Performance Evaluation of Propagation Model in DVB-T2 Broadcasting: Case Study in Kebumen

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Abstract— The widespread change from analog to digital television broadcasting in Indonesia has led to the emergence of blank spots in some areas. To overcome this problem, an optimal propagation model is needed to improve transmitter coverage, energy efficiency, and field strength through optimal transmit power for DVB-T2 broadcasts. This research addresses the selection and analysis of an appropriate propagation model, focusing on the application of the Longley-Rice and ITU-R.P 1546-6 models in the Kebumen region of Central Java, Indonesia. This study specifically compares the two models to determine the most effective model in reducing blank spots in the area. The results show that the Longley-Rice model produces greater field strength than the ITU-R.P 1546-6 model. In addition, this study also found that the farther the receiver is from the transmitter, the higher the free space loss value. This is because due to the hilly geographical conditions in the Kebumen area, it causes high loss. And the farther the receiver is from the transmitter and the greater the frequency value, the greater the field strength value. This research not only provides relevant empirical data for the Kebumen region but also offers insights that can be used in the optimization of digital broadcasting in other urban environments in the future.

Keywords— DVB-T2; Field Strength; Loss; Propagation

I. INTRODUCTION

In this world, in recent years, analog broadcasting has been replaced by digital broadcasting. Digital technology is considered more effective than analog technology. The first debate on the transition was on June 17, 2000, at the Regional Radiocommunication Conference (RRC-06) sponsored by the International Telecommunications Union (ITU). During the discussion, the Analogue Switch-Off (ASO) period used for the transition from analog to digital broadcasting officially ended.[1][2]. All countries are expected to switch to digital to meet the ITU's goals for the conference. The implementation of Analog Switch Off (ASO) has been implemented in a number of countries, and it will take at least 9 to 14 years, to reach the final digital television broadcasting stage. These countries are the United States which conducted ASO on June 12, 2009, Japan on July 24, 2011, Canada on August 31, 2011, the United Kingdom and Ireland on October 24, 2012, and Australia in 2013 [3].

Indonesia, which is a member of the ITU, only conducted an Analog Switch Off (ASO) in 2018, lagging other ASEAN countries [3]. However, the readiness of the community to migrate to digital TV broadcasts is not yet fully evenly distributed. Meanwhile, the switch to digital television broadcasts also brings significant benefits in improving the quality of the industry as a wholen [4]. Since 2012, Indonesia has officially joined the Digital Video Broadcasting-Terrestrial Second Generation (DVB-T2) [5]. DVB-T2 offers noise-free television broadcast quality, more broadcast channels, better picture quality, and more efficient use of frequency bands and infrastructure [4]. In this regard, DVB-T2 improves modulation and coding schemes by efficiently utilizing the frequency spectrum for broadcasting services. In Indonesia, the DVB-T2 standard is regulated in Ministerial Regulation No. 05/PER/M.KOMINFO/2/2012 [6][7].

Despite the implementation of the ASO policy and the advantages of DVB-T2, migration to digital television in Indonesia still faces challenges, especially in equalizing access to broadcasts in urban areas. The main obstacles in this process include limited digital broadcasting infrastructure, lack of public socialization, and limited access to receiving equipment. In addition, the difference between analog and digital broadcasting often causes confusion, especially for people who do not fully understand the benefits of this change. As a result, negative perceptions of ASO have emerged, including the notion that the use of Set Top Boxes is an economic burden [8].

Terrestrial digital television broadcasting is a broadcasting system that utilizes Very High Frequency (VHF) and Ultra High Frequency (UHF) radio frequencies, similar to analog broadcasting, but with a digital-based content format, namely Digital Video Broadcasting-Terrestrial Second Generation (DVB-T2) [9]. In planning the design of DVB-T2 broadcasting networks, propagation models with accurate path loss calculations are very important. The path loss value is influenced by field contours, environmental conditions, ambient air, the distance between the transmitter and receiver, as well as the height and location of the antenna. The greater the path loss value, the lower the received signal quality and vice versa [5].

Propagation models are used to estimate the received signal strength based on the distance between the transmitter and receiver. The model helps determine the signal coverage as well as estimate the signal attenuation during propagation [10]. The radio waves emitted by the antenna propagate in all directions and are affected by natural conditions and their frequency while traveling to the receiver [11]. signals propagate through radio waves close to the earth's surface at VHF and UHF frequencies

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[12]. Path loss in telecommunications refers to the attenuation of a signal during propagation, which affects the field strength in the service area. These field strength measurements can be made across the entire frequency spectrum, including beyond UHF [13]. COST 231, Okumura-Hatta, ITU-R P.1546-6, Longley Rice, dan Lee Macro Cell is a category of empirical propagation models according to the theory of electromagnetic wave propagation where the model based on a large amount of measurement data is very simple but not very accurate [13].

The Longley-Rice model was developed by the National Telecommunications and Information Administration (NTIA) and the Institute for Telecommunication Sciences irregular Terrain Model (ITS-ITM) in the United States [13]. While the ITU-R P.1546-6 model was developed by the International Telecommunication Union - Radiocommunication Sector (ITU-R) [14]. The Longley–Rice model is widely adopted due to its relatively advanced and comprehensive approach, which incorporates various environmental parameters. As a result, it is considered appropriate for television and radio broadcasting applications under a broad range of environmental conditions [5]. This study [5] not only provides empirical data specific to the city of Semarang but also provides insights that can guide the optimization of digital broadcasting in similar urban environments in the future.

This study aims to determine the most optimal propagation model by comparing parameters free space loss, attenuation, cluter loss, field strength and coverage area [15] [16]. The ITU-R P.1546-6 and Longley-Rice models were applied for DVB-T2 in urban areas, specifically in the Kebumen area with an area of 1,281.115 km² [17]. The Kebumen region is categorized as an urban area with varied topography, coastal areas, hills and lowlands that can produce approaches that are close to real propagation conditions in the field. Thus, this study can evaluate the performance of each model to understand its advantages and limitations. Despite using different methods, this comparison helps identify models that are more accurate and reliable in predicting real conditions.

II. Method

A. Research Framework

Figure 1 illustrates of the signal propagation from the digital television transmitter (TV Operator) to the receiver (TV Viewers) in the DVB-T2 system. Where the propagation model in this context explains how the TV signal spreads from the transmitter to the receiver. The area of coverage area is shown in several colored circles, which can indicate zones with different signal reception quality.

In this research, the propagation model used is ITU-R P.1546-6 and Longley Rice with urban areas specifically in the Kebumen area, Central Java with an area of 1,281.115 km² with 26 sub-districts and a population of 1,446,833 [17]. This study uses a radio simulation software approach that considers the characteristic parameters of each propagation model used, enabling comprehensive analysis and comparison of propagation performance.

The parameters were obtained from one of the television stations in Kebumen, Central Java and have been adjusted to the environmental conditions. The parameters can be seen in Table I. In this research, the values of field strength, free space loss, attenuation, clutter loss and coverage area of the two propagation models are considered. Illustration of the DVB-T2 antenna propagation image can be seen in Figure 1 [18].

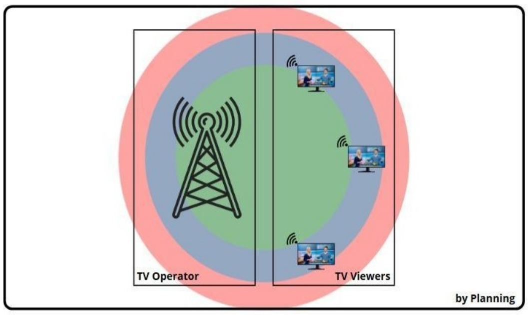

Figure 1. Propagation Urban Area

TABLE I. Environmental Parameter

Parameter	Limits
Latitude Tx	7.69758 LS
Longitude Tx	109.72041 BT
Site Elevation (m)	108.6
Frequency (Mhz)	570
Tx Power (watt)	650
Type Cable (inch)	LDF4-50A 1/2”
Cable length (m)	80
Cable Loss (dB)	4.3
Additional loss (dB)	0.27
Antenna Height (m)	60
Antenna Gain (dBi)	17
Azimuth antenna (deg.)	0
Beam Tilt (you.)	0
Distance (km)	40

B. Propagation Models

1) ITU-R P.1546-6

Signals in wireless communications suffer transmission loss due to distance, frequency, topography, weather, and environment. Basic transmission loss estimates the amount of signal attenuation during propagation [5]. This propagation model is a method to predict the propagation of telecommunication transmissions in the frequency range of 30 MHz to 3000 MHz [2]. Field Strength is calculated for 1 Kw Effective Radiated Power (ERP). The path loss value can be seen in the equation (1) [2].

$$L_f = 61.851 + 20 *log\ log\ (d) \quad (1)$$

2) Longley Rice

This propagation model is used for frequencies from 20 MHz to 2000 MHz, antenna heights from 0.5 to 3000 m and distances from 200 m to 500 km. It is based on electromagnetics and statistics taking into account terrain features and radio measurements [19]. The parameters Longley-Rice can be seen in Table II.

TABLE II. Longley-Rice parameters [5]

Parameter	Definition	Limits	Units
f	Operating frequency	$20 - 20000$	MHz
d	Horizontal length	$1 - 2000$	km
p	Percentage time	$0.1 - 99.9\%$	%
h_1	Transmitter antenna height	< 3000	m
h_a	Transmitter antenna height above ground	> 0.5	m
h_b	Effective antenna height of transmitter	None	m
h_2	Receiver antenna height above ground	$0.5 < h_2 < 3000$	m
Δh	Terrain irregularity	0 - 500	m
N_s	Mean surface refractivity	ITU-R Rec. P.527	N-units
$\sigma - \varepsilon_r$	Ground constants (conductivity/ permittivity)	Function of the surface type ()	mho/m

C. Field Strength

One of the main factors in digital television broadcasting is field strength, which is the strength of the signal received by the television set [20]. Based on the Minister of KOMINFO Regulation No. 6 in 2019, the minimum field strength value set uses (2) [7].

$$E = U + 20\ log\ log\ f - Hg - 33{,}7 \qquad (2)$$

where:
E = Field strength of electromagnetic waves (dB)
U = Energy of electromagnetic waves (dB)
F = Frequency (GHz)
Hg = Receiver antenna height (m) [21].

D. Free Space Loss

Free space loss is the loss of wave signal strength, electromagnetic that will be generated from a line-of-sight path in an open space without any obstructions around to produce reflection or diffraction using (3) [15].

$$Lfs = 92.44 + 20\ log\ log\ d + 2\ \ log\ log\ f \qquad (3)$$

Although free space loss and path space loss have slightly different meanings. Free space loss is the part of path loss that occurs when a signal passes through free space without obstacles, where the signal power decreases according to the inverse square law of distance. Path loss itself includes all power losses during signal propagation, including free space loss, clutter loss, and other factors that affect transmission [5][22].

III. Results and Discussion

This study compares two DVB-T2 propagation models in an urban area to find the most optimal model. According to existing standards, the ITU-R P.1546-6 and Longley-Rice models have differences in frequency, range, and transmitting antenna height as show in Table III and Table IV.

In this study, the two propagation models have different values for some parameters. However, the parameters used in this study are equalized but remain within the range of values that cover both propagation models.

In this study, data was collected from different sample points. The sample points were determined based on the west direction. The distance between sample points is set in stages, namely at 8 km, 16 km, 24 km, 32 km, and 40 km as shown in Figure 2. This approach aims to evaluate network quality performance at various distances, so as to provide a more accurate picture of the quality of service in the tested area. The transmitter used as a reference in this research is the transmitter used by Ratih TV Kebumen.

This research uses different frequencies namely 554, 562, 570, 578 and 586 MHz. The frequency is adjusted to the regulation of the Minister of KOMINFO No. 6 of 2019 concerning the radio frequency master plan for the purpose of organizing terrestrial digital broadcast television in the ultra-high frequency radio frequency band [23]. with different frequencies, can see the value of field strength, free space loss, path loss, attenuation, clutter loss and coverage area in the research area.

TABLE III. The Difference Between the ITU-R P.1812-4 Model and the Longley-Rice Model

Parameter	ITU-R P 1546-6	Lngley-Rice
Frequency (MHz)	30 - 3000	20 - 20000
Range (km)	0.25 - 3000	1 - 2000
Tx Height (m)	Up to 300	0.5 - 3000

TABLE IV. Research Parameters

Parameter	ITU-R P 1546-6	Lngley-Rice
Frequency (MHz)	554; 562; 570; 578; 586	554; 562; 570; 578; 586
Range (km)	40	40
Tx Height (m)	60	60

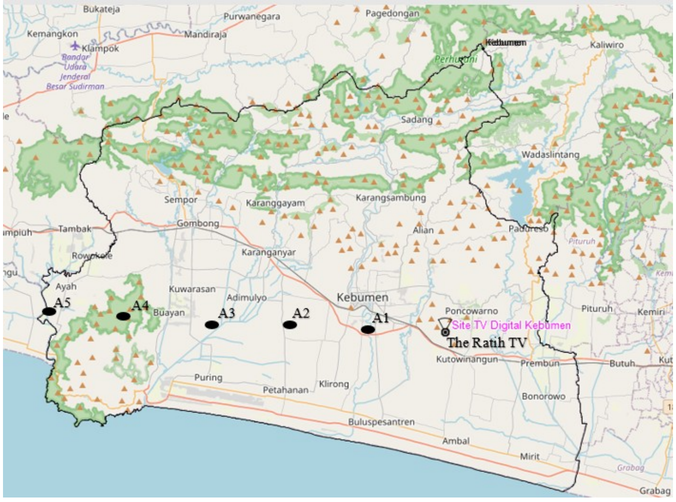

Figure 2. Point of urban area usen in research.

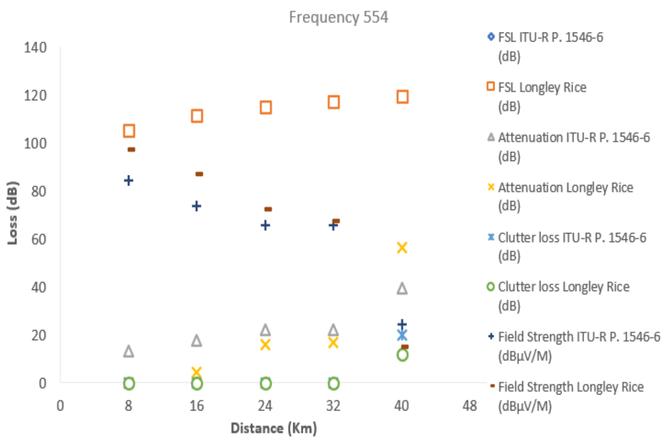

Figure 3. The comparison of loss values at a frequency of 554 MHz for the ITU-R P.1546-6 model and the LongleyRice model

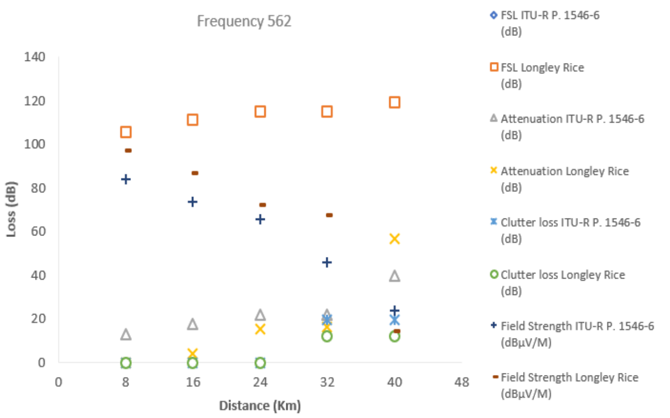

Figure 4. The comparison of loss values at a frequency of 562 MHz for the ITU-R P.1546-6 model and the LongleyRice model.

The simulation results seen in Figure 3 show the values of free space loss, attenuation, clutter loss and field strength with the ITU-R.P. 1546-6 and Longley-Rice models at a frequency of 554 MHz. The average free space loss value generated by the simulation is 113.7 dB for both the ITU-R.P. 1546-6 and Longley-Rice propagation models. For the attenuation value, the ITU-R.P. 1546-6 model produces a greater value of 22.86 dB compared to the Longley-Rice model, which is 18.58 dB. Similarly, the clutter loss value for the ITU-R.P. 1546-6 model is greater at 3.92 dB compared to the Longley-Rice model of 2.4 dB. In contrast, the field strength value for the ITU-R.P. 1546-6 model is smaller at 62.7 dBµV/m compared to the Longley-Rice model of 67.82 dBµV/m.

The simulation results seen in Figure 4 show the values of free space loss, attenuation, clutter loss and field strength with the ITU-R.P. 1546-6 and Longley-Rice models at a frequency of 562 MHz. The average free space loss value generated by the simulation is 113.3 dB for both the ITU-R.P. 1546-6 and Longley-Rice propagation models. For the attenuation value, the ITU-R.P. 1546-6 model produces a greater value of 22.92 dB compared to the Longley-Rice model which is 18.6 dB. Similarly, the clutter loss value for the ITU-R.P. 1546-6 model is greater at 7.84 dB compared to the Longley-Rice model of 4.8 dB. In contrast, the field strength value for the ITU-R.P. 1546-6 model is smaller at 58.72 dBµV/m compared to the Longley-Rice model of 67.76 dBµV/m.

The simulation results seen in Figure 5 show the values of free space loss, attenuation, clutter loss and field strength with the ITU-R.P. 1546-6 and Longley-Rice models at a frequency of 570 MHz. The average free space loss value generated by the simulation is 113.94 dB for both the ITU-R.P. 1546-6 and Longley-Rice propagation models. For the attenuation value, the ITU-R.P. 1546-6 model produces a greater value of 28.36 dB compared to the Longley-Rice model, which is 28.02 dB. While the clutter loss value for the ITU-R.P. 1546-6 model and the Longley-Rice model produces the same value of 0 dB. In contrast, the field strength value for the ITU-R.P. 1546-6 model is smaller at 60.54 dBµV/m compared to the Longley-Rice model of 60.86 dBµV/m.

The simulation results shown in Figure 6 show the values of free space loss, attenuation, clutter loss and field strength with the ITU-R.P. 1546-6 and Longley-Rice models at a frequency of 578 MHz. The average free space loss value generated by the simulation is 113.82 dB for both the ITU-R.P. 1546-6 and Longley-Rice propagation models. For the attenuation value, the ITU-R.P. 1546-6 model produces a greater value of 22.92 dB compared to the Longley-Rice model which is 16.72 dB. Similarly, the clutter loss value for the ITU-R.P. 1546-6 model is greater at 7.84 dB compared to the Longley-Rice model of 4.8 dB. In contrast, the field strength value for the ITU-R.P. 1546-6 model is smaller at 58.56 dBµV/m compared to the Longley-Rice model of 67.84 dBµV/m.

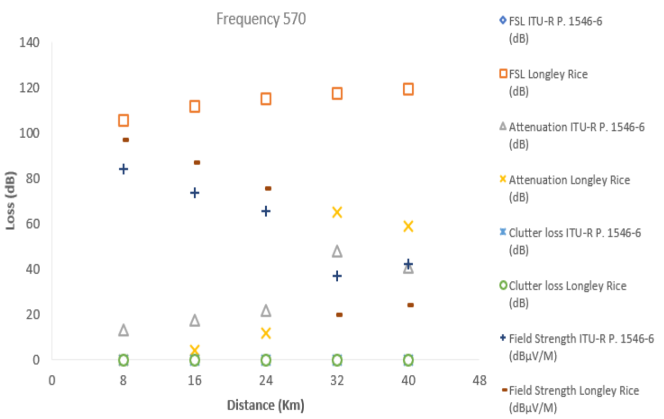

Figure 5. The comparison of loss values at a frequency of 570 MHz for the ITU-R P.1546-6 model and the LongleyRice model.

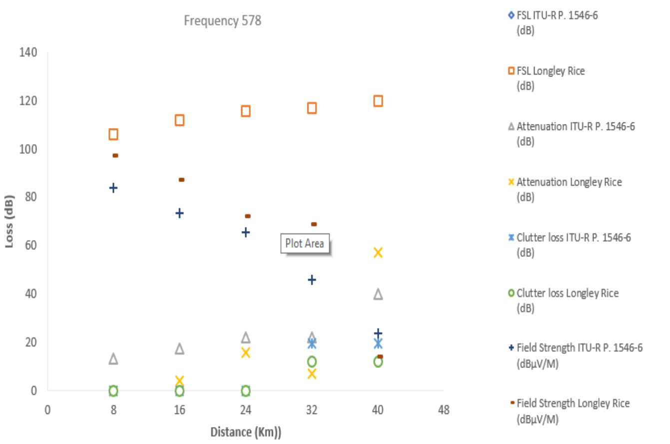

Figure 6. The comparison of loss values at a frequency of 578 MHz for the ITU-R P.1546-6 model and the LongleyRice model.

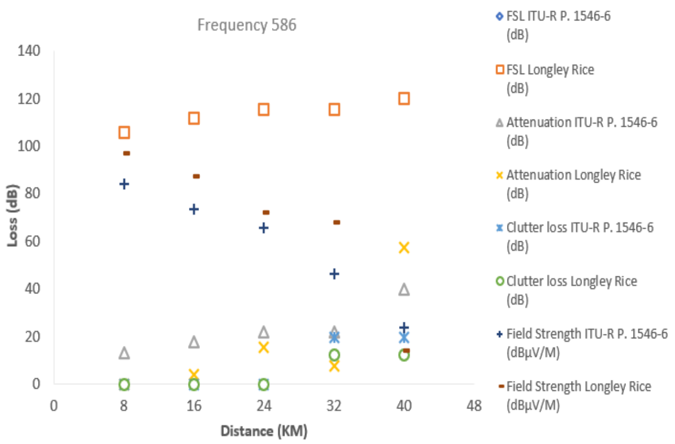

Figure 7. The comparison of loss values at a frequency of 586 MHz for the ITU-R P.1546-6 model and the LongleyRice model.

The simulation results shown in Figure 7 show the values of free space loss, attenuation, clutter loss and field strength with the ITU-R.P. 1546-6 and Longley-Rice models at a frequency of 586 MHz. The average free space loss value generated by the simulation is 113.68 dB for both the ITU-R.P. 1546-6 and Longley-Rice propagation models. For the attenuation value, the ITU-R.P. 1546-6 model produces a greater value of 22.96 dB compared to the Longley-Rice model which is 16.92 dB. Similarly, the clutter loss value for the ITU-R.P. 1546-6 model is greater at 7.84 dB compared to the Longley-Rice model at 4.8 dB. In contrast, the field strength value for the ITU-R.P. 1546-6 model is smaller at 58.58 dBµV/M compared to the Longley-Rice model of 67.6 dBµV/M.

It can be concluded that the farther the distance of the receiver from the transmitter and the greater the frequency, the higher the free space loss value will be. This is due to the hilly geographical conditions in urban areas causing high loss.

In contrast to the simulation results for the attenuation value in the Longley-rice propagation model is smaller than the ITU-R.P 1546-6 propagation model. However, in both propagation models, the farther the receiver is from the transmitter, the greater the attenuation value received.

In contrast to the simulation results for the attenuation value in the Longley-rice propagation model is smaller than the ITU-R.P 1546-6 propagation model. However, in both propagation models, the farther the receiver is from the transmitter, the greater the attenuation value received. As for the value of clutter loss in both models tend to have the same value and small because in the sample area there are no obstacles such as buildings, trees, and hills.

Figure 8 shows that for the Longley-Rice model when viewed from a distance. At a distance of 8 km, the average field strength value is 97.22 dBμV/m. at a distance of 16 km, the average field strength value is 89.1 dBμV/m. at a distance of 24 km, the average field strength value is 72.8 dBμV/m. at a distance of 32 km, the average field strength value is 59.2 dBμV/m. at a distance of 40 km, the average field strength value is 14.44 dBμV/m.

Meanwhile, when viewed from the frequency for the Longley-Rice model shows that at a frequency of 554 MHz the average value of field strength is 62.7 dBμV/m. At a frequency of 562 MHz the average value of field strength is 58.7 dBμV/m. At a frequency of 570 MHz the average field strength value is 65.68 dBμV/m. At a frequency of 578 MHz the average field strength value is 48.26 dBμV/m. At a frequency of 586 MHz the average field strength value was 23.92 dBμV/m.

For the ITU-R.P 1546-6 model as shows in Figure 9, at a distance of 8 km, the average field strength value is 83.98 dBμV/m. at a distance of 16 km, the average field strength value is 73.58 dBμV/m. at a distance of 24 km, the average field strength value is 65.68 dBμV/m. at a distance of 32 km, the average field strength value is 48.28 dBμV/m. at a distance of 40 km, the average field strength value is 23.92 dBμV/m.

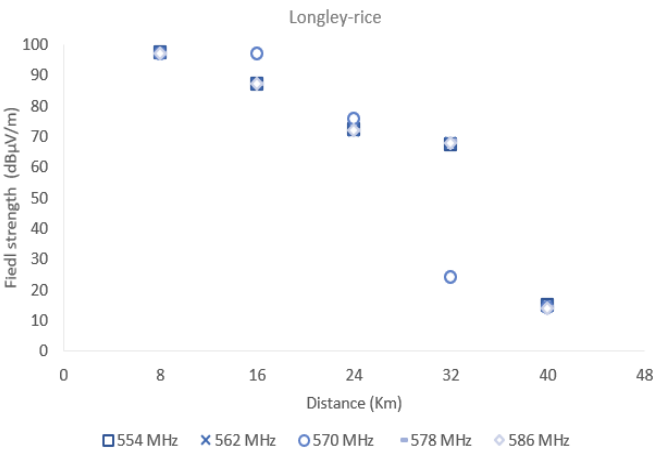

Figure 8. The field strength for the Longley-Rice model with various frequency values

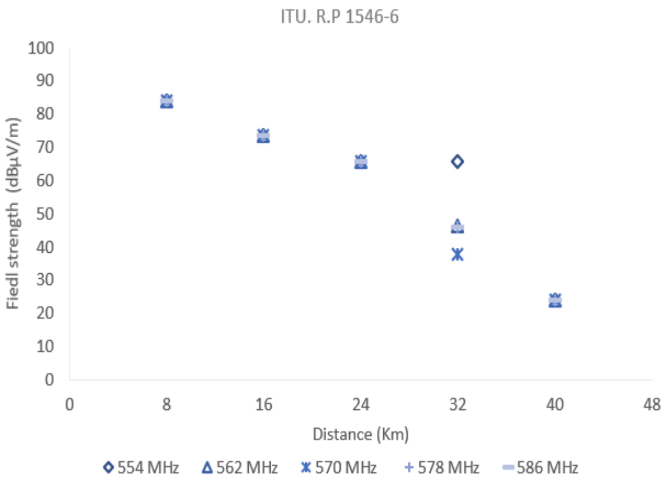

Figure 9. The field strength for the ITU-R P.1546-6 with various frequency values

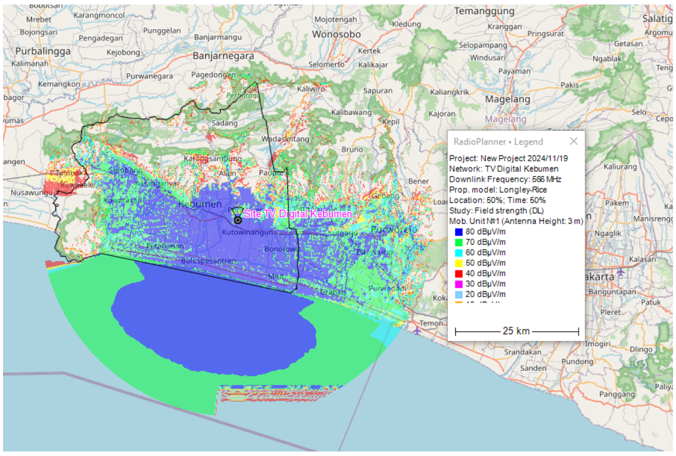

Figure 10. The coverage of the Longley-Rice model

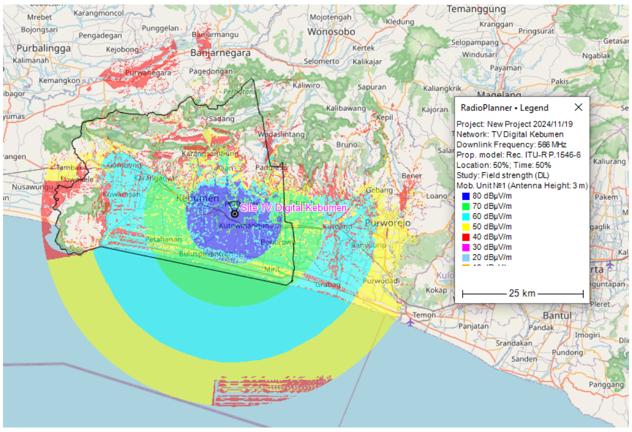

Figure 11. The coverage of the ITU-R P.1546-6 model

Meanwhile, when viewed from the frequency for the ITU-R.P 1546-6 model shows that at a frequency of 554 MHz the average field strength value is 67.82 dBμV/m. At a frequency of 562 MHz the average value of field strength is 67.76 dBμV/m. At a frequency of 570 MHz the average field strength value is 61.74 dBμV/m. At a frequency of 578 MHz the average value of field strength is 67.84 dBμV/m. At a frequency of 586 MHz, the average value is 67.6 dBμV/m.

It can be concluded for both models that the farther the distance of the receiver to the transmitter and the greater the frequency value, the smaller the field strength value that occurs

In Figure 10 shows the coverage area for the Longley-Rice propagation model, where the dark blue color category is an area that has a large field strength value and has good signal strength, but it does not rule out the possibility that in other areas there are still uneven signal quality.

Meanwhile, figure 11 shows the coverage area for the Longley-Rice model. Similar to the previous model, the highest field strength values above 80 dBμV/m are colored dark blue while the lowest field strength values of 10-19 dBμV/m are colored orange.

IV. Conclusion

This study evaluates the performance of the Longley–Rice and ITU-R P.1546-6 propagation models for DVB-T2 deployment in the Kebumen region, focusing on field strength distribution, coverage capability, and propagation characteristics under realistic terrain conditions. The results indicate that the Longley–Rice model consistently yields higher field strength values (78.69 dBμV/m) compared to ITU-R P.1546-6 (61.23 dBμV/m), with a difference of 17.46 dBμV/m, while both models exhibit comparable trends in free space path loss with respect to distance and frequency. The observed increase in path loss with distance is further influenced by the hilly terrain, which introduces additional attenuation. Based on these findings, the Longley–Rice model demonstrates superior suitability for DVB-T2 coverage prediction in complex environments, offering improved signal strength distribution and potential advantages in transmission planning.

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