TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

THESIS NO: 076/MSICE/010

5G COVERAGE PLANNING FOR URBAN AREA AT KATHMANDU CITY, NEPAL

BY:
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A THESIS
SUBMITTED TO THE DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN INFORMATION AND COMMUNICATION ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING
LALITPUR, NEPAL

SEPTEMBER, 2022

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076/MSICE/010

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Information and Communication Engineering

Master of Science in Information and Communication Engineering (MSICE)
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SEPTEMBER, 2022

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I hereby declare that the report of the thesis entitled **“5G Coverage Planning for Urban Area at Kathmandu City, Nepal”** which is being submitted to the **Department of Electronics and Computer Engineering, IOE, Pulchowk Campus**, in the partial fulfillment of the requirements for the award of the Degree of MSc in **Information and Communication Engineering**, is a bonafide report of the work carried out by me. The materials contained in this report have not been submitted to any University or Institution for the award of any degree and I am the only author of this complete work and no sources other than the listed here have been used in this work.

Nirmala Sharma

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RECOMMENDATION

The undersigned certify that they have read and recommended to the Department of Electronics and Computer Engineering for acceptance, a thesis entitled **“5G Coverage Planning for Urban Area at Kathmandu City, Nepal”**, submitted by **Nirmala Sharma** in partial fulfillment of the requirement for the award of the degree of **“Master of Science in Information and Communication Engineering”**.

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DEPARTMENTAL ACCEPTANCE

The thesis entitled **“5G Coverage Planning for Urban Area at Kathmandu City, Nepal”**, submitted by **Nirmala Sharma** in partial fulfillment of the requirement for the award of the degree of **“Master of Science in Information and Communication Engineering”** has been accepted as a bonafide record of work independently carried out by her in the department.

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ACKNOWLEDGEMENT

I would like to thank from the bottom of my heart to my supervisor **Prof. Dr. Subarna Shakya** for his valuable support, suggestions and guidance which motivated me throughout the entire duration of this thesis.

I would like to express my deepest gratitude to **Prof. Dr. Ram Krishna Maharjan** for guiding me to choose my thesis topic and **Assoc Prof. Dr. Nanda Bikram Adhikari** for providing his valuable suggestions on my research topic.

I am extremely grateful to our thesis coordinator **Asst Prof. Dr. Babu R. Dawadi** and the Department of Electronics and Computer Engineering for providing this opportunity and guiding us for choosing the field of research.

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ABSTRACT

The excitement about the 5G wireless network has passed. Mobile Network Operators (MNO) have begun rolling out 5G networks alongside 4G cellular networks in lower frequency and mid-frequency bands (i.e., 3-6 GHz) all over the world. The mid-frequency band can greatly improve the performance of the current network (i.e., 50 MHz–100 MHz). All we know that the wider spectrum can be provided by the high frequency bands which is required to fulfill the greatest bitrates (20 Gb/s), lowest latencies, and constantly increasing capacity demands. The free space propagation loss rapidly increases as we move to higher frequency bands, which will reduce the individual cell site radius for the high-frequency band to 100 m from several kilometers in 4G. To offer consistent 5G coverage, the MNOs will have significant challenges in precisely planning and acquiring these enormous numbers of new cell site locations. This paper describes about the signal characteristics at 800MHz, 1800MHz for 4G and at 700MHz, 2300MHz, 2600MHz, 3500MHz for 5G and the upgradation of 4G towards 5G in the test environment. The 5G Coverage Planning with three sector cells and its SINR Mapping in advance antenna array will be performed to provide better coverage in 5G environments.

Keywords: 4G, 5G, 5G Coverage Planning, massive MIMO, antenna array, millimeter-wave, SINR Mapping

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

5G	Fifth Generation
SRD	Short Range Device
BBU	Base Band Unit
BS	Base Station
DRoF	Digital Radio-Over-Fiber
FSPL	Free Space Path Loss
IMT	International Mobile Telecommunications
ISD	Inter-Site Distance
ITU	International Telecommunication Union
LOS	Line-of-Sight
MAN	Macro Area Network
MCs	Microcells
MIMO	Multiple-Input Multiple-Output
mmWave	millimeter-wave
NR	New Radio
NT	Nepal Telecom
O2I	Outdoor-to-Indoor
PL	Path Loss
QoS	Quality of Service
RF	Radio Frequency
RRHs	Remote Radio Heads
RT	Ray-Tracing
SCs	Smaller Cells
SINR	Signal to Interference Plus Noise Ratio
UE	User Equipment
Uma	Urban Macro
Umi	Urban Micro
URA	Uniform Rectangular Array
uRLLC	Ultra-Reliable Low Latency Communications
V2V	Vehicle-to-Vehicle

CHAPTER ONE: OVERVIEW

1.1 Introduction

We all know that every year mobile users want faster throughputs and quality of service (QoS) must be high. The launch of 5G opens up opportunities for numerous economic sectors to grow. High speed (for transferring more data), decreased latency (for better responsiveness), and the ability to connect more devices simultaneously are all advantages of 5G technology (for sensors and smart devices)[1]. Fifth-generation network technology, in conjunction with artificial intelligence and the Internet of Things, will be employed in many aspects of life. 5G will deliver high data rates, expand coverage, and integrate network capabilities into all mobile communication system equipment.

In 5G wireless networks, the development of network densification is extensive, with a New Radio (NR) designed for new frequency bands such as millimeter wave[2].When using mm-wave in 5G, coverage is limited. As a result, network densification is required. New access technologies offer high backbone capacity and deployment flexibility. For an efficient network, a hybrid optical-wireless access network combines a wireless front-end with an optical backhaul[3]. Massive MIMO(Multiple-Input Multiple-Output) antennas in 5G ultra-dense cellular networks allow wireless cellular connections to be dispersed. Massive MIMO technology’s main purpose is to utilize all of the benefits of classic MIMO technology in a broader context that is energy efficient, resilient, secure, and spectrum efficient[2].

Studies on millimeter wave (mmWave) antennas and propagation are critical for 5G wireless communications to attain the requisite coverage of mobile systems. The ray tracing method has been used to predict wave propagation for wireless communications with great success[4].

Previously, Nepal Telecom has announced to launch the country’s first 5G technology trials on June 2022 if everything goes as per planned by the operator. Unfortunately, the 5G trial was not performed as per the plan by the Nepal Telecom and it will be performed very soon if everything goes well. According to Nepalitelecom.com, NT has been granted permission to test services in the 2600MHz band for up to a year. Calculating the signal behavior for a specific frequency in present conditions would be useful when frequencyterritorial planning of the 5G infrastructure. Appropriate modeling of radio wave propagation in metropolitan environments, where the density and number of storeys are constantly rising, becomes an essential problem in conjunction with the active adoption of new communication and broadcasting systems for diverse reasons [1].

On the one hand, mmWave has a vast spectrum and allows for the integration of a large number of antennas in a small space in order to achieve high antenna gain [5]. On the other hand, mmWave communication has significant disadvantages, including increased Path Loss (PL), weak penetrating properties, high foliage loss in dense vegetation, and strong air absorption at certain mmWave frequencies, among others. Fortunately, atmosphere absorption is almost non-existent at the 26 GHz frequency of operation, whereas atmospheric absorption loss at 60 GHz is roughly 20 dB/km [5].

Outdoor Base Stations (BSs) are used to offer coverage to both outdoor and indoor customers in a typical cellular network running at sub-6 GHz frequencies. However, because to considerable building penetration loss for Outside to Indoor (O2I) propagation at mmWave frequencies, distinct 5G solutions/architectures for indoor and outdoor users are likely [6].

1.2 Problem Statement

Users of fifth-generation (5G) mobile networks could expect high throughputs and ultra-low latency networks, as well as a large number of devices connected to the network. However, there is high population density in urban areas and it is must to provide coverage in urban areas so that all the people living in the dense area will get access to the internet. To address this problem, one method is to map SINR for a 5G urban macro-cell where user density is very much high and also traffic load is very much high. Also using three-dimensional ray tracing, we can know the optimum coverage of the urban dense area.

1.3 Objectives

- To determine the signal characteristics at 800MHz, 1800MHz for 4G
- To determine the signal characteristics at 700MHz, 2300MHz, 2600MHz and 3500MHz for 5G
- To analyze signal characteristics of different 4G and 5G spectrum and suggest upgradation plan from 4G to 5G with minimum cost effort

1.4 Scope of Work

Currently Nepal Telecom is only using 800MHz and 1800MHz for 4G network all over the country Nepal. In future Nepal Telcom is planning to upgrade its existing 4G network towards 5G. Also, Nepal Telecommunication Authority has already given permission to Nepal Telecom to do trial for 5G with frequency of 2600MHz. MNO needs to plan about the cell site when doing upgradation and also about the antenna to cover optimum coverage. So, this research helps us to know in which frequency it will be best in context of Nepal to upgrade from 4G towards 5G. Also, the network layout for 5G can be built in such a way that there is no interference. We can have analysis on 700MHz, 2300MHz, 2600MHz and 3500MHz frequencies and thus we can use required frequency in future according to the need and also according to its maximum antenna directivity, maximum power transmits and optimum coverage.

CHAPTER TWO: LITERATURE REVIEW

A significant amount of research has been done for urban areas in order to provide better services to urban people where there is high traffic load and population density is also very much high. Many of these researches are based on MIMO.

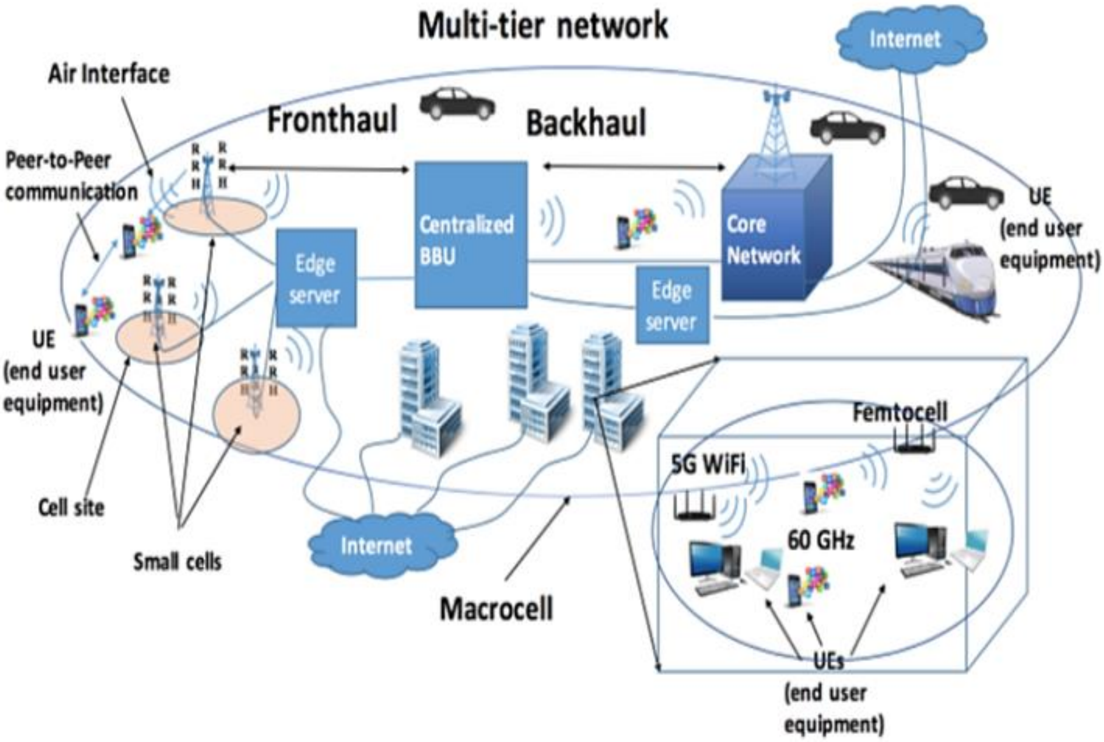


Figure 1. 5G with multi-tier architecture [7]

The architecture of a 5G network is depicted in Figure 1, which includes a macro-cell along with small cells, user equipment (UEs), Remote Radio Heads (RRHs), Base Band Unit (BBU), and its Core Network. Small cells have been acknowledged as a key advancement in 5G networks, but they aren't the only base stations that will deliver 5G connectivity.

In comparison to small cells, high-frequency millimeter wave (mmwave) capabilities, 5G networks will utilize macro cells such as cell towers for connectivity and these larger base stations will enable to lower 5G frequencies.

As indicated in Figure 1, fronthaul is the connection in both ways between the RRH and the BBU whereas, backhaul is the connection in both directions between the BBU and the core network. A digital radio-over-fiber (DRoF) connection which is also known as fronthaul, transports the digital baseband signal from the BBU to the RRH [7]. The RRH converts the uplink signal from the UEs' received radio frequency (RF) into a digital baseband signal. The entire macro area network (MAN) is divided into microcells (MCs), and each of the microcell is again divided into smaller cells (SCs) to achieve full network coverage [8]. Small cells are superimposed on the top of macrocells, resulting in a multi-tiered network structure.

Densification reduces the burden on individual BSs, whereas dense tiny cells reduce communication end-to-end delay. They also improve energy efficiency because their BSs use less power than macrocells.

At mmWave frequencies, propagation properties differ from those below 6 GHz, which has a substantial impact on system design efforts. Where there is dense vegetation, mmwave transmission can suffer severe attenuation along with narrow transmitter and also receiver beams which diminish angular and Doppler spreads. As a result, new air interface designs for wireless systems operating in the mmWave bands will be required to fit the unique propagation characteristics of mmWave channels. While several 3GPP models, such as the WINNER II[9] and 3GPP SCM[10] , are being built based on the architecture of models below 6 GHz, those models were developed under a tight deadline and do not reflect all of the important features of mmWave channels.

The analysis of spatio-temporal channel properties such as multipath delay, angular statistics, and path loss, as well as the consequent channel modeling, are required as a first step toward the construction of mmWave cellular channel models. Some channel measuring campaigns which is for outdoor cellular networks using mmWave frequencies have been published in this regard [11].

As the demand for higher frequencies rises, a number of academics have expressed interest in millimeter waves, particularly at 60 GHz. Future high-transmission-rate communications are an excellent fit for the 60 GHz bandwidth due to its enormous capacity and flexibility possibilities[12]. The problem of providing enough power margins for a reliable and effective communication link in 60 GHz systems is exceedingly difficult.

CHAPTER THREE: METHODOLOGY

3.1 Urban Channel Model

The coverage of the network may be defined as the area surrounding its base station and cell site in which the user can request for any service and it will connect to that cell site to get the requested service. The radius of the cell is calculated as the maximum distance between the cell site and the user from which the user can send and receive service requests without interruption.

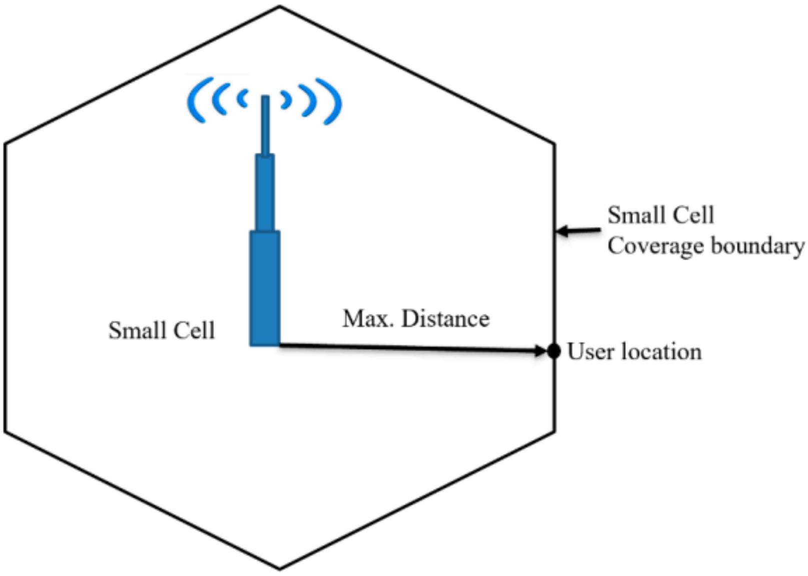


Figure 2. Small Cell Network Coverage [13]

3.2 Proposed Channel Model

First of all, the real time dataset for 4G networks are taken from one of the Telecommunication Operators of Nepal. Here real time 4G subscriber's dataset is used from Nepal Telecom. We experiment on the urban dense area of Kathmandu City, Nepal for 4G coverage in the existing network and compared the data with the real time dataset of Nepal Telecom. After the 4G coverage is preformed, we build our test environment for 5G on the same area which was taken for 4G coverage so that to plan the upgradation of existing network 4G towards the Next Generation Network which is 5G in our case.

The UE reports the received power level using the RSRP (Reference Signal Received Power) number. The power of the received reference signal which is from the eNodeB determines the RSRP, which is defined with a 1 dBm step in a range in between -140 dBm to -44 dBm. RSRQ (Reference Signal Received Quality) is a result of the formula(i), where N is the number of used resource blocks (PRBs) and RSSI (Received Signal Strength Indicator) represents the all of the received power by the UE in which interfering signals are also included[14].

$$RSRQ = N\frac{RSRP}{RSSI} \qquad (i)$$

Table 1. Relationship between RSRP, RSRQ and SINR

RF Conditions	RSRP [dBm]	RSRQ [dB]	SINR [dB]
Excellent	≥ -80	≥ -10	≥ 20
Good	-80 to -90	-10 to -15	13 to 20
Mid Cell	-90 to -100	-15 to -20	0 to 13
Cell Edge	≤ -100	≤ -20	≤ 0

First of all, the sites and transmitters on the densely populated area of Kathmandu City, Nepal are simulated using the ATOLL Simulator. The data set here is used from the Nepal Telecom in case of 4G. The simulation is done in both 800MHz and 1800MHz frequency since Nepal Telecom is using both 800MHz and 1800MHz frequencies to provide 4G service all over the country Nepal. After the simulation is done, the analysis is done on the coverage area and the best signal given by the transmitters in case of 4G by the downlink. We can know the maximum area covered by the transmitters in the test environment. After the simulation of 4G is performed, now we move towards 5G on the same test environment.

Now, we build the test environment for the 5G macro cell and after that visualization of Signal-To-Interference-Plus-Noise Ratio is obtained on the open street map of the Kathmandu City, Nepal. We all know that Kathmandu City is densely populated city of our country Nepal along with high traffic load, so the test environment taken here is Kathmandu City with its reference center at latitude of 27.700769 and longitude of 85.3298. A hexagonal cell network is used in our test environment for 5G and the antenna is custom antenna array.

The test environment standards for 5G technologies utilize Section 8.3 of Report ITU-R M.2135-1 [15] network configuration which is for 4G technologies which is mentioned below for our test environment. The layout of it comprises of 19 hexagonally arranged sites, each with three cells. The inter-site distance (ISD) between neighboring sites is determined by the test usage scenario. The ISD should be 200m for the dense urban test environment.

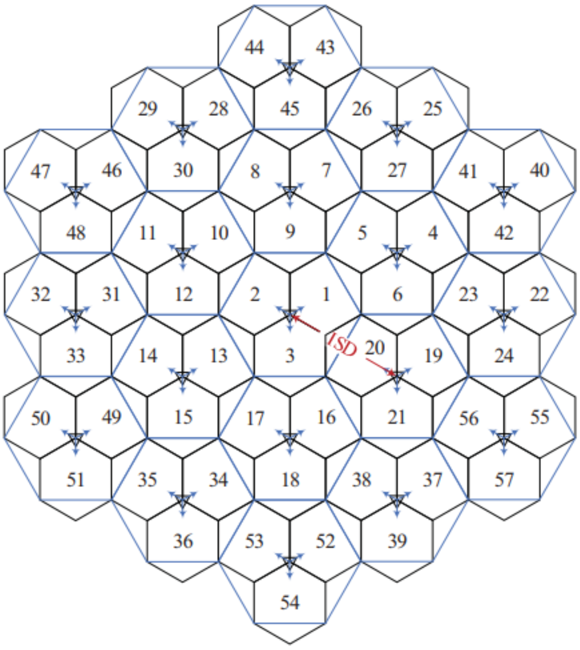


Figure 3. 5G Hexagonal Cell Layout [16]

Each site is divided into three sectors, each having its own name, latitude, longitude, antenna angle, and transceiver settings.

Free space propagation, in which the transmitter and receiver have a direct line of sight with no absorbing or reflecting impediments, is considered the optimum propagation situation. The free space path loss is the signal attenuation under the ideal state which is given in equation (ii).

$$L_{FS} = \left(\frac{\lambda}{4\Pi d}\right)^2 \qquad (ii)$$

Where $\lambda = \frac{c}{f}$ represents the transmitted signal wavelength

c represents the light speed which is 3*10^8 m/s f represents the frequency of operation of the signal transmitted

d represents the propagation path length

When a radio frequency (RF) signal travels through a rainy zone, it loses strength that is attenuation takes place. The model which is recommended by the ITU for rainfall is ITU-R P.838-3 which is shown in equation (iii) [17]. This particular attenuation model works for frequencies ranging from 1 to 1000 GHz.

$$L = d_{eff} k R^{\alpha} \qquad (iii)$$

Where R represent the rate of rain in mm/hr

Both parameter k and α are dependent on the polarization state, the frequency and the angle of elevation of the signal path. Here d_{eff} is the effective propagation distance which is equal to its geometric distance d and its multiplication is done with scale factor of r[17].

$$r = \frac{1}{0.477 d^{0.633} R_{0.01}^{0.073\alpha} f^{0.123} - 10.579(1 - \exp(-0.024d))} \qquad (iv)$$

Where f is the operating frequency

The RF link budget represents the equation which accounts all of the gain of the power and losses that an RF signal experiences as it travels from a transmitter to its receiver. It's used to figure out how much received signal power is needed to get a good signal-to-noise ratio (SNR) when the signal arrives at the receiver. The equation (v) represents the RF link budget.

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} \qquad (v)$$

Here, the receive signal power (dBm) is P_{RX}, and the sent signal power (dBm) is P_{TX} (dBm). G_{TX} (dBi) and G_{RX} (dBi) represent the antenna gains of transmitter and receiver respectively. L_{TX} (dB) and L_{RX} (dB) are losses related with transmitters and receivers, respectively (e.g., loss at feeder, loss at cable and loss at connection, etc.). The free space pathloss is given by L_{FS}. Also $L_M(dB)$ is used to represent all remaining miscellaneous losses such as atmospheric loss, body loss, fading margin, polarization mismatch, etc.

The pathloss of the urban dense area can be calculated using equation (vi) [18]:

$$PL = PL_b + PL_{tw} + PL_{in} + N\left(0, {\sigma^2}_p\right) \qquad (vi)$$

Where PL_b refers to the basic outdoor Pathloss

PL_{tw} refers the Outdoor-To-Indoor (O2I) building penetration loss

PL_{in} refers the inside loss dependent on the depth into the building

σ_p refers the standard deviation for the penetration loss

The SINR of the urban dense area can be calculated using equation (vii) which is the formula for SINR [18].

$$SINR = \frac{P^R}{I + N} \qquad (vii)$$

Where P^R represent the received power

I represent the sum of interference powers and

N represent the noise power

Table 2. 5G NR Frequency Bands for Simulation

Band	Duplex Mode	Frequency(MHz)	Common Name	Frequency Range(MHz)	Channel Bandwidth(MHz)
n12	FDD	700	Lower SMH	UL(699-716) DL(729 – 746)	15
n40	TDD	2300	S-Band	2300-2400	100
n7	FDD	2600	IMT-E	UL(2500 – 2570) DL(2620 – 2690)	50
n78	TDD	3500	C-Band	3300 – 3800	100

Different frequencies for 5G simulation and its associated channel bandwidth are used for simulation as represented in Table 2 along with different parameters for 5G coverage and SINR mapping as mentioned in Table 3.

Table 3. Parameters used in simulation for 5G Coverage and SINR

Parameters Used For 5G	Corresponding Values
Operational Frequencies	700MHz, 2300MHz, 2600MHz, 3500MHz
Bandwidths	15MHz, 100MHz, 50MHz, 100MHz
Antenna Height of BS	25m
Transmit Power of BS	44dBm
Antenna Gain of BS	10dBi
Noise Figure of BS antenna	7dB
Height of Receiver	1.5m
Noise Figure of Receiver	7dB
Gain of Receiver	8dBi
Number of cell sites	19
Inter-Site Distance	200m

3.2.1 Proposed Channel Algorithm

First of all, the collection of information about the network planning for 4G is done using Nepal Telecom dataset and the test environment is taken from the open street map. After that we study the 5G network characteristics on that area along with the network dimension and its coverage area. Now the capacity planning is performed.

After the capacity planning is performed, now we know about the different parameter’s efficiency and relationship between all the other parameters. After that we study the test environment nature and its effect on the 5G network. Now we test the SINR map and performance of the network at different frequencies 700MHz, 2300MHz, 2600MHz and 3500MHz.

Now we check if the SINR is greater or equal to 20dB or not. If SINR is greater or equal to 20dB then we get our results in the tested environment and execute our results. This is our final results after execution and we stop our simulation here.

If the SINR is not greater or equal to 20dB then we do our work again from the collection of information about the network planning and its open street map which is also shown in flowchart of the given model in Figure 4 and we do the same process until the SINR is greater or equal to 20dB.

The flowchart of the given model is shown in Figure 4.

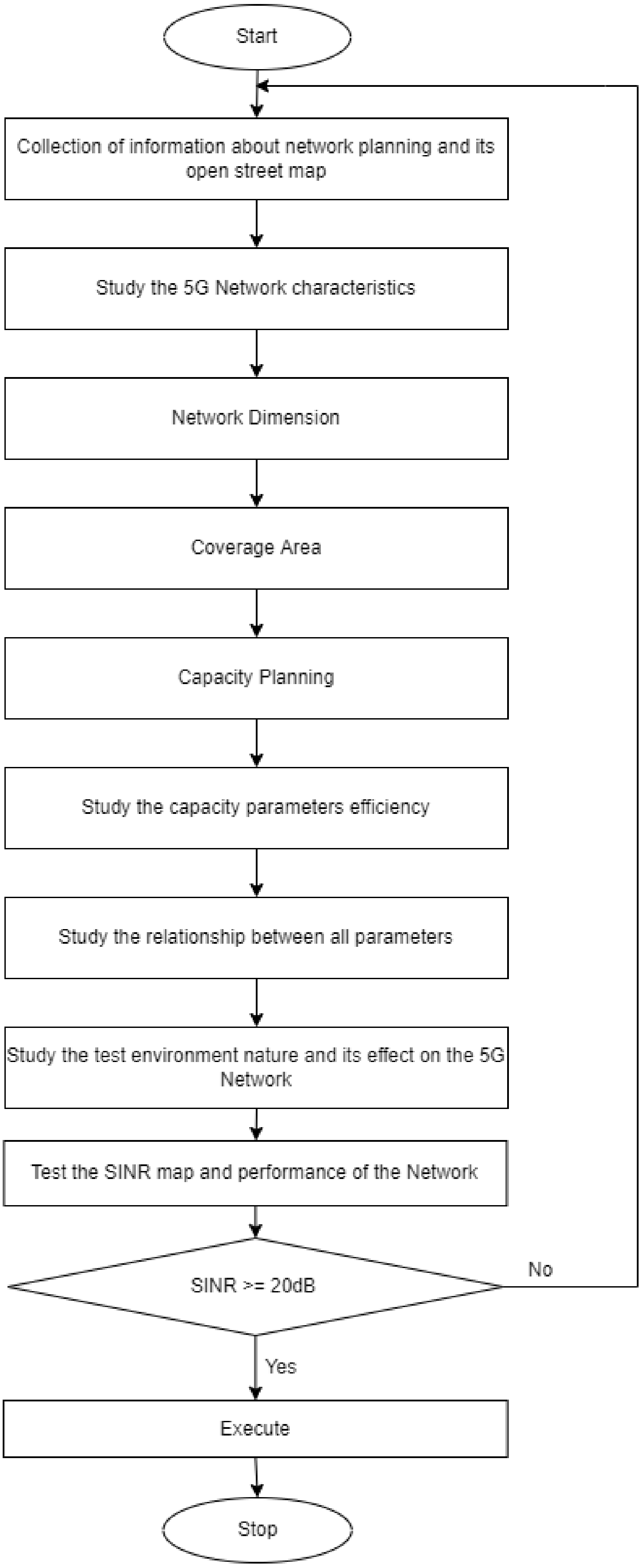


Figure 4. 5G Urban Area Network Planning Diagram

3.3 Tools Used

3.3.1 ATOLL Version 3.3.2

ATOLL is an open source simulator. ATOLL Version 3.3.2 is used here for the simulation of 4G networks. The modeling of LTE networks can be done using ATOLL simulator. First of all, 4G real time dataset is loaded on the ATOLL simulator and after that the analysis is done on both 800MHz and 1800MHz frequencies. For this, first coverage prediction is done in both frequencies. After that, prediction analysis is done. Now, network planning is done and finally PCI planning and capacity planning can be done. Thus, using ATOLL simulator, we can have analysis on both 800MHz and 1800MHz frequencies in case of 4G networks along with its area of coverage and its best signal transmit.

3.3.2 MATLAB R2021a

MATLAB R2021a is an open source simulator. Using MATLAB R2021a we can simulate both 4G and 5G networks. In our research, we have used MATLAB 2021a for 5G simulation at different frequencies 700MHz, 2300MHz, 2600MHz and 3500MHz. For simulation of 5G at different frequencies, first of all 19 different cells are simulated using open street map of Kathmandu City, Nepal with the help of MATLAB 2021a. After the 19 cells are simulated, the simulation of single antenna element, 8 by 8 rectangular antenna array and 16 by 16 rectangular antenna array are used for the simulation of 5G networks in different frequencies and the SINR mapping is also done.

CHAPTER FOUR: RESULTS AND DISCUSSION

ATOLL Version 3.3.2 is used for the simulation of 4G while MATLAB 2021a is used for the simulation of 5G. Both of the simulators are open source.

4.1 4G Analysis

Using the dataset of Nepal Telecom, the sites and transmitters are plotted in the open street map with the help of ATOLL Version 3.3.2 simulator which is shown in Figure 5. Here total of 99 sites and 504 numbers of transmitters are used including Band3(1800MHz) and Band20(800MHz) for 4G.

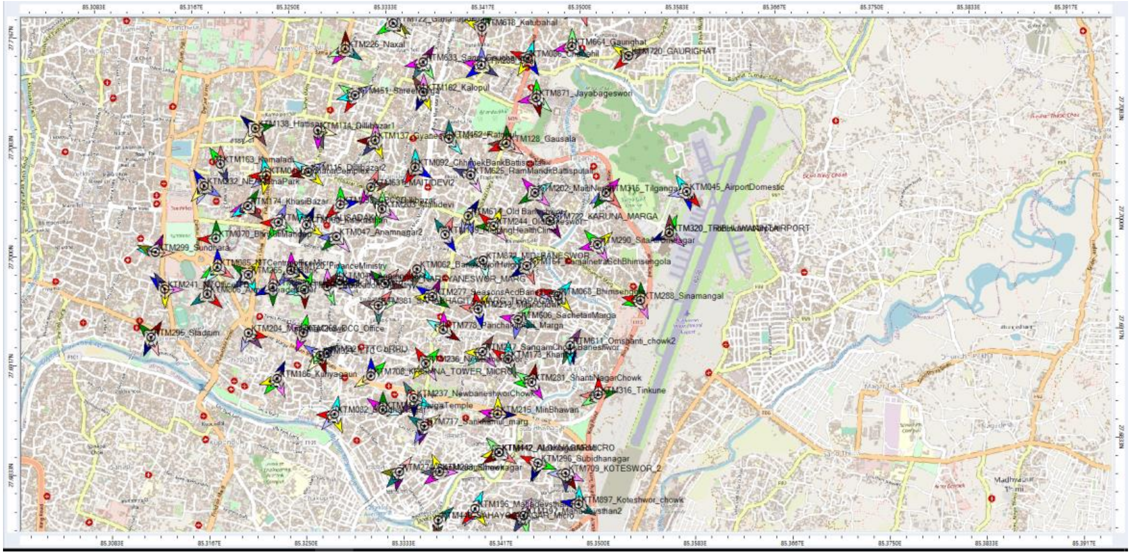


Figure 5. Plotting for 4G Sites and Transmitters

After the sites and transmitters are plotted, now the plotting of the coverage for the 4G on frequency of 800MHz and 1800MHz are done. Here we can know, how much coverage is done by 4G networks in case of 800MHz and 1800MHz frequencies respectively.

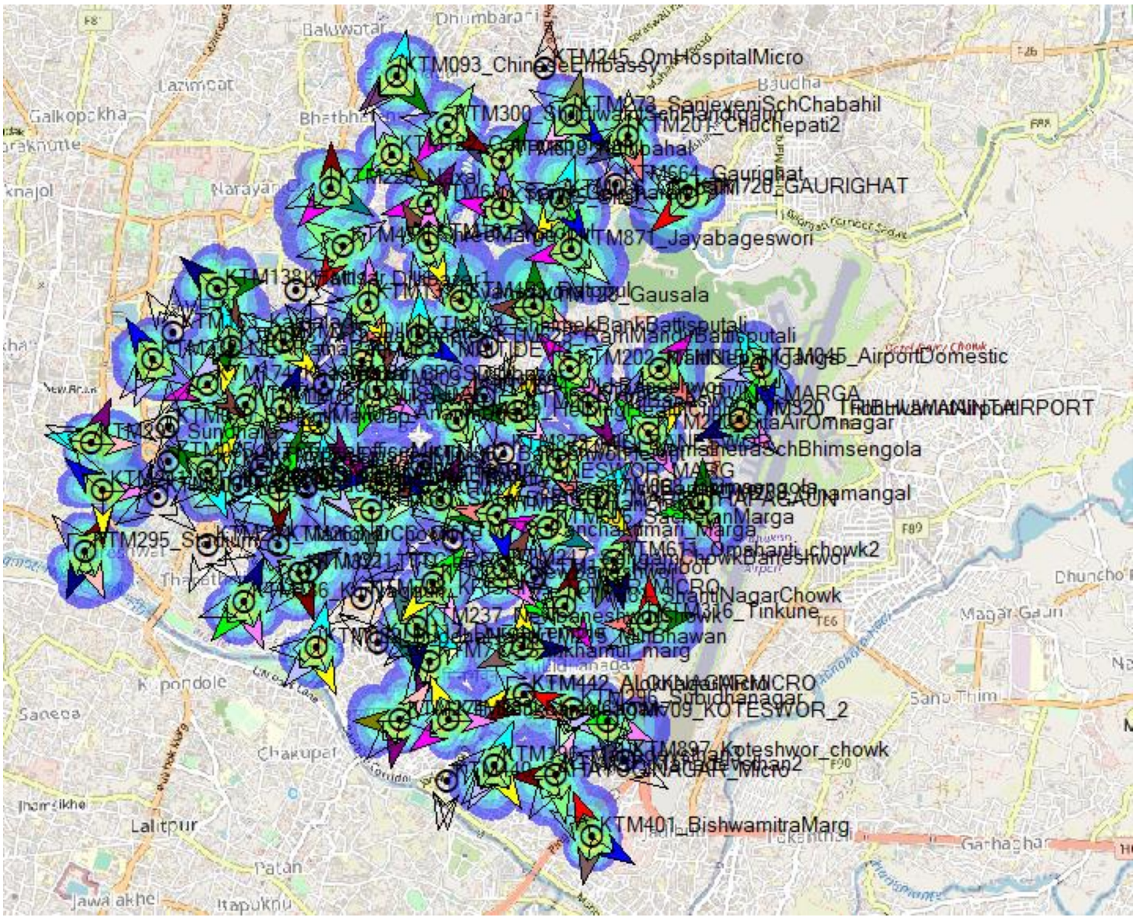


Figure 6. 800MHz 4G Coverage by Downlink

Figure 6 is the 4G coverage by the downlink signal at 800MHz frequency. At 800MHz frequency, the antenna angle is kept at 65 degree with antenna directivity of 17dBi and antenna tilt is at 0 tilt.

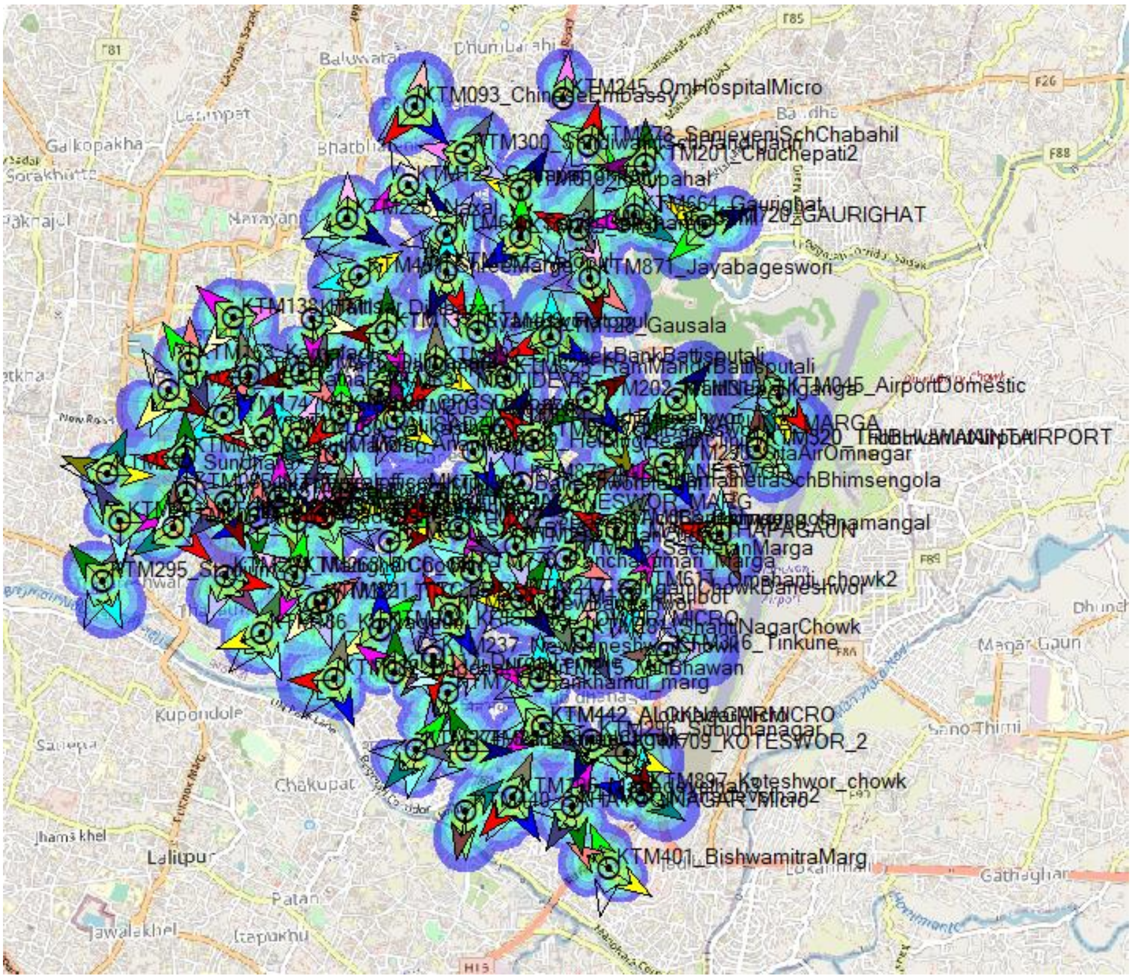
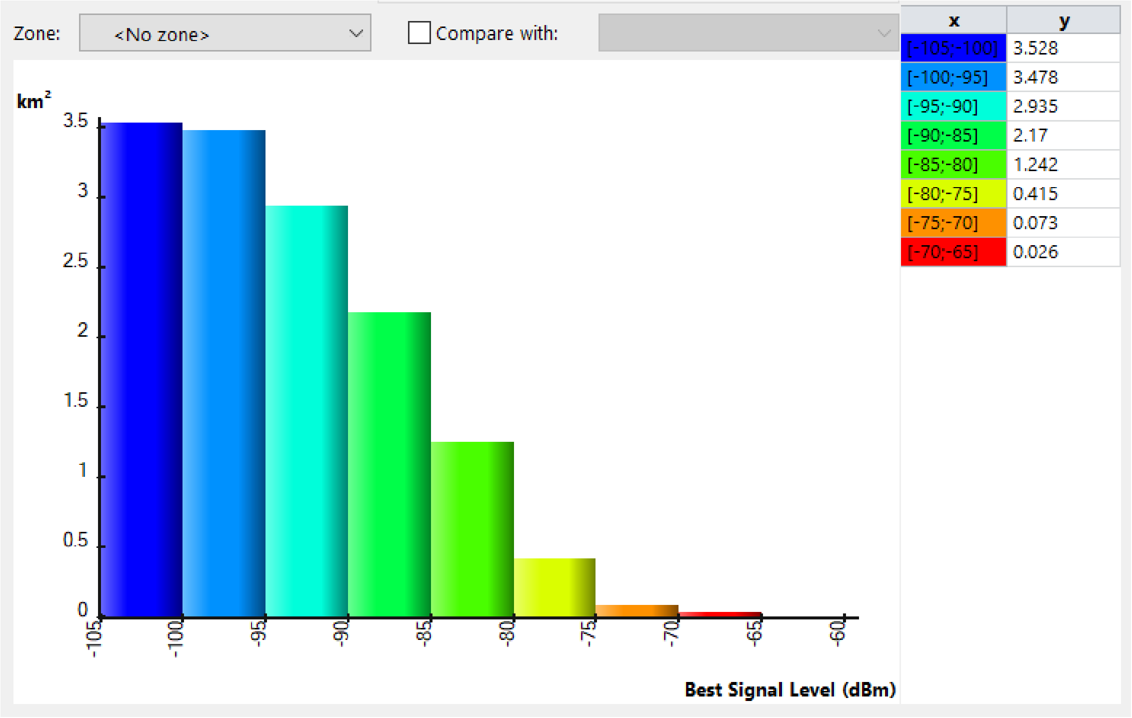


Figure 7. 1800MHz 4G Coverage by Downlink

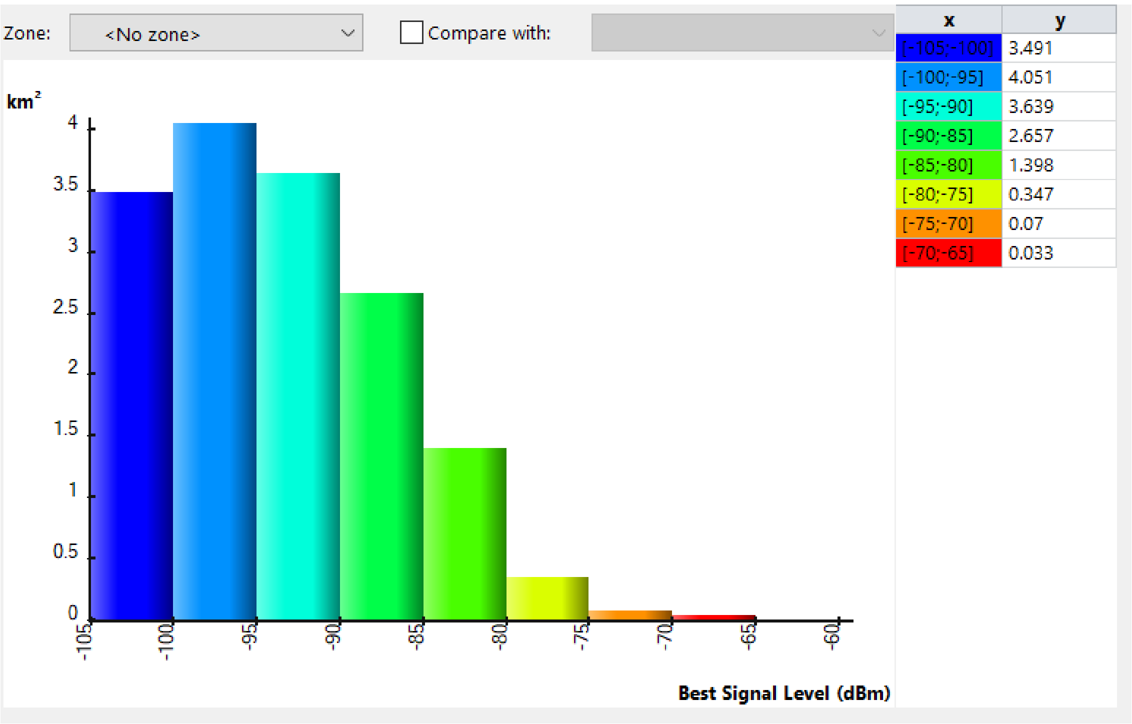
Figure 7 is the 4G coverage by the downlink signal at 1800MHz frequency. At 1800MHz frequency, the antenna angle is kept at 65 degree with antenna directivity of 17dBi and antenna tilt is at 0 tilt.

The area covered by 4G on the frequencies of 800MHz and 1800MHz can be illustrated in Figure 8 and Figure 9 respectively.



x	y
[-105;-100]	3.528
[-100;-95]	3.478
[-95;-90]	2.935
[-90;-85]	2.17
[-85;-80]	1.242
[-80;-75]	0.415
[-75;-70]	0.073
[-70;-65]	0.026

Figure 8. Area Covered by Downlink Signal at 800MHz



x	y
[-105;-100]	3.491
[-100;-95]	4.051
[-95;-90]	3.639
[-90;-85]	2.657
[-85;-80]	1.398
[-80;-75]	0.347
[-75;-70]	0.07
[-70;-65]	0.033

Figure 9. Area Covered by Downlink at 1800MHz

The area of coverage by 800MHZ is 3.5sqKm and by 1800MHz is 4sqKm with the best signal level by 1800MHz than that of 800MHz. We can know that the more power is delivered by 1800MHz frequency than that of 800MHz frequency. The RSRP is shown in x-axis with its area of coverage in y-axis in Figure 8 and Figure 9.

4.2 5G Analysis

SINR Mapping on the given test environment is done with the help of MATLAB 2021a simulator. Using Table 2 and Table 3 for 5G coverage and SINR mapping, firstly 19 cell sites are created in the given test environment at different frequencies 700MHz, 2300MHz, 2600MHz and 3500MHz respectively. Here cell sector angles are taken at 30, 150 and 270 degree.

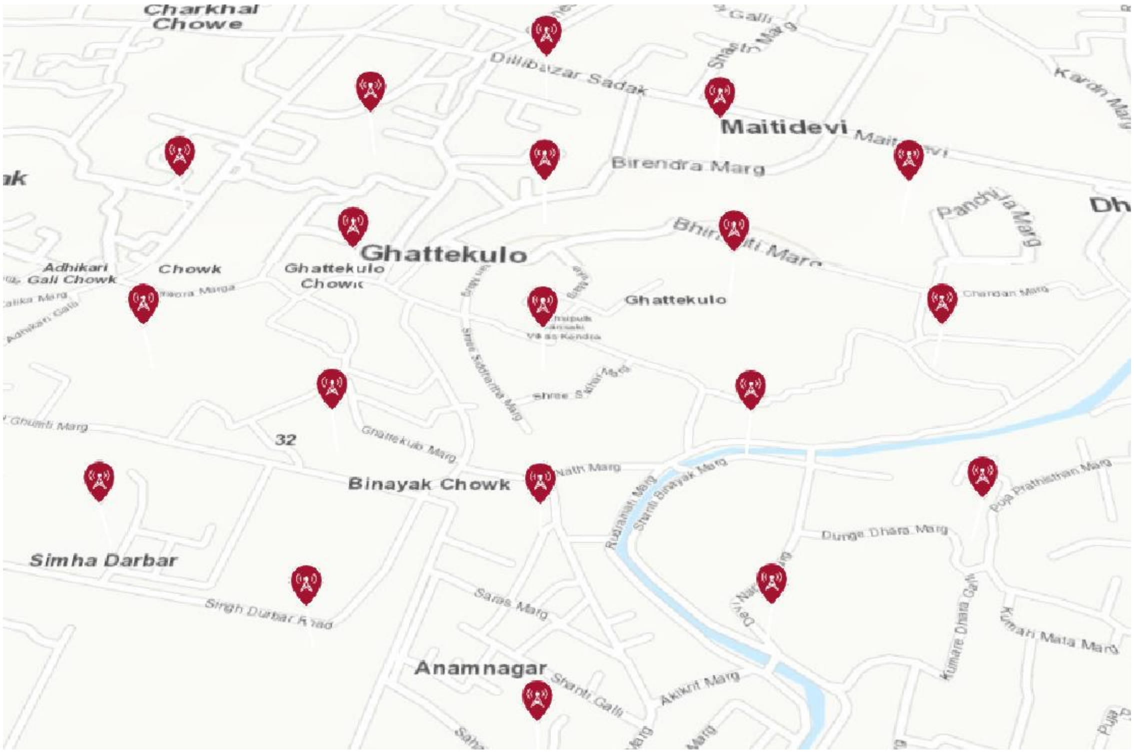


Figure 10. Network Layout with Cell Parameters for Transmitter Sites for 5G at 700MHz

Figure 10 is the network layout with different 19 cell parameters for transmitter sites for 5G which is at 700MHz frequency. From Figure 10 also we can know that the cell 19 cells are located at different places of Kathmandu City, Nepal. Here inter-site distance of 200m is taken so that there is no interference with site angles of 30, 60 and 360 degrees respectively. Other parameters are used using Table 2 and Table 3.

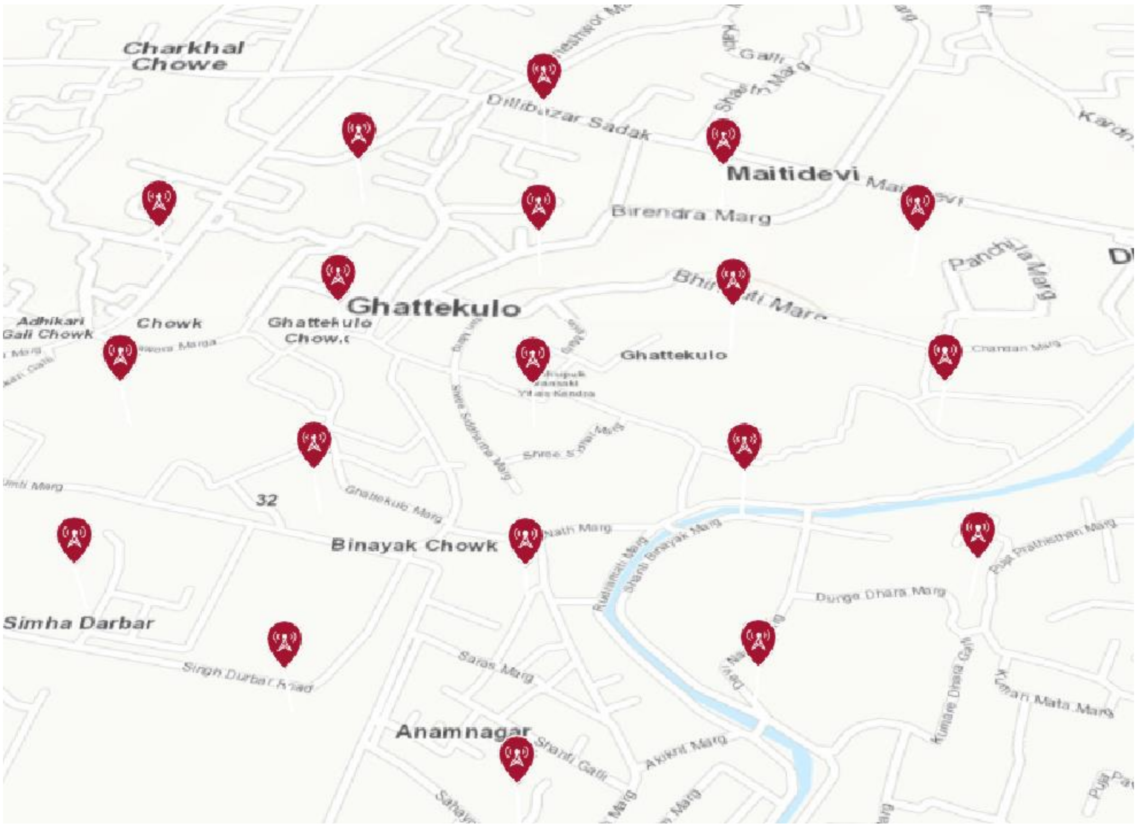


Figure 11.Network Layout with Cell Parameters for Transmitter Sites for 5G at 2300MHz

Figure 11 is the network layout with different 19 cell parameters for transmitter sites for 5G which is at 2300MHz frequency. From Figure 11 also we can know that the cell 19 cells are located at different places of Kathmandu City, Nepal. Here inter-site distance of 200m is taken so that there is no interference with site angles of 30, 60 and 360 degrees respectively. Other parameters are used using Table 2 and Table 3.

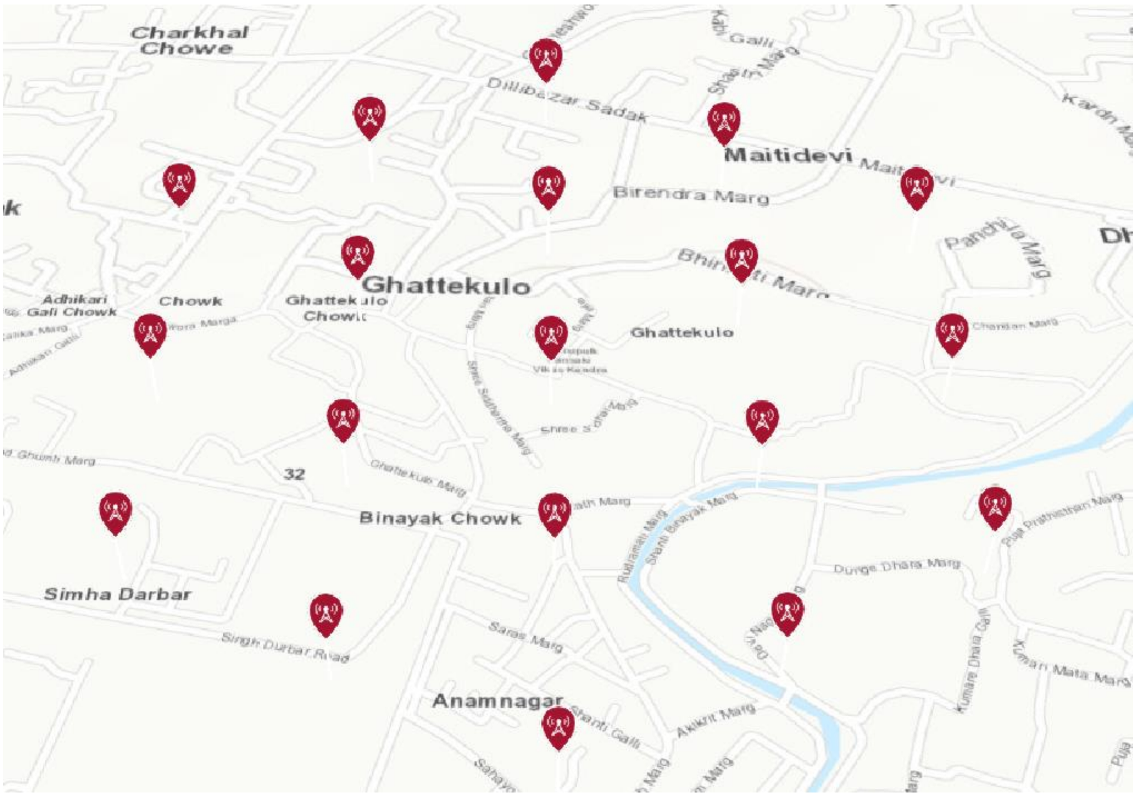


Figure 12.Network Layout with Cell Parameters for Transmitter Sites for 5G at 2600MHz

Figure 12 is the network layout with different 19 cell parameters for transmitter sites for 5G which is at 2600MHz frequency. From Figure 12 also we can know that the cell 19 cells are located at different places of Kathmandu City, Nepal. Here inter-site distance of 200m is taken so that there is no interference with site angles of 30, 60 and 360 degrees respectively. Other parameters are used using Table 2 and Table 3.

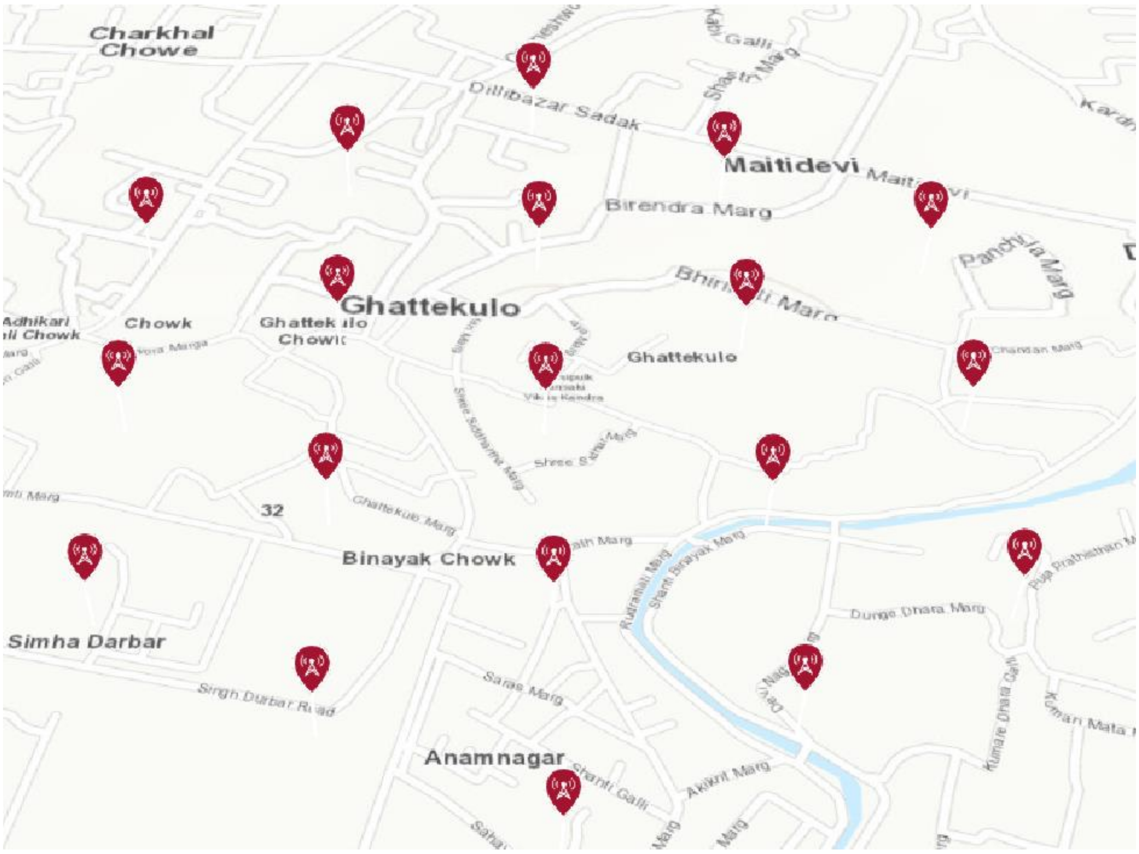


Figure 13. Network Layout with Cell Parameters for Transmitter Sites for 5G at 3500MHz

Figure 13 is the network layout with different 19 cell parameters for transmitter sites for 5G which is at 3500MHz frequency. From Figure 13 also we can know that the cell 19 cells are located at different places of Kathmandu City, Nepal. Here inter-site distance of 200m is taken so that there is no interference with site angles of 30, 60 and 360 degrees respectively. Other parameters are used using Table 2 and Table 3.

After the 19 transmitters are created, we now create antenna element using phased array system which is shown in Figure 14.

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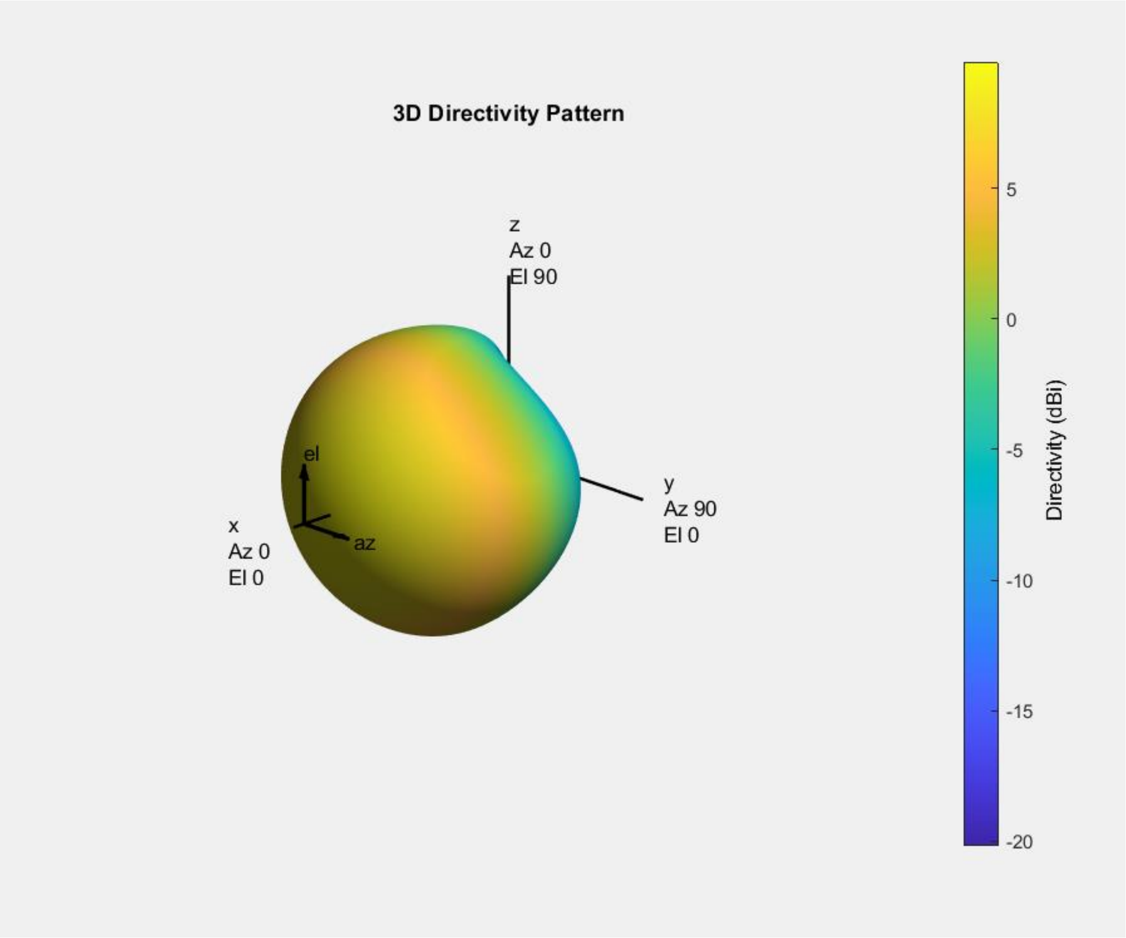

Figure 14. 3D Directivity Pattern Phased Array for Single Antenna Element

Figure 14 is the 3D directivity pattern phased array when only single antenna is used. From Figure 14, we can have analysis that the directivity of antenna is only up to 5dBi which is very much less thus the coverage must be very much less when only single element antenna is used.

Now the visualization of SINR mapping for the single antenna element is done in the test environment and the free space propagation model is used. The antenna coverage can be seen in 5G and we can also conclude that the range is very much less when only single antenna is used since the SINR is very much less for each transmitter.

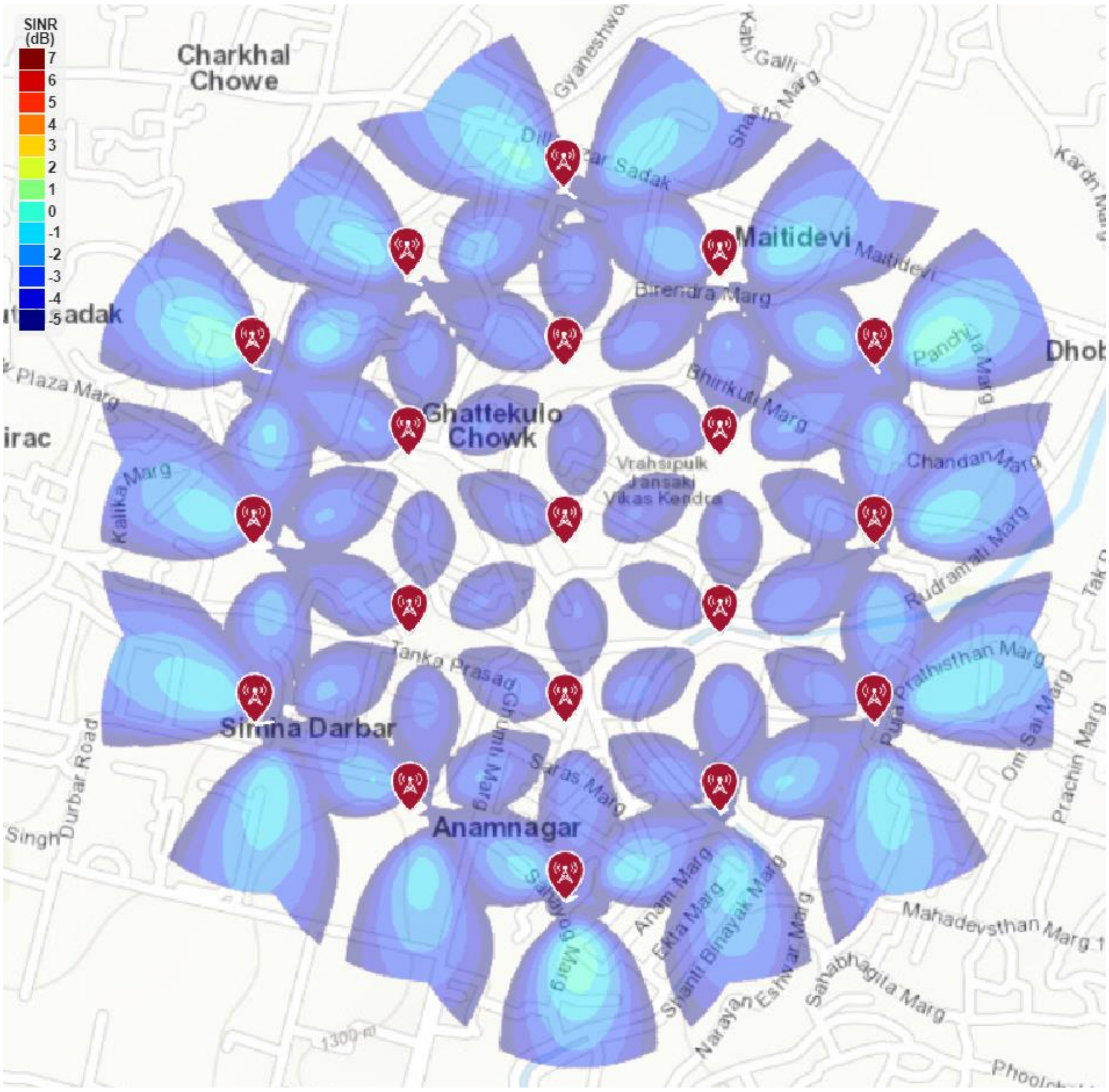

Figure 15. 700MHz Output 5G Network Coverage and SINR Map for Single Antenna

Figure 15 is the 700MHz output for 5G network coverage and it's SINR mapping when only single antenna element is used. From Figure 15, we can know that the SINR lies on the cell edge since it is on the range of ≤ 0 dB which is also included in Table 1. When the SINR range lies on the cell edge of ≤ 0 dB then two of the things take place, either there is no any coverage or there is frequent disconnection due to low coverage. Thus, we can say that the coverage is very much less when only single antenna element is used.

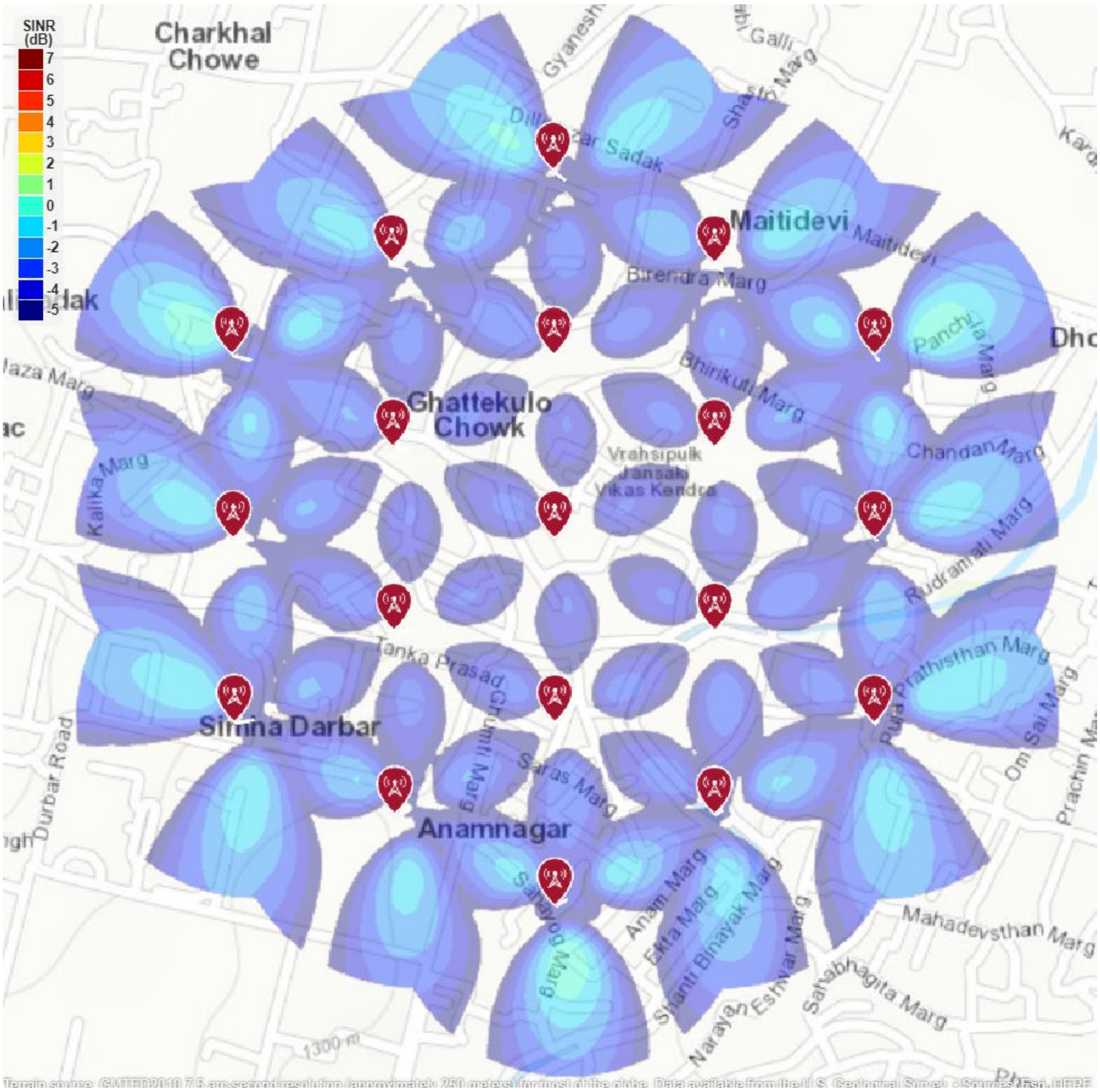

Figure 16. 2300MHz Output 5G Network Coverage and SINR Map for Single Antenna

Figure 16 is the 2300MHz output for 5G network coverage and it’s SINR mapping when only single antenna element is used. From Figure 16, we can know that the SINR lies on the cell edge since it is on the range of ≤ 0 dB which is also included in Table 1. When the SINR range lies on the cell edge of ≤ 0 dB then two of the things take place, either there is no any coverage or there is frequent disconnection due to low coverage. Thus, we can say that the coverage is very much less when only single antenna element is used.

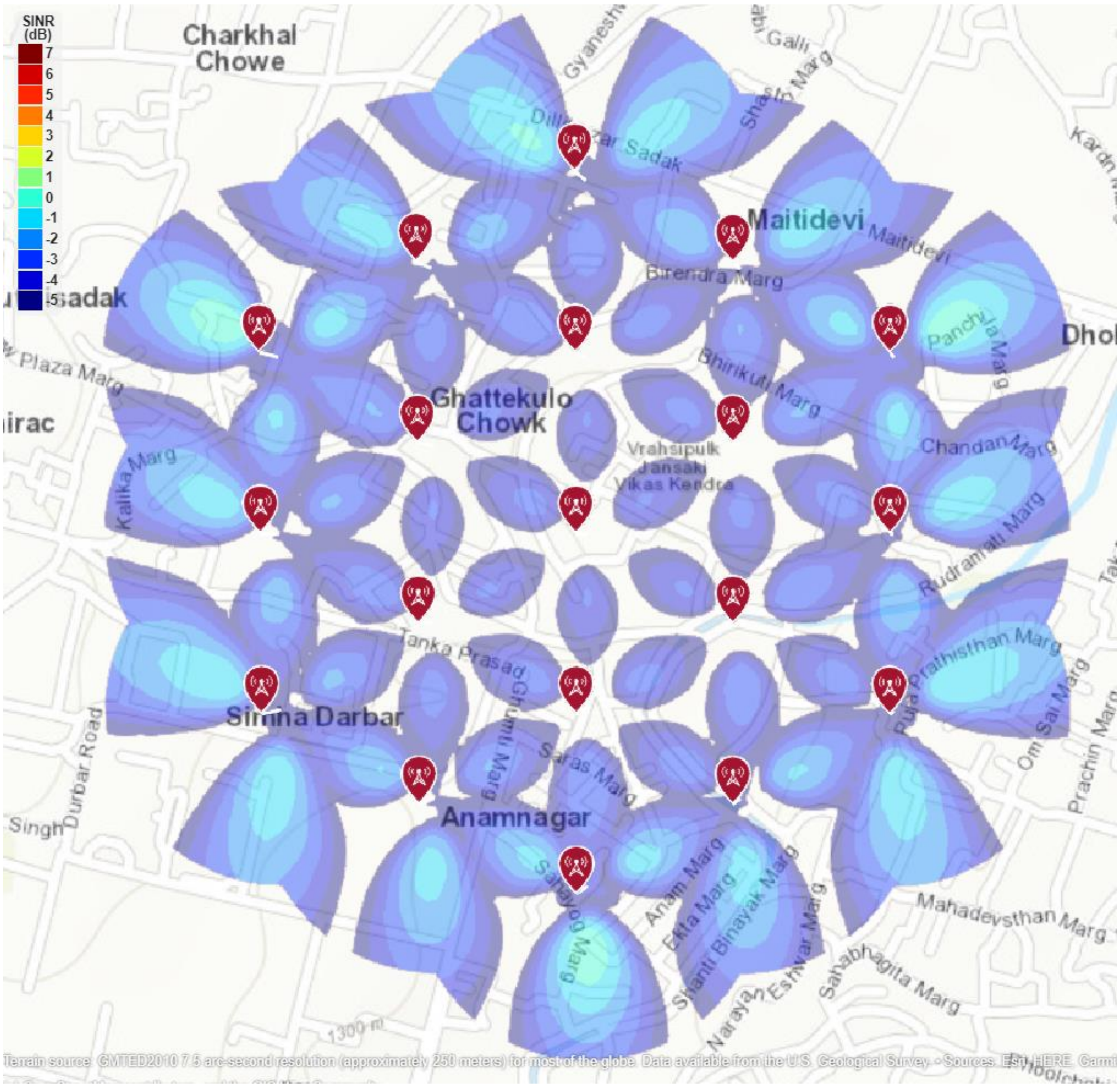

Figure 17. 2600MHz Output 5G Network Coverage and SINR Map for Single Antenna

Figure 17 is the 2600MHz output for 5G network coverage and it’s SINR mapping when only single antenna element is used. From Figure 17, we can know that the SINR lies on the cell edge since it is on the range of ≤ 0 dB which is also included in Table 1. When the SINR range lies on the cell edge of ≤ 0 dB then two of the things take place, either there is no any coverage or there is frequent disconnection due to low coverage. Thus, we can say that the coverage is very much less when only single antenna element is used.

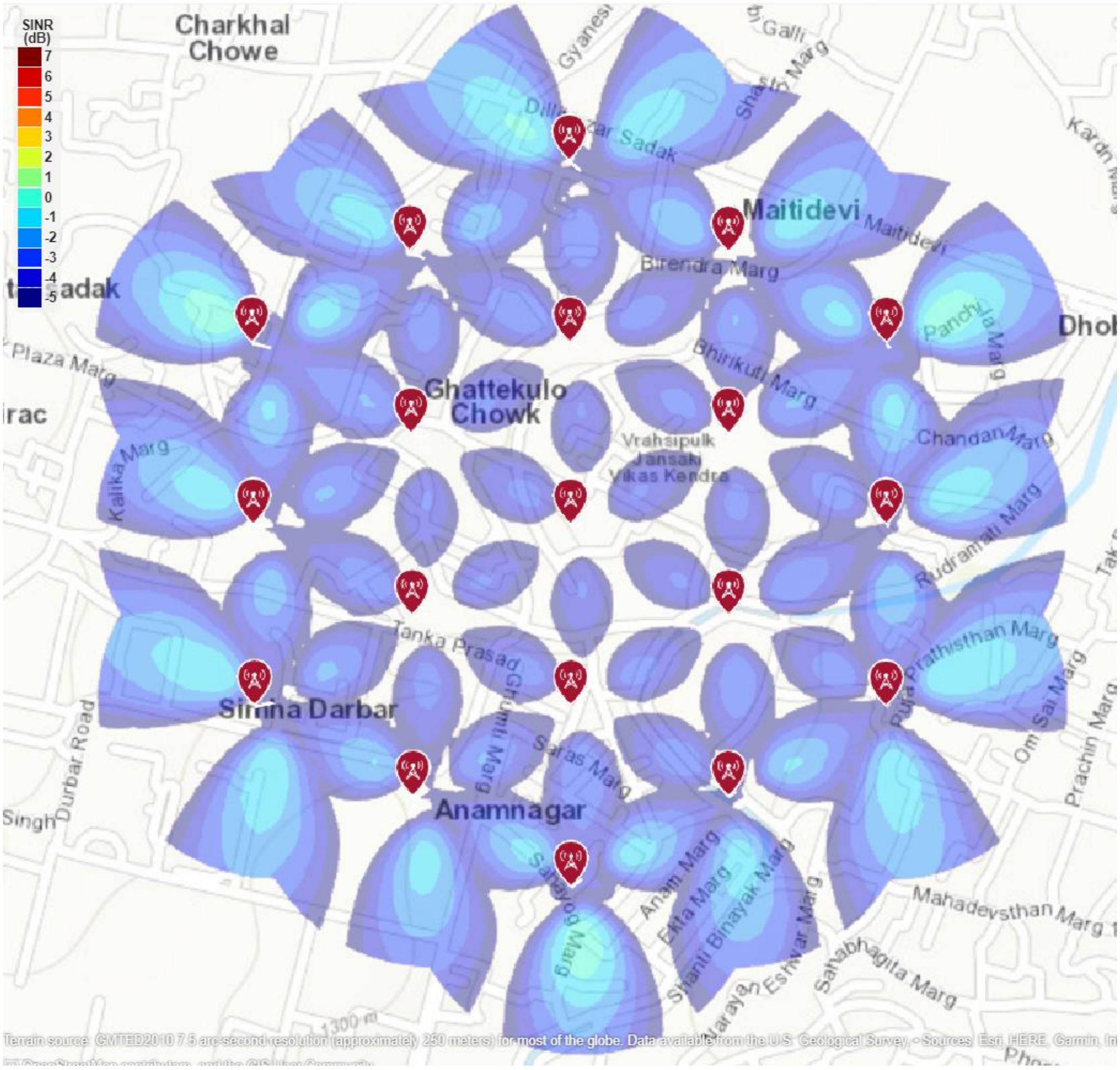

Figure 18. 3500MHz Output 5G Network Coverage and SINR Map for Single Antenna

Figure 18 is the 3500MHz output for 5G network coverage and it’s SINR mapping when only single antenna element is used. From Figure 18, we can know that the SINR lies on the cell edge since it is on the range of ≤ 0 dB which is also included in Table 1. When the SINR range lies on the cell edge of ≤ 0 dB then two of the things take place, either there is no any coverage or there is frequent disconnection due to low coverage. Thus, we can say that the coverage is very much less when only single antenna element is used.

Now, we can conclude that the SINR for single antenna is very much less. Thus, the coverage is also very much less. So, to improve the SINR mapping, now we check it by rectangular antenna array of 8*8 and 16*16. After that we can know using which rectangular antenna array does the optimum SINR is obtained.

Using rectangular antenna array of 8 by 8, the following 3D directivity pattern is obtained.

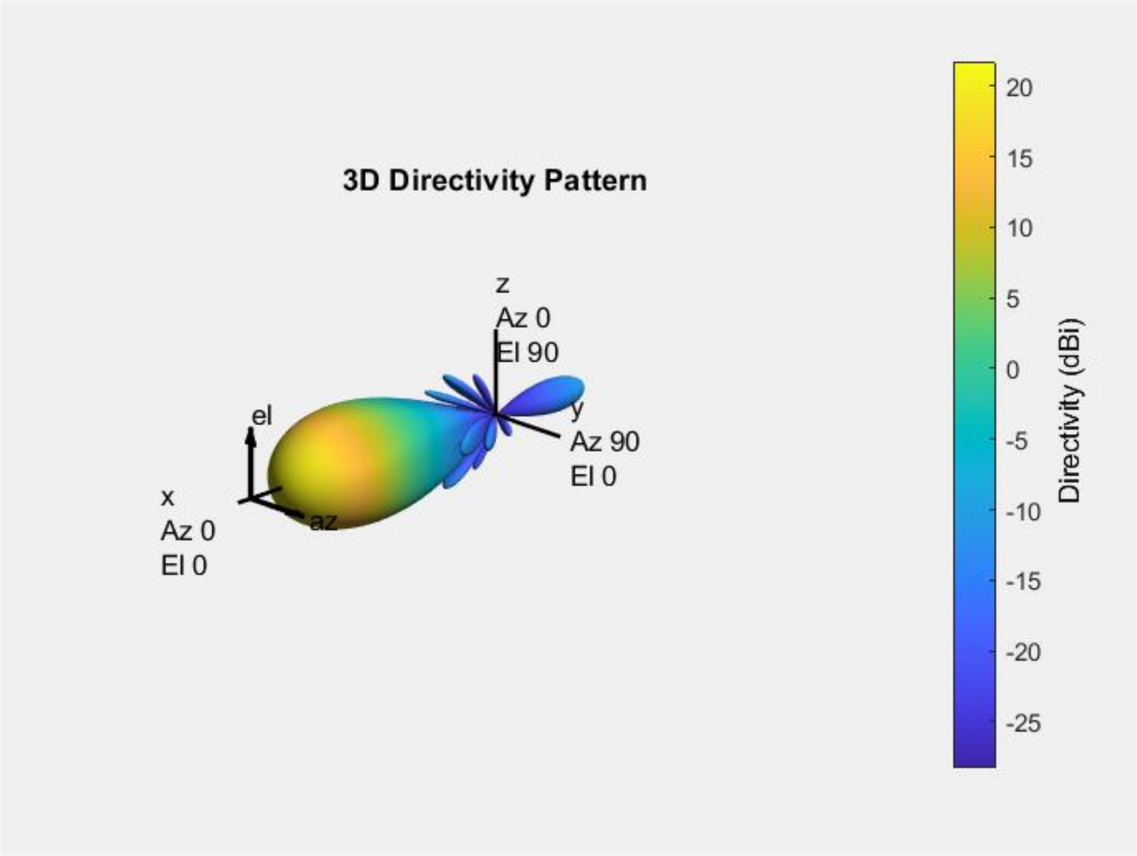

Figure 19. 3D Directivity Pattern Phased Array for 8 by 8 Rectangular Antenna Array

Figure 19 is the 3D directivity pattern phased array for 8 by 8 rectangular antenna array. We can see that using 8 by 8 rectangular antenna array, the 3D directivity pattern is much better when compared to that of single antenna element since the antenna directivity is up to 20dBi when 8 by 8 rectangular antenna is used. Thus, the antenna gain must be high when using 8 by 8 rectangular antenna array than that of single antenna element. Also, we can say that when the antenna directivity increases then the antenna board field becomes very much less with the narrower direction and the long range is covered by the antenna. Thus, the coverage must be high when antenna directivity increases.

Now, SINR Mapping is done on different frequencies using rectangular antenna array of 8 by 8 and we can have analysis on it and also about the coverage by the antenna at different frequencies.

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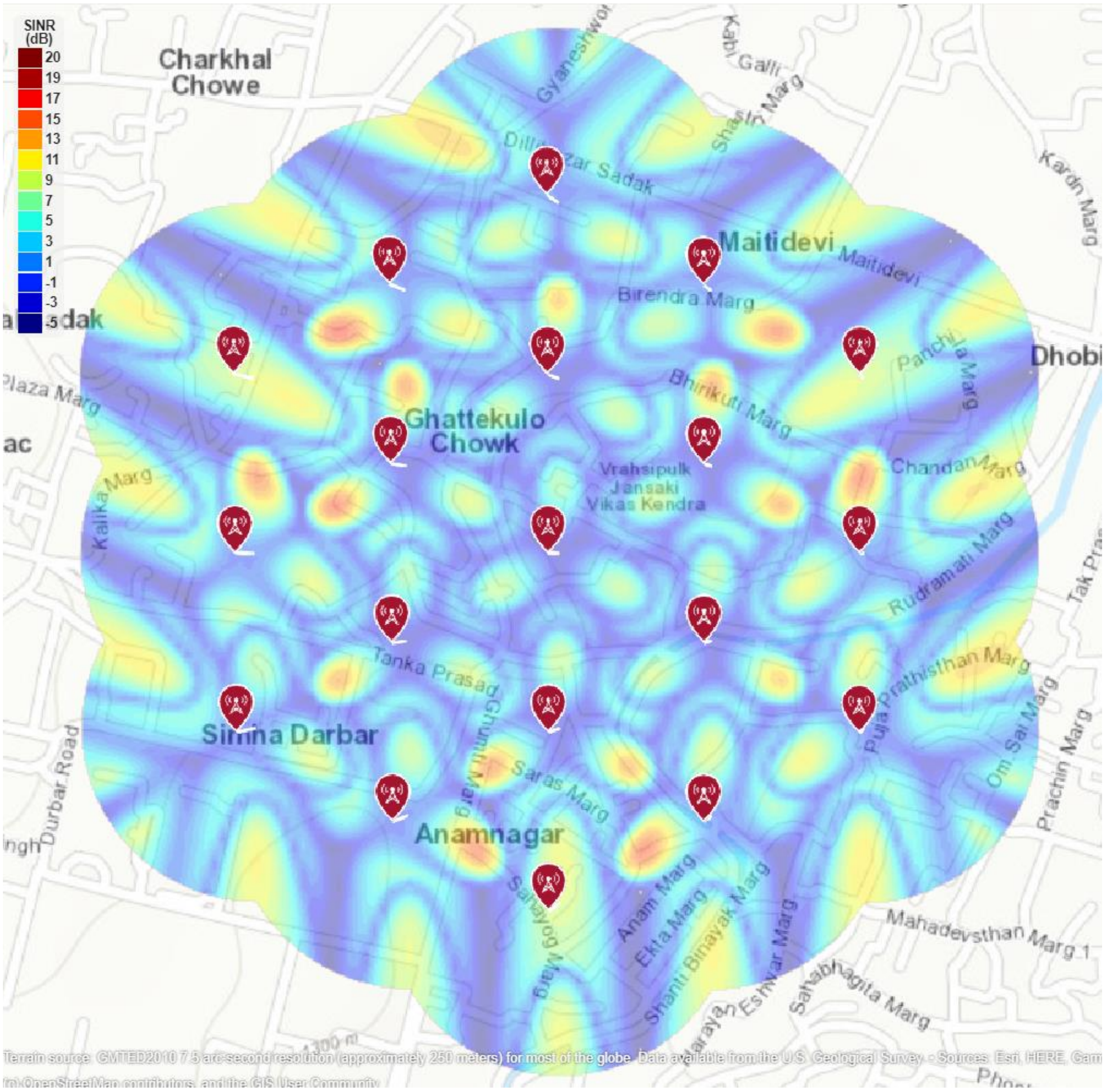
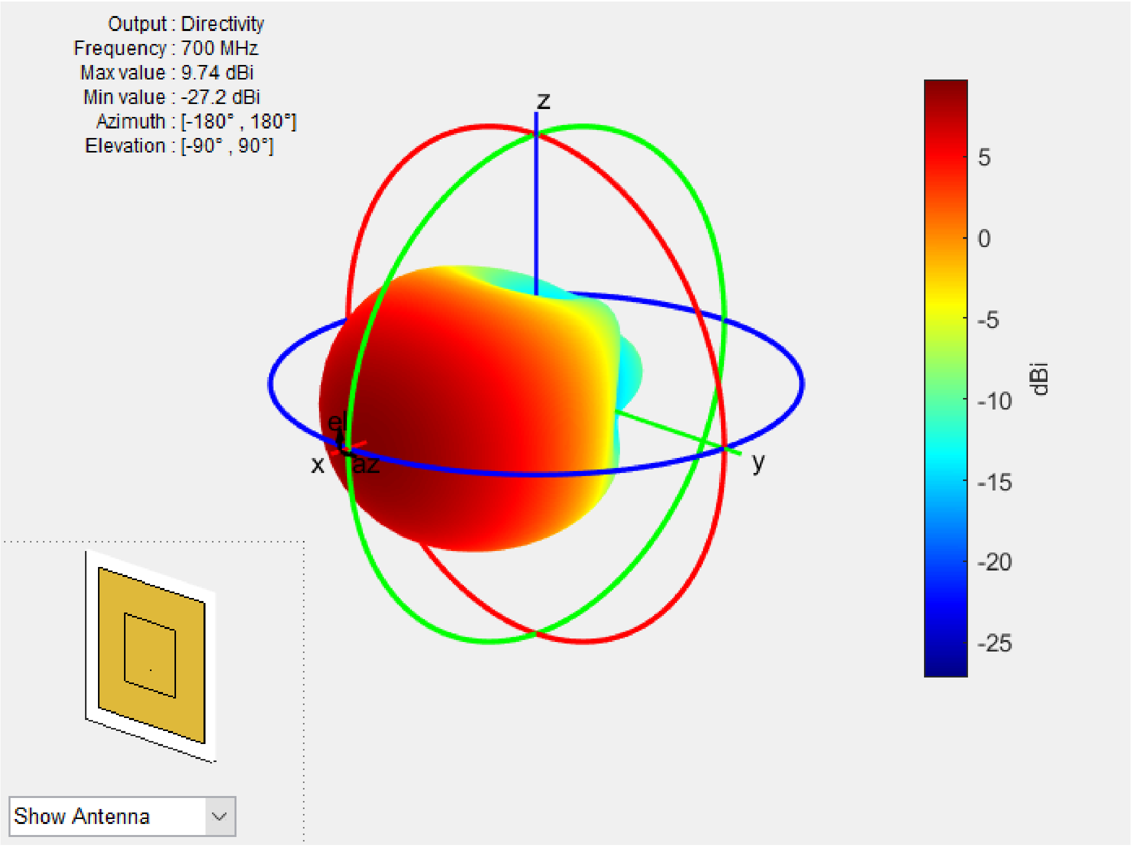


Figure 20. 700MHz Output 5G Network Coverage and SINR Map for 8 by 8 Antenna Array

Figure 20 is the 700MHz output for 5G network coverage and it's SINR mapping when 8 by 8 rectangular antenna array is used. From Figure 20, we can know that the SINR lies on the mid-cell since it is on the range of 0dB to 13dB which is also included in Table 1. When the SINR lies on the mid-cell range then the signal strength is fair to poor. It is feasible to achieve reliable data speeds, however mediocre data with drop-outs is also possible. Performance will suffer greatly when this value approaches zero. Thus, we can say that the coverage is still very much less when 8 by 8 rectangular antenna array is used since the optimum range is not obtained.



Output : Directivity
Frequency : 700 MHz
Max value : 9.74 dBi
Min value : -27.2 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

Figure 21. 700MHz 3D Directivity Pattern Rectangular Antenna Array for 8 by 8

Figure 21 is the 700MHz 3D directivity pattern rectangular antenna array for 8 by 8. From Figure 21 we can conclude that using 8 by 8 rectangular antenna array, the maximum antenna directivity at 700MHz frequency is 9.74dBi and minimum antenna directivity is -27.2dBi. The azimuth is taken from -180 degree to + 180 degree. The elevation is taken from -90 degree to +90 degree. Since antenna directivity is more than that of the single antenna element, the coverage must also be more when 8 by 8 rectangular antenna array is used than that of the single antenna element.

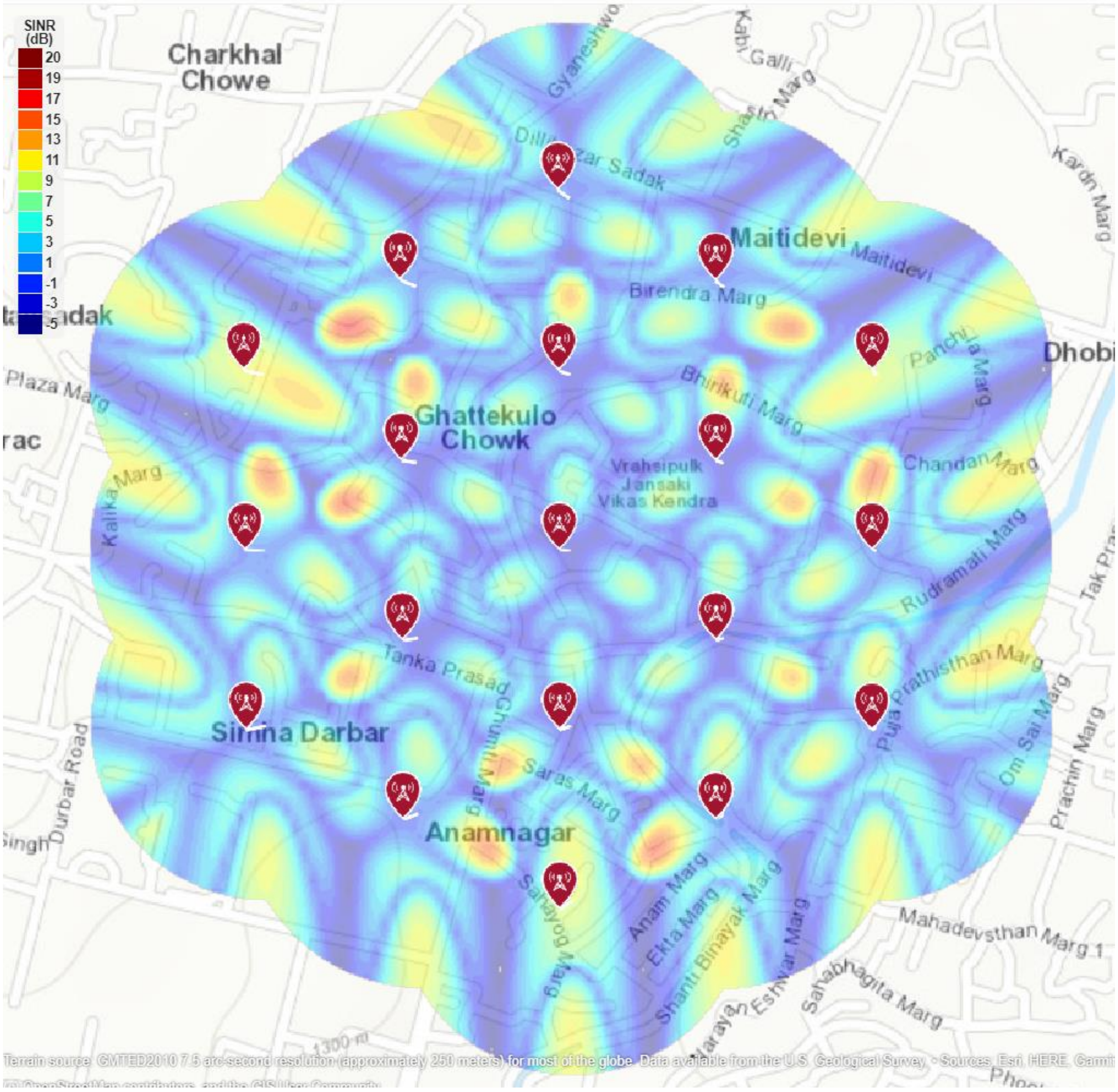


Figure 22. 2300MHz Output 5G Network Coverage and SINR Map for 8 by 8 Antenna Array

Figure 22 is the 2300MHz output for 5G network coverage and it's SINR mapping when 8 by 8 rectangular antenna array is used. From Figure 22, we can know that the SINR lies on the mid-cell since it is on the range of 0dB to 13dB which is also included in Table 1. When the SINR lies on the mid-cell range then the signal strength is fair to poor. It is feasible to achieve reliable data speeds, however mediocre data with drop-outs is also possible. Performance will suffer greatly when this value approaches zero. Thus, we can say that the coverage is still very much less when 8 by 8 rectangular antenna array is used since the optimum range is not obtained.

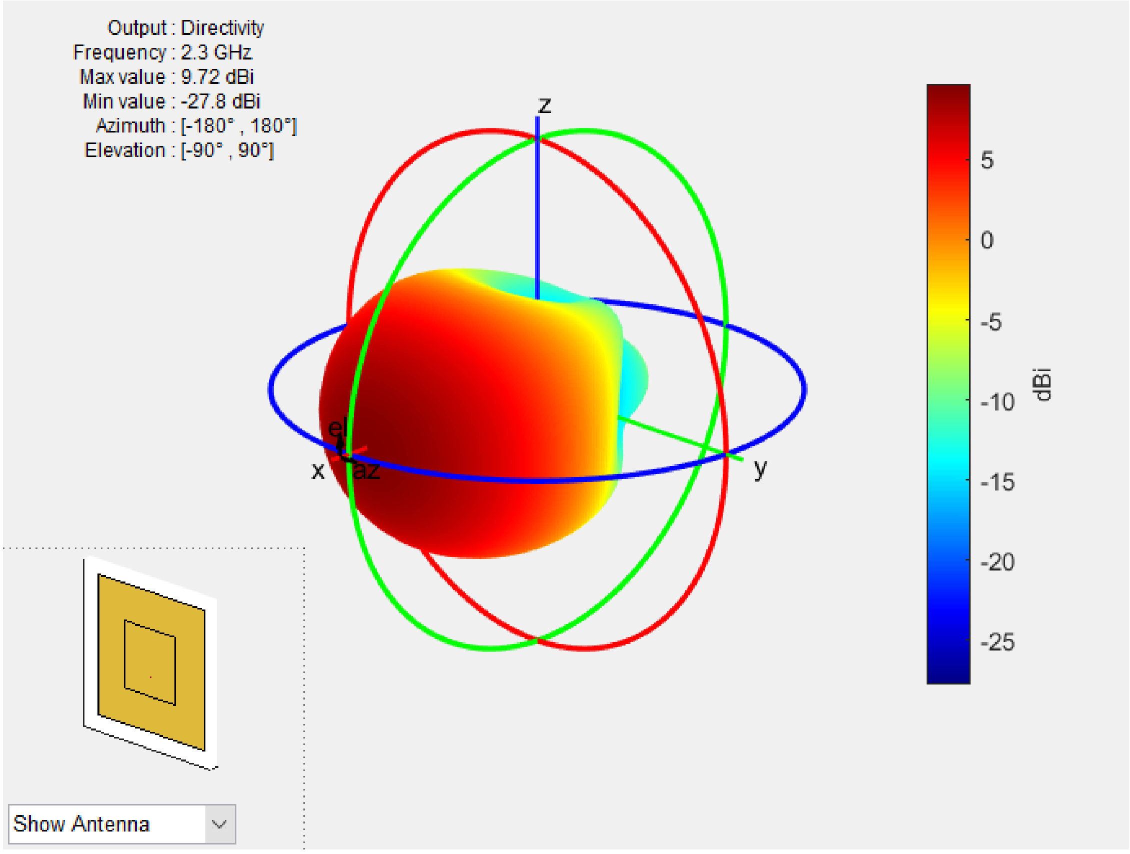


Figure 23. 2300MHz 3D Directivity Pattern Rectangular Antenna Array for 8 by 8

Figure 23 is the 2300MHz 3D directivity pattern rectangular antenna array for 8 by 8. From Figure 23 we can conclude that using 8 by 8 rectangular antenna array, the maximum antenna directivity at 2300MHz frequency is 9.72dBi and minimum antenna directivity is -27.8dBi. The azimuth is taken from -180 degree to + 180 degree. The elevation is taken from -90 degree to +90 degree. Since antenna directivity is more than that of the single antenna element, the coverage must also be more when 8 by 8 rectangular antenna array is used than that of the single antenna element.

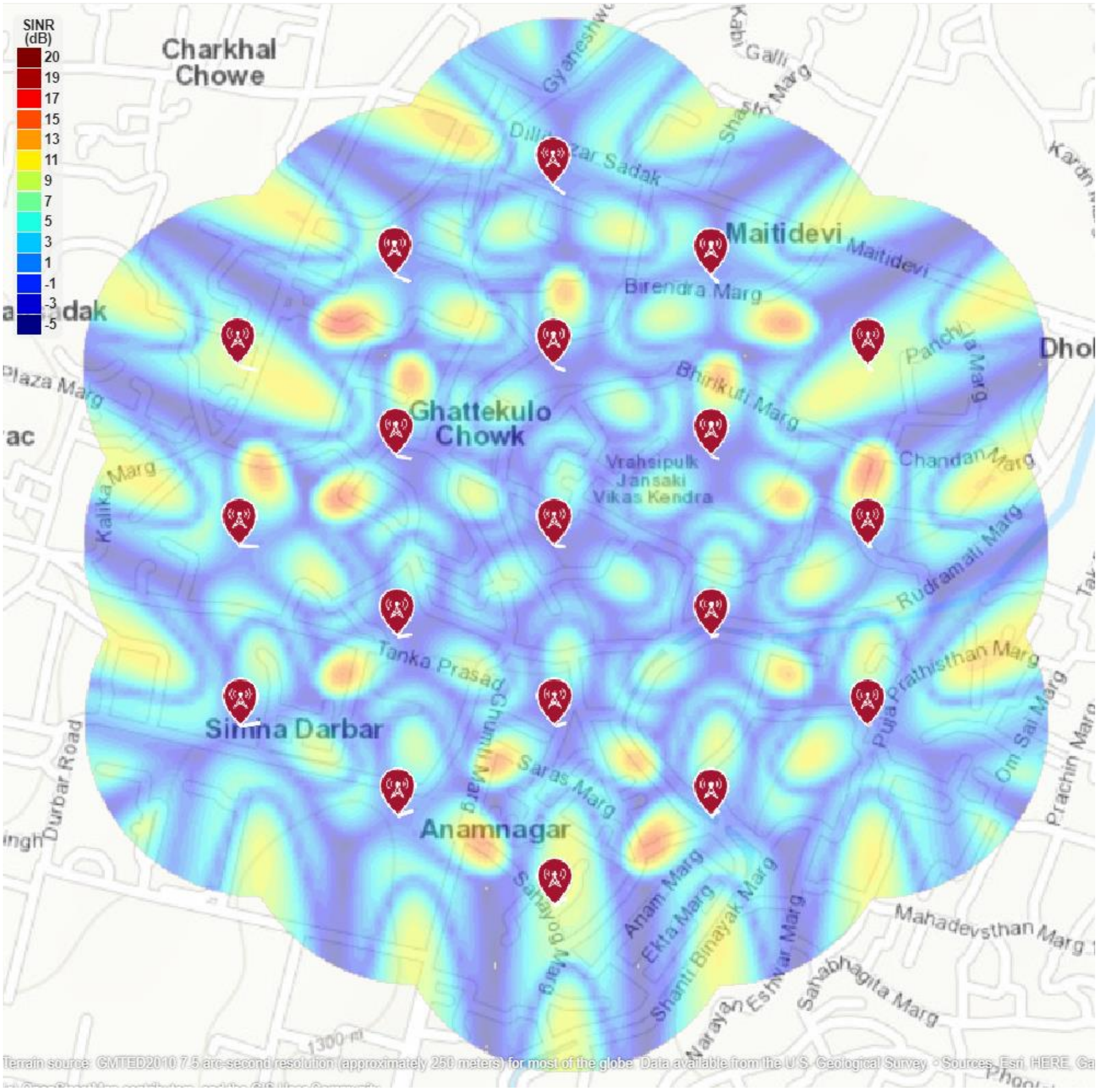


Figure 24. 2600MHz Output 5G Network Coverage and SINR Map for 8 by 8 Antenna Array

Figure 24 is the 2600MHz output for 5G network coverage and it’s SINR mapping when 8 by 8 rectangular antenna array is used. From Figure 24, we can know that the SINR lies on the mid-cell since it is on the range of 0dB to 13dB which is also included in Table 1. When the SINR lies on the mid-cell range then the signal strength is fair to poor. It is feasible to achieve reliable data speeds, however mediocre data with drop-outs is also possible. Performance will suffer greatly when this value approaches zero. Thus, we can say that the coverage is still very much less when 8 by 8 rectangular antenna array is used since the optimum range is not obtained.

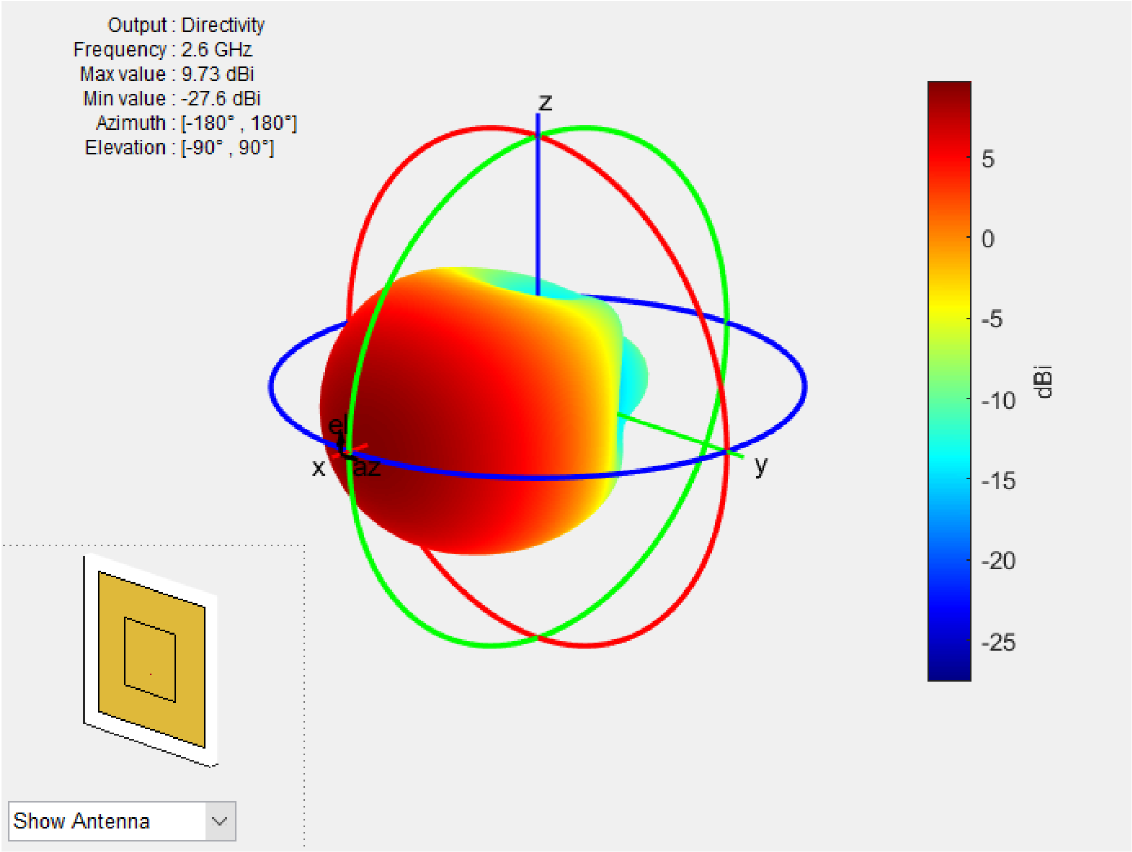


Figure 25. 2600MHz 3D Directivity Pattern Rectangular Antenna Array for 8 by 8

Figure 25 is the 2600MHz 3D directivity pattern rectangular antenna array for 8 by 8. From Figure 25 we can conclude that using 8 by 8 rectangular antenna array, the maximum antenna directivity at 2600MHz frequency is 9.73dBi and minimum antenna directivity is -27.6dBi. The azimuth is taken from -180 degree to + 180 degree. The elevation is taken from -90 degree to +90 degree. Since antenna directivity is more than that of the single antenna element, the coverage must also be more when 8 by 8 rectangular antenna array is used than that of the single antenna element.

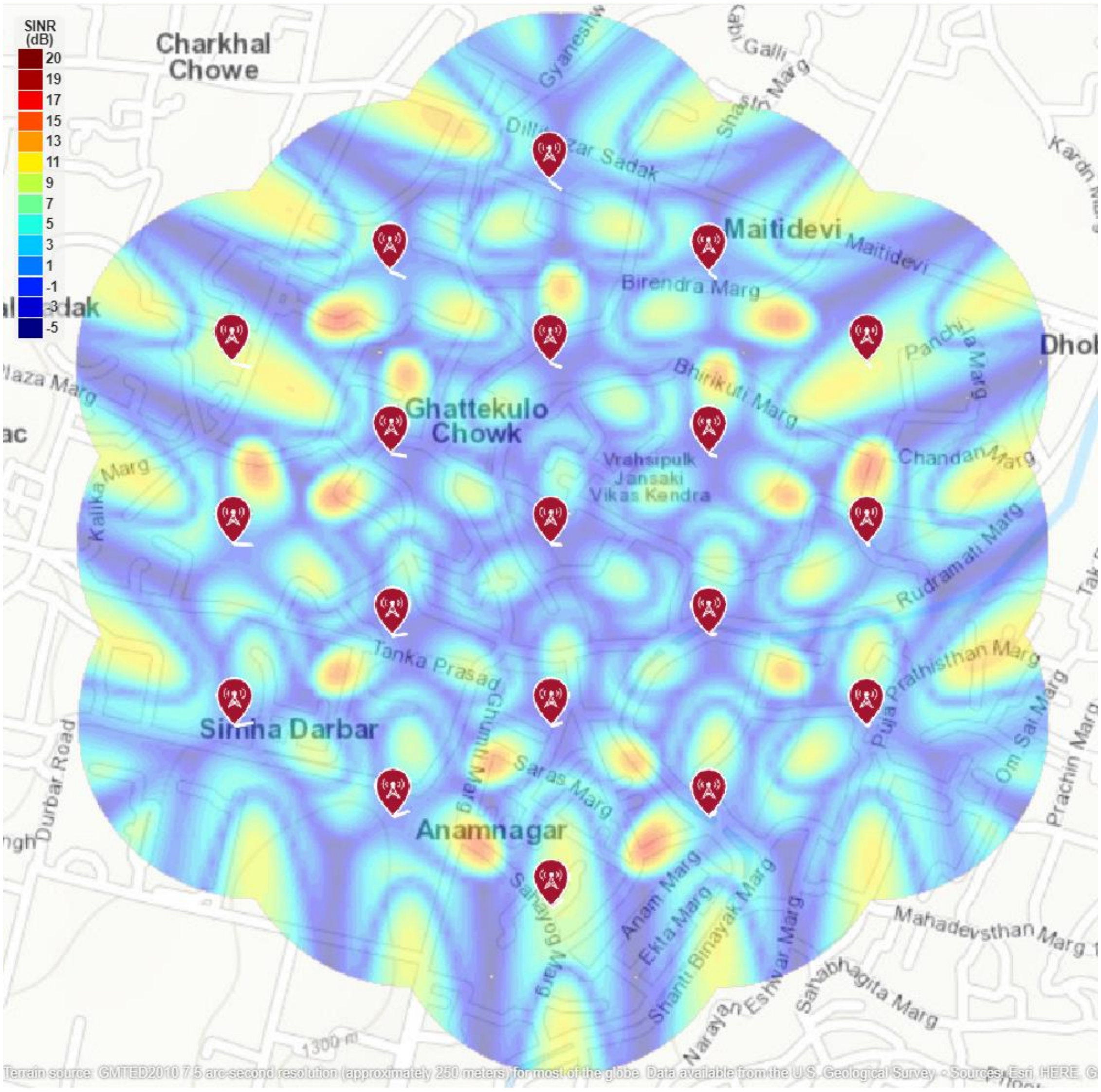
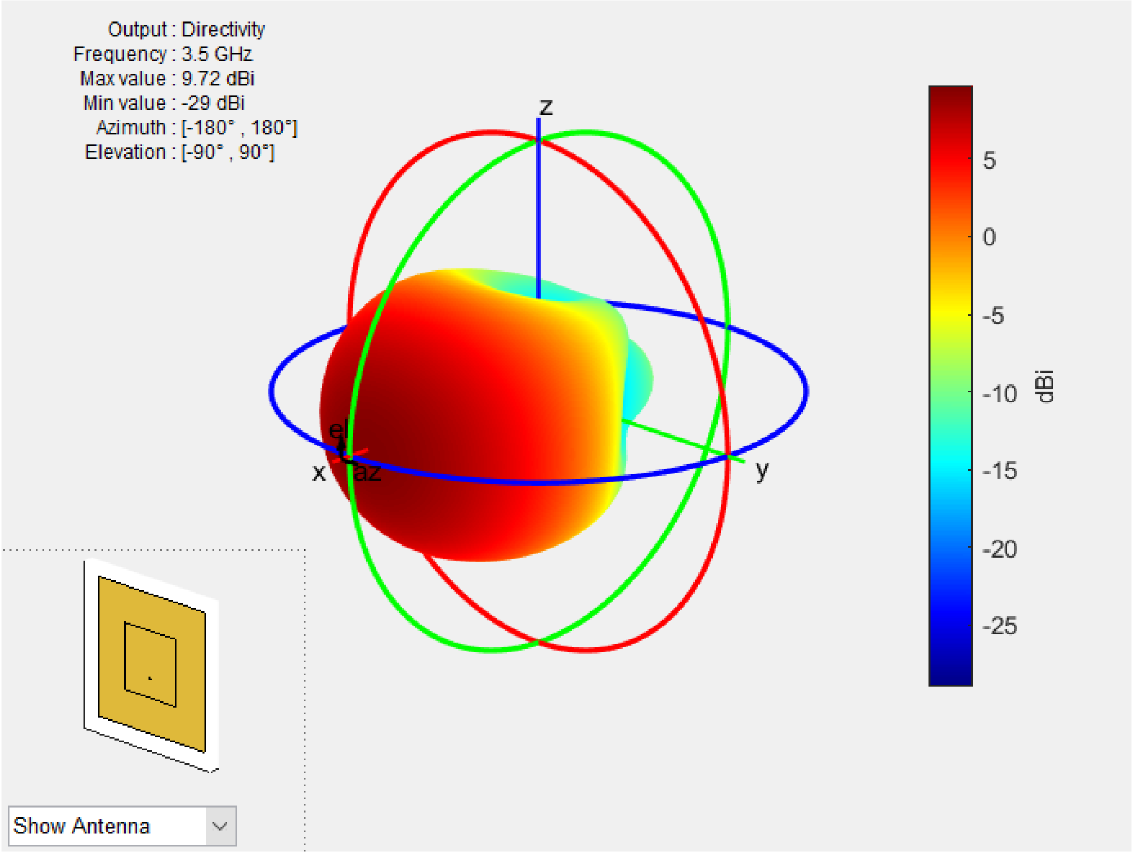


Figure 26. 3500MHz Output 5G Network Coverage and SINR Map for 8 by 8 Antenna Array

Figure 26 is the 3500MHz output for 5G network coverage and it’s SINR mapping when 8 by 8 rectangular antenna array is used. From Figure 26, we can know that the SINR lies on the mid-cell since it is on the range of 0dB to 13dB which is also included in Table 1. When the SINR lies on the mid-cell range then the signal strength is fair to poor. It is feasible to achieve reliable data speeds, however mediocre data with drop-outs is also possible. Performance will suffer greatly when this value approaches zero. Thus, we can say that the coverage is still very much less when 8 by 8 rectangular antenna array is used since the optimum range is not obtained.



Output : Directivity
Frequency : 3.5 GHz
Max value : 9.72 dBi
Min value : -29 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

Figure 27. 3500MHz 3D Directivity Pattern Rectangular Antenna Array for 8 by 8

Figure 27 is the 3500MHz 3D directivity pattern rectangular antenna array for 8 by 8. From Figure 27 we can conclude that using 8 by 8 rectangular antenna array, the maximum antenna directivity at 3500MHz frequency is 9.72dBi and minimum antenna directivity is -29dBi. The azimuth is taken from -180 degree to + 180 degree. The elevation is taken from -90 degree to +90 degree. Since antenna directivity is more than that of the single antenna element, the coverage must also be more when 8 by 8 rectangular antenna array is used than that of the single antenna element.

We can have analysis that the SINR is not maximum and still the coverage is not best when antenna array of 8 by 8 is used. Now, using rectangular antenna array of 16 by 16, the following 3D directivity pattern is obtained and we can have analysis on its directivity and coverage on different frequencies.

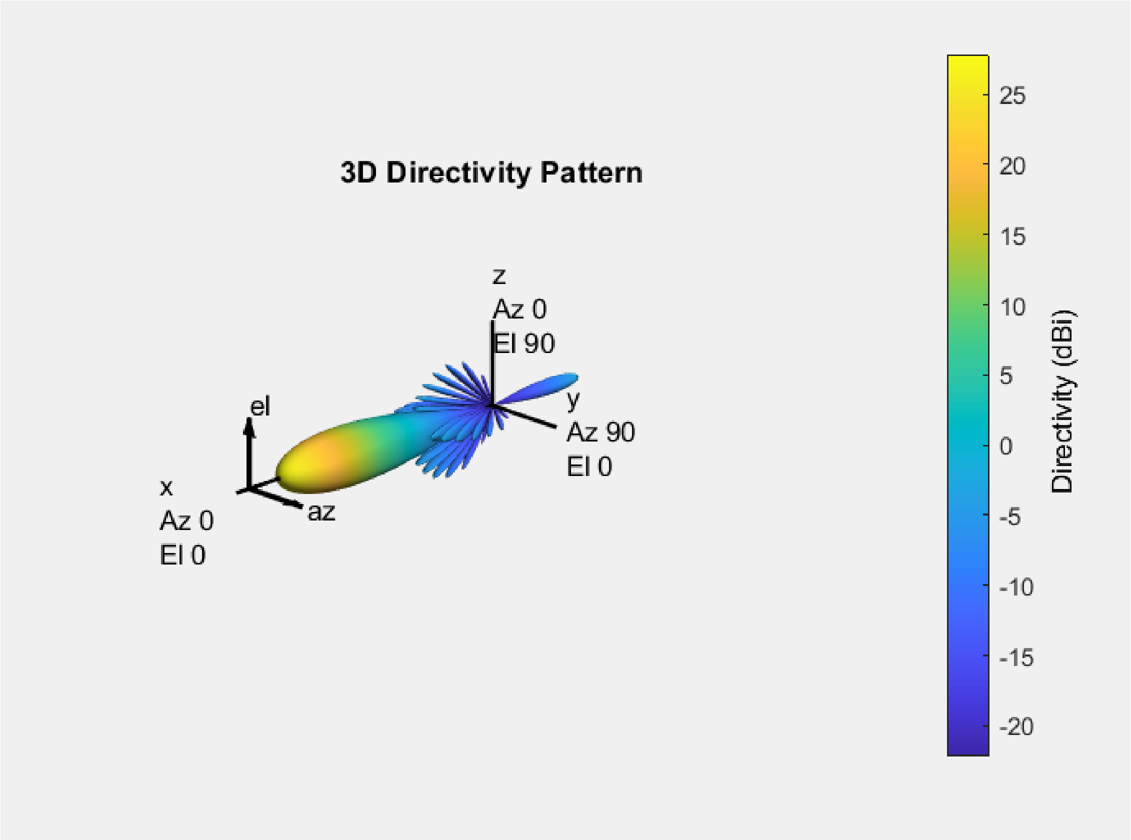


Figure 28. 3D Directivity Pattern Phased Array for 16 by 16 Rectangular Antenna Array

Figure 28 is the 3D directivity pattern phased array for 16 by 16 rectangular antenna array. We can see that using 16 by 16 rectangular antenna array, the 3D directivity pattern is much better than that of 8 by 8 rectangular antenna element. Antenna gain is up to 25dBi when 16 by 16 rectangular antenna array is used which is more than that of the 8 by 8 rectangular antenna array. Thus, the antenna coverage must be high when 16 by 16 rectangular antenna element is used since the signal strength must go to long range and the direction becomes narrower.

Now, SINR Mapping is done on different frequencies using rectangular antenna array of 16 by 16 and we can have analysis on it and we will be able to know about the coverage by the antenna at different frequencies.

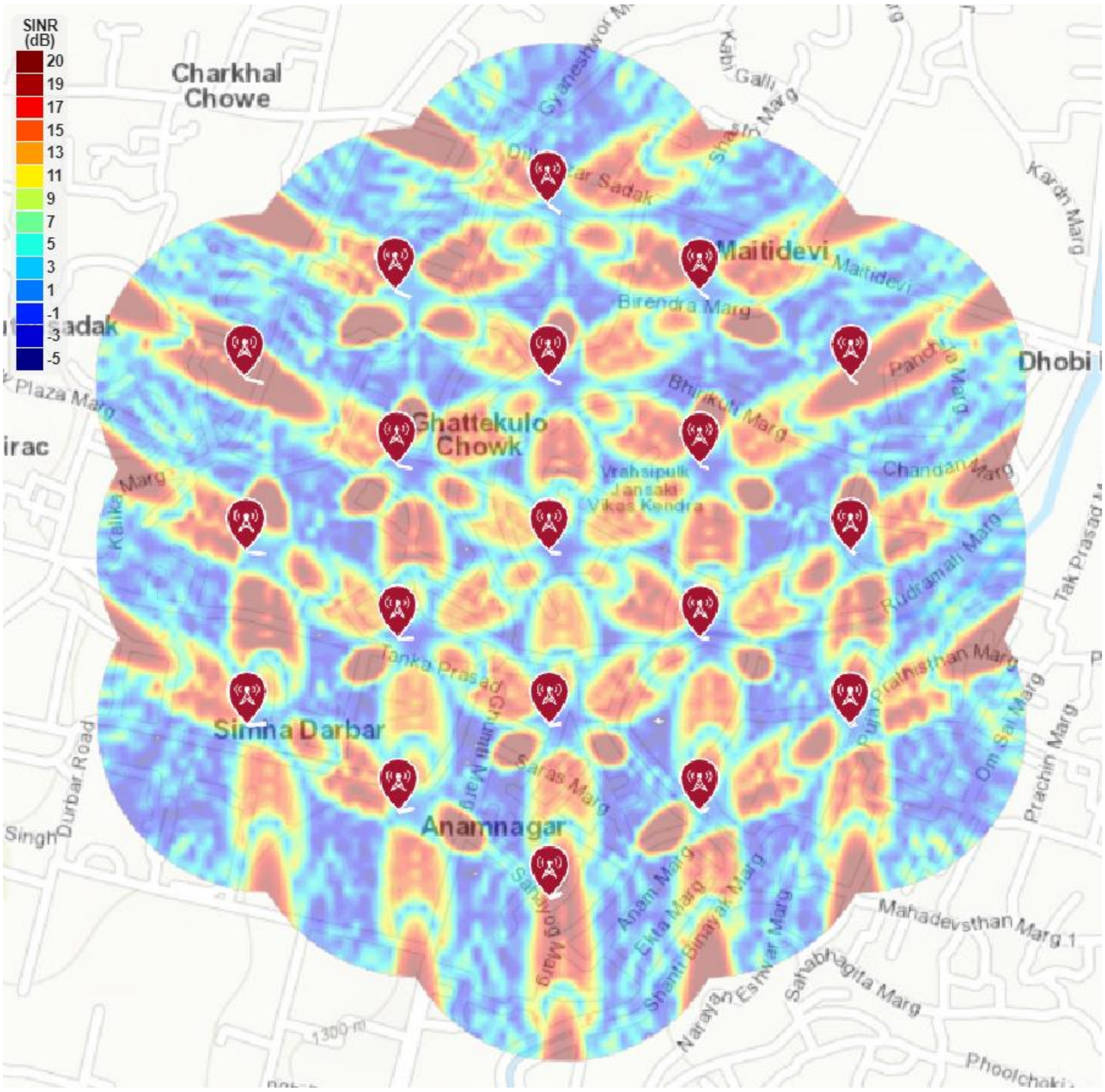
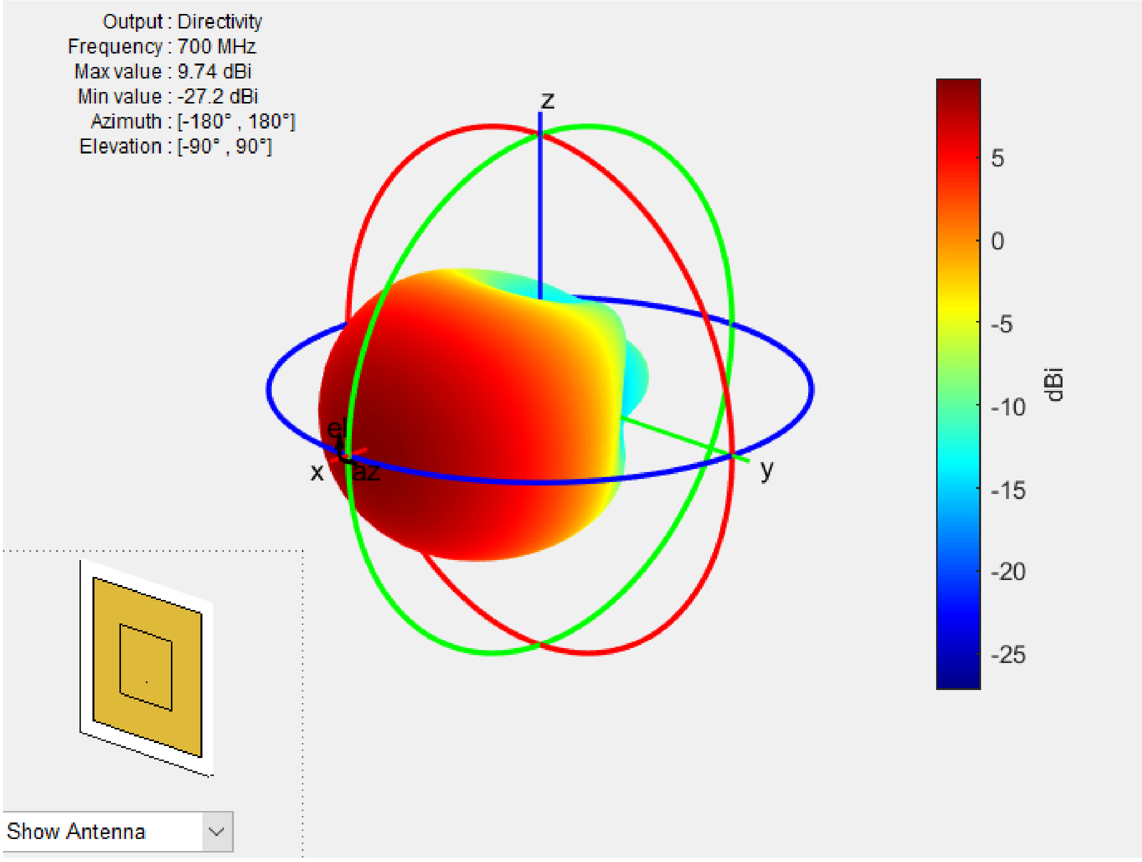


Figure 29. 700MHz Output 5G Network Coverage and SINR Map for 16 by 16 Antenna Array

Figure 29 is the 700MHz output network coverage and its SINR mapping when 16 by 16 rectangular antenna array is used. From Figure 29, we can know that the SINR lies on the excellent RF conditions since it is on the range of ≥ 20dB which is also included in Table 1. When the SINR is ≥ 20dB then the signal is very much strong and the maximum data speeds can be obtained. Thus, we can say that the coverage is optimum when 16 by 16 antenna array is used since the SINR obtained is also optimum.



Output : Directivity
Frequency : 700 MHz
Max value : 9.74 dBi
Min value : -27.2 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

Figure 30. 700MHz 3D Directivity Pattern Rectangular Antenna Array for 16 by 16

Figure 30 is the 700MHz 3D directivity pattern rectangular antenna array for 16 by 16. From Figure 30, we can know that the 3D directivity for 16 by 16 rectangular antenna array is same as that of 8 by 8 rectangular antenna array. So maximum and minimum antenna gain or antenna directivity is also same using 8 by 8 rectangular antenna array or 16 by 16 rectangular antenna array.

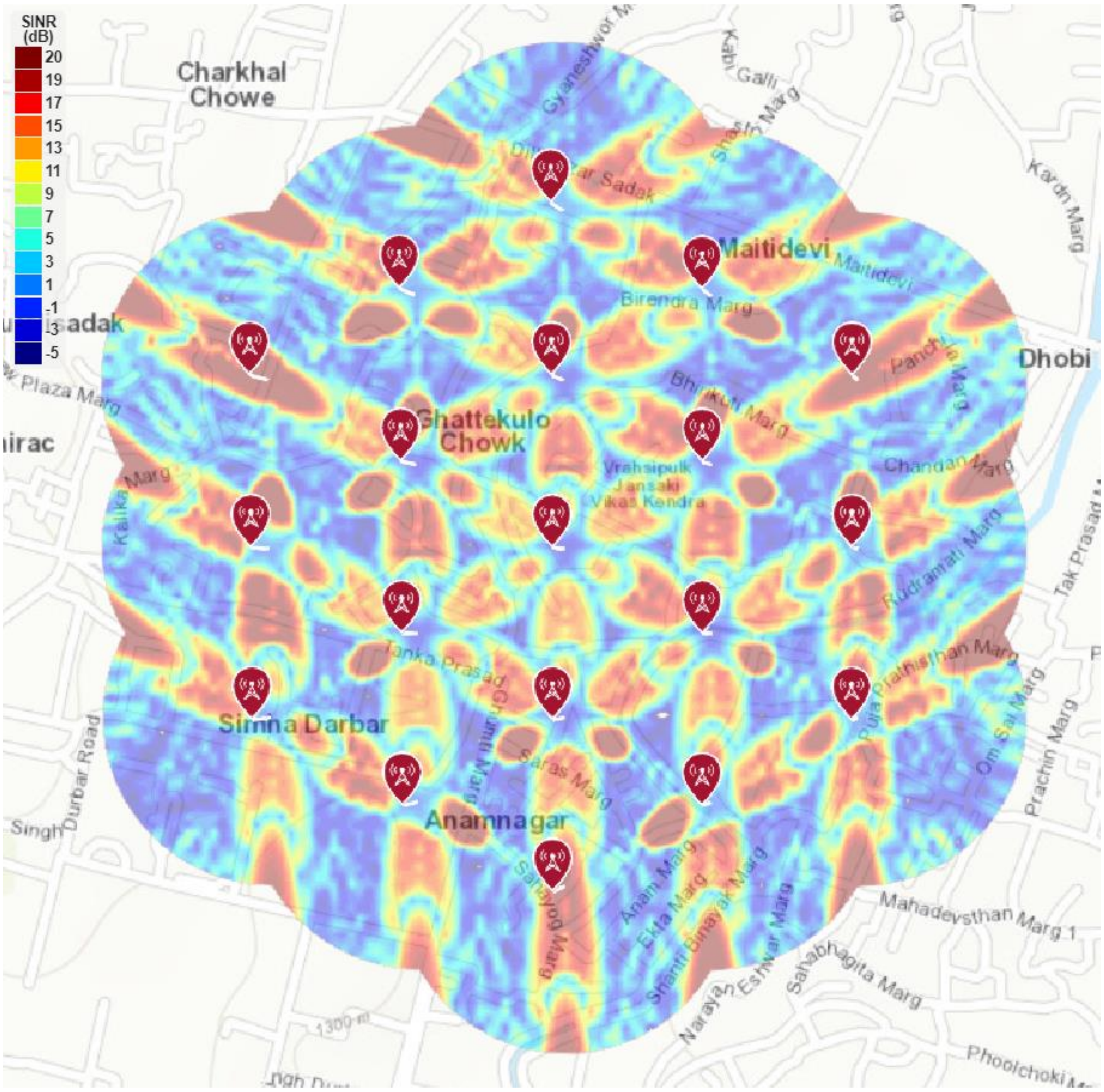


Figure 31. 2300MHz Output 5G Network Coverage and SINR Map for 16 by 16 Antenna Array

Figure 31 is the 2300MHz output network coverage and its SINR mapping when 16 by 16 rectangular antenna array is used. From Figure 31, we can know that the SINR lies on the excellent RF conditions since it is on the range of ≥ 20dB which is also included in Table 1. When the SINR is ≥ 20dB then the signal is very much strong and the maximum data speeds can be obtained. Thus, we can say that the coverage is optimum when 16 by 16 antenna array is used since the SINR obtained is also optimum.

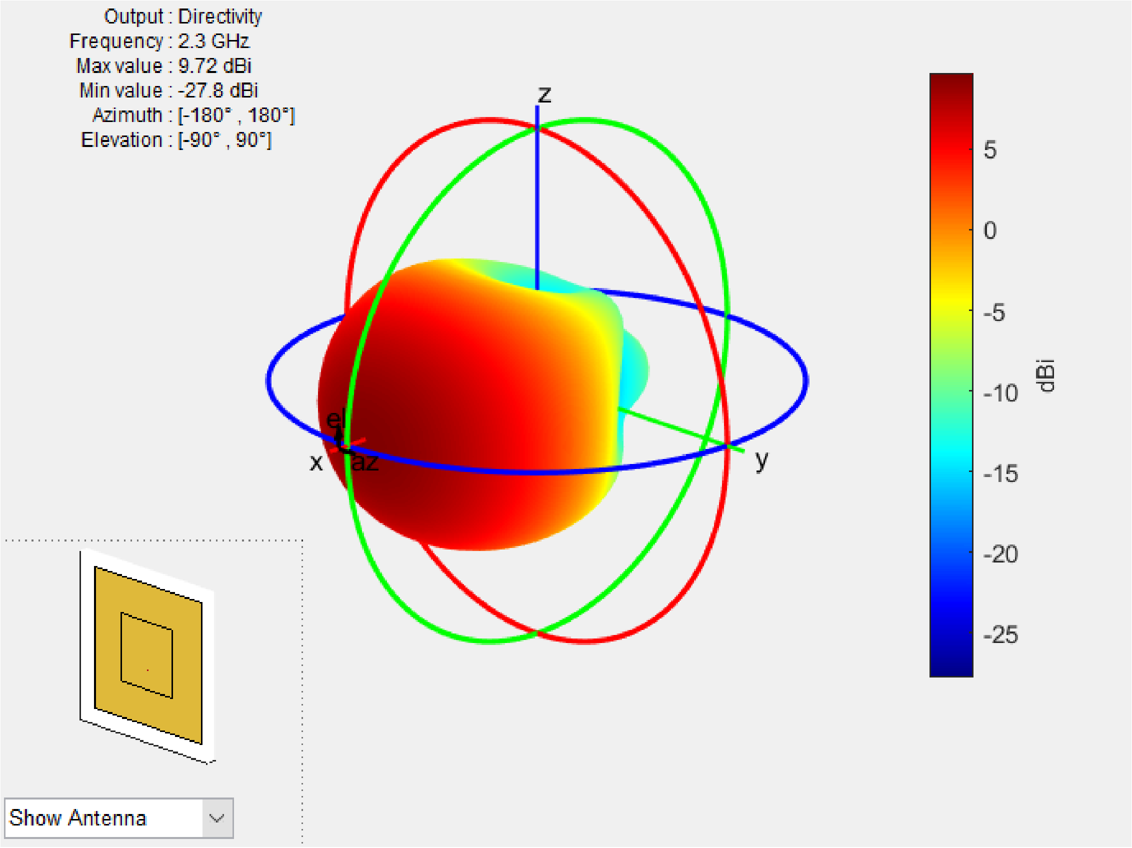


Figure 32. 2300MHz 3D Directivity Pattern Rectangular Antenna Array for 16 by 16

Figure 32 is the 2300MHz 3D directivity pattern rectangular antenna array for 16 by 16. From Figure 32, we can know that the 3D directivity for 16 by 16 rectangular antenna array is same as that of 8 by 8 rectangular antenna array. So maximum and minimum antenna gain or antenna directivity is also same using 8 by 8 rectangular antenna array or 16 by 16 rectangular antenna array.

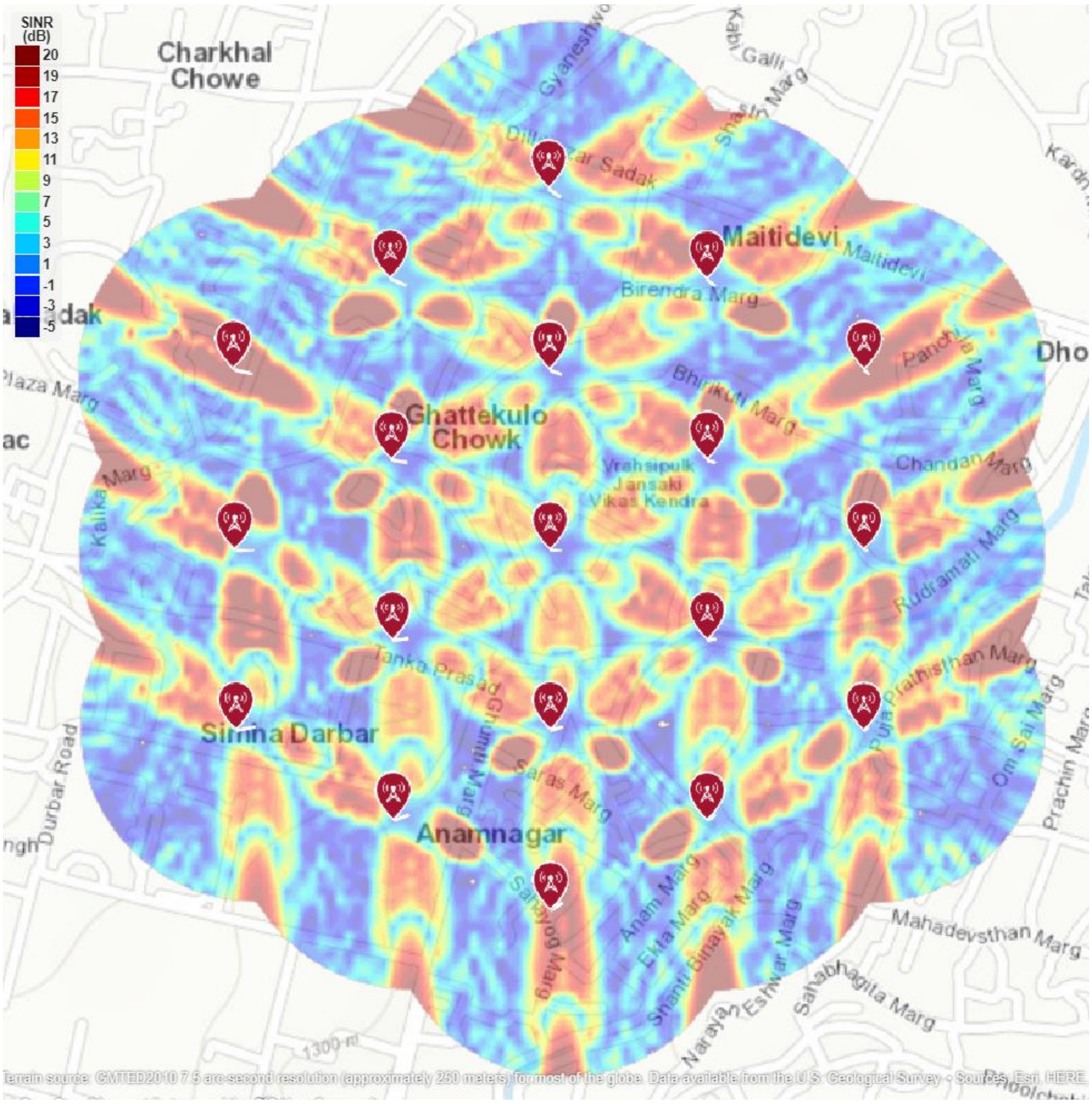
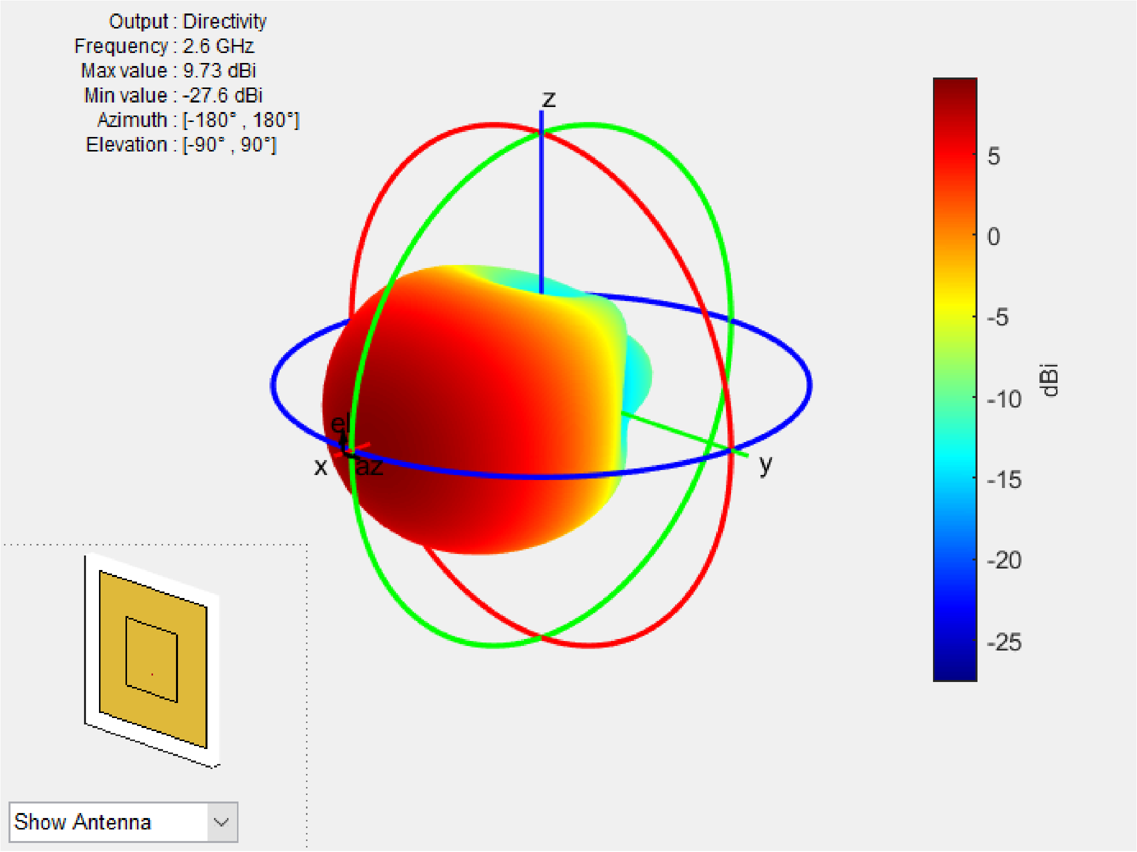


Figure 33. 2600MHz Output 5G Network Coverage and SINR Map for 16 by 16 Antenna Array

Figure 33 is the 2600MHz output network coverage and its SINR mapping when 16 by 16 rectangular antenna array is used. From Figure 33, we can know that the SINR lies on the excellent RF conditions since it is on the range of ≥ 20dB which is also included in Table 1. When the SINR is ≥ 20dB then the signal is very much strong and the maximum data speeds can be obtained. Thus, we can say that the coverage is optimum when 16 by 16 antenna array is used since the SINR obtained is also optimum.



Output : Directivity
Frequency : 2.6 GHz
Max value : 9.73 dBi
Min value : -27.6 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

Figure 34. 2600MHz 3D Directivity Pattern Rectangular Antenna Array for 16 by 16

Figure 34 is the 2600MHz 3D directivity pattern rectangular antenna array for 16 by 16. From Figure 34, we can know that the 3D directivity for 16 by 16 rectangular antenna array is same as that of 8 by 8 rectangular antenna array. So maximum and minimum antenna gain or antenna directivity is also same using 8 by 8 rectangular antenna array or 16 by 16 rectangular antenna array.

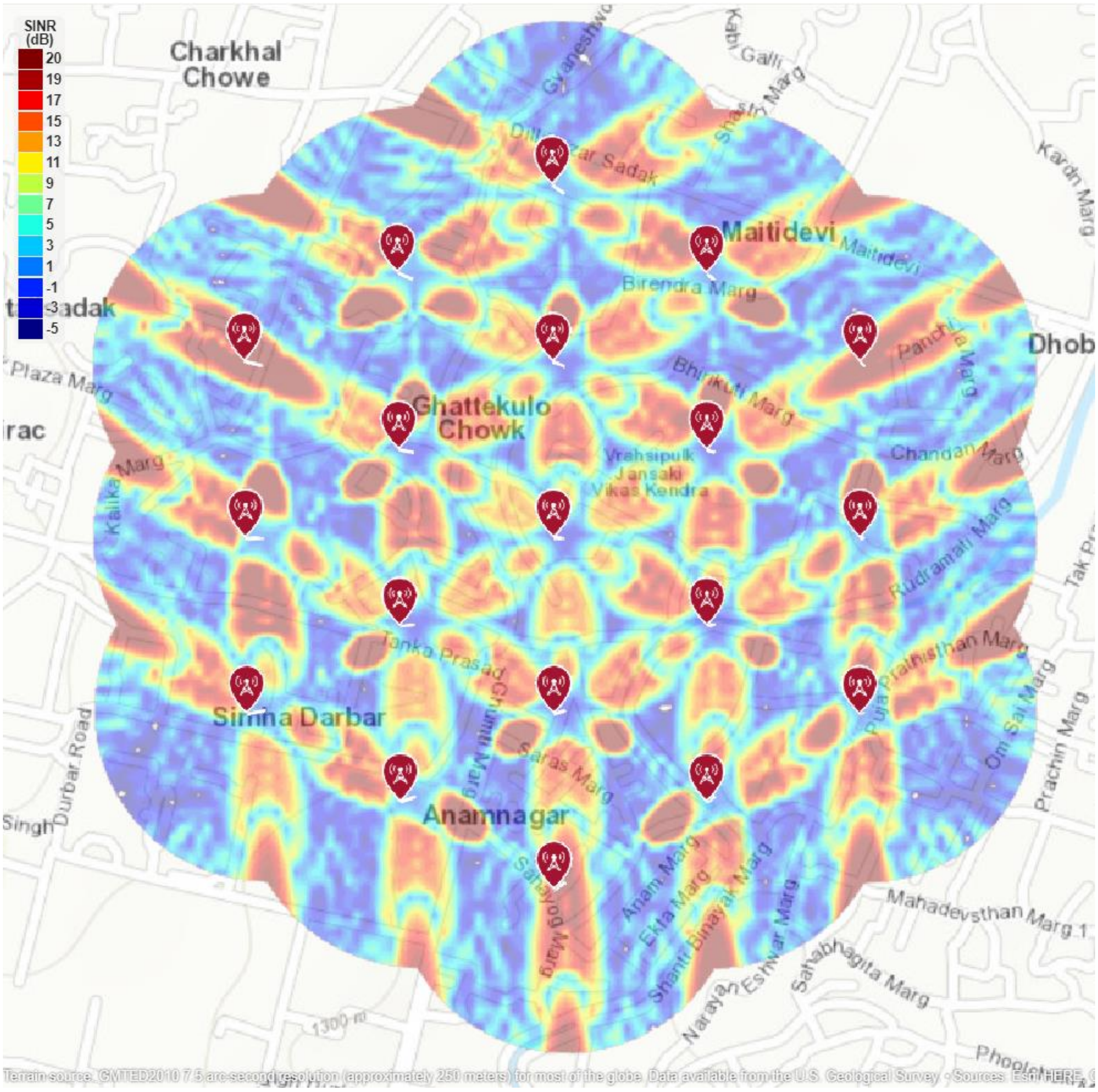
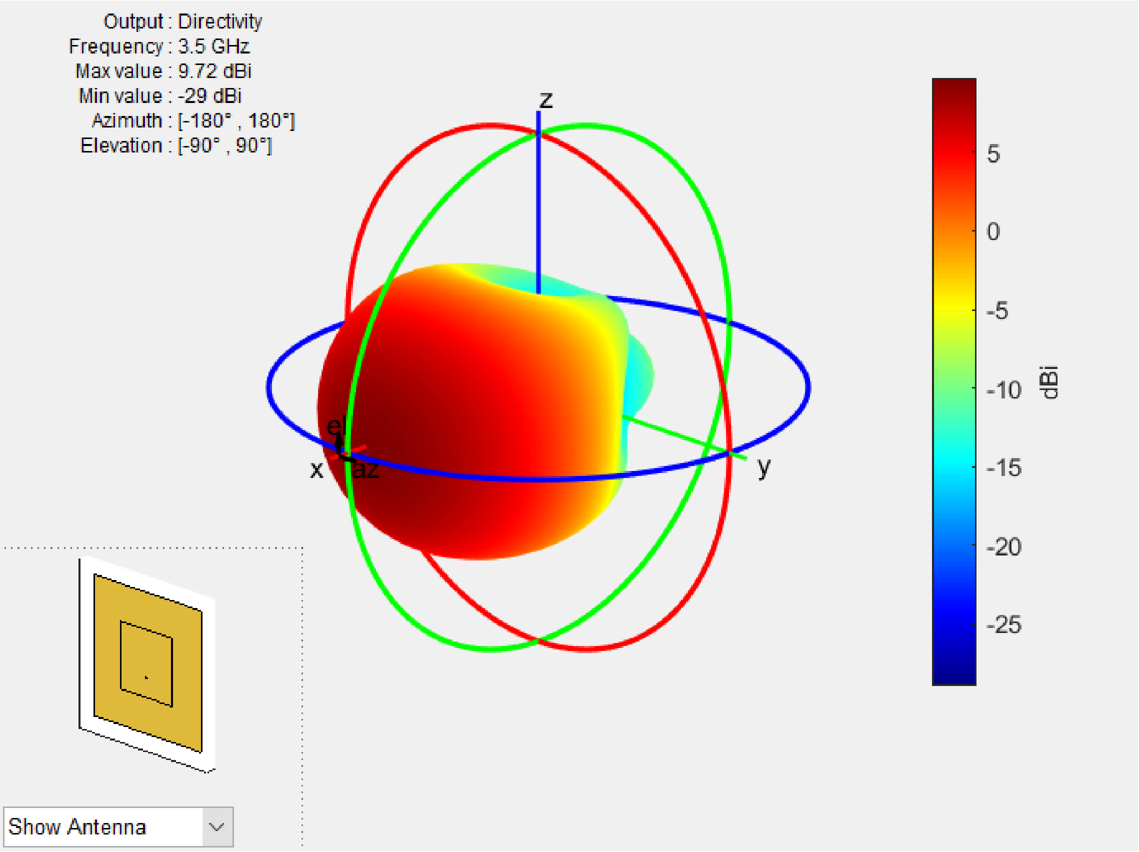


Figure 35. 3500MHz Output 5G Network Coverage and SINR Map for 16 by 16 Antenna Array

Figure 35 is the 3500MHz output network coverage and its SINR mapping when 16 by 16 rectangular antenna array is used. From Figure 35, we can know that the SINR lies on the excellent RF conditions since it is on the range of ≥ 20dB which is also included in Table 1. When the SINR is ≥ 20dB then the signal is very much strong and the maximum data speeds can be obtained. Thus, we can say that the coverage is optimum when 16 by 16 antenna array is used since the SINR obtained is also optimum.



Output : Directivity
Frequency : 3.5 GHz
Max value : 9.72 dBi
Min value : -29 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]

Figure 36. 3500MHz 3D Directivity Pattern Rectangular Antenna Array for 16 by 16

Figure 36 is the 3500MHz 3D directivity pattern rectangular antenna array for 16 by 16. From Figure 36, we can know that the 3D directivity for 16 by 16 rectangular antenna array is same as that of 8 by 8 rectangular antenna array. So maximum and minimum antenna gain or antenna directivity is also same using 8 by 8 rectangular antenna array or 16 by 16 rectangular antenna array.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

We came to conclusion that in case of 4G, the maximum area is covered by 1800MHz frequency than that of 800MHz frequency.

In case of 5G, we can conclude that using antenna array of 16 by 16, maximum SINR can be obtained thus the coverage will also be very much high in the higher frequency spectrum. Maximum antenna gain is delivered at 700MHz frequency. The maximum antenna gain delivered at 700MHz frequency is 9.74dBi and minimum power of -27.2dBi. The maximum antenna gain delivered at 2600MHz frequency is 9.73dBi which little bit less than that of 700MHz frequency and minimum antenna gain is -27.6dBi at 2600MHz. At 2300MHz frequency, the maximum antenna gain delivered is 9.72dBi and minimum is -27.8dBi. At 3500MHz frequency, the maximum antenna gain delivered is 9.72dBi and minimum is -29dBi.

Also, we can conclude that using 16 by 16 rectangular antenna array optimum range is obtained and there is optimum coverage but the antenna gain delivered by the rectangular antenna is same for the 8 by 8 and 16 by 16 rectangular antenna.

This research also discusses the difficulties that must be overcome for a quicker rollout of the 5G network, such as accurate cell site design, acquiring thousands of new cell site locations, energy efficiency, etc.

5.2 Recommendation

Thus, in context of Nepal, we can use 700MHz frequency for network planning of 5G in Kathmandu City, so that to cover optimum range in the existing 4G environment and the cell should be planned in such a way that there is no interference. In order to plan cell without interference SINR Mapping works very well and 16 by 16 rectangular antenna array can be used while planning. In this way, we can analyze the signal characteristics of different 4G and 5G spectrum. Thus, for the upgradation from 4G to 5G, we suggest to use 700MHz frequency in context of Nepal by Mobile Network Operators.

5.3 Future Works

The research is carried out using three sector cells, to make it more effective, we can have analysis using six sector cells in 16 by 16 rectangular antenna array for more signal strength. Also, we can have analysis by changing antenna down tilt. Here only test is done in 700MHz, 2300MHz, 2600MHz and 3500MHz for 5G. So, in future we can test on other frequencies too according to requirement.

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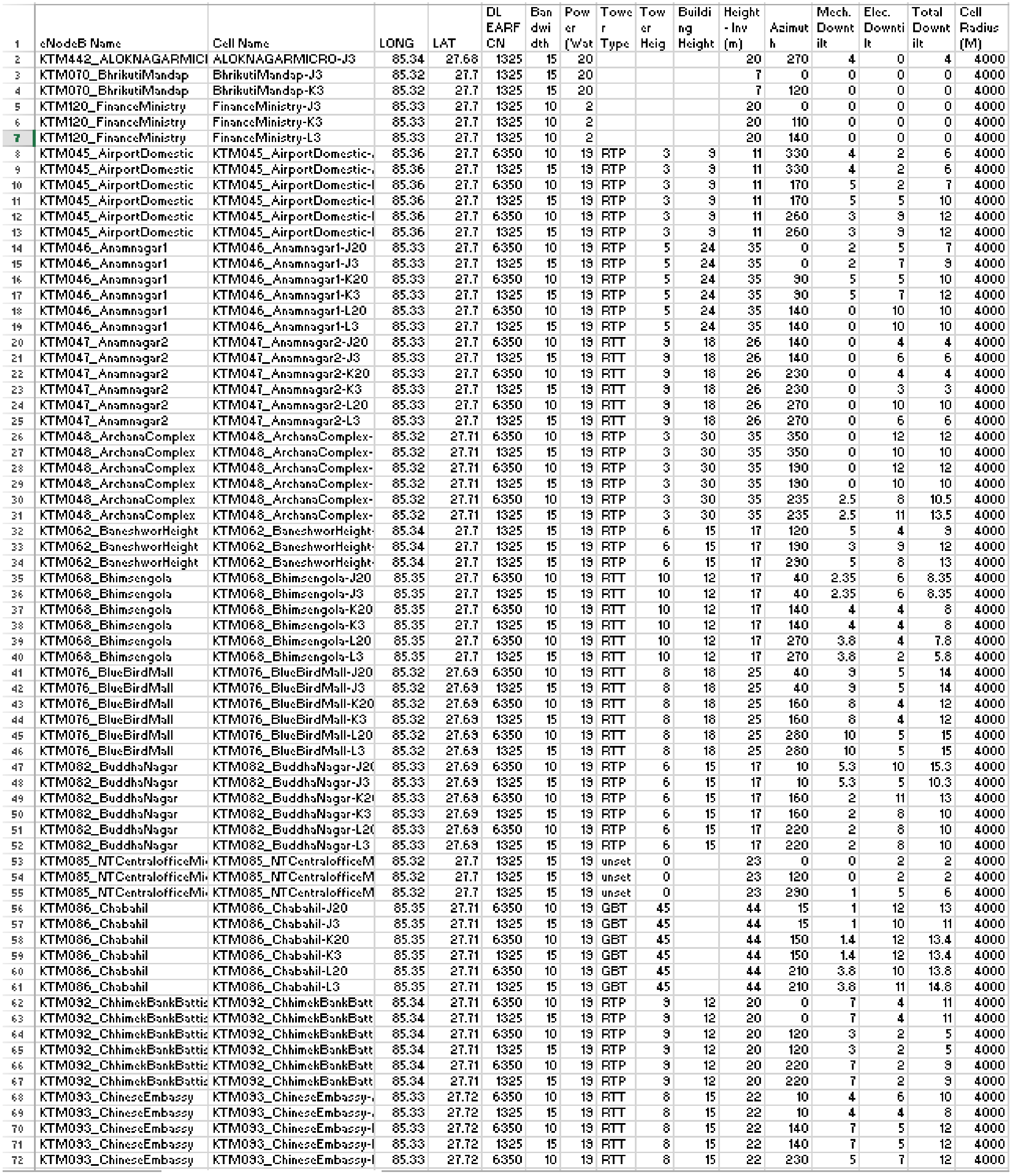
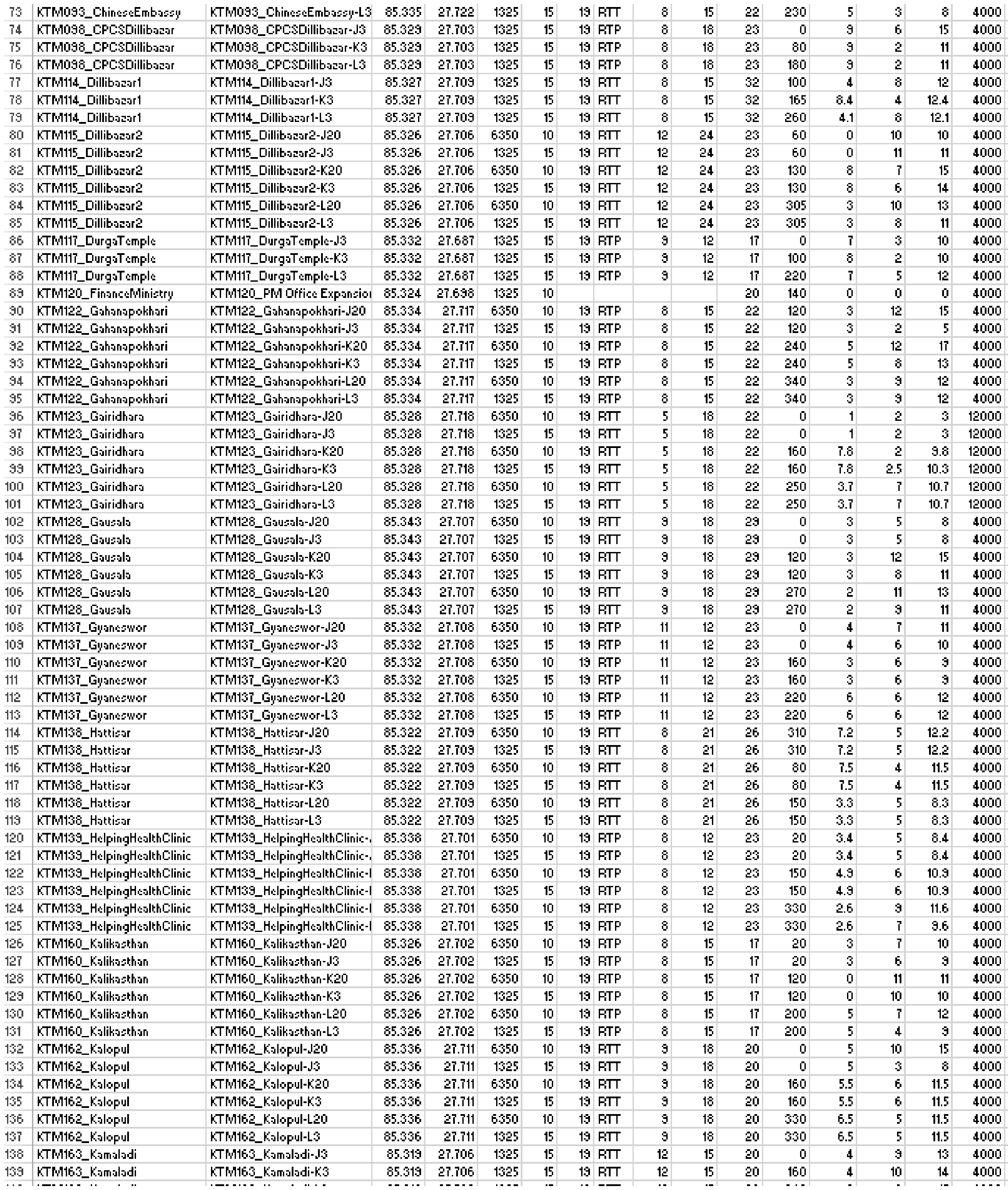
APPENDIX

Nepal Telecom 4G Sample Dataset



1	eNodeB Name	Cell Name	LONG	LAT	DL EARFCN	Bandwidth	Power (Wat	Tower Type	Tower Heig	Building Height	Height - Inv (m)	Azimuth	Mech. Downtilt	Elec. Downtilt	Total Downtilt	Cell Radius (M)
2	KTM442_ALOKNAGARMICI	ALOKNAGARMICRO-J3	85.34	27.68	1325	15	20				20	270	4	0	4	4000
3	KTM070_BhrikutiMandap	BhrikutiMandap-J3	85.32	27.7	1325	15	20				7	0	0	0	0	4000
4	KTM070_BhrikutiMandap	BhrikutiMandap-K3	85.32	27.7	1325	15	20				7	120	0	0	0	4000
5	KTM120_FinanceMinistry	FinanceMinistry-J3	85.33	27.7	1325	10	2				20	0	0	0	0	4000
6	KTM120_FinanceMinistry	FinanceMinistry-K3	85.33	27.7	1325	10	2				20	110	0	0	0	4000
7	KTM120_FinanceMinistry	FinanceMinistry-L3	85.33	27.7	1325	10	2				20	140	0	0	0	4000
8	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	6350	10	19	RTP	3	9	11	330	4	2	6	4000
9	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	1325	15	19	RTP	3	9	11	330	4	2	6	4000
10	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	6350	10	19	RTP	3	9	11	170	5	2	7	4000
11	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	1325	15	19	RTP	3	9	11	170	5	5	10	4000
12	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	6350	10	19	RTP	3	9	11	260	3	9	12	4000
13	KTM045_AirportDomestic	KTM045_AirportDomestic-	85.36	27.7	1325	15	19	RTP	3	9	11	260	3	9	12	4000
14	KTM046_Anamnagar1	KTM046_Anamnagar1-J20	85.33	27.7	6350	10	19	RTP	5	24	35	0	2	5	7	4000
15	KTM046_Anamnagar1	KTM046_Anamnagar1-J3	85.33	27.7	1325	15	19	RTP	5	24	35	0	2	7	9	4000
16	KTM046_Anamnagar1	KTM046_Anamnagar1-K20	85.33	27.7	6350	10	19	RTP	5	24	35	90	5	5	10	4000
17	KTM046_Anamnagar1	KTM046_Anamnagar1-K3	85.33	27.7	1325	15	19	RTP	5	24	35	90	5	7	12	4000
18	KTM046_Anamnagar1	KTM046_Anamnagar1-L20	85.33	27.7	6350	10	19	RTP	5	24	35	140	0	10	10	4000
19	KTM046_Anamnagar1	KTM046_Anamnagar1-L3	85.33	27.7	1325	15	19	RTP	5	24	35	140	0	10	10	4000
20	KTM047_Anamnagar2	KTM047_Anamnagar2-J20	85.33	27.7	6350	10	19	RTT	9	18	26	140	0	4	4	4000
21	KTM047_Anamnagar2	KTM047_Anamnagar2-J3	85.33	27.7	1325	15	19	RTT	9	18	26	140	0	6	6	4000
22	KTM047_Anamnagar2	KTM047_Anamnagar2-K20	85.33	27.7	6350	10	19	RTT	9	18	26	230	0	4	4	4000
23	KTM047_Anamnagar2	KTM047_Anamnagar2-K3	85.33	27.7	1325	15	19	RTT	9	18	26	230	0	3	3	4000
24	KTM047_Anamnagar2	KTM047_Anamnagar2-L20	85.33	27.7	6350	10	19	RTT	9	18	26	270	0	10	10	4000
25	KTM047_Anamnagar2	KTM047_Anamnagar2-L3	85.33	27.7	1325	15	19	RTT	9	18	26	270	0	6	6	4000
26	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	6350	10	19	RTP	3	30	35	350	0	12	12	4000
27	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	1325	15	19	RTP	3	30	35	350	0	10	10	4000
28	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	6350	10	19	RTP	3	30	35	190	0	12	12	4000
29	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	1325	15	19	RTP	3	30	35	190	0	10	10	4000
30	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	6350	10	19	RTP	3	30	35	235	2.5	8	10.5	4000
31	KTM048_ArchanaComplex	KTM048_ArchanaComplex-	85.32	27.71	1325	15	19	RTP	3	30	35	235	2.5	11	13.5	4000
32	KTM062_BaneshworHeight	KTM062_BaneshworHeight-	85.34	27.7	1325	15	19	RTP	6	15	17	120	5	4	9	4000
33	KTM062_BaneshworHeight	KTM062_BaneshworHeight-	85.34	27.7	1325	15	19	RTP	6	15	17	190	3	9	12	4000
34	KTM062_BaneshworHeight	KTM062_BaneshworHeight-	85.34	27.7	1325	15	19	RTP	6	15	17	290	5	8	13	4000
35	KTM068_Bhimsengola	KTM068_Bhimsengola-J20	85.35	27.7	6350	10	19	RTT	10	12	17	40	2.35	6	8.35	4000
36	KTM068_Bhimsengola	KTM068_Bhimsengola-J3	85.35	27.7	1325	15	19	RTT	10	12	17	40	2.35	6	8.35	4000
37	KTM068_Bhimsengola	KTM068_Bhimsengola-K20	85.35	27.7	6350	10	19	RTT	10	12	17	140	4	4	8	4000
38	KTM068_Bhimsengola	KTM068_Bhimsengola-K3	85.35	27.7	1325	15	19	RTT	10	12	17	140	4	4	8	4000
39	KTM068_Bhimsengola	KTM068_Bhimsengola-L20	85.35	27.7	6350	10	19	RTT	10	12	17	270	3.8	4	7.8	4000
40	KTM068_Bhimsengola	KTM068_Bhimsengola-L3	85.35	27.7	1325	15	19	RTT	10	12	17	270	3.8	2	5.8	4000
41	KTM076_BlueBirdMall	KTM076_BlueBirdMall-J20	85.32	27.69	6350	10	19	RTT	8	18	25	40	9	5	14	4000
42	KTM076_BlueBirdMall	KTM076_BlueBirdMall-J3	85.32	27.69	1325	15	19	RTT	8	18	25	40	9	5	14	4000
43	KTM076_BlueBirdMall	KTM076_BlueBirdMall-K20	85.32	27.69	6350	10	19	RTT	8	18	25	160	8	4	12	4000
44	KTM076_BlueBirdMall	KTM076_BlueBirdMall-K3	85.32	27.69	1325	15	19	RTT	8	18	25	160	8	4	12	4000
45	KTM076_BlueBirdMall	KTM076_BlueBirdMall-L20	85.32	27.69	6350	10	19	RTT	8	18	25	280	10	5	15	4000
46	KTM076_BlueBirdMall	KTM076_BlueBirdMall-L3	85.32	27.69	1325	15	19	RTT	8	18	25	280	10	5	15	4000
47	KTM082_BuddhaNagar	KTM082_BuddhaNagar-J2	85.33	27.69	6350	10	19	RTP	6	15	17	10	5.3	10	15.3	4000
48	KTM082_BuddhaNagar	KTM082_BuddhaNagar-J3	85.33	27.69	1325	15	19	RTP	6	15	17	10	5.3	5	10.3	4000
49	KTM082_BuddhaNagar	KTM082_BuddhaNagar-K2	85.33	27.69	6350	10	19	RTP	6	15	17	160	2	11	13	4000
50	KTM082_BuddhaNagar	KTM082_BuddhaNagar-K3	85.33	27.69	1325	15	19	RTP	6	15	17	160	2	8	10	4000
51	KTM082_BuddhaNagar	KTM082_BuddhaNagar-L2	85.33	27.69	6350	10	19	RTP	6	15	17	220	2	8	10	4000
52	KTM082_BuddhaNagar	KTM082_BuddhaNagar-L3	85.33	27.69	1325	15	19	RTP	6	15	17	220	2	8	10	4000
53	KTM085_NTCentralofficeMi	KTM085_NTCentralofficeM	85.32	27.7	1325	15	19	unset	0		23	0	0	2	2	4000
54	KTM085_NTCentralofficeMi	KTM085_NTCentralofficeM	85.32	27.7	1325	15	19	unset	0		23	120	0	2	2	4000
55	KTM085_NTCentralofficeMi	KTM085_NTCentralofficeM	85.32	27.7	1325	15	19	unset	0		23	290	1	5	6	4000
56	KTM086_Chabahil	KTM086_Chabahil-J20	85.35	27.71	6350	10	19	GBT	45		44	15	1	12	13	4000
57	KTM086_Chabahil	KTM086_Chabahil-J3	85.35	27.71	1325	15	19	GBT	45		44	15	1	10	11	4000
58	KTM086_Chabahil	KTM086_Chabahil-K20	85.35	27.71	6350	10	19	GBT	45		44	150	1.4	12	13.4	4000
59	KTM086_Chabahil	KTM086_Chabahil-K3	85.35	27.71	1325	15	19	GBT	45		44	150	1.4	12	13.4	4000
60	KTM086_Chabahil	KTM086_Chabahil-L20	85.35	27.71	6350	10	19	GBT	45		44	210	3.8	10	13.8	4000
61	KTM086_Chabahil	KTM086_Chabahil-L3	85.35	27.71	1325	15	19	GBT	45		44	210	3.8	11	14.8	4000
62	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	6350	10	19	RTP	9	12	20	0	7	4	11	4000
63	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	1325	15	19	RTP	9	12	20	0	7	4	11	4000
64	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	6350	10	19	RTP	9	12	20	120	3	2	5	4000
65	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	1325	15	19	RTP	9	12	20	120	3	2	5	4000
66	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	6350	10	19	RTP	9	12	20	220	7	2	9	4000
67	KTM092_ChhimekBankBattis	KTM092_ChhimekBankBatt	85.34	27.71	1325	15	19	RTP	9	12	20	220	7	2	9	4000
68	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-	85.33	27.72	6350	10	19	RTT	8	15	22	10	4	6	10	4000
69	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-	85.33	27.72	1325	15	19	RTT	8	15	22	10	4	4	8	4000
70	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-	85.33	27.72	6350	10	19	RTT	8	15	22	140	7	5	12	4000
71	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-	85.33	27.72	1325	15	19	RTT	8	15	22	140	7	5	12	4000
72	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-	85.33	27.72	6350	10	19	RTT	8	15	22	230	5	7	12	4000



73	KTM093_ChineseEmbassy	KTM093_ChineseEmbassy-L3	85.335	27.722	1325	15	19	RTT	8	15	22	230	5	3	8	4000
74	KTM098_CPCSDillibazar	KTM098_CPCSDillibazar-J3	85.329	27.703	1325	15	19	RTP	8	18	23	0	9	6	15	4000
75	KTM098_CPCSDillibazar	KTM098_CPCSDillibazar-K3	85.329	27.703	1325	15	19	RTP	8	18	23	80	9	2	11	4000
76	KTM098_CPCSDillibazar	KTM098_CPCSDillibazar-L3	85.329	27.703	1325	15	19	RTP	8	18	23	180	9	2	11	4000
77	KTM114_Dillibazar1	KTM114_Dillibazar1-J3	85.327	27.709	1325	15	19	RTT	8	15	32	100	4	8	12	4000
78	KTM114_Dillibazar1	KTM114_Dillibazar1-K3	85.327	27.709	1325	15	19	RTT	8	15	32	165	8.4	4	12.4	4000
79	KTM114_Dillibazar1	KTM114_Dillibazar1-L3	85.327	27.709	1325	15	19	RTT	8	15	32	260	4.1	8	12.1	4000
80	KTM115_Dillibazar2	KTM115_Dillibazar2-J20	85.326	27.706	6350	10	19	RTT	12	24	23	60	0	10	10	4000
81	KTM115_Dillibazar2	KTM115_Dillibazar2-J3	85.326	27.706	1325	15	19	RTT	12	24	23	60	0	11	11	4000
82	KTM115_Dillibazar2	KTM115_Dillibazar2-K20	85.326	27.706	6350	10	19	RTT	12	24	23	130	8	7	15	4000
83	KTM115_Dillibazar2	KTM115_Dillibazar2-K3	85.326	27.706	1325	15	19	RTT	12	24	23	130	8	6	14	4000
84	KTM115_Dillibazar2	KTM115_Dillibazar2-L20	85.326	27.706	6350	10	19	RTT	12	24	23	305	3	10	13	4000
85	KTM115_Dillibazar2	KTM115_Dillibazar2-L3	85.326	27.706	1325	15	19	RTT	12	24	23	305	3	8	11	4000
86	KTM117_DurgaTemple	KTM117_DurgaTemple-J3	85.332	27.687	1325	15	19	RTP	9	12	17	0	7	3	10	4000
87	KTM117_DurgaTemple	KTM117_DurgaTemple-K3	85.332	27.687	1325	15	19	RTP	9	12	17	100	8	2	10	4000
88	KTM117_DurgaTemple	KTM117_DurgaTemple-L3	85.332	27.687	1325	15	19	RTP	9	12	17	220	7	5	12	4000
89	KTM120_FinanceMinistry	KTM120_PM Office Expansior	85.324	27.698	1325	10					20	140	0	0	0	4000
90	KTM122_Gahanapokhari	KTM122_Gahanapokhari-J20	85.334	27.717	6350	10	19	RTP	8	15	22	120	3	12	15	4000
91	KTM122_Gahanapokhari	KTM122_Gahanapokhari-J3	85.334	27.717	1325	15	19	RTP	8	15	22	120	3	2	5	4000
92	KTM122_Gahanapokhari	KTM122_Gahanapokhari-K20	85.334	27.717	6350	10	19	RTP	8	15	22	240	5	12	17	4000
93	KTM122_Gahanapokhari	KTM122_Gahanapokhari-K3	85.334	27.717	1325	15	19	RTP	8	15	22	240	5	8	13	4000
94	KTM122_Gahanapokhari	KTM122_Gahanapokhari-L20	85.334	27.717	6350	10	19	RTP	8	15	22	340	3	9	12	4000
95	KTM122_Gahanapokhari	KTM122_Gahanapokhari-L3	85.334	27.717	1325	15	19	RTP	8	15	22	340	3	9	12	4000
96	KTM123_Gairidhara	KTM123_Gairidhara-J20	85.328	27.718	6350	10	19	RTT	5	18	22	0	1	2	3	12000
97	KTM123_Gairidhara	KTM123_Gairidhara-J3	85.328	27.718	1325	15	19	RTT	5	18	22	0	1	2	3	12000
98	KTM123_Gairidhara	KTM123_Gairidhara-K20	85.328	27.718	6350	10	19	RTT	5	18	22	160	7.8	2	9.8	12000
99	KTM123_Gairidhara	KTM123_Gairidhara-K3	85.328	27.718	1325	15	19	RTT	5	18	22	160	7.8	2.5	10.3	12000
100	KTM123_Gairidhara	KTM123_Gairidhara-L20	85.328	27.718	6350	10	19	RTT	5	18	22	250	3.7	7	10.7	12000
101	KTM123_Gairidhara	KTM123_Gairidhara-L3	85.328	27.718	1325	15	19	RTT	5	18	22	250	3.7	7	10.7	12000
102	KTM128_Gausala	KTM128_Gausala-J20	85.343	27.707	6350	10	19	RTT	9	18	29	0	3	5	8	4000
103	KTM128_Gausala	KTM128_Gausala-J3	85.343	27.707	1325	15	19	RTT	9	18	29	0	3	5	8	4000
104	KTM128_Gausala	KTM128_Gausala-K20	85.343	27.707	6350	10	19	RTT	9	18	29	120	3	12	15	4000
105	KTM128_Gausala	KTM128_Gausala-K3	85.343	27.707	1325	15	19	RTT	9	18	29	120	3	8	11	4000
106	KTM128_Gausala	KTM128_Gausala-L20	85.343	27.707	6350	10	19	RTT	9	18	29	270	2	11	13	4000
107	KTM128_Gausala	KTM128_Gausala-L3	85.343	27.707	1325	15	19	RTT	9	18	29	270	2	9	11	4000
108	KTM137_Gyaneswor	KTM137_Gyaneswor-J20	85.332	27.708	6350	10	19	RTP	11	12	23	0	4	7	11	4000
109	KTM137_Gyaneswor	KTM137_Gyaneswor-J3	85.332	27.708	1325	15	19	RTP	11	12	23	0	4	6	10	4000
110	KTM137_Gyaneswor	KTM137_Gyaneswor-K20	85.332	27.708	6350	10	19	RTP	11	12	23	160	3	6	9	4000
111	KTM137_Gyaneswor	KTM137_Gyaneswor-K3	85.332	27.708	1325	15	19	RTP	11	12	23	160	3	6	9	4000
112	KTM137_Gyaneswor	KTM137_Gyaneswor-L20	85.332	27.708	6350	10	19	RTP	11	12	23	220	6	6	12	4000
113	KTM137_Gyaneswor	KTM137_Gyaneswor-L3	85.332	27.708	1325	15	19	RTP	11	12	23	220	6	6	12	4000
114	KTM138_Hattisar	KTM138_Hattisar-J20	85.322	27.709	6350	10	19	RTT	8	21	26	310	7.2	5	12.2	4000
115	KTM138_Hattisar	KTM138_Hattisar-J3	85.322	27.709	1325	15	19	RTT	8	21	26	310	7.2	5	12.2	4000
116	KTM138_Hattisar	KTM138_Hattisar-K20	85.322	27.709	6350	10	19	RTT	8	21	26	80	7.5	4	11.5	4000
117	KTM138_Hattisar	KTM138_Hattisar-K3	85.322	27.709	1325	15	19	RTT	8	21	26	80	7.5	4	11.5	4000
118	KTM138_Hattisar	KTM138_Hattisar-L20	85.322	27.709	6350	10	19	RTT	8	21	26	150	3.3	5	8.3	4000
119	KTM138_Hattisar	KTM138_Hattisar-L3	85.322	27.709	1325	15	19	RTT	8	21	26	150	3.3	5	8.3	4000
120	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-.	85.338	27.701	6350	10	19	RTP	8	12	23	20	3.4	5	8.4	4000
121	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-.	85.338	27.701	1325	15	19	RTP	8	12	23	20	3.4	5	8.4	4000
122	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-I	85.338	27.701	6350	10	19	RTP	8	12	23	150	4.9	6	10.9	4000
123	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-I	85.338	27.701	1325	15	19	RTP	8	12	23	150	4.9	6	10.9	4000
124	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-I	85.338	27.701	6350	10	19	RTP	8	12	23	330	2.6	9	11.6	4000
125	KTM139_HelpingHealthClinic	KTM139_HelpingHealthClinic-I	85.338	27.701	1325	15	19	RTP	8	12	23	330	2.6	7	9.6	4000
126	KTM160_Kalikasthan	KTM160_Kalikasthan-J20	85.326	27.702	6350	10	19	RTP	8	15	17	20	3	7	10	4000
127	KTM160_Kalikasthan	KTM160_Kalikasthan-J3	85.326	27.702	1325	15	19	RTP	8	15	17	20	3	6	9	4000
128	KTM160_Kalikasthan	KTM160_Kalikasthan-K20	85.326	27.702	6350	10	19	RTP	8	15	17	120	0	11	11	4000
129	KTM160_Kalikasthan	KTM160_Kalikasthan-K3	85.326	27.702	1325	15	19	RTP	8	15	17	120	0	10	10	4000
130	KTM160_Kalikasthan	KTM160_Kalikasthan-L20	85.326	27.702	6350	10	19	RTP	8	15	17	200	5	7	12	4000
131	KTM160_Kalikasthan	KTM160_Kalikasthan-L3	85.326	27.702	1325	15	19	RTP	8	15	17	200	5	4	9	4000
132	KTM162_Kalopul	KTM162_Kalopul-J20	85.336	27.711	6350	10	19	RTT	9	18	20	0	5	10	15	4000
133	KTM162_Kalopul	KTM162_Kalopul-J3	85.336	27.711	1325	15	19	RTT	9	18	20	0	5	3	8	4000
134	KTM162_Kalopul	KTM162_Kalopul-K20	85.336	27.711	6350	10	19	RTT	9	18	20	160	5.5	6	11.5	4000
135	KTM162_Kalopul	KTM162_Kalopul-K3	85.336	27.711	1325	15	19	RTT	9	18	20	160	5.5	6	11.5	4000
136	KTM162_Kalopul	KTM162_Kalopul-L20	85.336	27.711	6350	10	19	RTT	9	18	20	330	6.5	5	11.5	4000
137	KTM162_Kalopul	KTM162_Kalopul-L3	85.336	27.711	1325	15	19	RTT	9	18	20	330	6.5	5	11.5	4000
138	KTM163_Kamaladi	KTM163_Kamaladi-J3	85.319	27.706	1325	15	19	RTT	12	15	20	0	4	9	13	4000
139	KTM163_Kamaladi	KTM163_Kamaladi-K3	85.319	27.706	1325	15	19	RTT	12	15	20	160	4	10	14	4000