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NOISE REDUCTION AND SIGNAL PATH LOSS ANALYSIS OF FM TRANSMISSION IN HILLY TERRAIN OF NEPAL: CASE STUDY OF DOLAKHA

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Abstract

This paper investigates the effects of terrain-induced signal loss on FM radio transmission for community radio stations operating in the hilly regions of Nepal, with a specific focus on Dolakha district. Using terrain profiling through Google Earth and signal modeling with Free Space Path Loss (FSPL) along with knife-edge diffraction loss assumptions, we simulate the received signal strength at various distances from a 100 MHz FM transmitter in Charikot. The results demonstrate critical signal degradation in NLoS areas due to terrain obstructions. Based on the findings, repeater stations and directional antennas are recommended to optimize signal delivery in shadowed zones.

1. Introduction

The effects of signal loss due to terrain obstructions have been widely studied in wireless communication literature [1, 2]. Community radio in Nepal plays a vital role in information dissemination, especially in rural and hilly areas. However, the complex topography of regions like Dolakha significantly affects signal propagation. Traditional FSPL models often underestimate the impact of hills and obstructions. This paper explores practical signal loss modeling by incorporating elevation profiles and simplified diffraction assumptions, aiming to propose a methodology suitable for low-resource environments.

Keywords and phrases: FM signal loss, terrain modeling, Dolakha, free space path loss, knife-edge diffraction, community radio, wireless propagation.

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2. Methodology

The transmitter is assumed to be located at Charikot, Dolakha (lat, long) 27.655329, 86.053439 broadcasting at 100 MHz with 50 dBm power and 3 dBi antenna gain. The receiver antenna is 2 meters above ground at certain miles from the transmitter to Melung, Dolakha. Terrain profiling was done using Google Earth, measuring elevation at 0.75-mile intervals up to 10.5 miles. The Free Space Path Loss (FSPL) model is used for LoS points. For NLoS segments-determined visually from elevation blocking the LoS-an additional 15 dB knife-edge diffraction loss is assumed.

The values used in these assumptions are guided by standard propagation references [1, 2].

- Frequency: 100 MHz.
- Transmit Power: 50 dBm (100W).
- Tx/Rx Antenna Gain: 3 dBi each.
- Receiver Sensitivity Threshold: ~ -90 dBm.
- Additional Diffraction Loss (NLoS only): 15 dB.

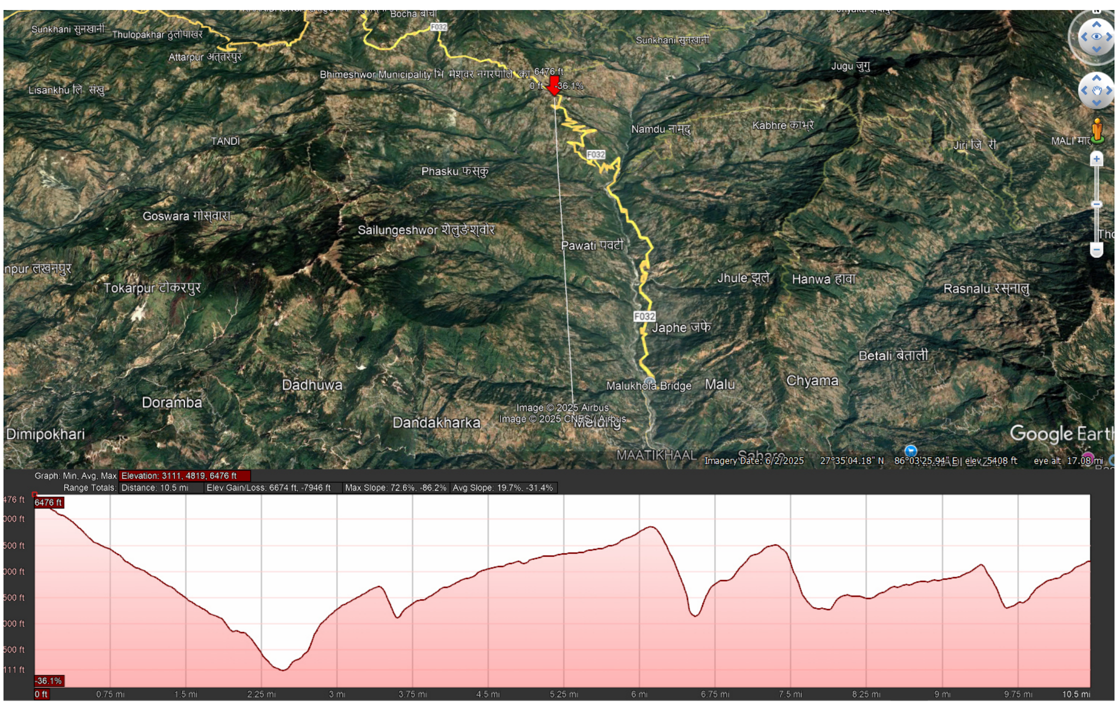

Figure 1. Elevation profile from Charikot to Melung.

Table 1. Data from elevation profile

Miles	Foot from sea level
0.75	5432
1.5	4484
2.25	3431
3	4288
3.75	4395
4.5	5053
5.25	5346
6	5772
6.75	4769
7.5	5155
8.25	4494
9	4851
9.75	4409
10.5	5206

3. Result and Analysis

Table 2. Power analysis across different location

Mile	Elev. (ft)	FSPL (dB)	Knife-Edge Loss (dB)	Total Path Loss (dB)	Received Power (dBm)
0.75	5432	74.07	0	74.07	-18.07
1.5	4484	80.09	0	80.09	-24.09
2.25	3431	83.62	0	83.62	-27.62
3.0	4288	86.12	0	86.12	-30.12
3.75	4395	88.05	15	103.05	-47.05
4.5	5053	89.64	0	89.64	-33.64
5.25	5346	90.98	0	90.98	-34.98
6.0	5772	92.14	0	92.14	-36.14
6.75	4769	93.16	15	108.16	-52.16
7.5	5155	94.07	15	109.07	-53.07
8.25	4494	94.90	15	109.90	-53.90
9.0	4851	95.66	15	110.66	-54.66
9.75	4409	96.35	15	111.35	-55.35
10.5	5206	97.00	15	112.00	-56.00

$$\text{LOS: FSPL(dB)} = 20\log10(\text{dkm}) + 20\log10(\text{fMHz}) + 32.44, \quad (1)$$

$$\text{NLOS: FSPL(dB)} + 15\text{dB}. \quad (2)$$

The results indicate that the received power begins at acceptable levels for line-of-sight (LoS) paths, ranging from approximately –18 dBm to –36 dBm up to 6 miles. However, beyond this point, where terrain obstructions cause non-line-of-sight (NLoS) conditions, the signal strength drops sharply due to added knife-edge diffraction losses. All NLoS segments show received power falling below the commonly accepted –50 dBm threshold required for reliable FM reception, with some reaching as low as –56 dBm. This significant reduction in power confirms the severe impact of hilly terrain on signal propagation and highlights the necessity of supplementary measures such as repeaters, directional antennas, or increased transmission elevation for consistent broadcast quality across remote regions. While the receiver sensitivity is around –90 dBm, a received power of at least –50 dBm is typically required for reliable and high-quality FM audio reception [1].

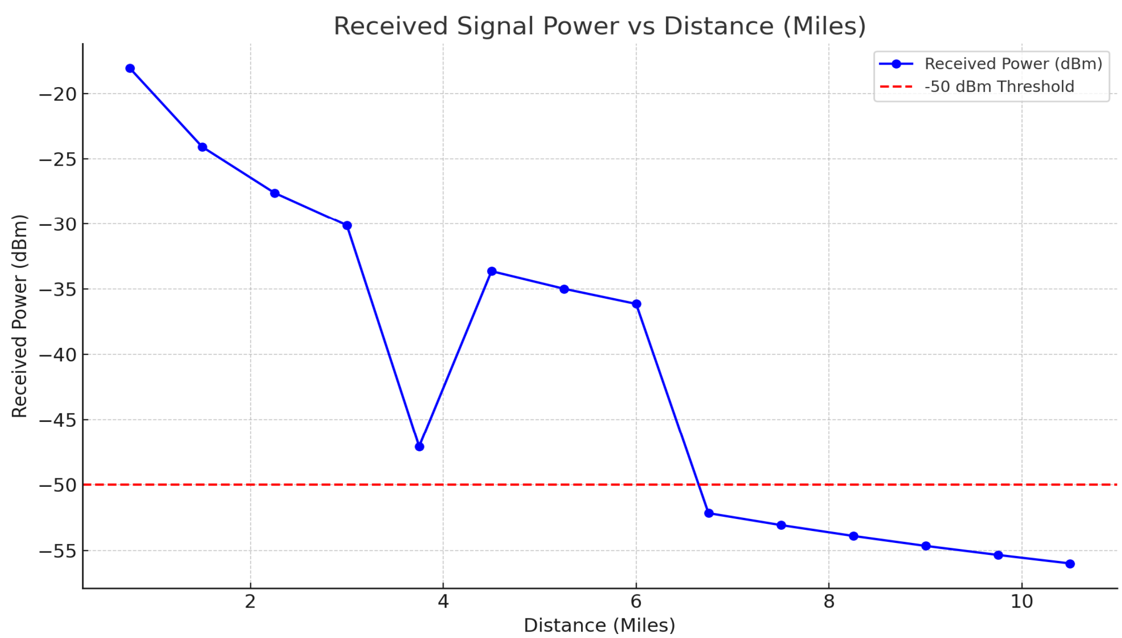

Figure 2. Received power at various distances from FM Transmitter (with -50dBm Threshold).

While the receiver sensitivity is around -90 dBm, a received power of at least -50 dBm is typically required for reliable and high-quality FM audio reception [1].

4. Conclusion

Using a combination of FSPL and knife-edge assumptions with real terrain data allows community radio stations to assess coverage feasibility in hilly areas like Dolakha. The severe drop in received power due to terrain blockages emphasizes the need for signal repeaters or alternate positioning strategies. Future work may involve exact ITU-based diffraction calculations or integrating clutter loss due to vegetation and buildings for more accuracy.

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