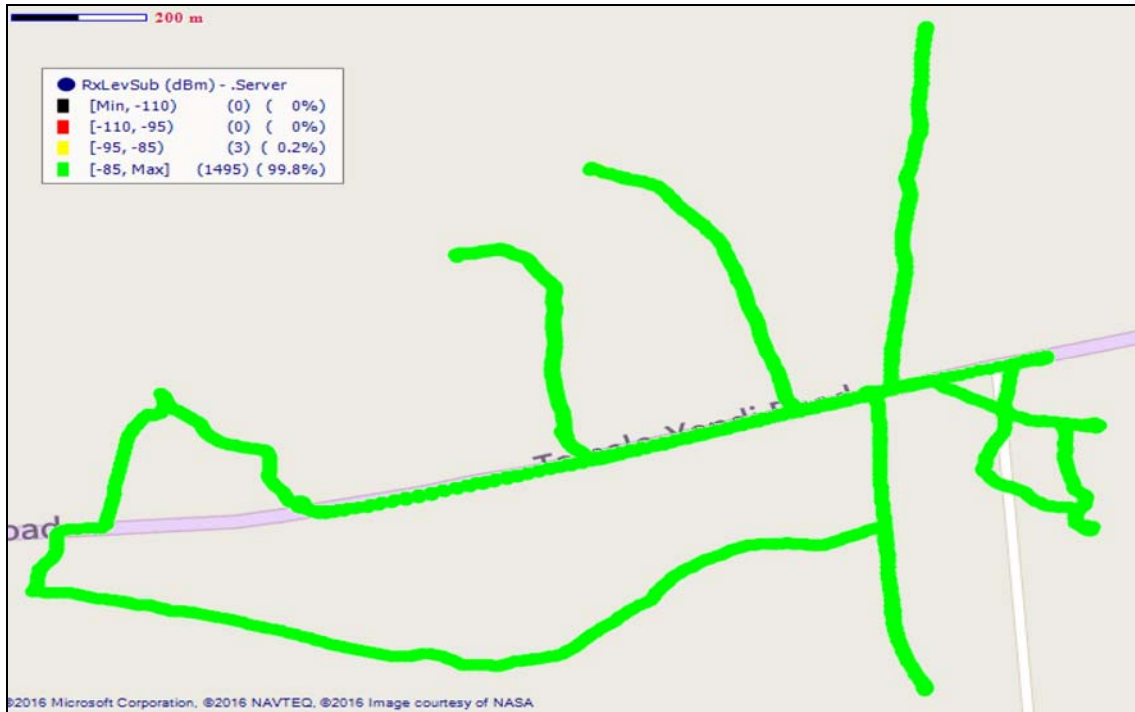

Remarks: Good 2G coverage in Kumbungu.

Fig. 32 - Tigo Coverage Map, Kumbungu - February 2016
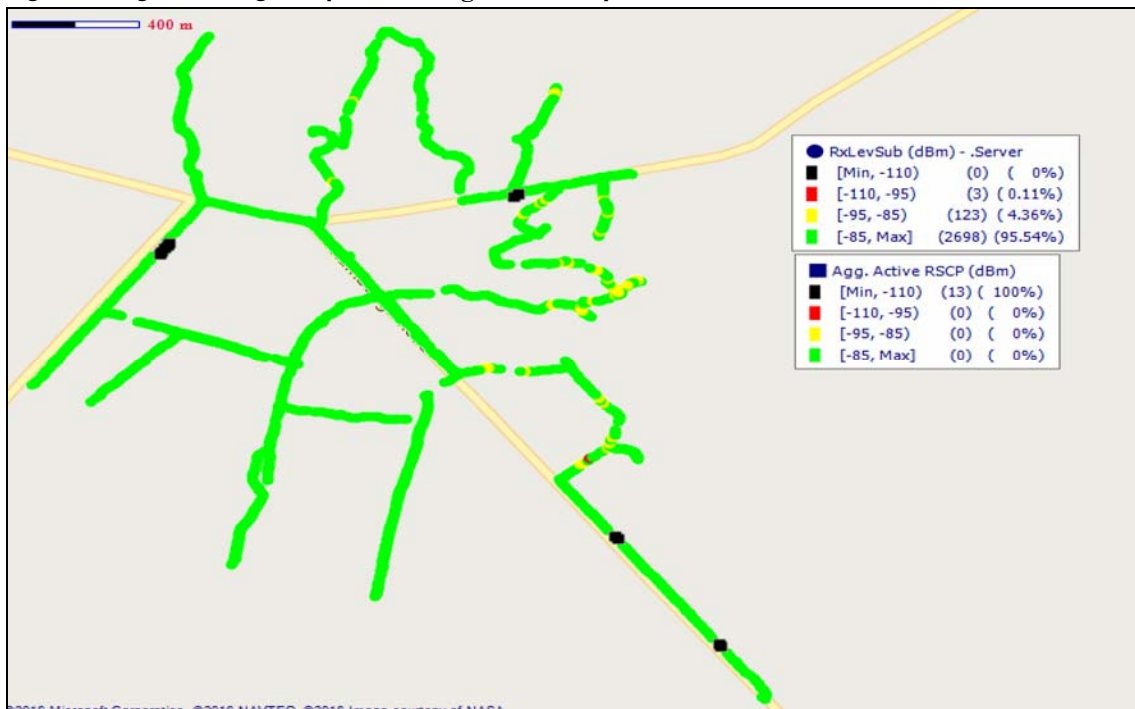
Remarks: Good 2G network coverage with no 3G coverage across Kumbungu.

Fig. 33 - Airtel Coverage Map, Kumbungu - February 2016
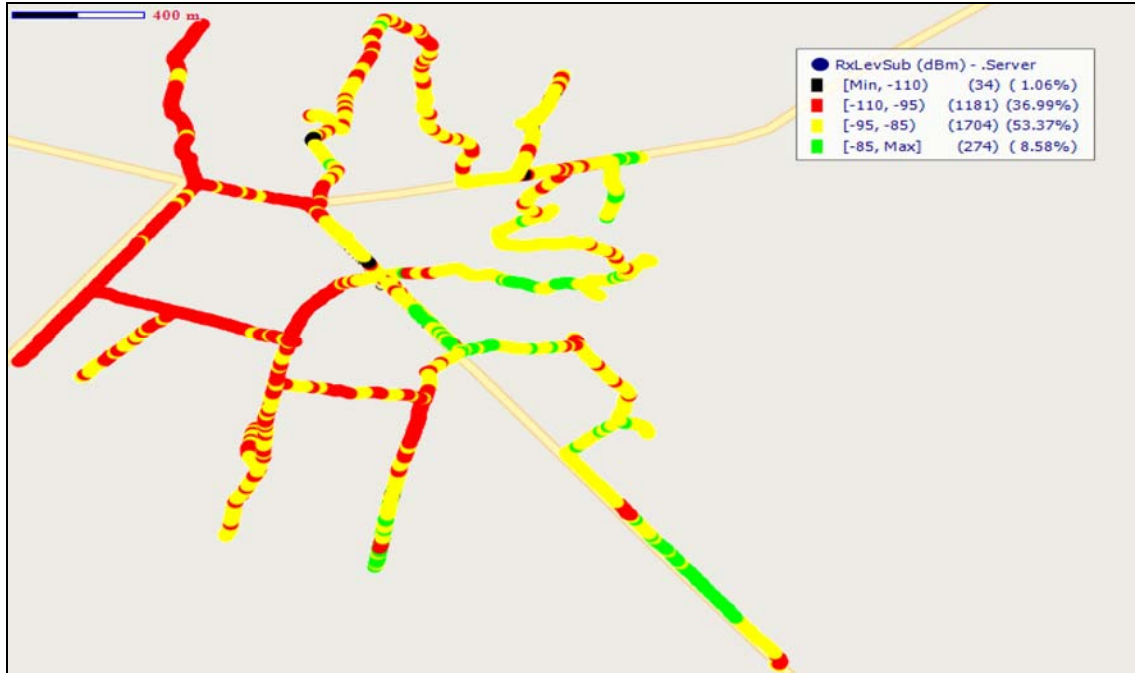
Remarks: Poor 2G coverage in Kumbungu. Major improvement needed.

COVERAGE AT SABOBA

Fig. 34 - MTN Coverage Map, Saboba - February 2016
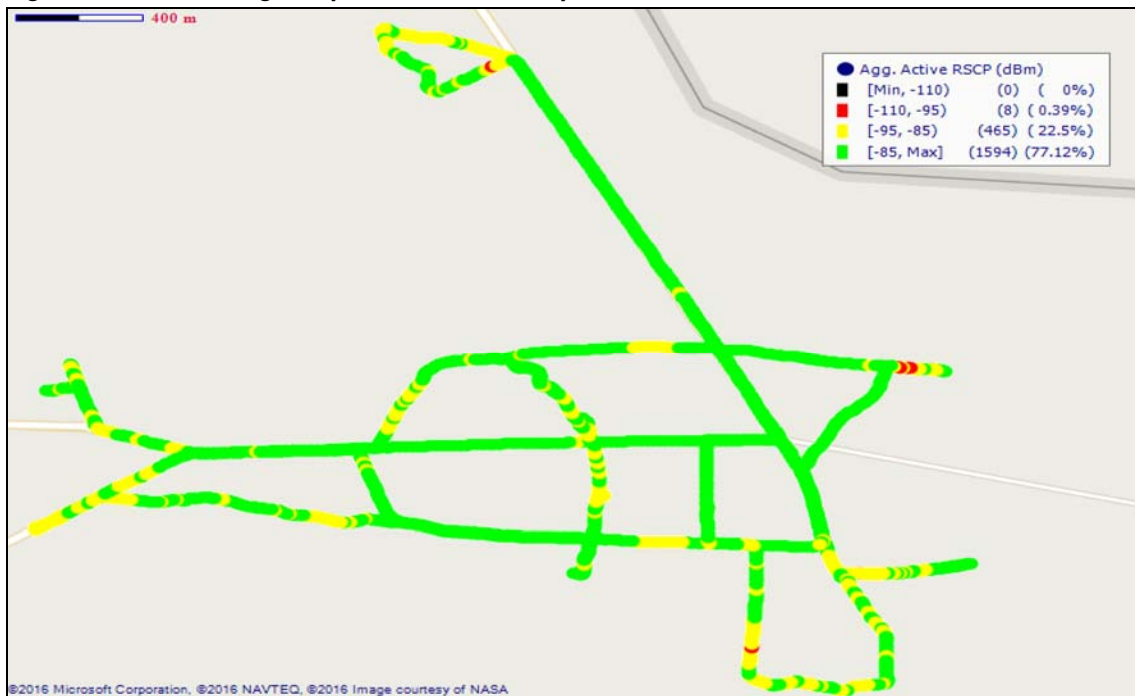
Remarks: Good 3G coverage in Saboba.

Fig. 35 - Vodafone Coverage Map, Saboba **- February 2016**
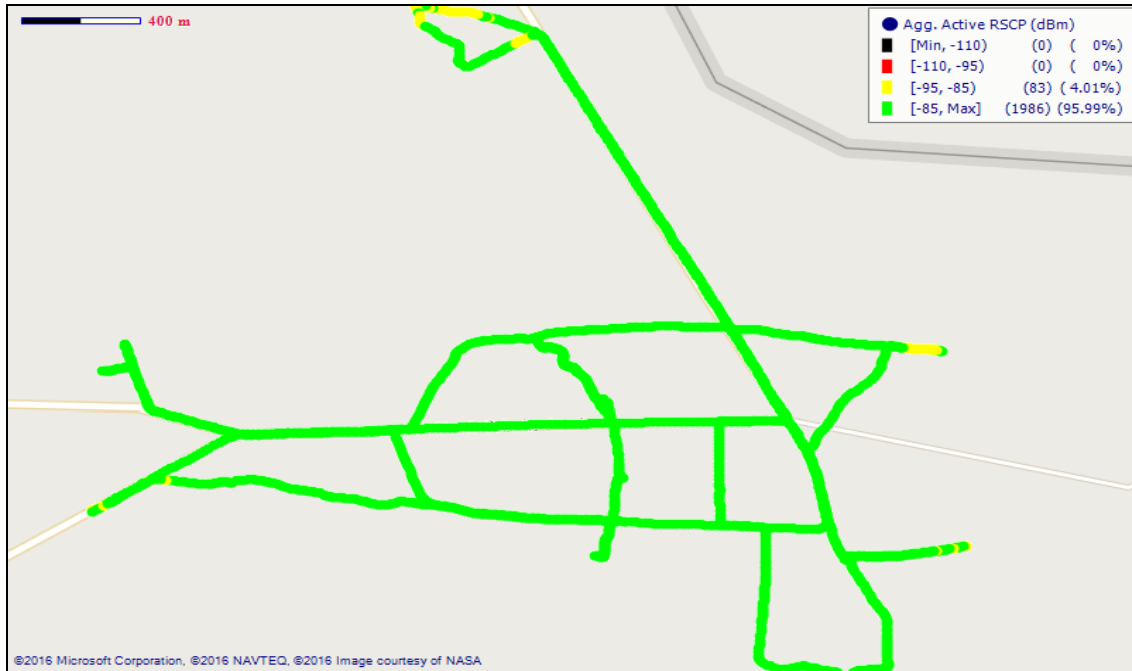
Remarks: Good 3G network coverage in Saboba.

Fig. 36 - Tigo Coverage Map, Saboba - February 2016
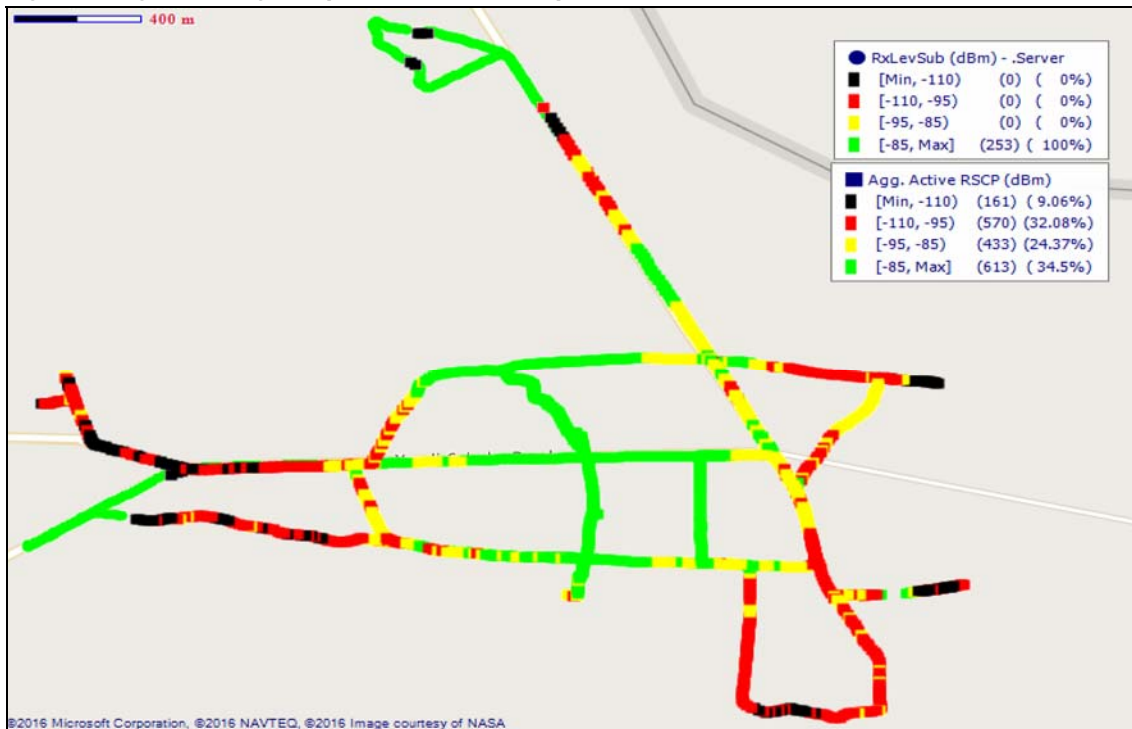
Remarks: Good 2G coverage in Saboba. However Tigo needs to improve its 3G coverage around Radio Gaaki Area, EP SHS, Market, Zongo and Takpelle.

Fig. 37 - Airtel Coverage Map, Saboba - February 2016
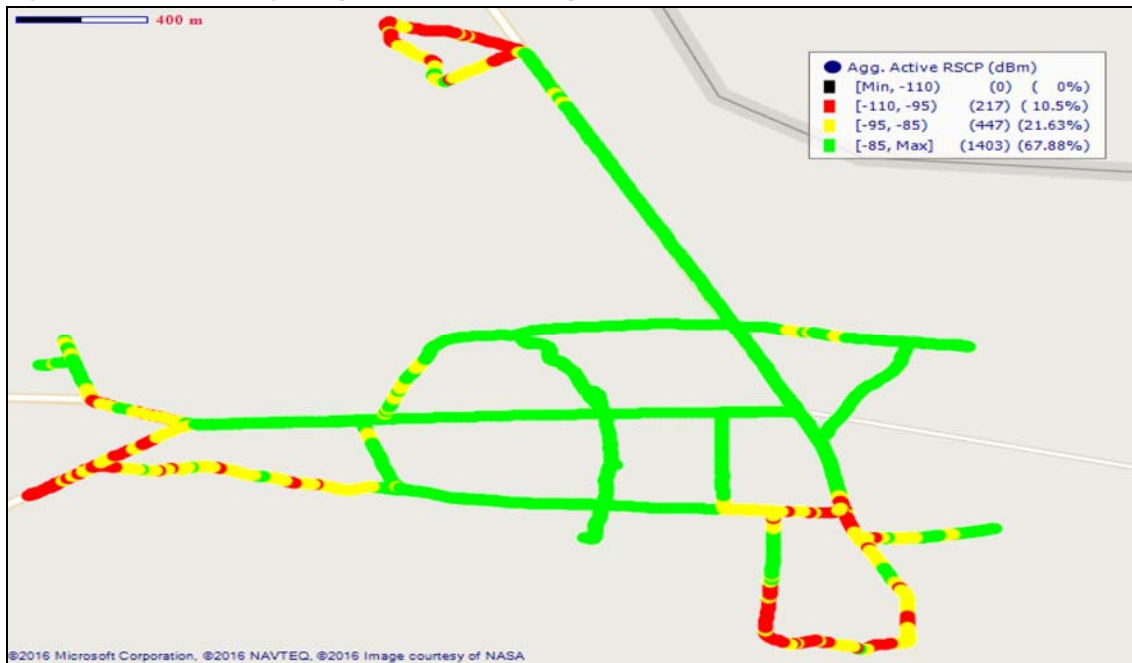
Remarks: Good 3G coverage in Saboba. Improvement is however needed at Market, Zongo, EP SHS and Saboba Health Center.

COVERAGE AT SAGNARIGU

Fig. 38 - MTN Coverage Map, Sagnarigu - February 2016
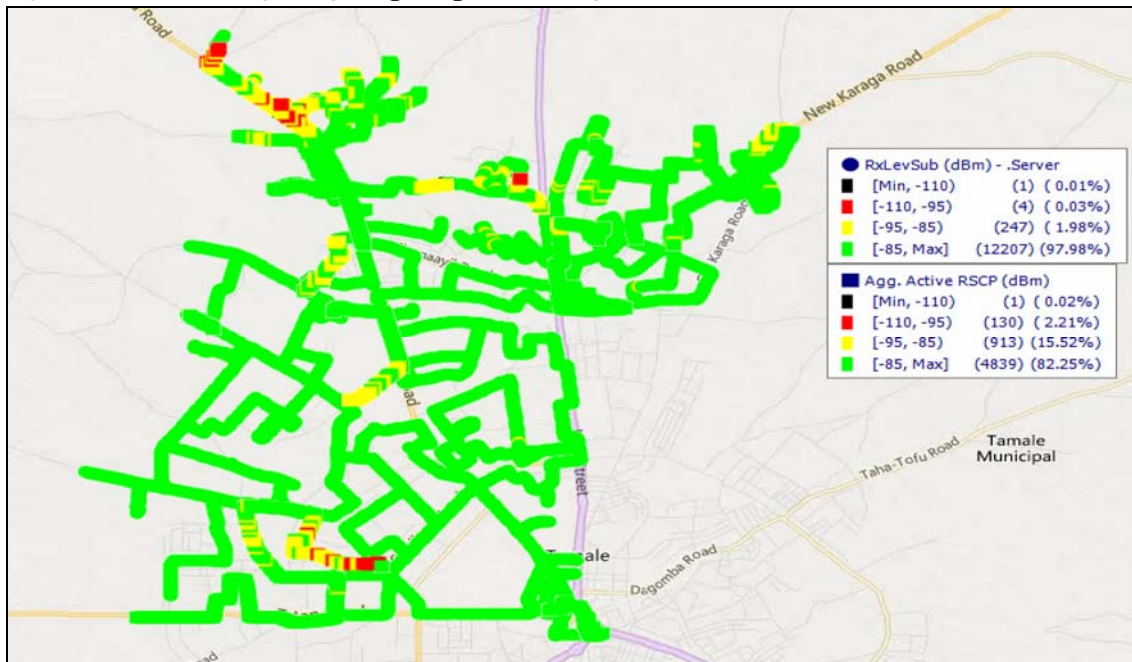
Remarks: Good network coverage in Sagnarigu District with improvement needed at Malshegu and Katoriga.

Fig. 39 - Vodafone Coverage Map, Sagnarigu - February2016
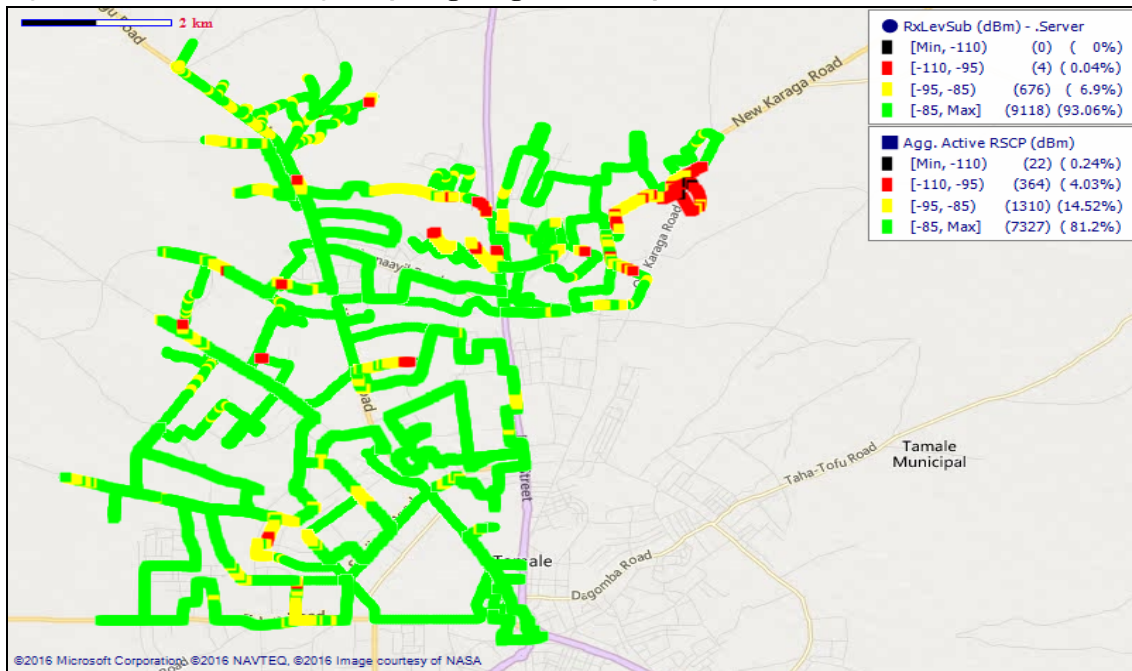
Remarks: Good network coverage with few fair spots across Sagnarigu . Improvement is needed around Norrip Village, Kamina and School of Hygiene Area.

Fig. 40 - Tigo Coverage Map, Sagnarigu - February 2016
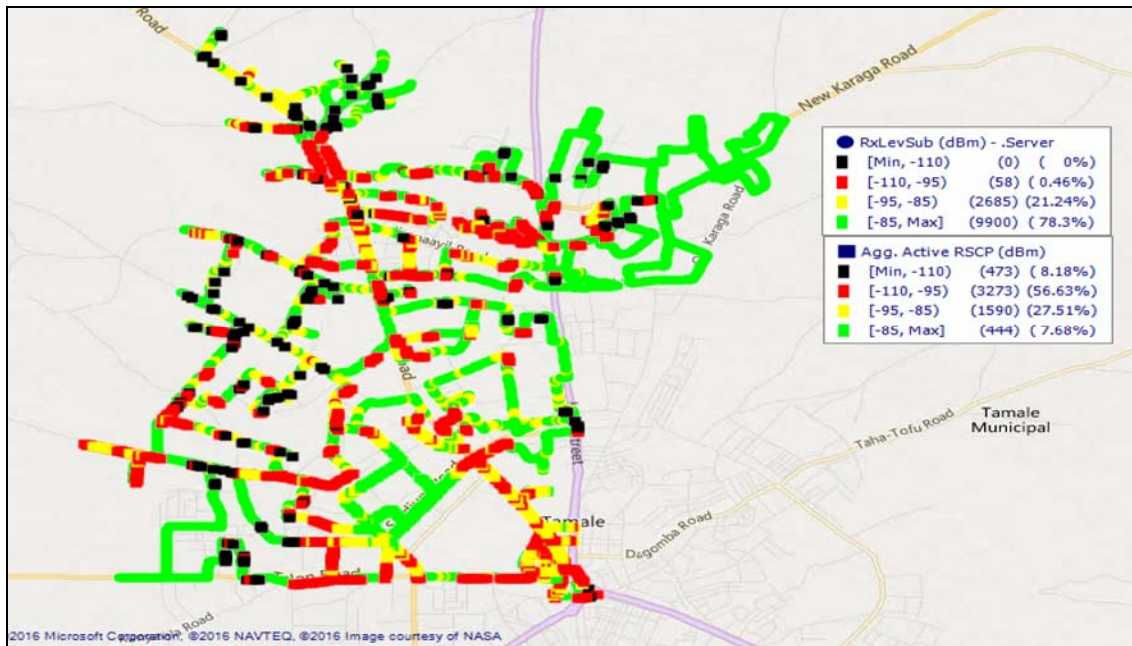
Remarks: Fair network coverage in Sagnarigu District. Major improvement need especially on the 3G network.

Fig. 41 - Airtel Coverage Map, Sagnarigu - February 2016
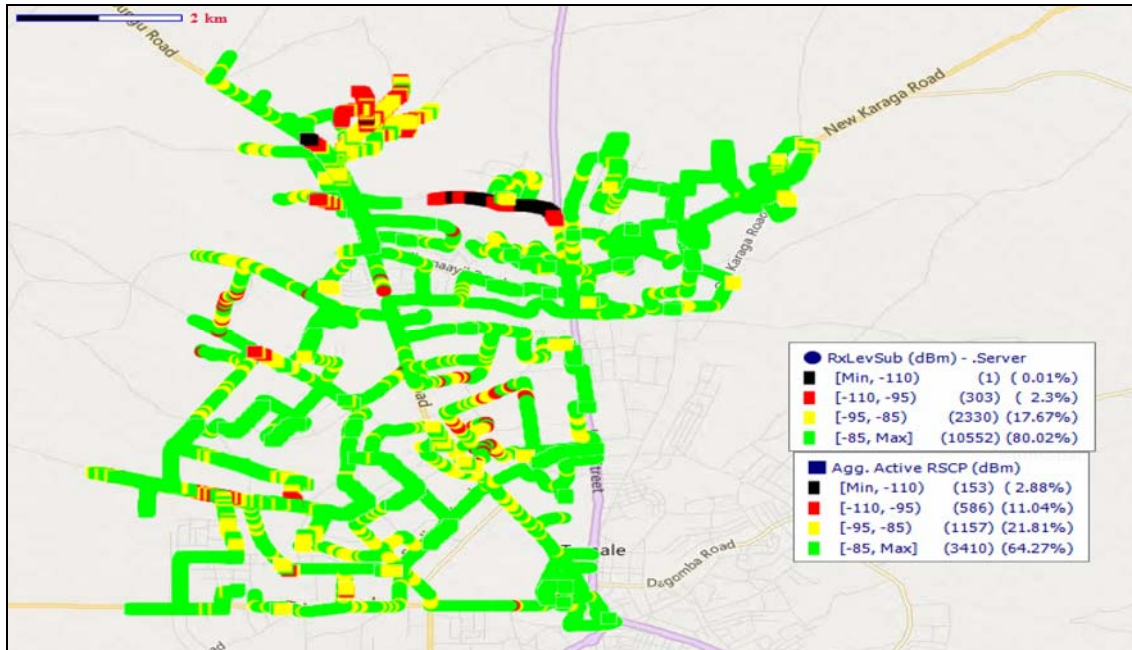
Remarks: Good network coverage in Sagnarigu district however with improvement needed at Nyohni, Tamale Stadium and Katoriga.

COVERAGE AT SALAGA

Fig. 42 - MTN Coverage Map, Salaga - February 2016
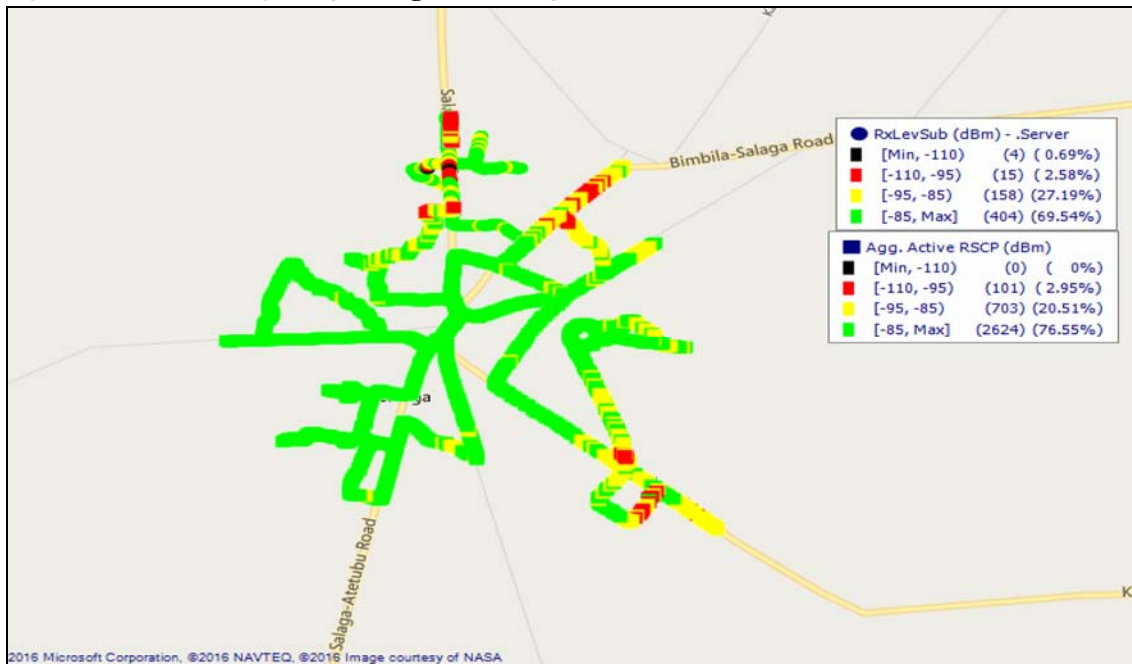
Remarks: Good network coverage in Salaga. Improvement is needed at Salaga SHS, Kanyitipe and Salaga Prisons.

Fig. 43 - Vodafone Coverage Map, Salaga - February 2016
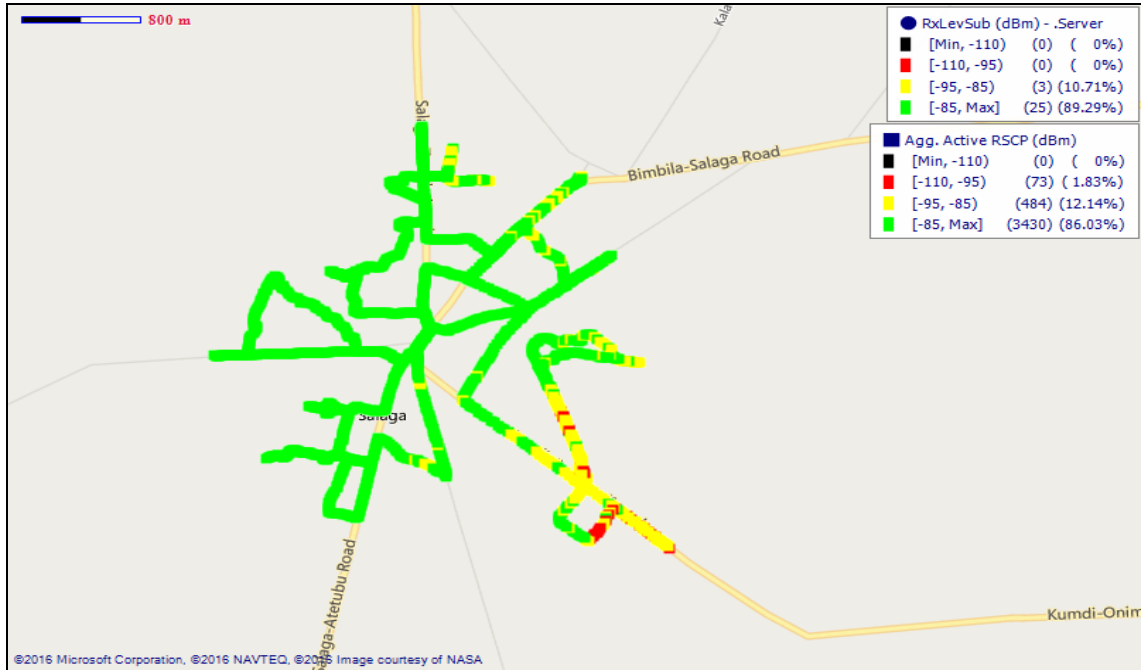
Remarks: Good network coverage in Salaga. Improvement is needed around Salaga SHS and District Assembly.

Fig. 44 - Tigo Coverage Map, Salaga - February 2016
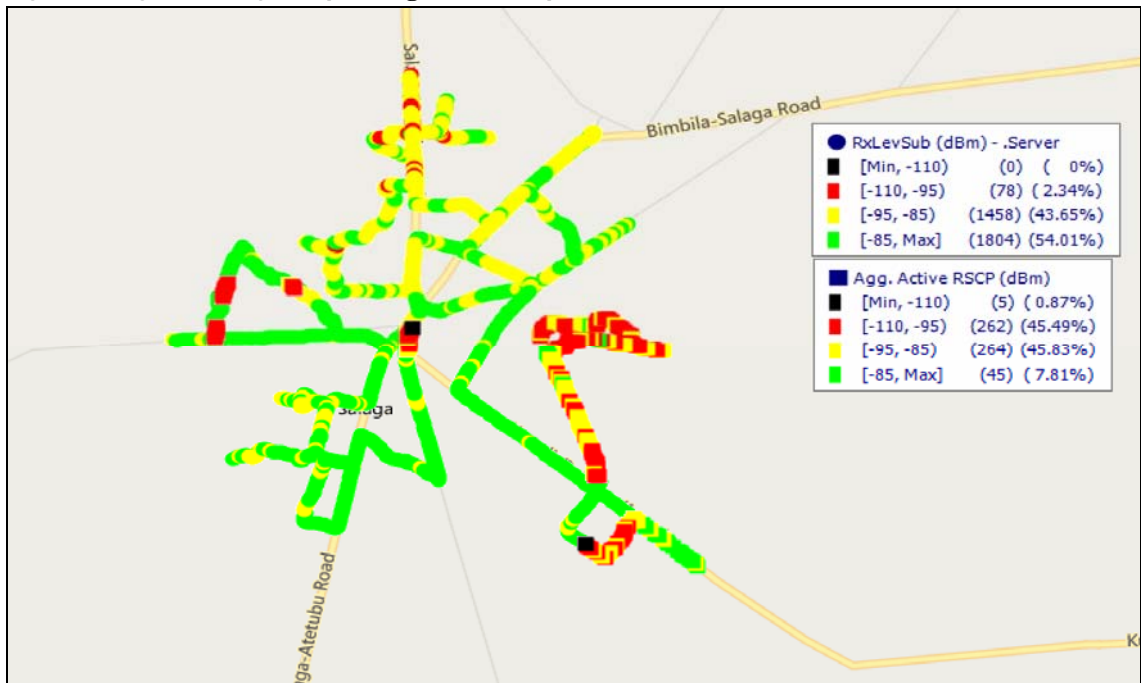
Remarks: Fair network coverage in Salaga. Major improvement is needed at Salaga Station, Ngwaimam, Kanyitipe, Salaga SHS and TI Ahmadiya SHS.

Fig. 45 - Airtel Coverage Map, Sagnarigu - February2016
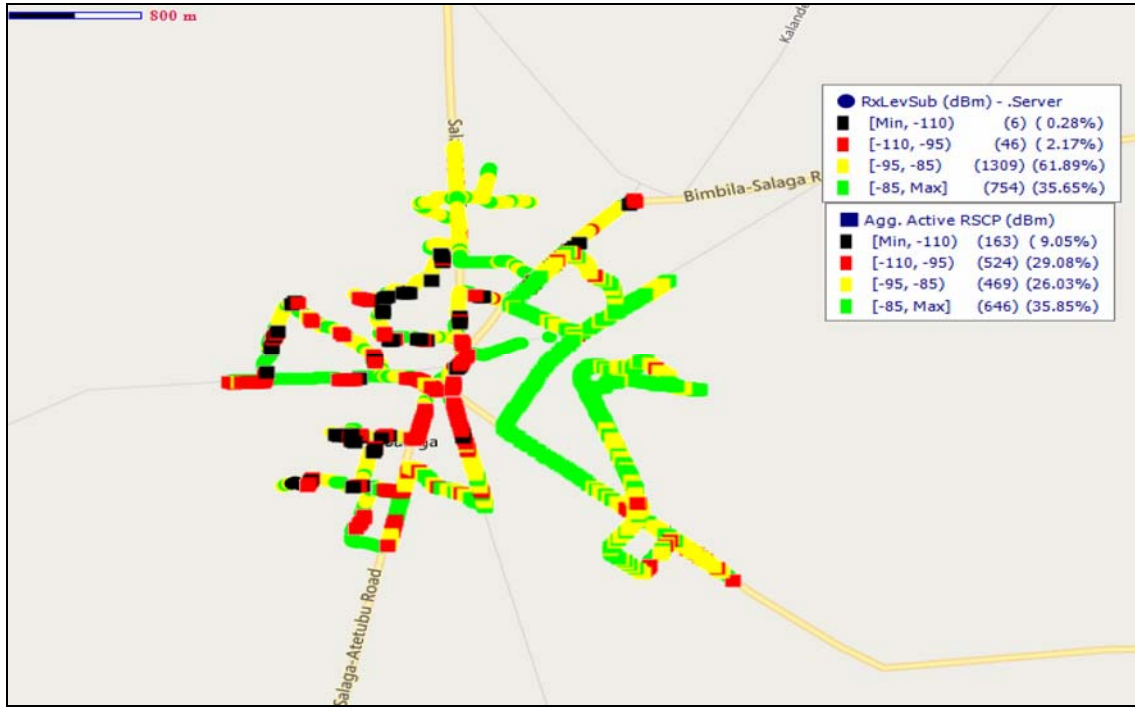
Remarks: Fair network coverage in Salaga with major improvement needed at Salaga Lorry Station, Kabiteh Gwadusi, Anyanbavilla, Kanyitipe and Mempeasem.

COVERAGE AT SANG

Fig. 46 - MTN Coverage Map, Sang - February 2016
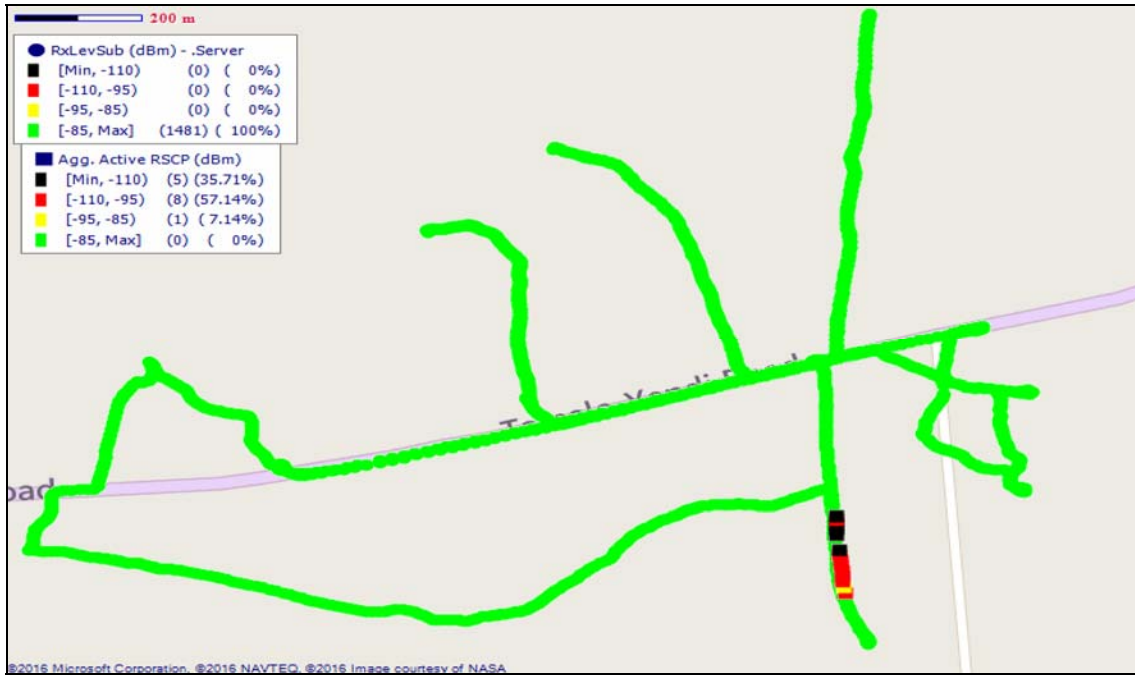
Remarks: Good 2G network coverage with poor 3G coverage. Major improvement on the 3G is needed in the entire Sang.

Fig. 47 - Vodafone Coverage Map, Sang - February 2016
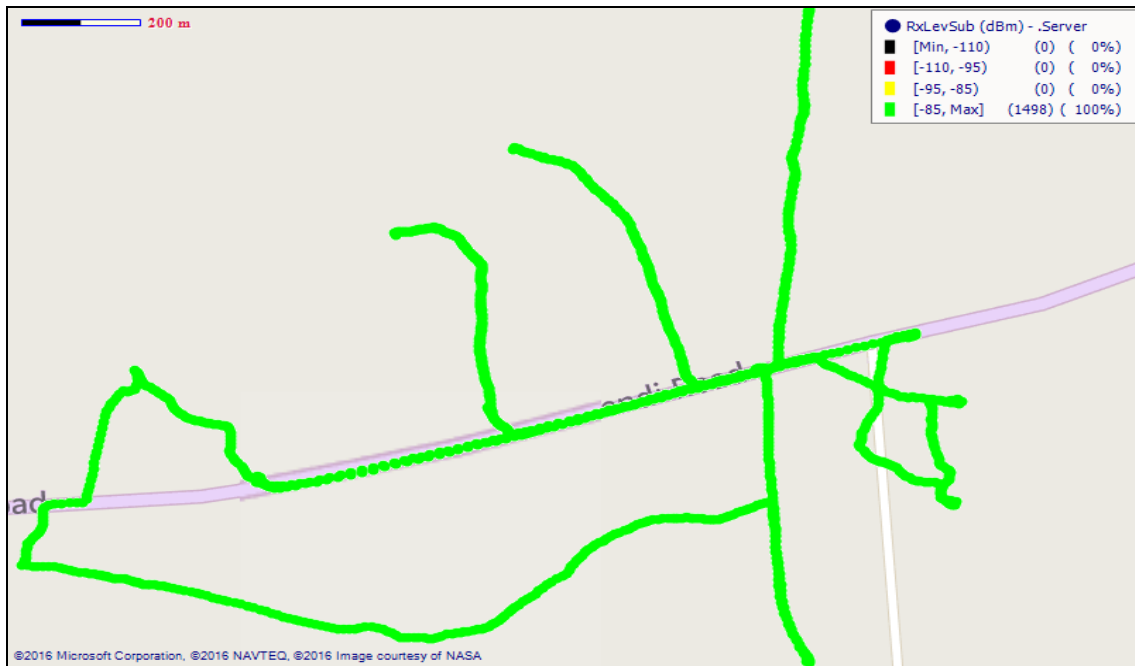
Remarks: Good 2G coverage in Sang.

Fig. 48 - Tigo Coverage Map, Sang - February 2016

Remarks: Good 2G network coverage in Sang with no 3G service.

Fig. 49 - Airtel Coverage Map, Sang - February 2016
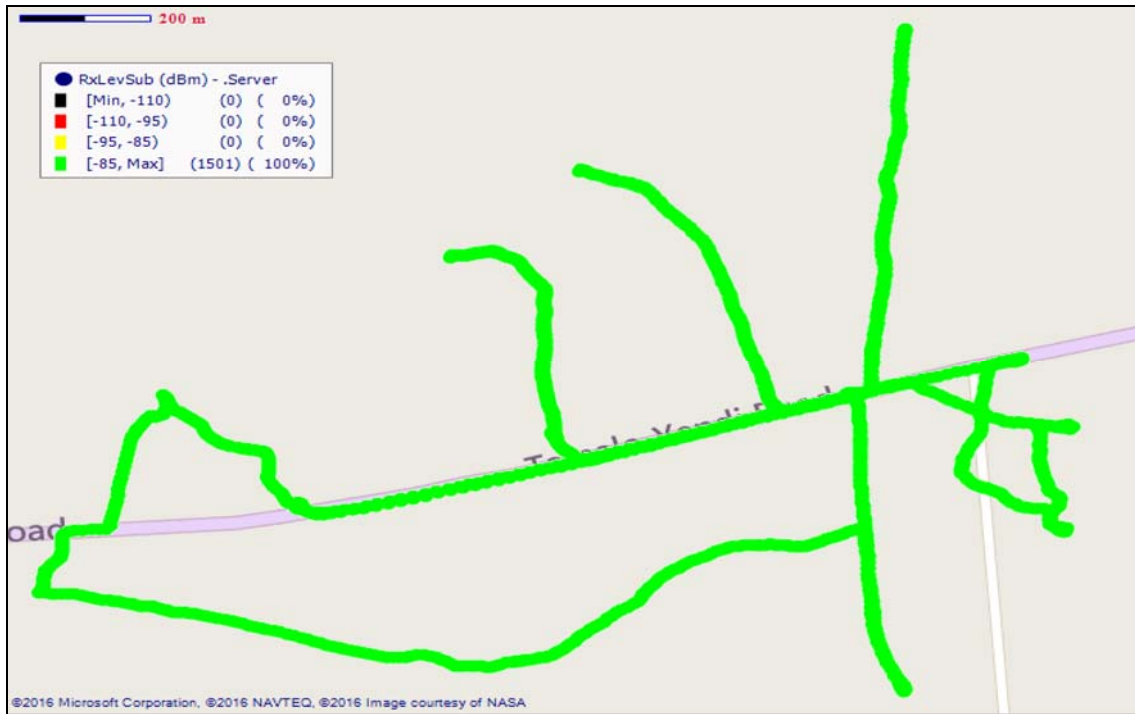
Remarks: Good 2G coverage in Sang.

COVERAGE AT SAVELUGU

Fig. 50 - MTN Coverage Map, Savelugu - February 2016
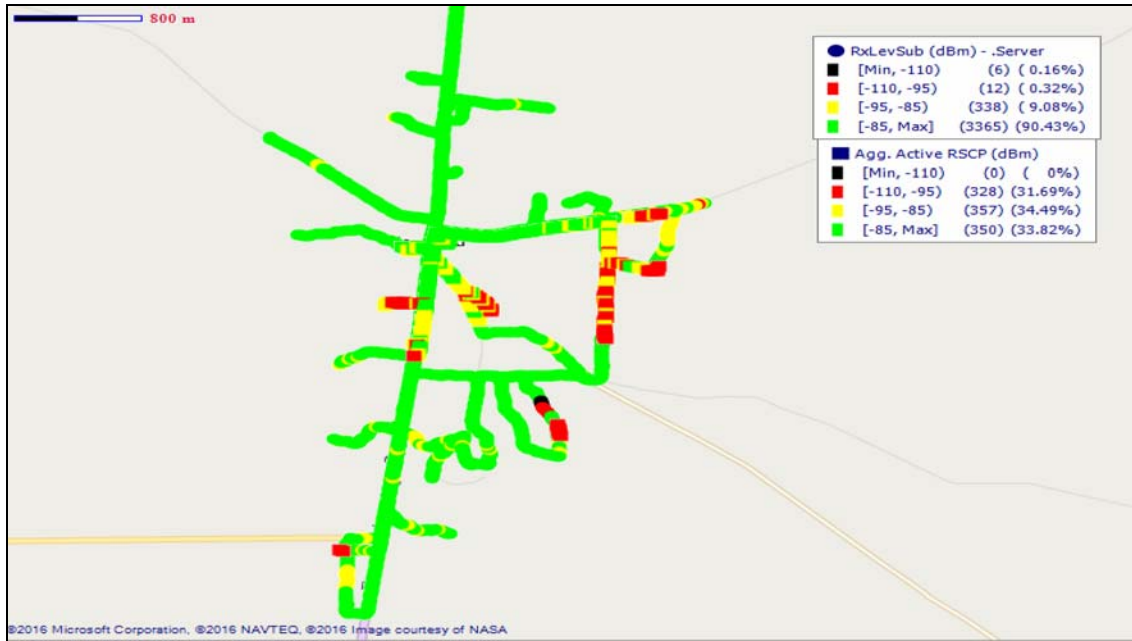
Remarks: 2G network coverage. Major improvement needed on the 3G network around the District Assembly, Yipala and Zagitasi.

Fig. 51 - Vodafone Coverage Map, Savelugu - February 2016
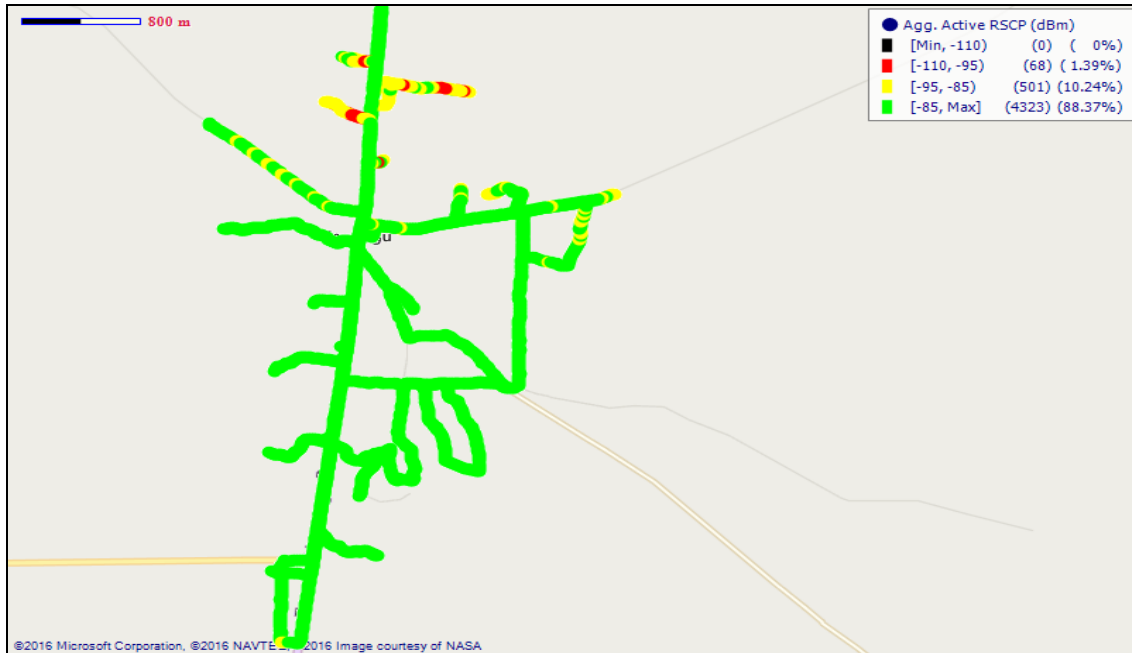
Remarks: Good 3G coverage in Savelugu yet improvement is needed at Savelugu SHS and Kwafong.

Fig. 52 - Tigo Coverage Map, Savelugu - February 2016
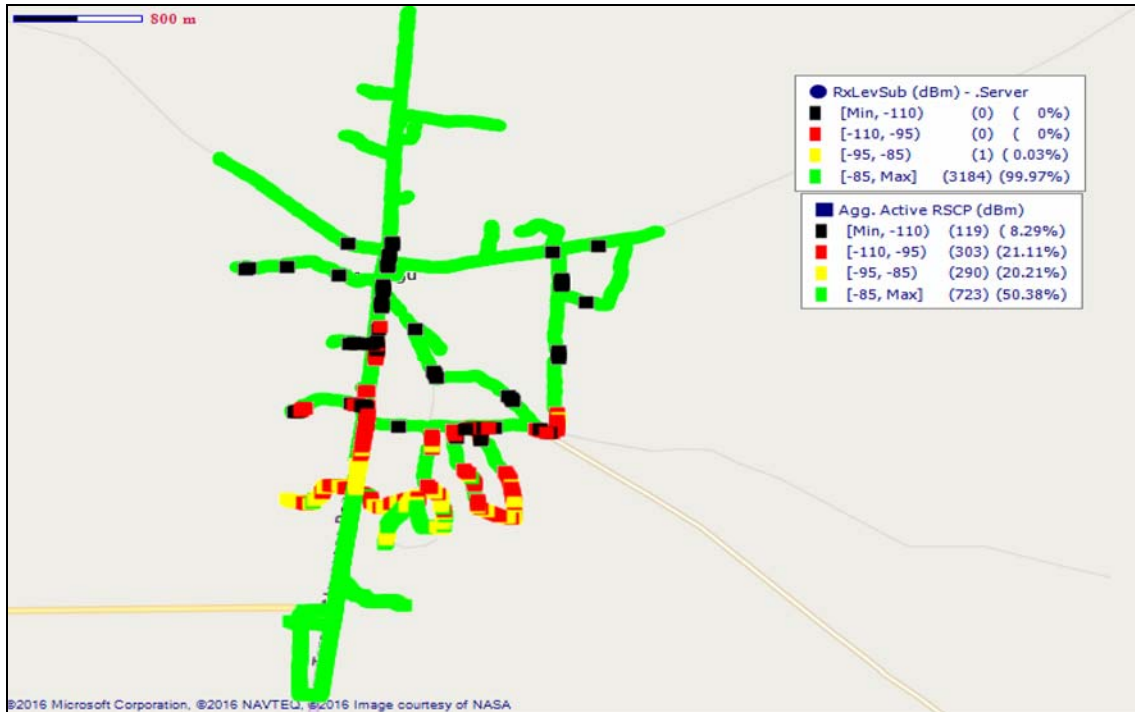
Remarks: Tigo has a good 2G network coverage in Savelugu but needs to improve its 3G service at areas around the District Assembly, Yipala, Zagitasi, Savelugu SHS, Market, Kambotoni and Sawaba.

Fig. 53 - Airtel Coverage Map, Savelugu - February2016
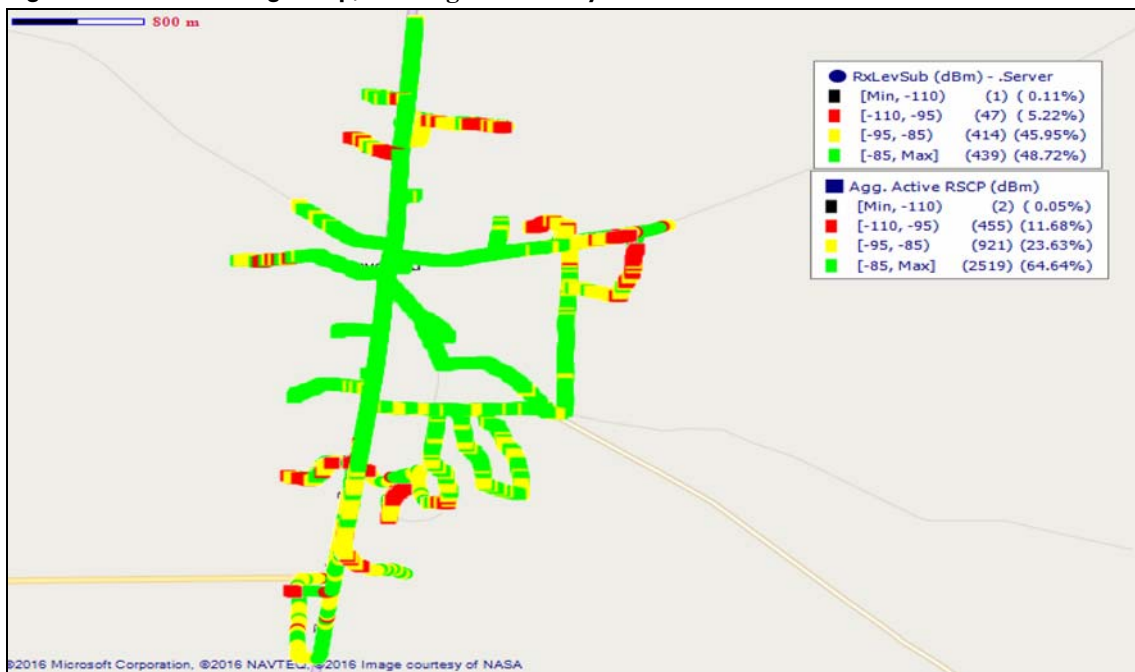
Remarks: Fair network coverage in Savelugu with improvement needed at Nimo Fong, Savelugu SHS, District Assembly, Yipala and Zagitasi.

COVERAGE AT SAWLA

Fig. 54 - MTN Coverage Map, Sawla - February2016
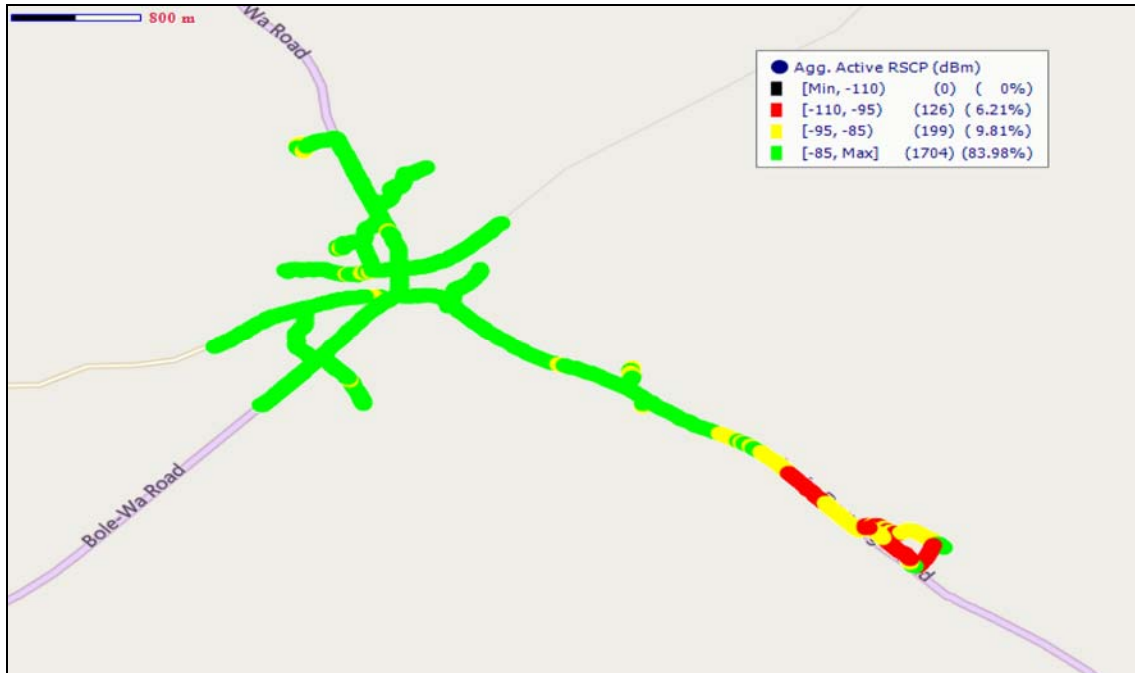
Remarks: Good 3G network coverage in Sawla yet, improvement is needed at District Assembly and Sawla Children's Home.

Fig. 55 - Vodafone Coverage Map, Sawla - February2016
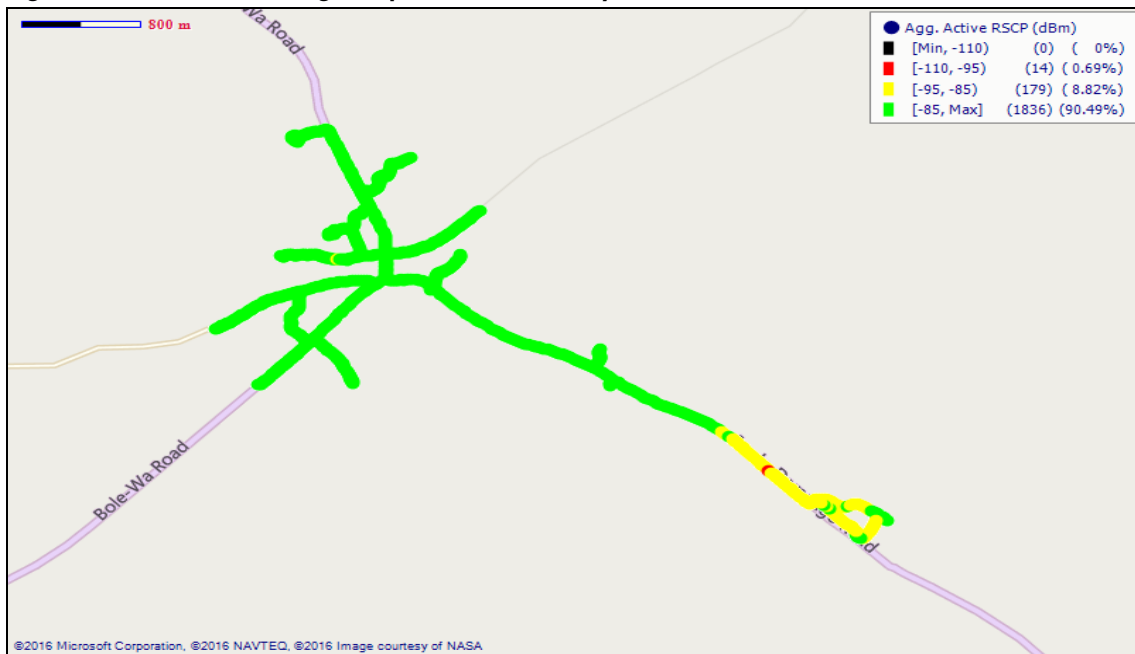
Remarks: Good 3G coverage in Sawla.

Fig. 56 - Tigo Coverage Map, Sawla - February2016
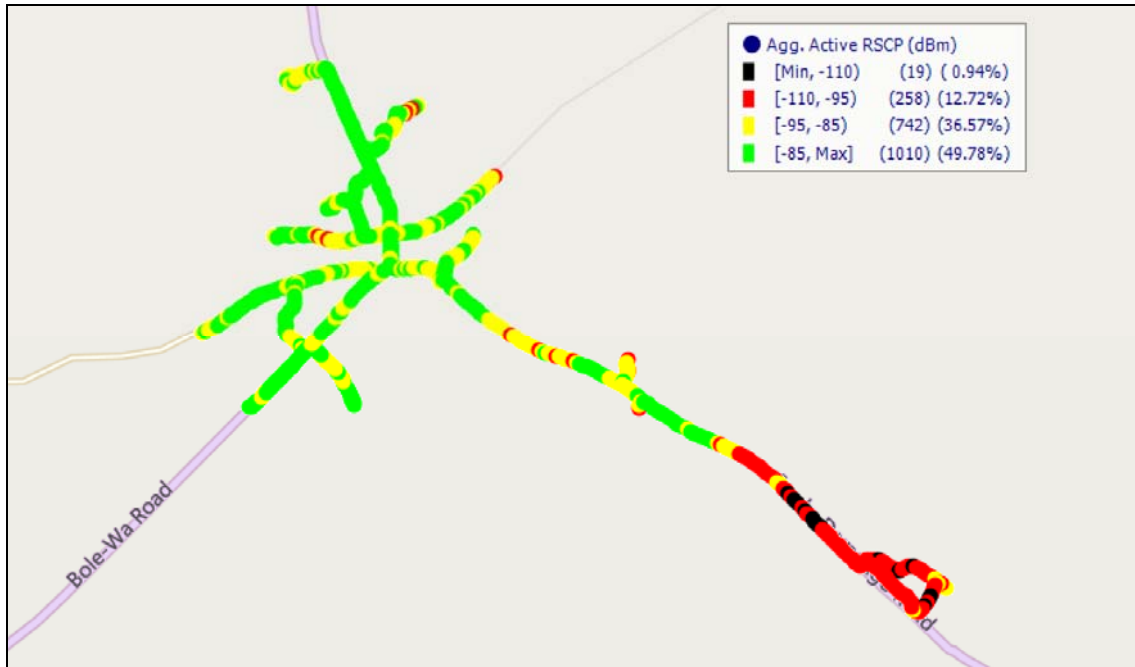
Remarks: Fair 3G network coverage in Sawla, with major improvement needed around District Assembly, Salwa Children's Home, Sindaa, Yipala and Chanbeleduru.

Fig. 57 - Airtel Coverage Map, Sawla - February2016
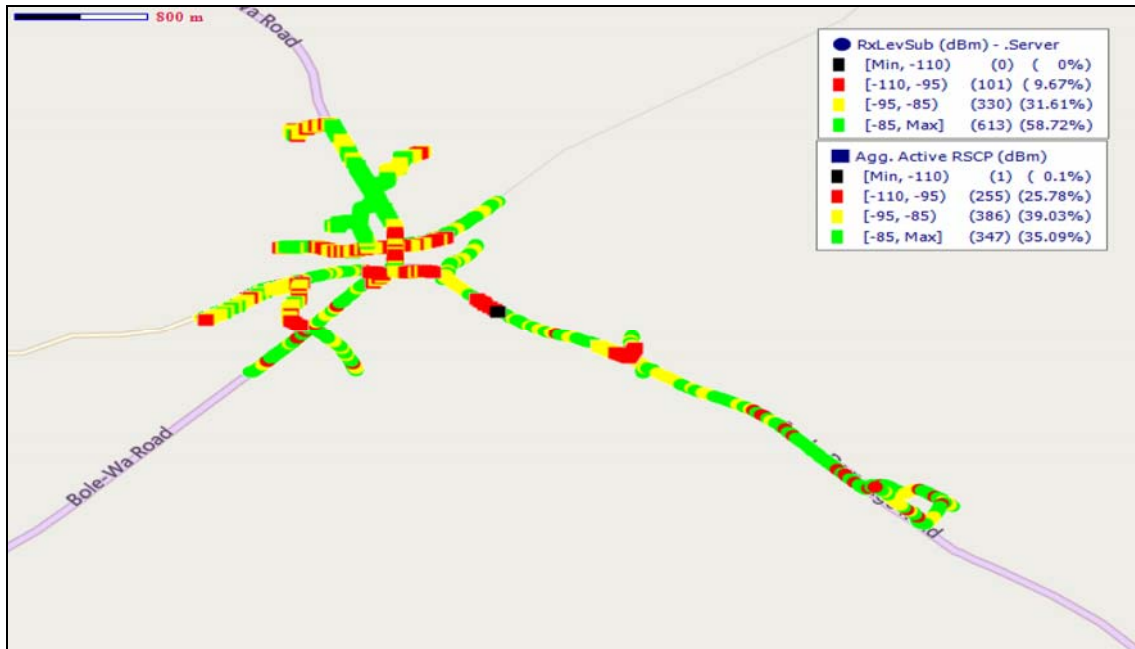
Remarks: Fair network coverage in Sawla. Major improvement needed around Sawla Lorry Station, Yipala, District Assembly, Chanbeleyili, Chanbeleduru and Sawla Girls Vocational Institute.

COVERAGE AT TAMALE

Fig. 58 - MTN Coverage Map, Tamale - February2016
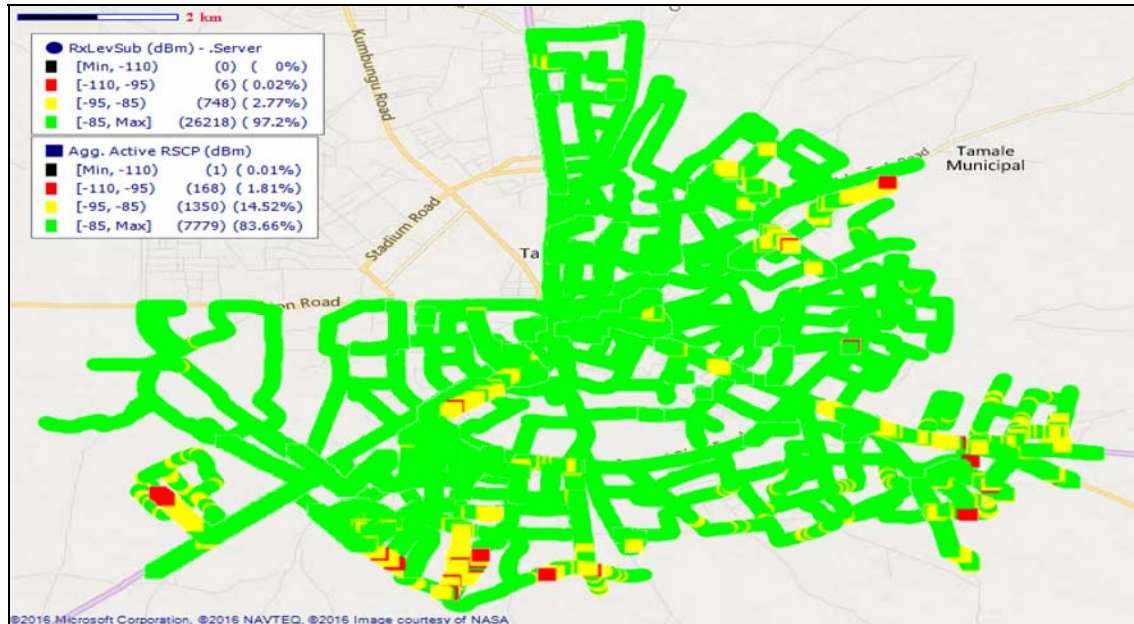
Remarks: Good network coverage in Tamale. Improvement is needed around Vittin, Kakpayilli, Fuo and UDS Tamale Campus.

Fig. 59 - Vodafone Coverage Map, Tamale - February2016
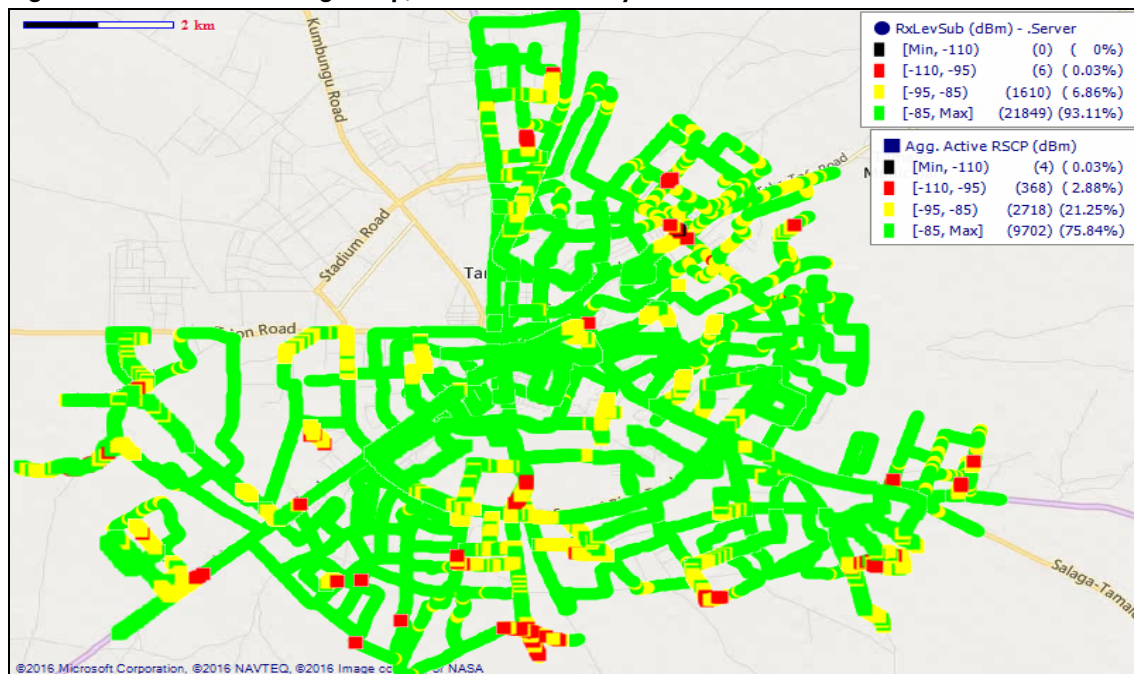
Remarks: Good network coverage in Tamale. Improvement is however needed at Vittin, Kakpayilli, Fuo, Sakasaka and SSNIT Flats.

Fig. 60 - Tigo Coverage Map, Tamale - February2016
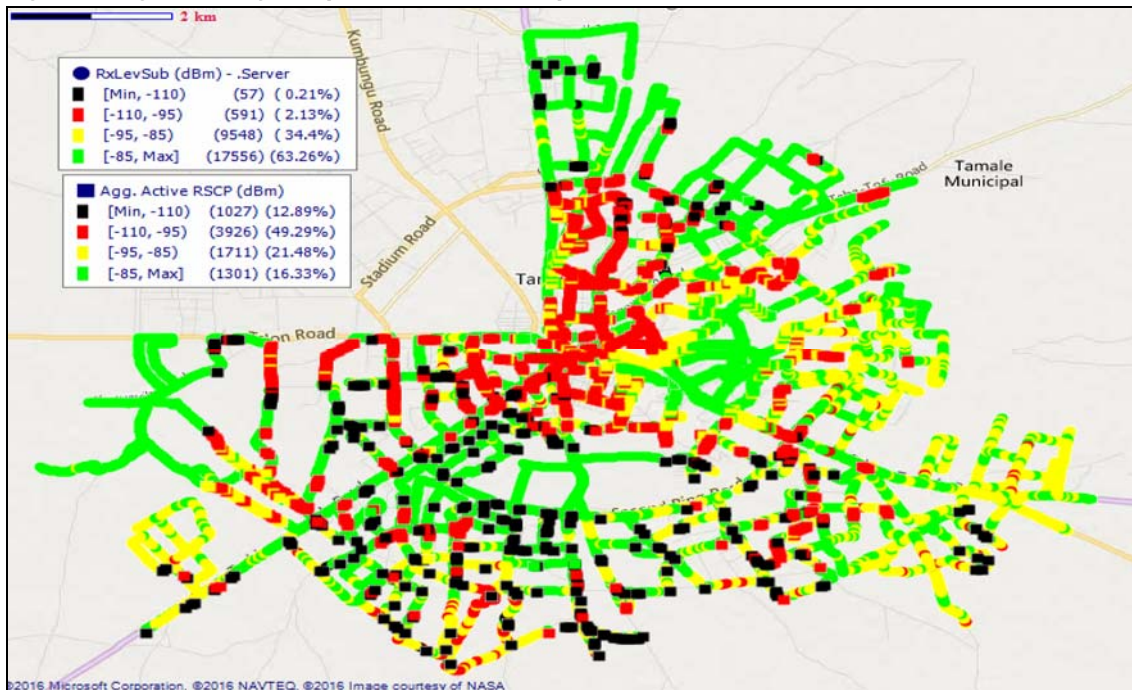
Remarks: Fair network for both 2G and 3G in Tamale. Major improvement is needed in the entire Tamale metropolis.

Fig. 61 - Airtel Coverage Map, Tamale - February2016
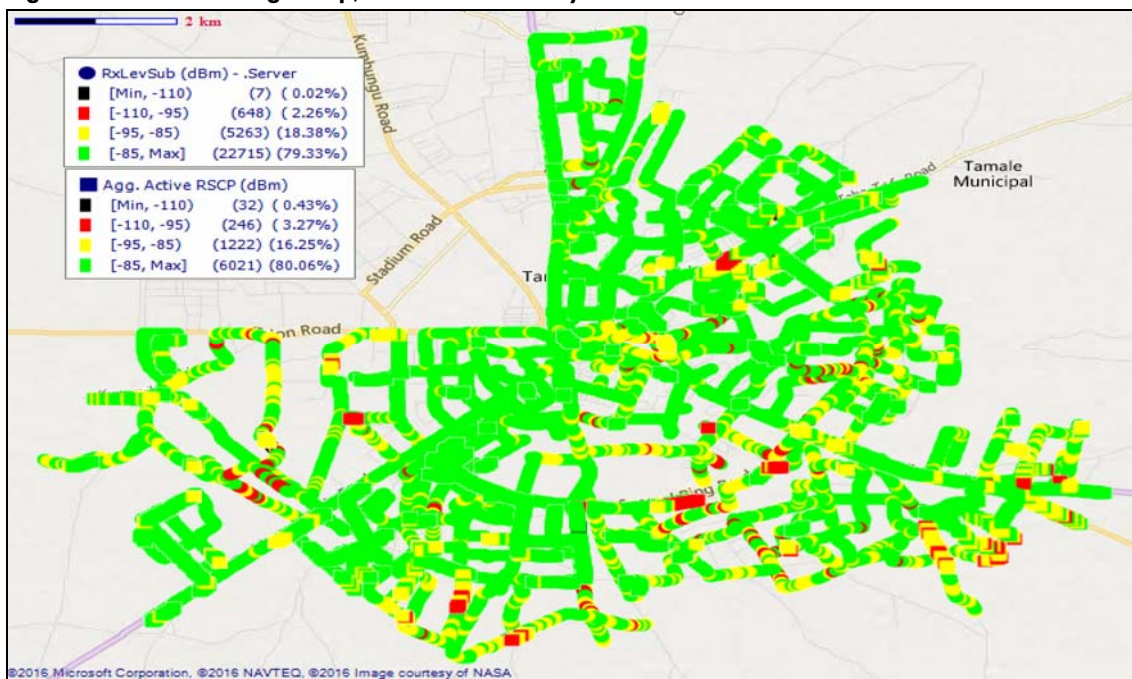
Remarks: Good network coverage in Tamale with improvement needed at Vittin, Vittin SHS, Ghanasco, Jekereyilli, Kakpayilli, Sakasaka and Lamashegu.

Fig. 62 - Glo Coverage Map, Tamale - February2016
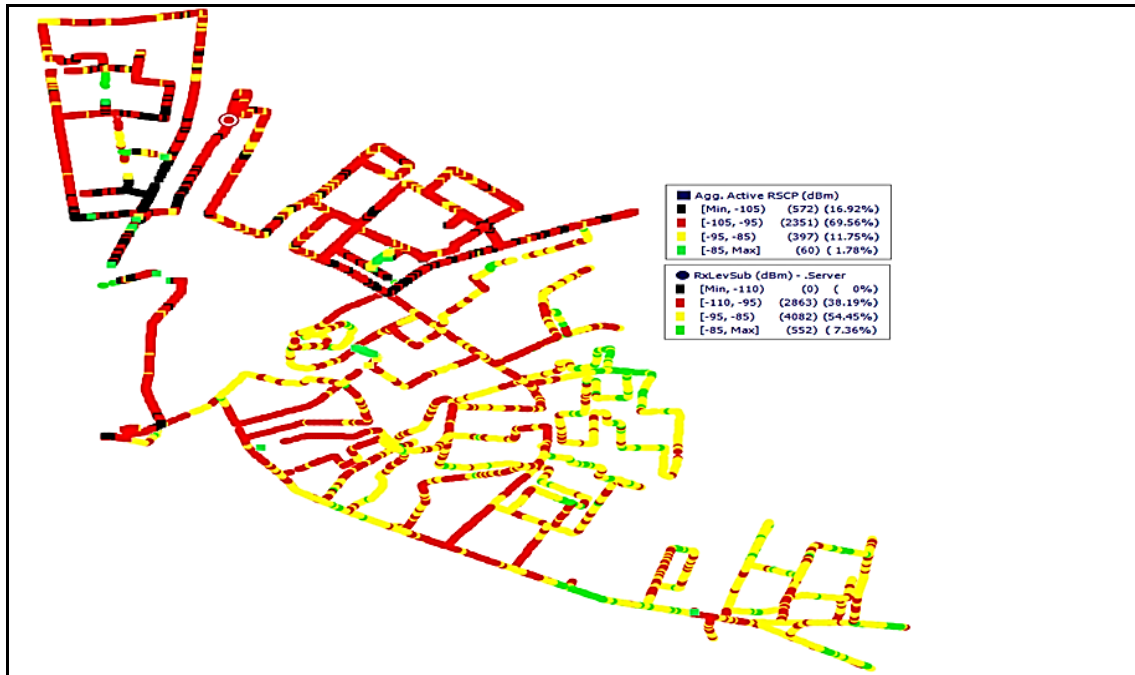
Remarks: Poor coverage in the Tamale metropolis.

COVERAGE AT TATALE

Fig. 63 - MTN Coverage Map, Tatale - February2016
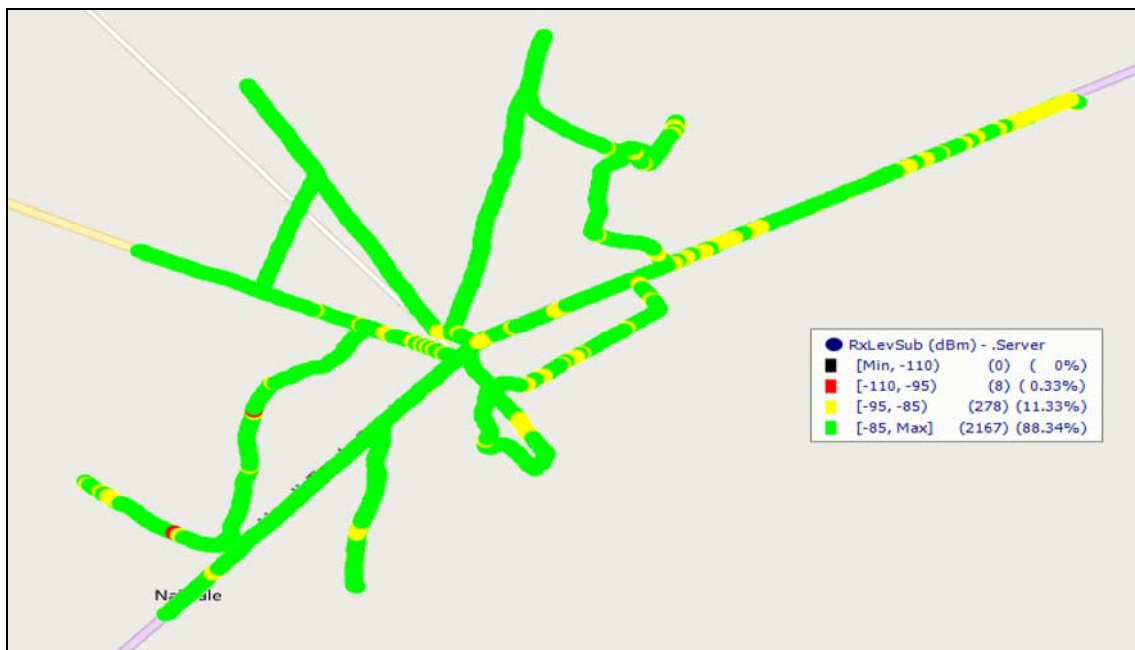
Remarks: Good 2G network coverage in Tatale.

Fig. 64 - Vodafone Coverage Map, Tatale - February2016
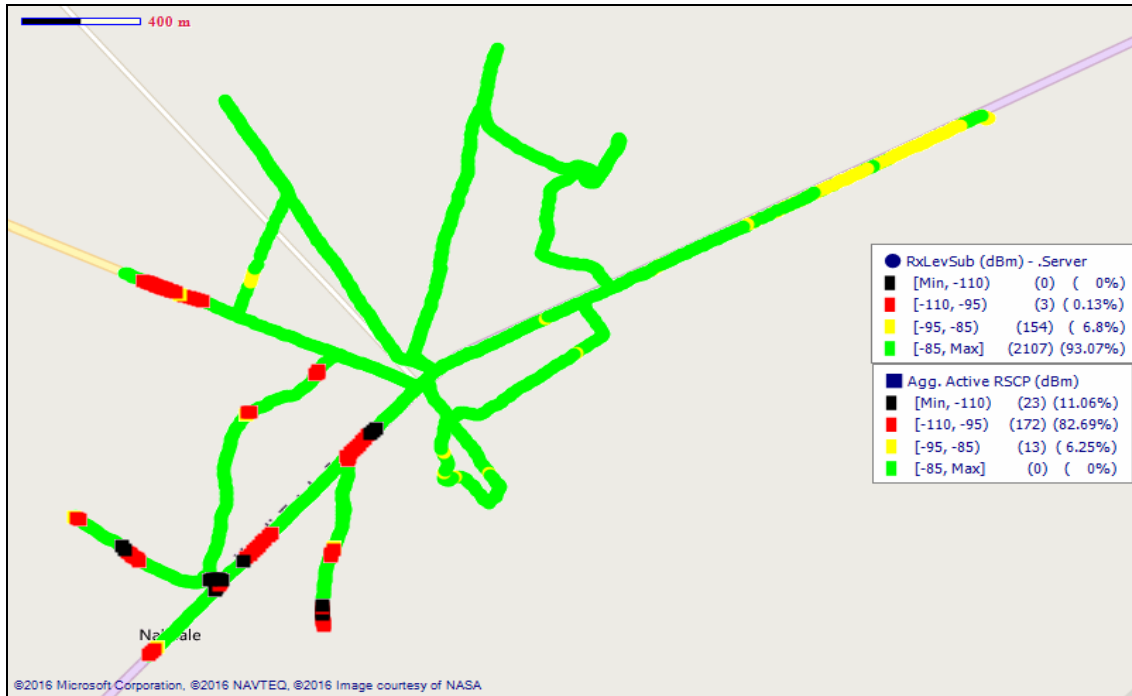
Remarks: Good 2G coverage in Tatale yet improvement is needed on the 3G network.

Fig. 65 - Tigo Coverage Map, Tatale - February2016
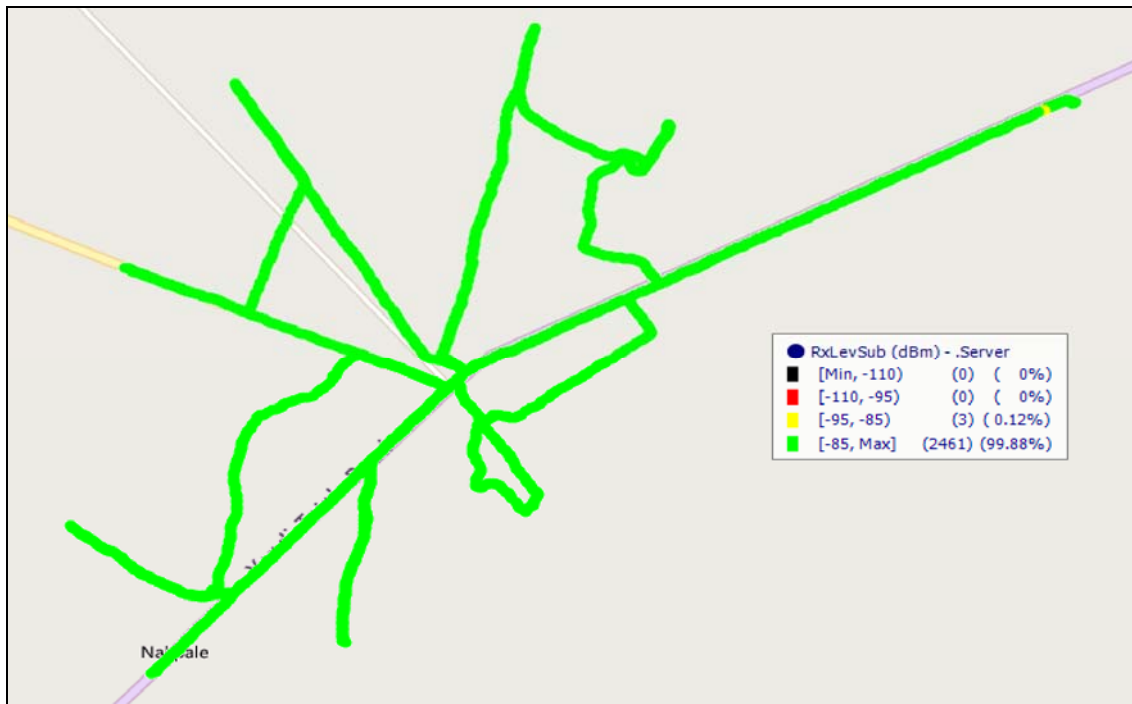
Remarks: Good 2G coverage in Tatale with no 3G coverage.

Fig. 66 - Airtel Coverage Map, Tatale - February2016
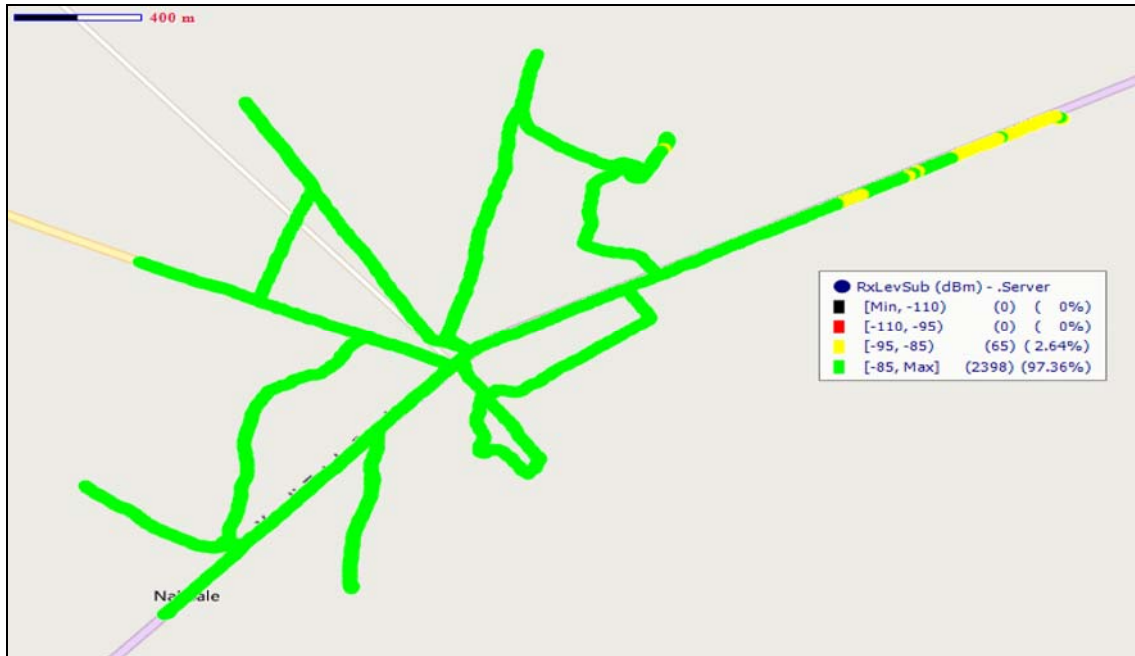
Remarks: Good 2G coverage in Tatale.

COVERAGE AT TOLON

Fig. 67 - MTN Coverage Map, Tolon - February2016
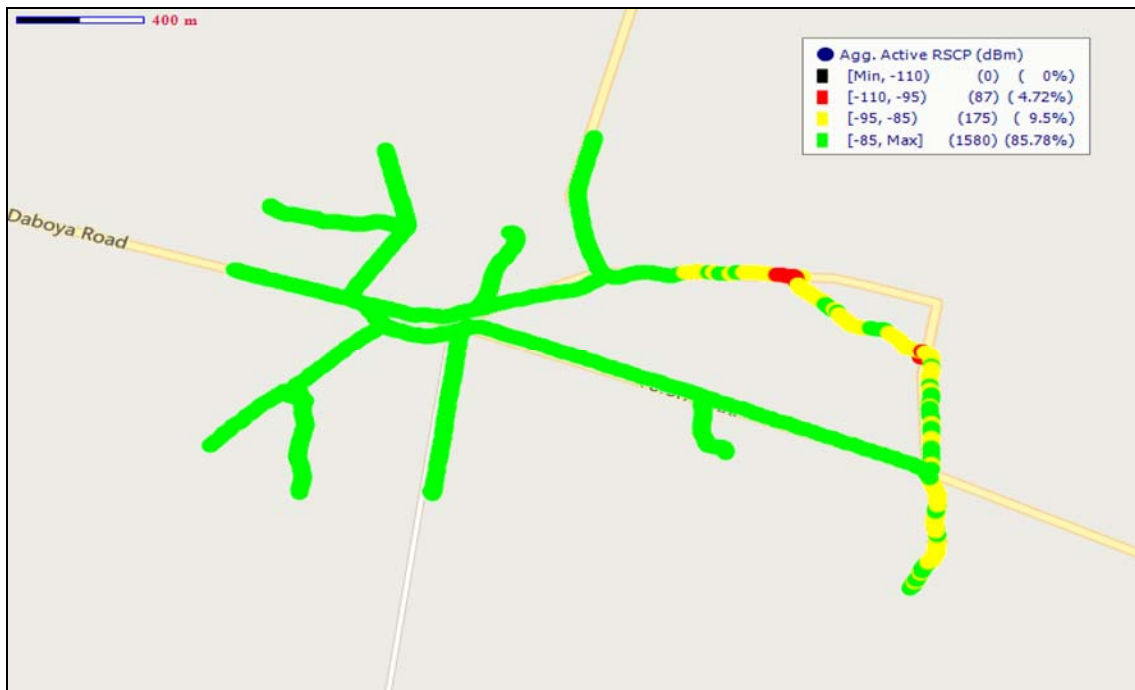
Remarks: Good 3G network coverage in Tolon. Improvement is however needed at Tolon SHS, Tolon District Assembly and Tolon District Health Center.

Fig. 68 - Vodafone Coverage Map, Tolon - February2016
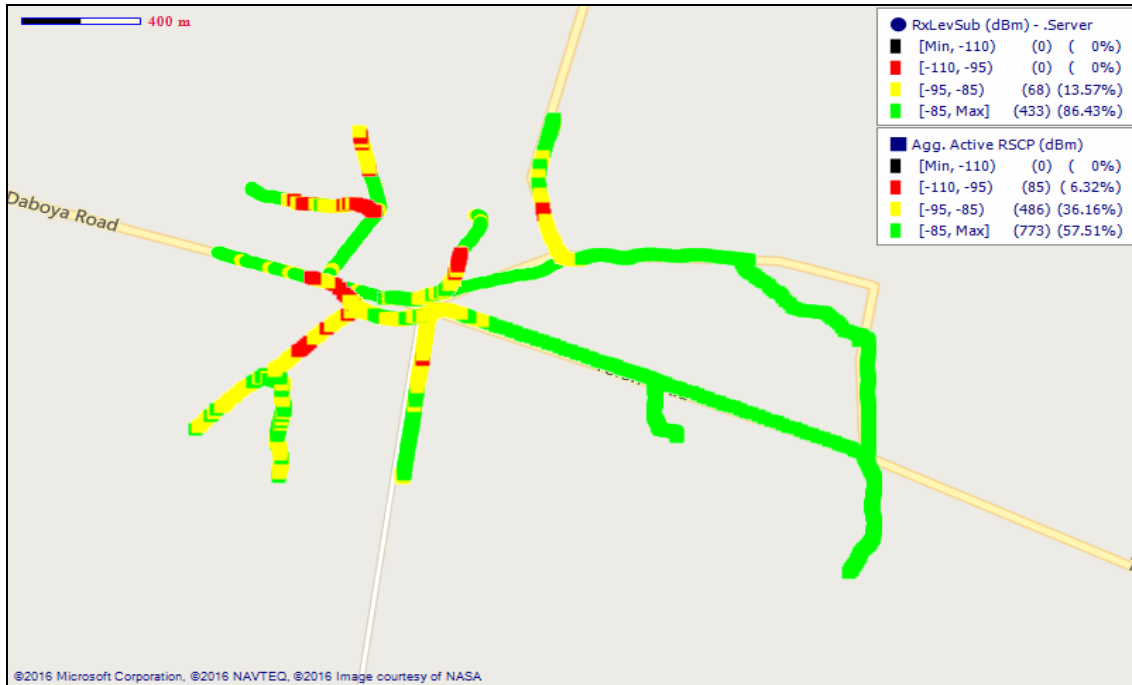
Remarks: Good network coverage in Tolon yet improvement is needed around Badule, Wulayifong, Imamfong and Kpaliyale.

Fig. 69 - Tigo Coverage Map, Tolon - February2016
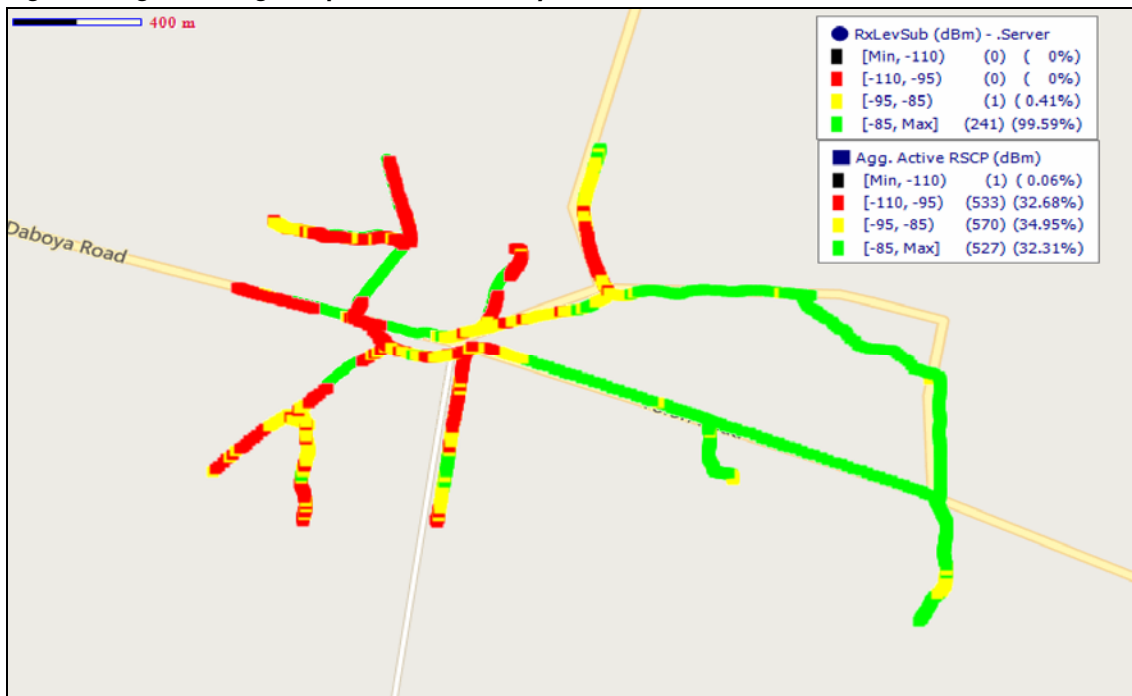
Remarks: Good 2G network coverage with improvement is needed on 3G network around Badule, Wulayifong, Imamfong and Kpaliyale.

Fig. 70 - Airtel Coverage Map, Tolon - February2016
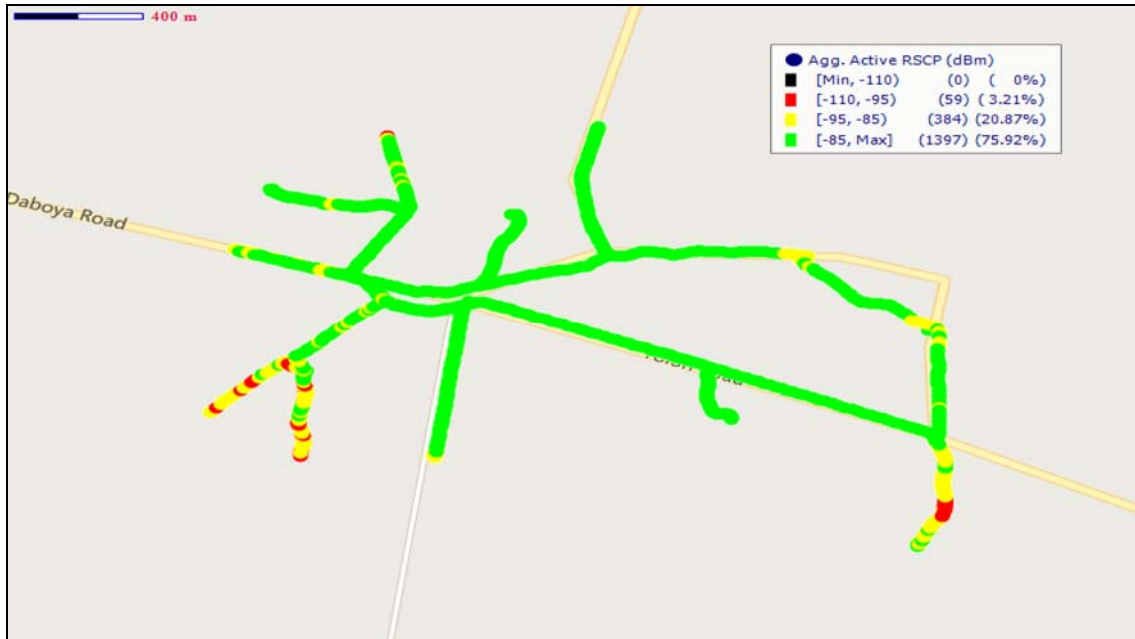
Remarks: Good 3G coverage in Tolon with fair coverage spots around Tolon SHS, Badule and Kpaliyale.

COVERAGE AT WULENSI

Fig. 71 - MTN Coverage Map, Wulensi - February2016
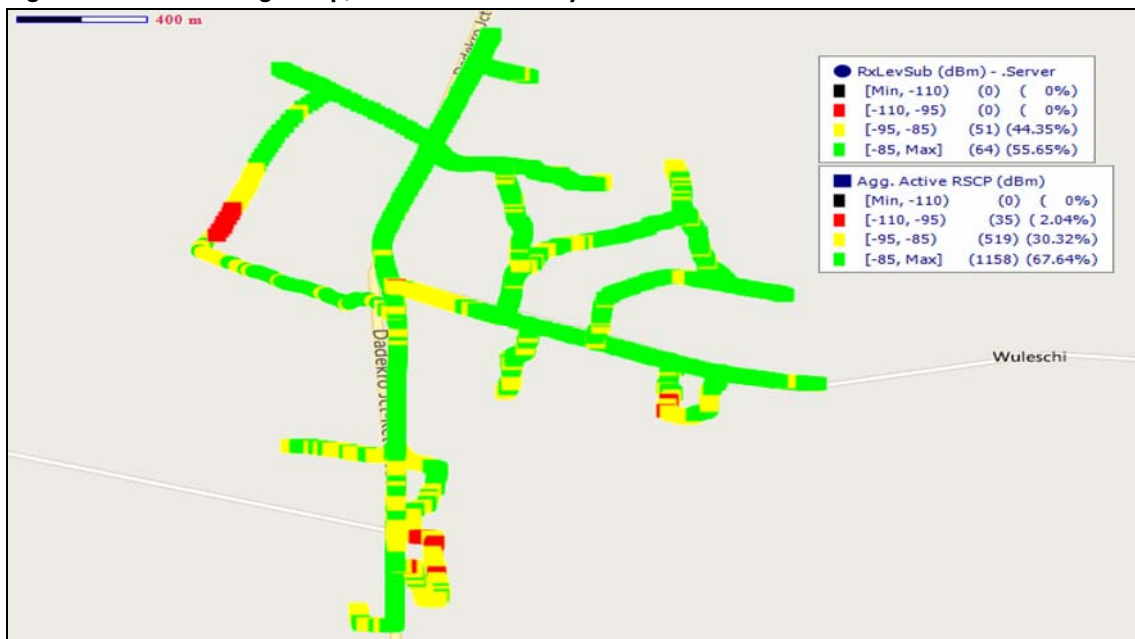
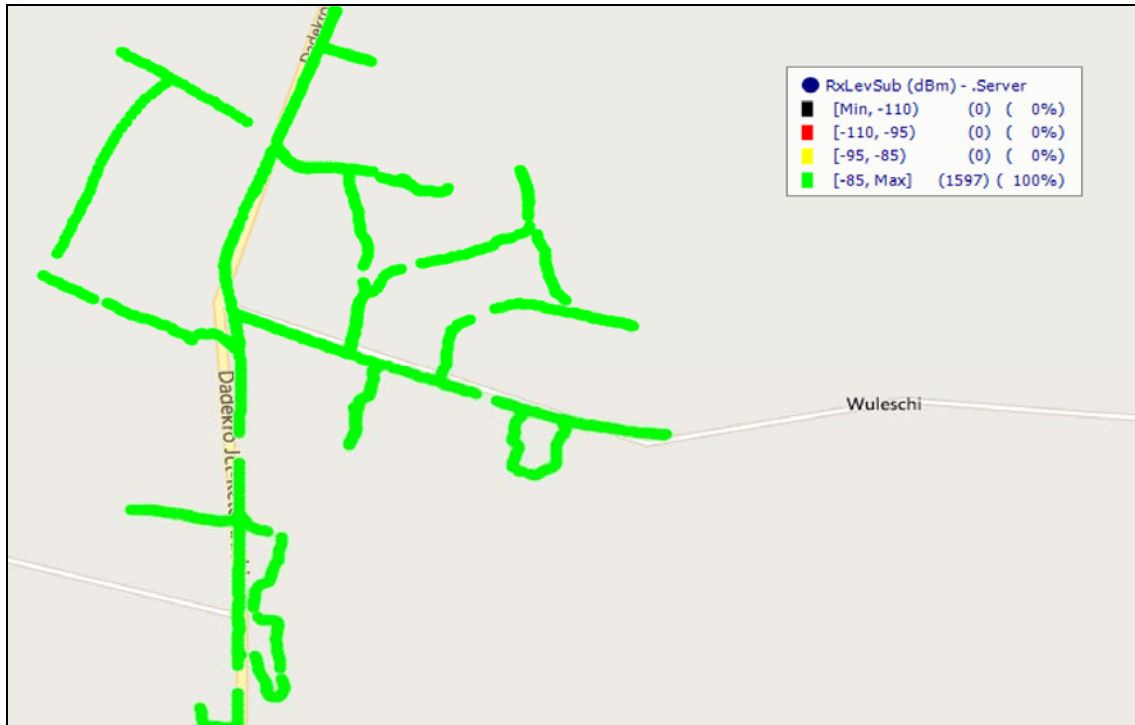Remarks: Good network coverage in Wulensi. Improvement is needed at Wulensi SHS, Market and Yipala.

Fig. 72 - Vodafone Coverage Map, Wulensi - February2016
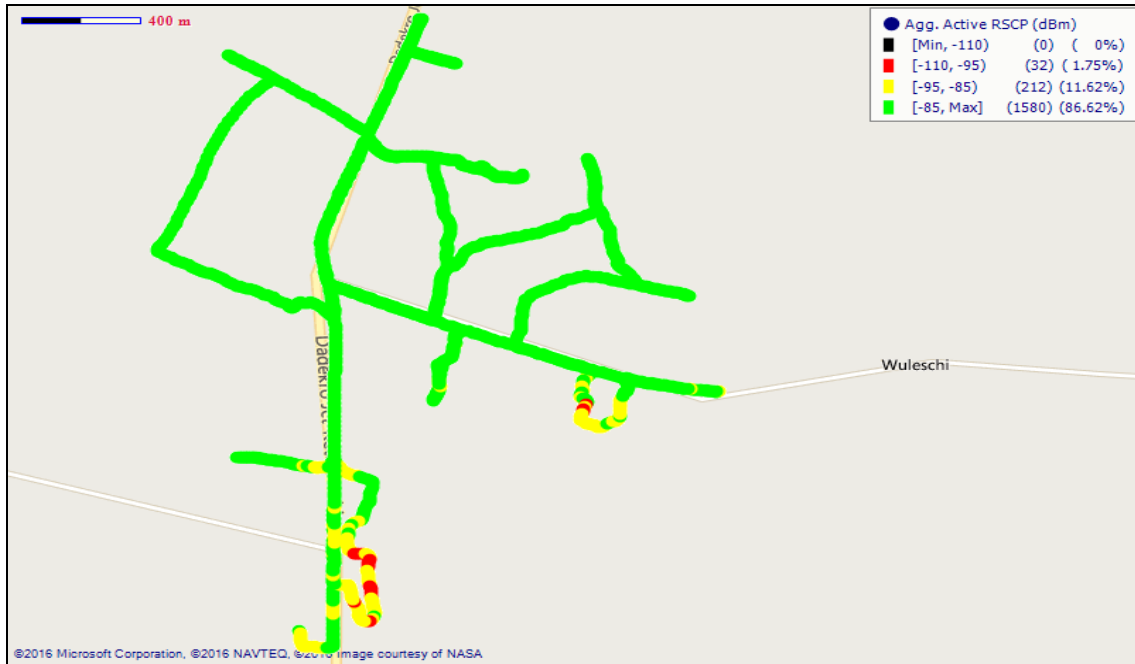
Remarks: Good 3G network coverage in Wulensi.

Fig. 73 - Tigo Coverage Map, Wulensi - February2016

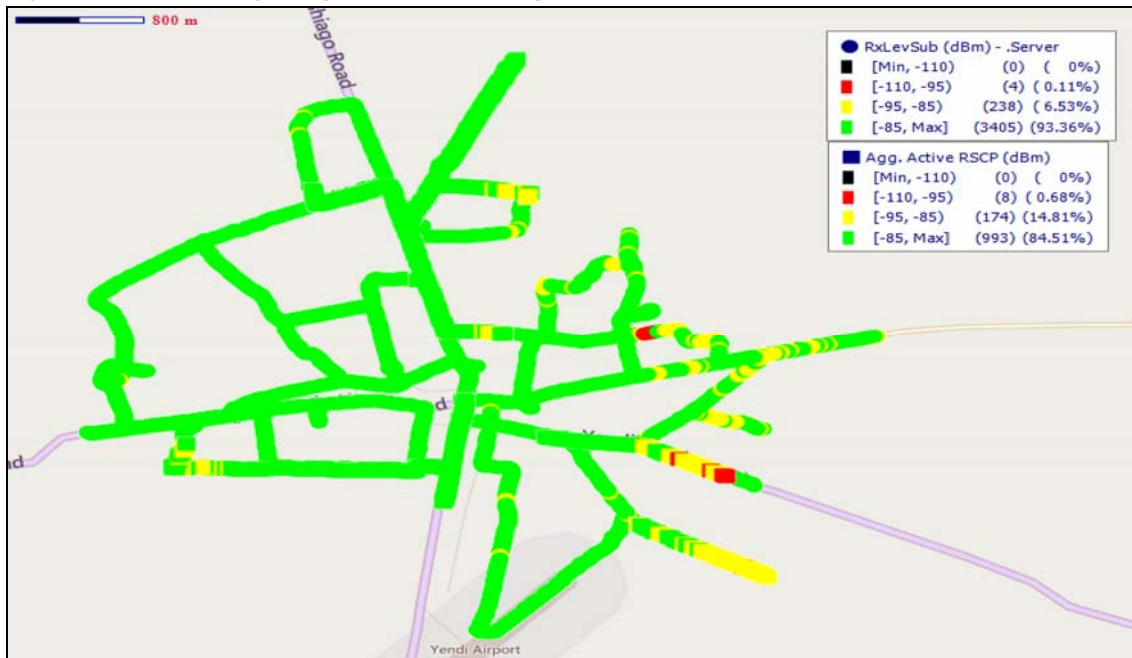Remarks: Good 2G coverage in Wulensi with no 3G service.

Fig. 74 - Airtel Coverage Map, Wulensi - February2016
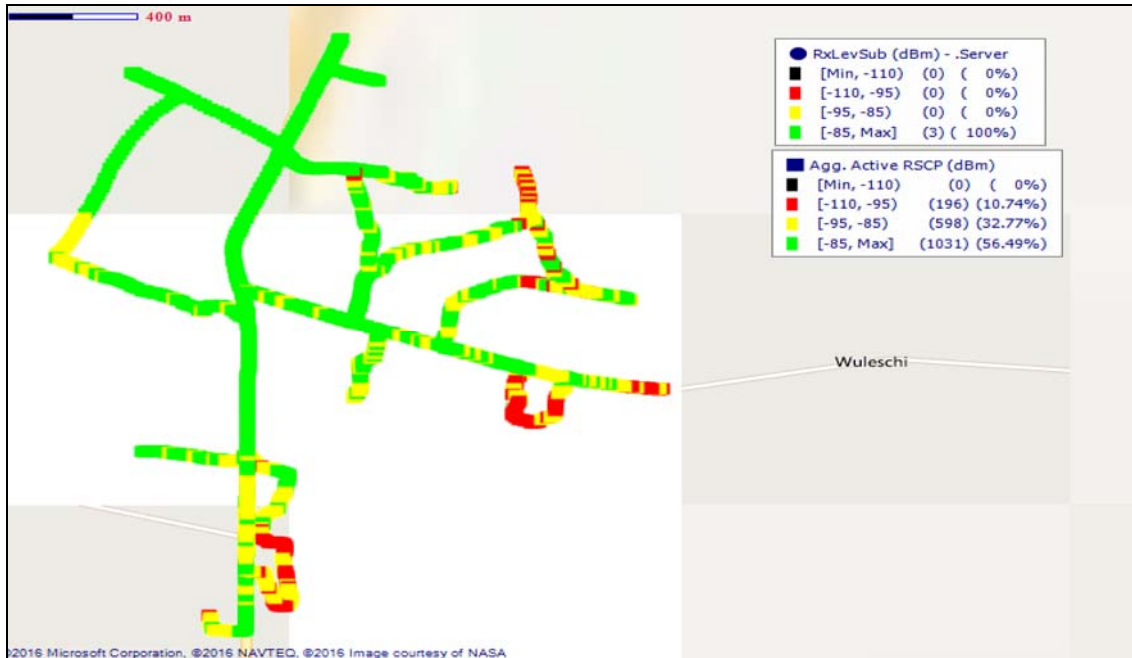
Remarks: **Good network coverage in Wulensi however improvement is needed at Wulensi SHS, District Magistrate Court, Health Center and Tuleboni.**

COVERAGE AT YENDI
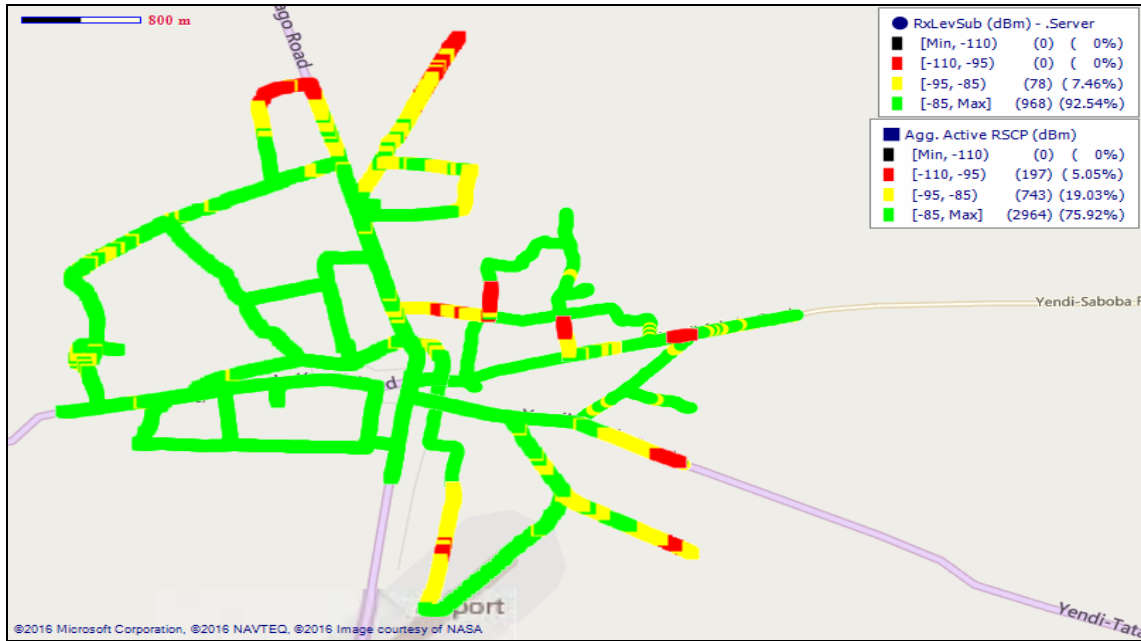
Fig. 75- MTN Coverage Map, Yendi - February2016
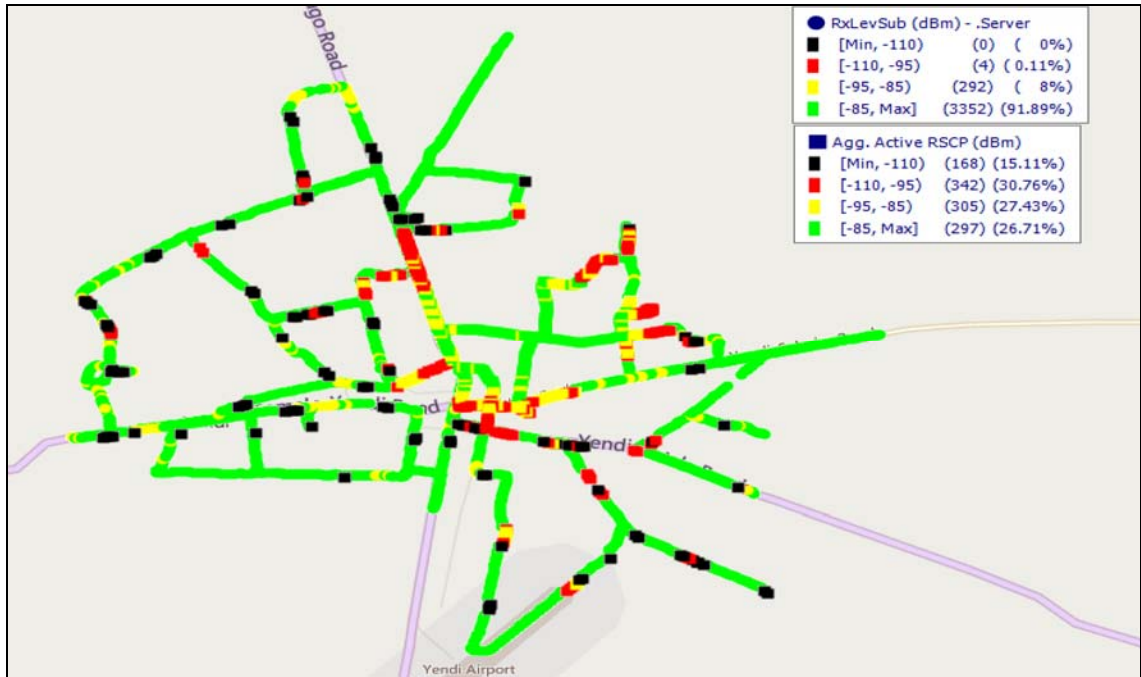

Remarks: **Good network coverage in Yendi.**

Fig. 76 - Vodafone Coverage Map, Yendi - February 2016

Remarks: Good network coverage in Yendi with few patches of poor coverage on the 3G network. Improvement is needed at Gupiapanyile, Sikafuo, Yendi SHS, Gundogo and Baloggu.

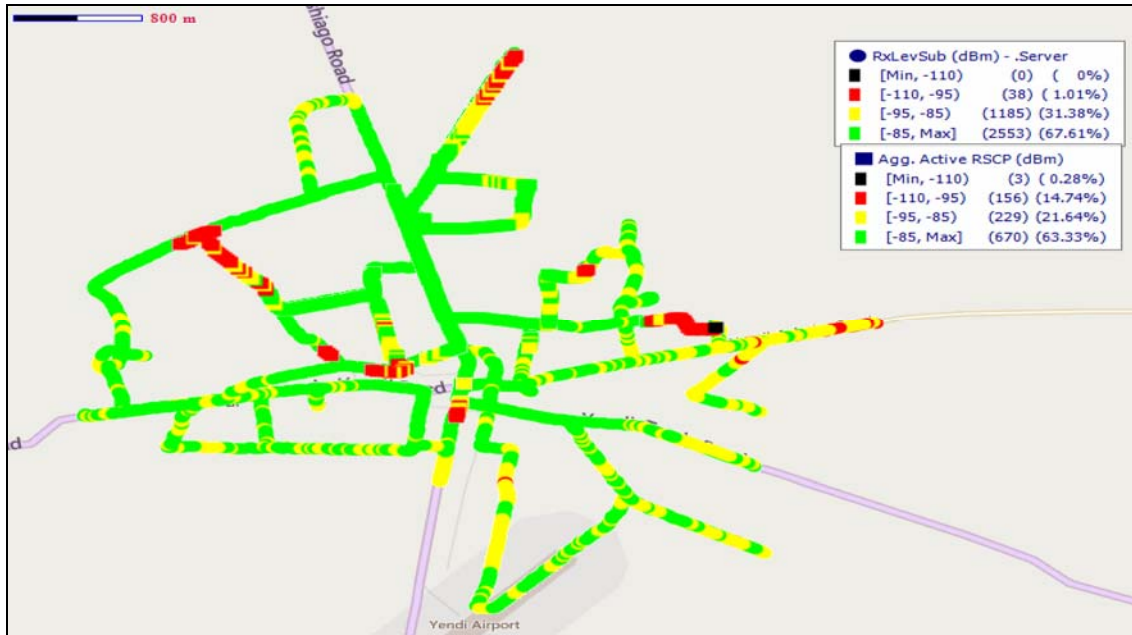**Fig. 77 - Tigo Coverage Map, Yendi - February 2016**

Remarks: Fair network coverage. Major 3G coverage improvement is needed in the entire Yendi Metropolis.
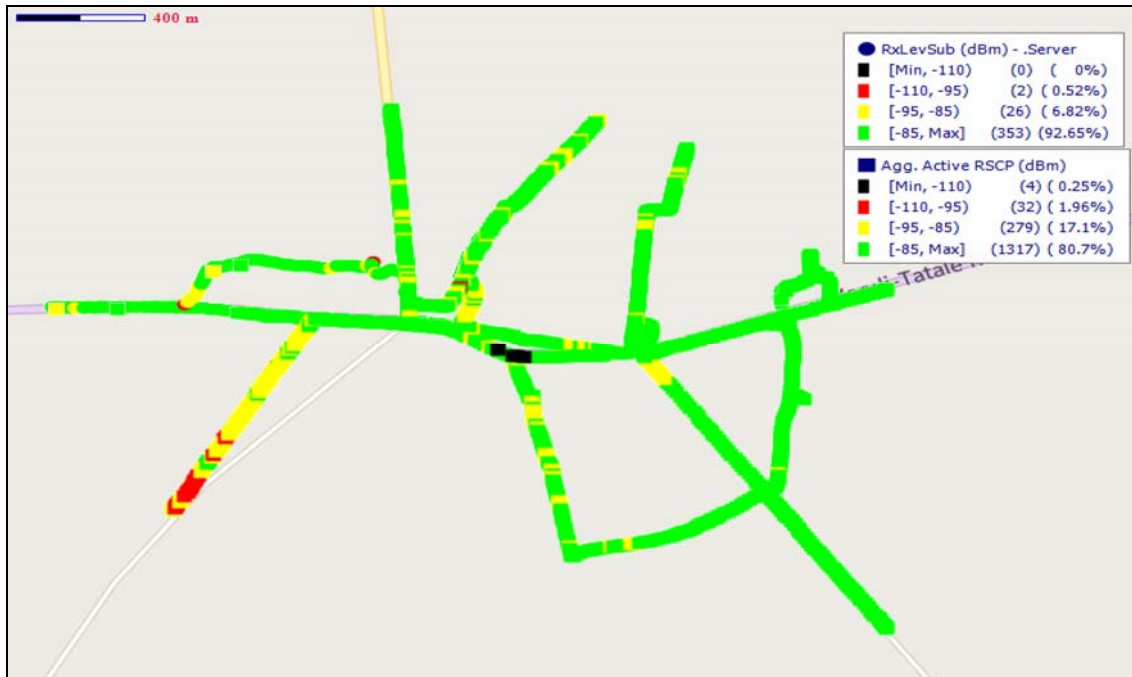
Fig. 78 - Airtel Coverage Map, Yendi - February2016

Remarks: Good network coverage in Yendi. Improvement is however needed at Gundogo, Sikafuo, Baloggu and Guntangli.
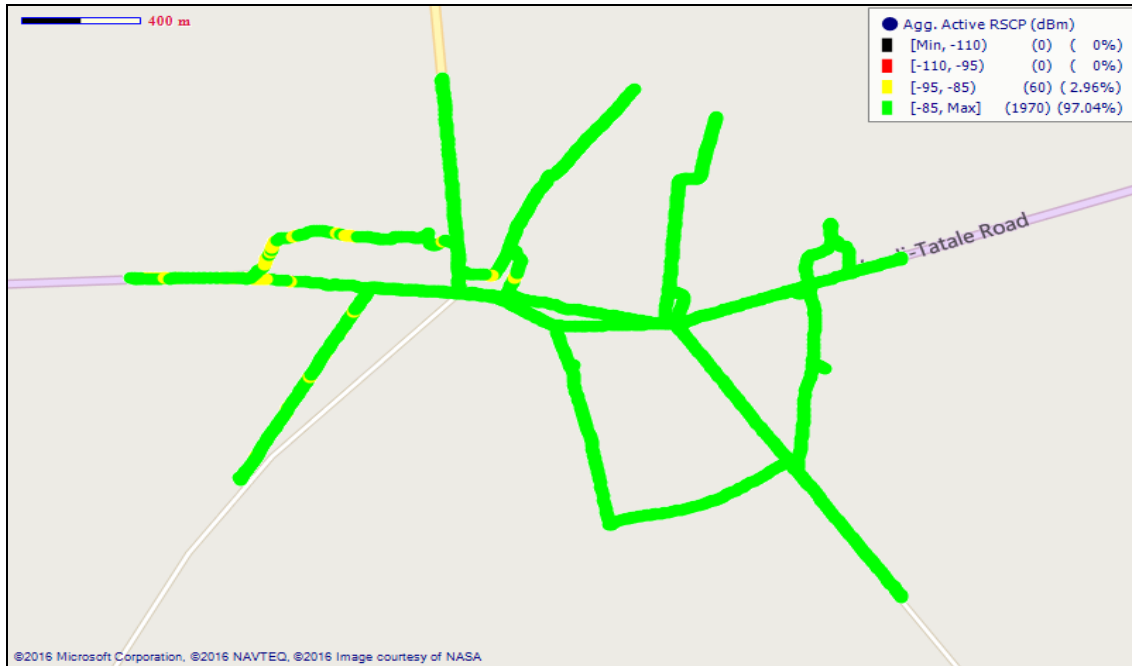
COVERAGE AT ZABZUGU

Fig. 79 - MTN Coverage Map, Zabzugu - February2016

Remarks: Good network coverage in Zabzugu yet improvement is needed at Naangeli, Naayilifong and Solayagli.
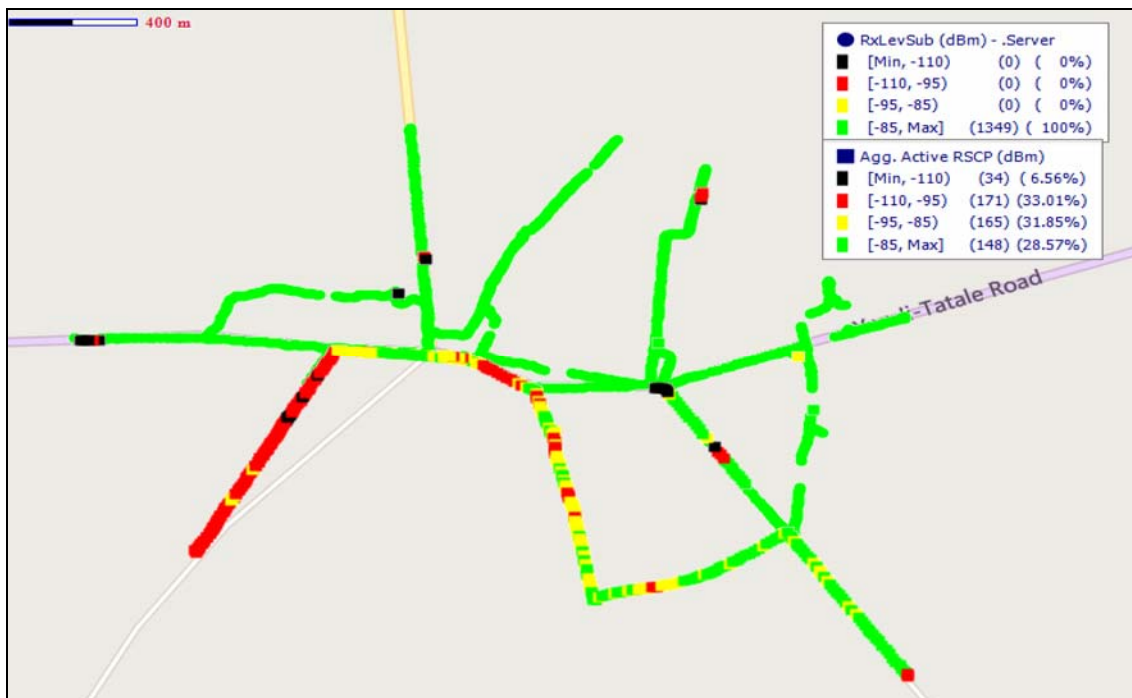
Fig. 80 - Vodafone Coverage Map, Zabzugu - February2016
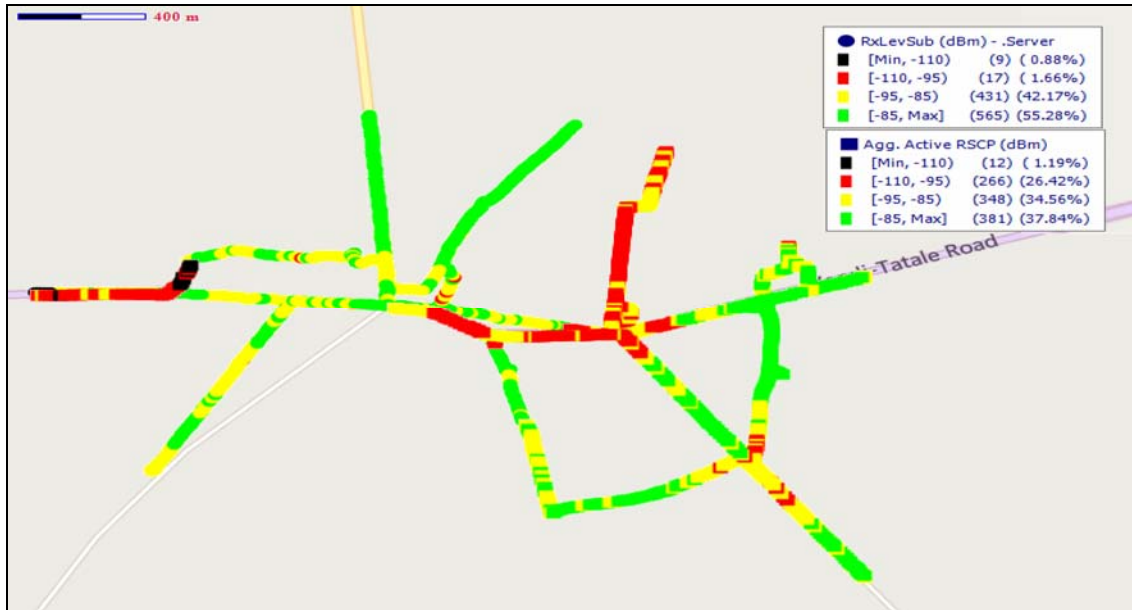

Remarks: Good 3G coverage in Zabzugu.

Fig. 81 - Tigo Coverage Map, Zabzugu - February2016

Remarks: Good 2G network yet improvement is needed on 3G network around Naangeli, Nayilifong, Zabzugu SHS, ABM Hotel and Solayili.

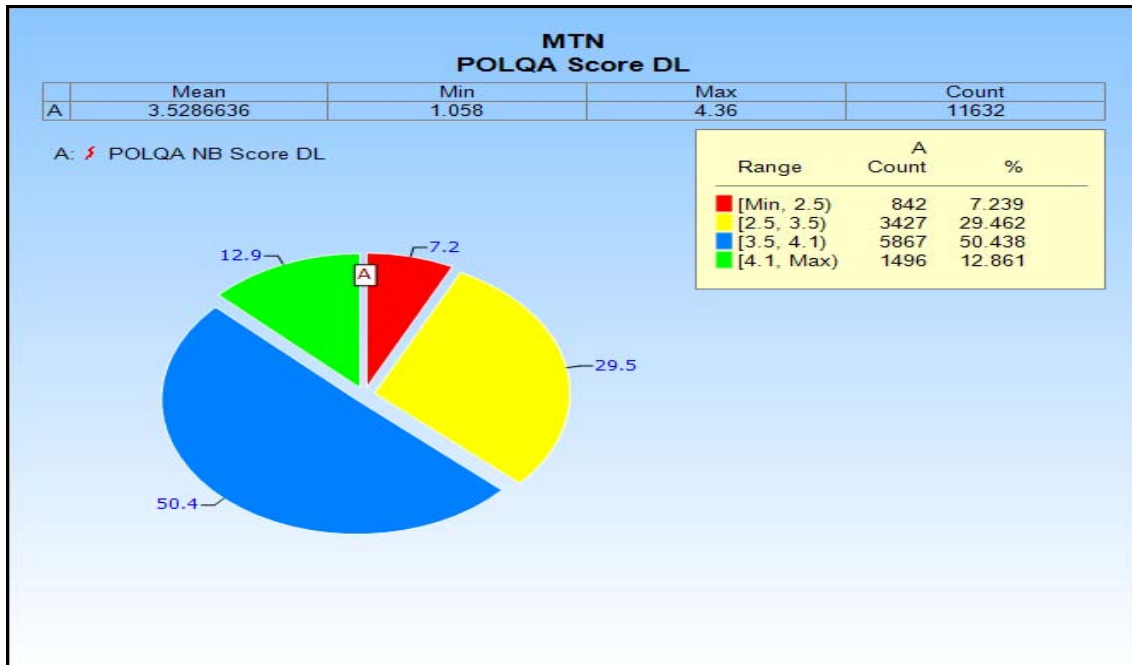**Fig. 82 - Airtel Coverage Map, Zabzugu - February2016**

Remarks: Fair 3G coverage in Zabzugu. Major improvement is needed at Zabzugu SHS, Nayilifong, District Assembly Bungalows and Nangeli.
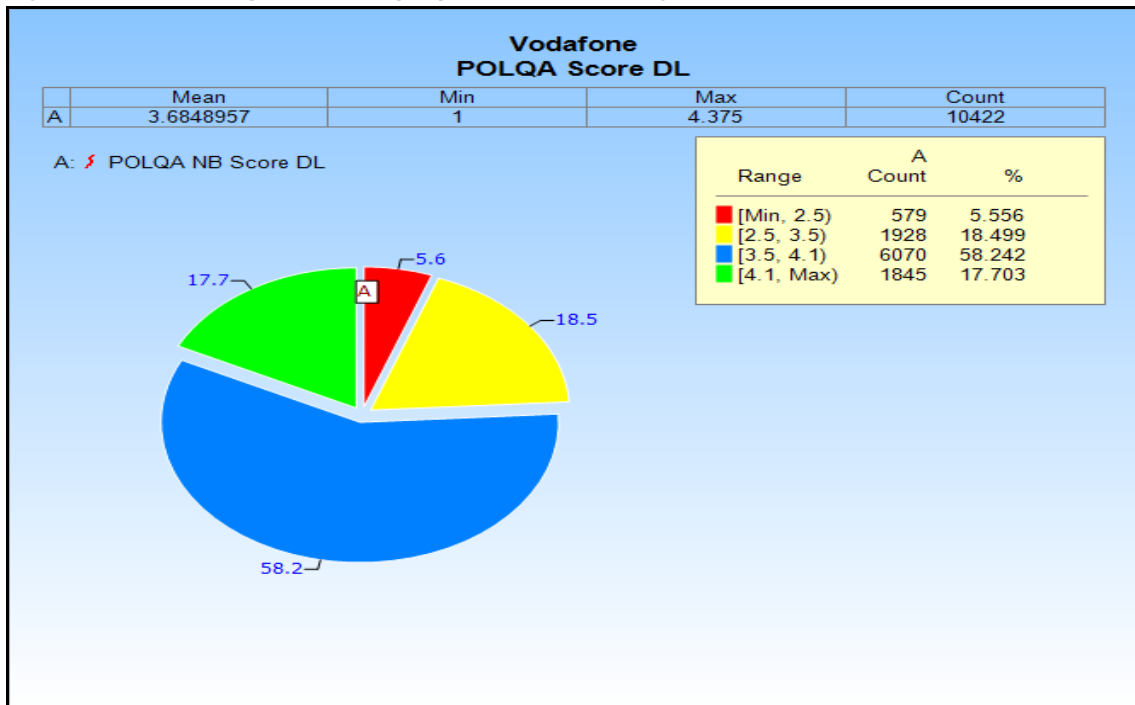
APPENDIX II

SPEECH QUALITY FOR OPERATORS

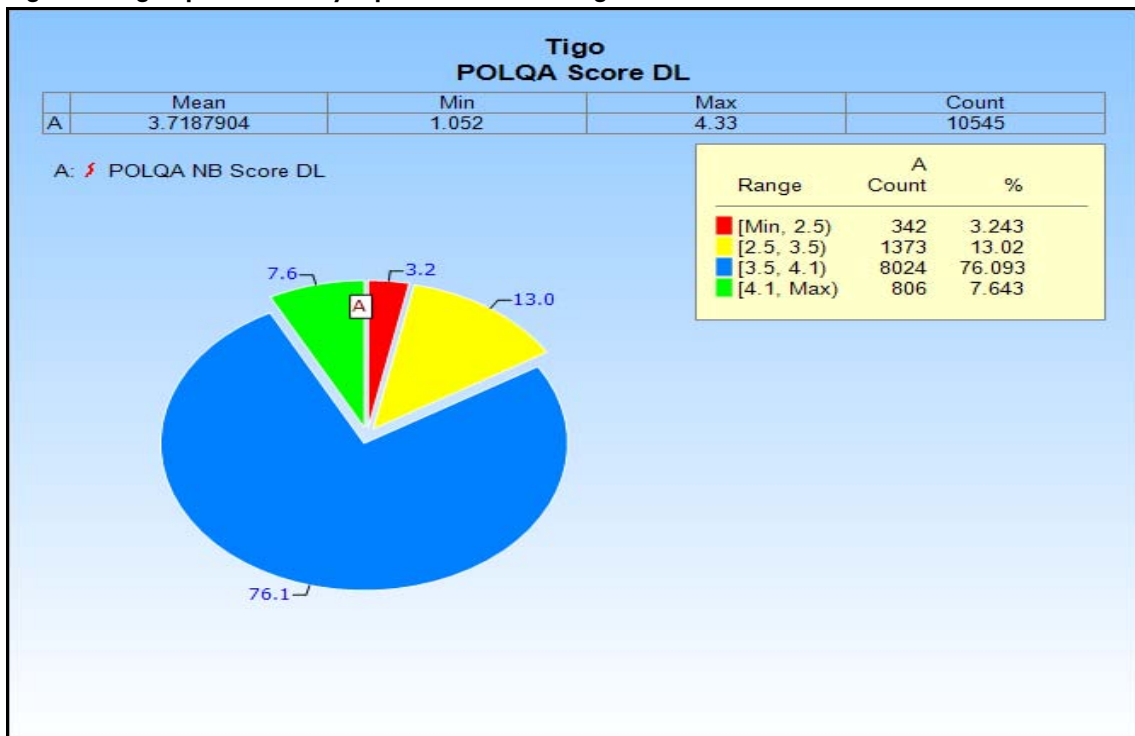**Fig. 83 - MTN Speech Quality report in Northern Region**

Fig. 84 - Vodafone Speech Quality report in Northern Region

Fig. 85 - Tigo Speech Quality report in Northern Region

Fig. 86 - Airtel Speech Quality report in Northern Region

Airtel POLQA Score DL

	Mean	Min	Max	Count
A	3.4498485	1.045	4.379	10621

A: ⚡ POLQA NB Score DL

Range	A Count	%
🟥 [Min, 2.5)	1195	11.251
🟨 [2.5, 3.5)	3185	29.988
🟦 [3.5, 4.1)	5027	47.331
🟩 [4.1, Max)	1214	11.43
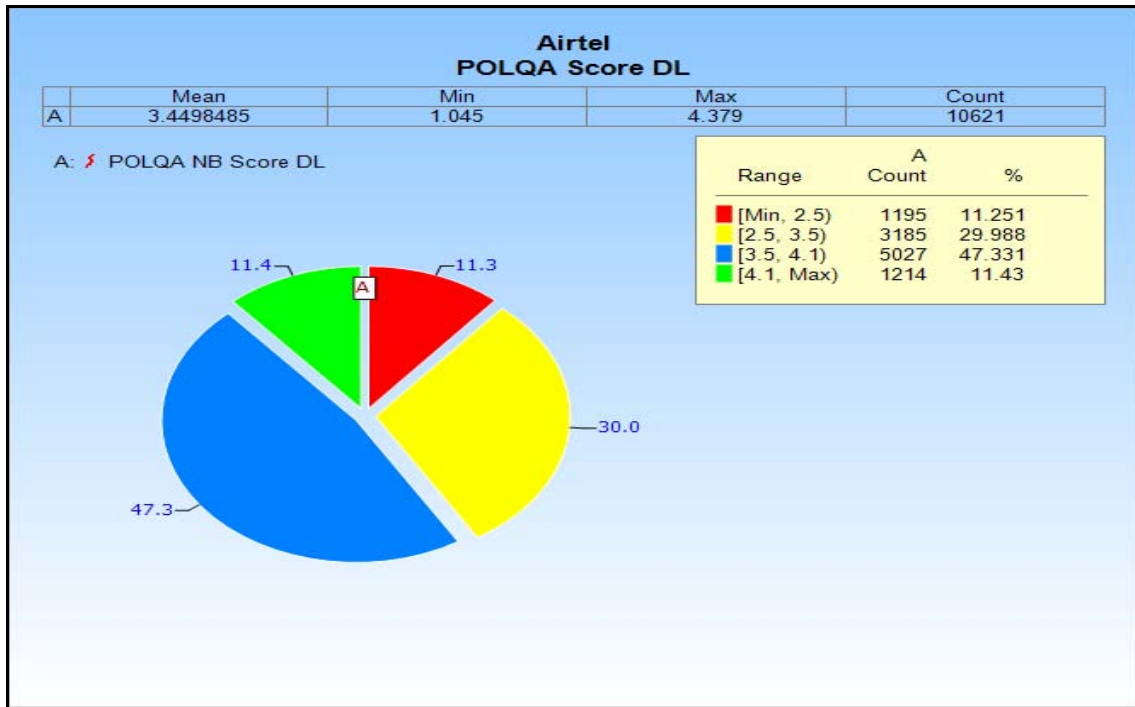
Fig. 87 - Glo Speech Quality report in Northern Region

Glo POLQA Score DL

	Mean	Min	Max	Count
A	3.6690135	1.133	4.087	668

A: ⚡ POLQA NB Score DL

Range	A Count	%
🟥 [Min, 2.5)	3	0.449
🟨 [2.5, 3.5)	116	17.365
🟦 [3.5, 4.1)	549	82.186
🟩 [4.1, Max)	0	0