Business Sustainability Model for Telecommunications Infrastructure in Rural Area

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Abstract: Developments in national information and communication technology (ICT) are always interesting to follow. Based on research and studies so far, ICT development is closely related to the level of the national economy and productivity. This is also the basis for the Indonesian government to actively increase ICT infrastructure development in the 3T areas (Frontier, Outermost, and Disadvantages areas; directly translated from Bahasa Indonesia: Terdepan, Terluar, Tertinggal). BAKTI was appointed as the agency responsible for building and operating ICT infrastructure in the rural area. However, BAKTI itself has experienced various difficulties in building ICT infrastructure in 3T. The lack of appropriate core competencies, the high need for development funds, the limited quality of internet services that can be provided, and the lack of clarity in preparing entry and exit strategies and scenarios mean that BAKTI programs often do not achieve their initial targets and fulfill their initial development intentions. Therefore, new development strategies and modeling are needed to address these challenges while complying with and meeting global standards for providing internet access in rural areas. Using Porter's Five Forces model and SWOT analysis, situations analysis was then carried out. The results of this analysis are then used to develop a TOWS matrix so that strategies can be developed that are relevant to the existing situation analysis. The results of this strategy emphasize the use of new technology which emphasizes cost efficiency, collaboration with the private sector, emphasizing a clear exit strategy, and optimizing the use of existing infrastructure. The usage of Fixed Wireless Access (FWA) is chosen for the proposed model in this study. A comparative analysis is then carried out by estimating the effectiveness and cost efficiency of the newly developed model and the existing model. A QSPM analysis was also carried out to answer the initial challenges by including all consideration factors, including cost-effectiveness and efficiency. The new model provides a higher score than the existing model, with a score of 4.65 versus 3.4.

Keywords: Rural, FWA, QSPM, Internet

1. Introduction

The Internet has revolutionized various aspects of our lives, including work, socializing, information creation, and sharing, as well as the organization of people, ideas, and goods worldwide. Though still not fully acknowledged, this transformation will continue to shape our society. People use the Internet to connect with others personally, access public information, and acquire new knowledge. Moreover, public organizations and nonprofits increasingly leverage the Internet to streamline their operations and improve a wide range of services, from coordinating disaster relief efforts to conducting public safety campaigns. The Internet's impact on society is closely intertwined with the development of the Internet ecosystem, which in turn correlates with rising living standards. Mainly, in developing economies, the Internet's ability to deliver these benefits rapidly offers immense potential for driving growth and advancement [1]. Indonesia's digital economy is experiencing rapid growth propelled by a shift in people's behavior towards increased usage of digital platforms across various sectors. As a result, Indonesia has emerged as the most sought-after investment destination in Southeast Asia [2]. According to a research report by Google, Temasek, and Bain & Company in 2021, the total value of deals in Indonesia's digital economy during the first half of the year reached a staggering

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$4.7 billion, surpassing the highest recorded value in the past four years [3]. These deals encompass investments made by venture capital firms, private equity companies, and strategic investors.

Projections indicate that Indonesia's digital economy will continue its upward trajectory, with an estimated value of $77 billion in 2022. This growth is expected to be driven by a remarkable 22% year-on-year increase in gross merchandise value (GMV). By 2025, Indonesia's digital economy is anticipated to reach a staggering $130 billion. Despite the deal count remaining steady, the total value of deals in the first half of 2022 decreased to $3 billion. Interestingly, a significant portion of these deals, accounting for 44%, were claimed by digital financial services (DFS), indicating a notable increase in their market share compared to previous years [4]. The government committed to developing a digital economy ecosystem in Indonesia and prepared a framework for developing the digital economy for 2021-2030. This framework will serve as a guideline in realizing the vision of becoming a digital economy power [2].

To accomplish the outcome of that framework, governments do not intend to deploy ICT infrastructure only in already crowded urban areas but also in the frontier, outermost, and least developed areas or often referred as 3T areas (from this point the term will be changed to rural areas). The definition of those least developed regions is regulated according to border areas determined by the National Agency for Border Management. On the other hand, the outermost regions are covered in Presidential Decree Number 6 of 2017, while the least developed regions are defined in Presidential Regulation Number 131 of 2015.

With this, the government hopes to create larger opportunities to increase Indonesia's economic level. In this context, Badan Aksesibilitas Telekomunikasi dan Informasi (BAKTI) acts as the government's representative to build IT infrastructure in rural areas. According to the Central Agency of Statistics (BPS), by 2020 about 56.7% people will live in urban areas. That means a big portion of people in Indonesia are still living in rural areas. Hence, developing rural IT infrastructure would also significantly leverage Indonesia's economic level.

This paper aims to: (1) identify the situation and environment in BAKTI's existing business model and rural ICT development; (2) define the gaps and challenges in implementing the Universal Service Obligation (USO) for internet access in Indonesia's rural areas; (3) define an effective, efficient, and sustainable business model for rural internet access (telecommunication infrastructure in rural areas); (4) define the effective and efficient model for BAKTI to solve all or part of the challenges. The scope and limitations of this study are as follows: (1) the deployment scenario is based on assumption, including several key parameters such as the number of locations, distance between nodes, the coverage of the BTS, etc.; (2) identification process of weight and score are done internally by experts hired by BAKTI; (3) the study does not consider economics or ICT threshold to identify when ICT market is considered feasible commercially in rural area; (4) this study does not consider the ability and willingness to pay for ICT services in rural area; (5) this study does not address further detailed strategies and action plans, including risk management, contingency planning, capacity building, etc.

2. Indonesia's Digital Landscape

A. Overview of Internet Penetration in Indonesia

With Indonesia's growing population and economic growth, it is an ideal location for developing its digital economy. Considering the population total, World Bank data indicate a significant market for digital services and a large labor force that can support technological innovation and growth. As a result of its positive GDP growth rate, the country has a robust economy that can support and benefit from increased digitalization. A growing number of individuals who use the internet is contributing to the expansion of the digital economy in Indonesia, which is crucial to integrating Indonesia into the global digital ecosystem and facilitating socioeconomic growth [5, 6, 7].

Indonesia's digital economy has grown rapidly, as demonstrated by a 52% increase in 2021, resulting in a total investment of $53 billion. Indonesia's digital economy is expected to grow to over $124 billion by 2022 and become a fundamental part of the economy. Detailed analysis of

this growth is provided in the E-Economies SEA 2022 report, which attributes it to sectors such as e-commerce, online travel, transportation and food, and online media. Additionally, digital financial services are expected to grow significantly, boosted by a high Compound Annual Growth Rate, especially in digital payments and investment platforms. Although private funding deal values have been declining, Bain Analysis indicates that B2B payments and lending services continue to attract substantial investments, particularly in digital financial services.

In addition to providing a detailed breakdown of internet usage, device ownership, and online activities, WeAreSocial's data complements this narrative. Indonesia has a significant digital reach, with 212.9 million internet users and 77.0% of the population online. As 98.3% of users access the internet from their mobile phones, the growth of mobile internet usage is particularly significant, suggesting the importance of mobile networks for digital inclusion. 94.2% of Indonesians have broadband mobile connections, and 7 hours per day are spent using the internet on average, which emphasizes the importance of digital connectivity to their day-to-day lives. Besides demonstrating the prevalence of the digital economy, such high engagement rates also indicate the potential for growth in online services, including e-commerce and digital content consumption.

B. Challenges of Digitalization in Indonesia

A significant digital divide has impeded Indonesia's path toward digitalization, according to the Asian Development Bank (ADB) reports. As a consequence, there is a significant disparity between urban and rural areas, as well as among socioeconomic groups in terms of access to digital technologies and internet connectivity. It is not merely geographical but also demographic, with people with disabilities, the elderly, and women facing disproportionate barriers to obtaining digital technologies. The issue is further compounded by the high cost of digital devices and services, which can be prohibitively expensive for many Indonesians, preventing them from fully participating in the digital economy. As a result, it is imperative that inclusive strategies be developed that address both geographic and demographic disparities in accessibility and affordability.

Additionally, the United Nations Conference on Trade and Development (UNCTAD) identifies limited digital infrastructure as a significant obstacle to technological adoption and access. There are many Indonesians who do not have access to technology and do not possess technological proficiency, which inhibits their ability to benefit from the digital economy. The limited use of credit cards restricts E-commerce, and policy challenges persist in providing an environment that supports small- and medium-sized businesses to adopt technology and promote research and development in the digital economy. Consequently, it is crucial to invest in infrastructure in addition to educational initiatives aimed at improving technological literacy to overcome these obstacles.

A study by the Indonesian Civil Society Organization's Digital Transformation Task Force (ID-CSO DTTF) indicates that even Java, one of Indonesia's most populous islands, lacks access to the internet. Inequality associated with digital infrastructure and connectivity is just one aspect of broader digital inequality, which is compounded by gender-based digital gaps and limited access to information. Better regulations must be implemented to safeguard the digital landscape and promote informed and secure digital participation in light of the widespread prevalence of hoaxes and the slow ratification of the Personal Data Protection Bill.

In addition to these challenges, McKinsey's research highlights the uneven nature of digitization throughout Indonesia. Internet penetration is closely related to income, with poorer regions lagging behind and significant areas with poor connectivity. It is difficult for Indonesia to provide widespread access to technology due to its geographical complexity and its thousands of islands, and the limited quality of internet connection makes efficient use of affordable mobile data difficult. To maximize the potential of its large market and enhance the quality of connectivity for its citizens, the country must prioritize expanding its digital infrastructure to harness the full potential of its sizable market.

Each piece of data highlights various aspects of Indonesia's digitalization challenge, ranging from infrastructure to affordability to literacy to regulation, among others. A concerted effort addressing each aspect is necessary to bridge the digital divide and enable Indonesia to utilize the opportunities presented by the digital economy.

C. Existing USO Initiatives in Indonesia

Currently the USO initiatives are being held by BAKTI, targeting at least 150.000 of rural locations. To reach that number, BAKTI has started two main programs which are called Broadband Backhaul (BB) and "Akses Internet" (AI). The BB program use cellular technology as access while the AI program uses unlicensed spectrum/ Wi-Fi as access. Both programs are using satellites as their backbone and backhaul. In terms of number of deployments, the AI program surpassed the BB program and is currently made as the primary program in BAKTI.

The AI Program itself is divided into three sub-programs, which are End-to-end (EtE), Ground Segment (GS), and Capital Expenditure (CAPEX). The EtE program is the first AI program deployed by BAKTI. The name itself indicates that all the internet services are provided by a single provider, from the satellite backbone to internet access. However, this program is considered high cost and experts are worried that the cost will be a burden to BAKTI's budget in the long run. Hence, the number of EtE's locations are being restricted and gradually reduced. To reduce the operational cost, BAKTI started to deploy a GS program. The main difference between EtE and GS programs is located at the provider's responsibility. In the EtE program, a sole provider is responsible for all the services, while in the GS program the services are mainly divided into two providers. The first provider will be responsible for satellite services or space segment and the second provider will be responsible for ground segment. However, the devices in rural locations are still being owned by providers.

The last program, the CAPEX program, has been identified as one that will further save BAKTI's budget. While the system architecture is similar to the GS program, in CAPEX program the devices in rural locations are owned by BAKTI and are procured by using state budget. Hence, the impact from the program to BAKTI's budget is reduced.

3. Research Methodology

A. Research Paradigm and Approach

This research uses pragmatism as a research paradigm. It focuses on practical, problem-centered approaches to addressing research questions. In order to obtain a comprehensive understanding of the problem at hand, it is imperative that all available methods are utilized. The philosophy of pragmatism is non-constrictive and open to multiple perspectives and approaches since it is not committed to any specific philosophy or reality system. The aim of pragmatism is to find innovative solutions to the research problem and to be able to make informed decisions by prioritizing the problem.

In the context of analyzing the deployment of internet access in rural areas of Indonesia, pragmatism is an appropriate approach. It allows for the utilization of both quantitative and qualitative methods to assess the existence and impact of internet access. Quantitative methods, such as surveys and data analysis, are utilized to determine the extent of internet access and its socio-economic impacts. In contrast, qualitative methods, such as interviews and focus groups, are employed to gain a deeper understanding of stakeholders'—including but not limited to private sectors, local communities, non-governmental organizations, and/or academia—experiences, challenges, and attitudes. By combining both types of methods, a comprehensive analysis can be achieved, allowing for a more comprehensive understanding of the rural internet connectivity in Indonesia.

This research uses a mixed-methods approach. A mixed-methods approach is a research strategy that combines both qualitative and quantitative research methods. This approach aims to capture the strengths of both methods, providing a more comprehensive analysis of the research problem. By integrating qualitative and quantitative approaches, researchers can gain a deeper understanding of the data, allowing for a more comprehensive understanding of the

research question. Mixed-methods approaches are commonly used in various fields, including social sciences, education, and business, as they allow for a more comprehensive understanding of the research problem.

The mixed-methods approach is suitable for this since it captures both the statistical data regarding internet access and its impacts (quantitative) and the nuanced understanding of individual and community experiences, perceptions, and challenges related to internet deployment (qualitative). This approach is justified because it recognizes the multifaceted nature of technology deployment in rural areas.

B. Research Design

This research uses an explanatory sequential design. An Explanatory Sequential Design is a research approach combining quantitative and qualitative data collection methods. This two-phase design involves gathering and analyzing quantitative data first, followed by qualitative data. The primary purpose of the qualitative phase is to provide additional insights and explanations based on the findings from the quantitative phase.

By conducting the quantitative phase, researchers can establish a foundation of knowledge and identify patterns and trends in the data collected. This initial analysis helps to guide and focus the qualitative phase, ensuring that the subsequent qualitative data collection is relevant and designed to address the gaps and insights uncovered in the quantitative phase. The qualitative phase in an Explanatory Sequential Design allows researchers to gain a deeper understanding of the factors and mechanisms that drive the patterns identified in the quantitative data. Through interviews, focus groups, or other forms of qualitative data collection, researchers can ask follow-up questions, explore nuances, and gain deeper insights into the phenomenon being studied.

The combination of quantitative and qualitative data in an Explanatory Sequential Design enhances the validity and reliability of the research findings. The quantitative data provides a general overview of the phenomenon, while the qualitative data adds depth and complexity to the interpretation. By combining these approaches, researchers can provide a comprehensive understanding of the research topic.

C. Data Collection and Analysis

C.1. Quantitative data collection

Surveys and existing data analysis are valuable tools for collecting quantitative data. Surveys involve systematically asking a series of structured questions to many respondents. These questions can be asked in person, over the phone, or online. Surveys are commonly used in various fields, including research, marketing, and polling. In this study, surveys can be used to gather data on various aspects of internet access in rural areas. By administering surveys, we can collect data on the extent of internet access, usage patterns, and perceptions of the impact of internet access on socio-economic conditions. This information can be analyzed to gain valuable insights into the challenges faced by rural communities in terms of internet connectivity and its potential benefits. Surveys provide a cost-effective and efficient means of collecting data from many participants. By designing well-structured surveys, we can ensure that the data collected is reliable and valid. Additionally, surveys allow for flexibility in data collection, as they can be administered through various channels, such as online platforms, in-person interviews, or telephone interviews. Existing data analysis involves the systematic examination and interpretation of existing data sources to gain insights and understanding. It involves identifying patterns, trends, and relationships within the data.

C.2. Qualitative data collection

This research uses interviews, focus groups, and document analysis for qualitative data collection. Interviews are a type of qualitative research method that involves direct, one-on-one conversations between the researcher and the participant. These interviews can be structured, semi-structured, or unstructured. Interviews are commonly used in various fields, including

market research, sociology, and psychology. One of the key advantages of interviews is their ability to gather in-depth information. By conversing with the participants, researchers can gather rich data and gain a deeper understanding of their perspectives and experiences. Additionally, interviews allow for open-ended questions and follow-up discussions, allowing researchers to explore complex topics in more detail. Interviews can be conducted in person, over the phone, or online, depending on the research constraints. Regardless of the method of communication, the interviewer should strive to build rapport and maintain a neutral and non-judgmental demeanor. This can help participants feel comfortable sharing their thoughts and feelings freely. Interviews can be structured or semi-structured. In a structured interview, the researcher has a predetermined set of questions, allowing for a systematic examination of the topic. On the other hand, semi-structured interviews provide more flexibility, allowing the researcher to explore unanticipated issues or topics that may arise during the interview.

Focus groups are another qualitative research method that involves bringing together a group of individuals who share a common interest or experience. The researcher facilitates a discussion among the group members, encouraging them to share their thoughts, opinions, and experiences. Focus groups can provide valuable insights into collective decision-making processes, social norms, and group dynamics. By engaging in an interactive discussion with their peers, participants can learn from each other's perspectives and gain a deeper understanding of the topic at hand. Conducting focus groups requires careful planning and moderation. The researcher should aim to create an inclusive and non-judgmental environment where participants feel comfortable sharing their thoughts and ideas. Additionally, the researcher should encourage active engagement and ensure that everyone has an opportunity to participate.

Document analysis is a qualitative research method that systematically examines written documents, such as reports, articles, or policies. Researchers use document analysis to gain insights into the language, content, and structure of a document, as well as the context in which it was written. Document analysis can be a valuable technique for analyzing texts that may not easily lend themselves to other data collection forms. It allows researchers to explore the nuances of language, identify patterns and themes, and track changes over time. When conducting document analysis, researchers should be mindful of the purpose and context in which the document was created. They should carefully read and analyze the written content, focusing on language, structure, and underlying messages or themes. Additionally, researchers should consider any external factors that may have influenced the document's creation or dissemination.

C.3. Data analysis

Statistical analysis is the process of applying statistical methods to analyze and interpret quantitative data. It involves the use of various techniques to gain insights from the data. Statistical analysis can be applied in various fields, including market research, social sciences, and health sciences. The purpose of statistical analysis is to identify patterns, relationships, and trends within the data. Researchers can draw conclusions and generalize about the population being studied by analyzing quantitative data. Statistical analysis allows for the quantification of variables and helps compare different groups or individuals.

There are several types of statistical analyses that are commonly used. Descriptive statistics summarize the data, including measures of central tendency (e.g., mean, median) and variability (e.g., standard deviation). Inferential statistics, on the other hand, allow researchers to make inferences about the population based on the sample data. Examples of inferential statistics include t-tests, chi-square tests, and regression analysis. This study uses statistical analysis to analyze quantitative data. For example, statistical analysis can be used to identify trends, relationships, and patterns within the survey data on internet access levels. This analysis can help the understanding of the factors influencing internet access levels, such as income level, education level, or geographical location.

This research uses thematic analysis for qualitative data analysis. A thematic analysis is an approach that is used to identify, analyze, and report patterns within data (themes) in qualitative research. It involves coding the data and identifying the themes that emerge from these codes.

This technique can be particularly useful for analyzing qualitative data, for instance, data collected in interviews, focus groups, and document analysis.

Triangulation follows quantitative and qualitative data analyses. Triangulation is a research method that uses multiple processes or data sources in qualitative research to develop a comprehensive understanding of phenomena. This technique is vital for enhancing research findings' validity and reliability. Triangulation would be crucial in corroborating findings from quantitative and qualitative analyses in this study. Combining data from these two distinct approaches gives a more comprehensive understanding of the research topic.

Integrating quantitative and qualitative data is critical in this research. After conducting separate quantitative and qualitative data analyses, this research will combine the findings in the discussion phase. This integration involves comparing and contrasting the results from both analyses and interpreting how they complement or contrast. By integrating quantitative and qualitative data, a deeper understanding of the phenomenon under investigation can be obtained. This integration allows researchers to triangulate their findings, providing a more comprehensive and accurate understanding of the research question.

C.4. Theoretical and Conceptual Frameworks

This subsection explains the process of constructing theoretical and conceptual frameworks. First, the key variables and constructs that will form the basis of this research are identified. Then, definitions and reasons regarding the variables' relevance to the study is narrated. Thereafter, a framework that connects the variables is formulated at the end of this section. There are various types of variables used in research. These variables can be categorized into four main groups: independent, dependent, mediating, and moderating. Creating a conceptual framework involves translating the theoretical framework into a more specific and operational model that guides empirical investigation. It involves describing how the variables should be measured and hypothesizing the particular relationships to be observed. The steps involved in creating a conceptual framework include four steps: operationalizing variables, hypothesizing relationships, developing the conceptual model, and writing the narrative.

1. Variables Identification

Independent variables are the variables that researchers manipulate or vary to observe their effect on the dependent variable. They are considered the cause or input to a study. For example, teaching methods could be an independent variable in studies examining education outcomes. On the other hand, dependent variables are observed or measured to assess the impact of the independent variable. They are considered the effect or outcome of a study. In the same education study, student performance could be a dependent variable. Mediating variables play a role by explaining the relationship between an independent variable and a dependent variable. They influence the dependent variable through an intermediate pathway. Moderating variables, on the other hand, affect the strength and direction of the relationship among variables. They can change the relationship between an independent variable and a dependent variable. Overall, understanding different types of variables is crucial for researchers to design and successfully conduct their studies. These are the variables in this research.

1. Independent variables:
   a. Technological infrastructure: types of networks/technology deployed in rural area (e.g., satellite, fiber optics, wireless networks).
   b. Government Policies and Initiatives: This includes USO (Universal Service Obligation) policies, digital infrastructure investment, and regulatory frameworks.
   c. Investment and Funding: Capital expenditure (CAPEX), operational expenditure (OPEX), and sources of funding for the Internet deployment projects.
   d. Geographical Challenges: Factors related to the physical geography of Indonesia impacting internet deployment (e.g., island distribution, rural-urban topography).

2. Dependent variables:
   a. Internet Access in Rural Areas: The quality of service of Internet access available in rural areas.
3. Mediating variables:
   a. Digital Literacy and Skills: The level of digital literacy and technical skills among the rural population.
   b. Local Community Engagement: The degree of involvement and support from local communities in internet deployment initiatives.
   c. Private Sector Participation: Involvement of private companies in internet infrastructure development.
4. Moderating variables:
   a. Policy Effectiveness: The impact of government policies on the actual implementation of internet access initiatives.
   b. Technological Advancements: Changes or advancements in internet technologies that could affect deployment strategies.

2. Constructing a theoretical framework

Constructing a theoretical framework involves integrating the identified variables into a coherent structure that guides this research. The theoretical framework will map out how these various elements interact and influence each other. Specifically, the framework establishes the foundation for understanding the relationship between the internet deployment and the desired outcomes. It also explores the potential mediating variables that can influence this relationship, such as infrastructure development or regulatory policies. Additionally, the framework considers moderating influences, such as cultural differences or economic conditions, which may impact the effectiveness and efficiency of the internet deployment. By constructing this theoretical framework, researchers can develop hypotheses or research questions to guide their studies and incorporate the insights of various theoretical perspectives. The framework is a valuable tool for organizing and understanding the complexities surrounding internet deployment in remote areas of Indonesia.

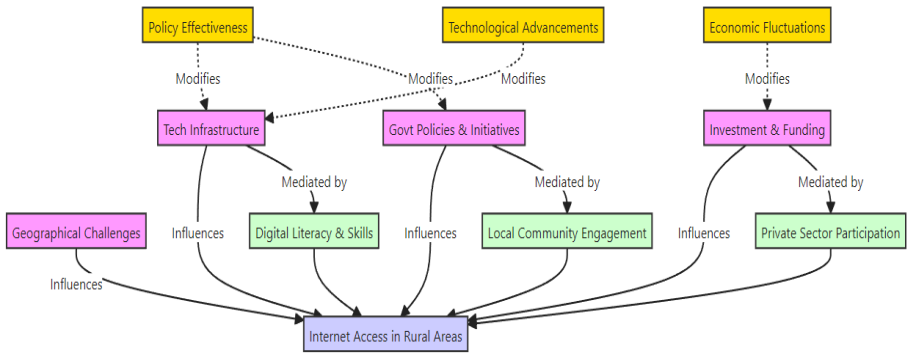

Figure 1. Theoretical Framework

Figure 1 represents the hypothesized relationships between the independent, dependent, mediating, and moderating variables in a study. The pink nodes represent the independent variables, which include Technological Infrastructure, Government Policies & Initiatives, Investment & Funding, and Geographical Challenges. These variables are hypothesized to exert a direct influence on Internet access in Rural Areas (the dependent variable). The blue nodes depict the mediating variables, Digital Literacy & Skills, Local Community Engagement, and Private Sector Participation. These variables are proposed to bridge the gap between the independent and dependent variables. Lastly, the yellow nodes represent the moderating variables, Policy Effectiveness, Technological Advancements, and Economic Fluctuations. These variables are proposed to modify the relationships between the independent and dependent

variables, influencing their intensity and direction. Overall, this visual representation provides a structured framework to explore the intricate relationships between the variables and shed light on the mechanisms driving Internet access in Rural Areas.

3. Conceptual framework

The steps involved in creating a conceptual framework include four steps: operationalizing variables, hypothesizing relationships, developing the conceptual model, and writing the narrative. First, operationalize the variables of interest. This involves translating abstract and complex concepts into measurable and observable indicators (see Table 1). Second, hypothesize the specific relationships among the variables expected to observe. Relationships can be quantitative (e.g., correlation coefficients), qualitative (e.g., causality), or mixed both of them. As a third step, the conceptual model is developed to visualize the relationships between variables. The framework provides a structured framework for analyzing and interpreting the data. It maps out the directions, strength, and nature of these relationships. A narrative should describe the study's purpose and significance as the last step in creating a conceptual framework. The narrative usually consists of a clear statement of the research question, a theoretical framework, an operationalization of variables, hypothesized relationships, and implications for the research.

Table 1. Variable Operationalization

No.	Variable	Operationalization
1	Technological Infrastructure	Measure the types of technologies used (e.g., satellite, fiber optics, wireless networks) and the extent of their deployment. Include metrics like coverage area, bandwidth capacity, number of connections made, and adoption rates among the rural population.
2	Government Policies and Initiatives	Analyze policies in detail, categorizing types of policies (e.g., USO), examining their implementation status, and evaluating their alignment with rural internet access goals.
3	Investment and Funding	Estimate the costs of rural internet projects using financial data, such as the total investment in rural internet projects, the source of funding (government, private, international aid), and the breakdown of expenditures (CAPEX vs OPEX).
4	Geographical Challenges	Analyze geographic and demographic data, including terrain analysis, rural-urban distribution, and logistical complexities in the deployment area.
5	Internet Access in Rural Areas	Assess connectivity metrics, such as the number of new internet connections established, service quality parameters (speed, reliability), and user satisfaction surveys.
6	Digital Literacy and Skills	Assess computer literacy, internet navigation skills, and usage patterns for a variety of purposes using existing data from previous research on surveys and skill assessments.
7	Local Community Engagement	Analyze the level of community involvement in internet projects, their feedback, and their support for such initiatives by using qualitative methods such as interviews, focus groups, or secondary data analyses.
8	Private Sector Participation	Assess the extent of private investment, the nature of public-private partnerships, and corporate social responsibility initiatives related to rural internet access by analyzing case studies and corporate reports.
9	Policy Effectiveness, Technological Advancements, Economic Fluctuations	Analyze these moderating variables involves policy analysis, technological trends review, and macroeconomic data assessment.

In hypothesizing relationships, it is important to consider how each independent variable (technology, policy, investment, geography) directly influences internet access and socio-economic development in rural areas. Technology, for example, plays a crucial role in expanding internet connectivity in rural areas. Policies that promote infrastructure development and

investment in telecommunications infrastructure can also contribute significantly to improving internet access in these areas. Geography, on the other hand, can impact internet access in rural areas due to factors such as remoteness, terrain, and weather. Additionally, mediating variables such as digital literacy and community engagement can shape the relationship between independent variables and outcomes. Digital literacy refers to the knowledge and skills required to effectively utilize digital technologies, while community engagement involves fostering collaboration between the government, private sector, and local communities to improve internet access. Moderating variables, such as the effectiveness of policies and technological advancements, can also impact the relationships between independent variables and outcomes. These factors should be considered when developing hypotheses and conducting empirical research to understand the complexities of improving internet access in rural areas. The following hypotheses seek to explore the relationship between internet access and socio-economic development in rural areas:

- Relationship between Technological Infrastructure and Internet Access: The deployment of advanced technological infrastructure (e.g., fiber optics, satellite internet) in rural areas of Indonesia is positively associated with improved internet access in these areas (Hypothesis 1 or H1).
- Impact of Government Policies on Internet Deployment: Effective implementation of government policies and initiatives (such as USO) positively correlates with the successful deployment of Internet infrastructure and increased Internet access in rural areas (H2).
- Role of Investment and Funding in Internet Access: Higher levels of investment and funding for rural Internet projects are significantly associated with enhanced Internet connectivity and coverage in rural Indonesia (H3).
- Influence of Geographical Challenges on Deployment: Geographical challenges, such as remote locations and difficult terrains, negatively impact the deployment of internet infrastructure in rural areas of Indonesia (H4).
- Digital Literacy as a Mediator: Digital literacy and skills mediate the relationship between the availability of Internet infrastructure and the effective use of Internet services, contributing to socio-economic development in rural areas (H5).
- Local Community Engagement as a Mediator: The degree of local community engagement positively influences the effectiveness of internet deployment and its subsequent impact on socio-economic development (H6).
- Private Sector Participation in Internet Deployment: Active participation of the private sector in rural internet deployment projects leads to more sustainable and effective internet connectivity solutions (H7).
- Moderating Role of Policy Effectiveness: The effectiveness of government policies moderates the relationship between technological infrastructure and the extent of internet access in rural areas, with more effective policies enhancing this relationship (H8).
- Moderating Role of Technological Advancements: Technological advancements moderate the relationship between infrastructure investment and internet access quality, where more advanced technologies result in better access (H9).
- Moderating Role of Economic Fluctuations: Economic fluctuations moderate the impact of investment on internet infrastructure deployment, with stable economic conditions leading to more effective investment utilization (H10).

Developing a conceptual model involves creating a visual representation of the relationships and hypotheses derived from the theoretical framework of a study. This model serves as a guide for understanding how different variables interact and influence each other in the context of deploying internet access in rural areas of Indonesia. By visualizing these relationships, researchers can gain a better understanding of the complex dynamics of internet connectivity in rural areas. Additionally, the conceptual model can help communicate the study's findings and implications to a wider audience. Overall, developing a conceptual model is an essential

component of scientific research, enabling a deeper understanding of the factors affecting internet connectivity in rural areas in Indonesia.

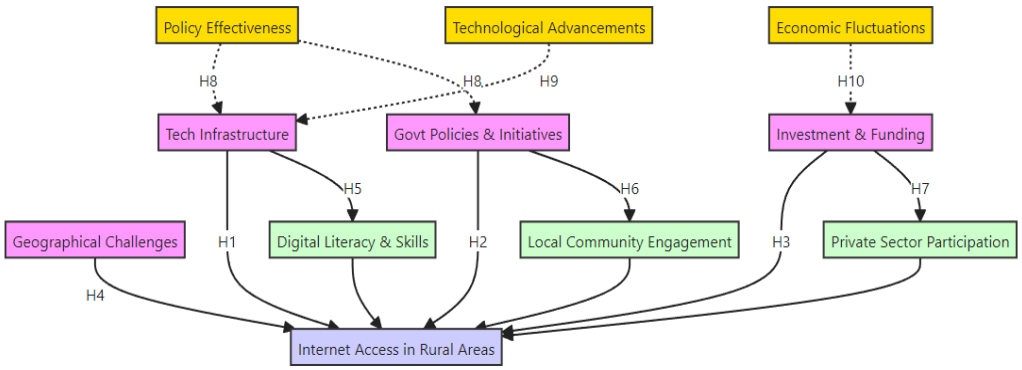

Figure 2. Conceptual Diagram

The conceptual diagram (Figure 2) represents nodes and their connections. The pink nodes represent the independent variables, which include Technological Infrastructure, Government Policies & Initiatives, Investment & Funding, and Geographical Challenges. The blue nodes represent the dependent variables, which are Internet Access in Rural Areas and Socio-Economic Development. The green nodes represent the mediating variables, which are Digital Literacy & Skills, Local Community Engagement, and Private Sector Participation. Finally, the yellow nodes depict the moderating variables, which are Policy Effectiveness, Technological Advancements, and Economic Fluctuations. The diagram also includes solid arrows indicating hypothesized direct relationships, labeled with the corresponding hypothesis numbers (e.g., H1, H2). The dashed arrows represent the moderating effects.

4. Results and Discussions

A. Defining Model for New Rural Development Strategy

The government plays a crucial role in creating a conducive regulatory environment to attract private sector investments in telecommunication infrastructure. The USO Fund works in tandem with government policies by providing financial and technical support to facilitate public-private partnerships (PPPs) in remote areas. Clear policies and regulations ensure transparency, accountability, and fairness in the selection of PPP partners, fostering a competitive and efficient telecommunication market. The USO Fund promotes capacity building initiatives to enhance the technical expertise of local stakeholders involved in infrastructure deployment. Knowledge sharing platforms, workshops, and training programs facilitate the transfer of best practices, fostering collaboration between the government, private sector, and local communities. By enhancing the capacity of local stakeholders, the USO Fund strengthens the sustainability of telecommunication infrastructure in remote areas, paving the way for long-term growth and development.

GSMA has recommended the three-gap model to help decide when such intervention is needed and to design successful universal access strategies. This model allows them to distinguish the "market efficiency gap" from the "true access gap" [8]. The proposed model then will be focused on those two zones, which are the true access gap and smart subsidy zone (see illustration in Figure 3). While still maintaining the true nature of internet access programs, which is serving a fixed small coverage of location, the proposed model will use a different access method and different backhaul method than the current model. The proposed model will use Fixed Wireless Access (FWA) as access method and use fiber optic as backhaul method as opposed to Wi-Fi and VSAT Satellite as access and backhaul method respectively in current model. Another key difference is the need of building a new Point of Presence (PoP's) which connects the existing nearest PoP to Base Transceiver Station (BTS) owned by BAKTI. Those

PoP's will serve as an interconnection hub between BAKTI's BTS to other PoP which can take form as Palapa Ring's PoP or PoP form commercial operators.

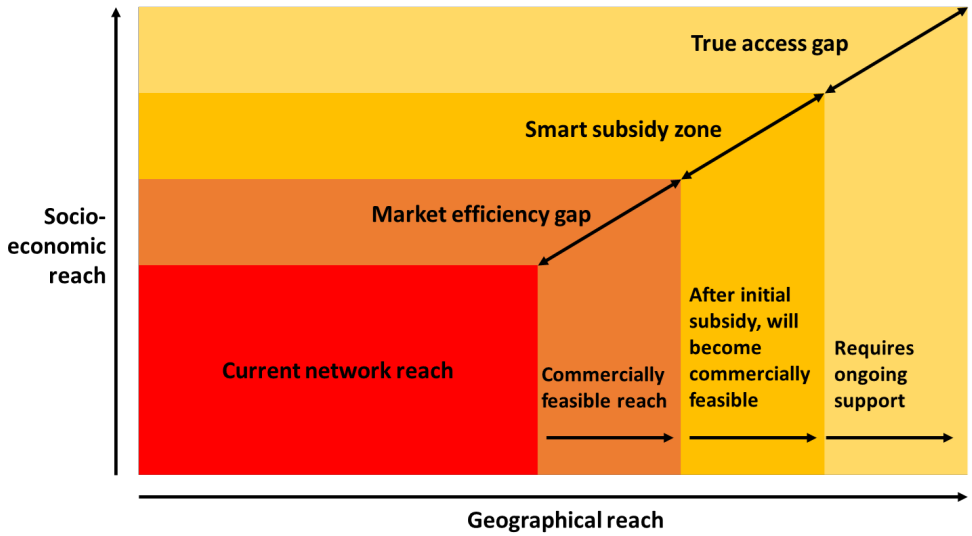

Figure 3. Universal service: distinctions within the access gap (redrawn from [8])

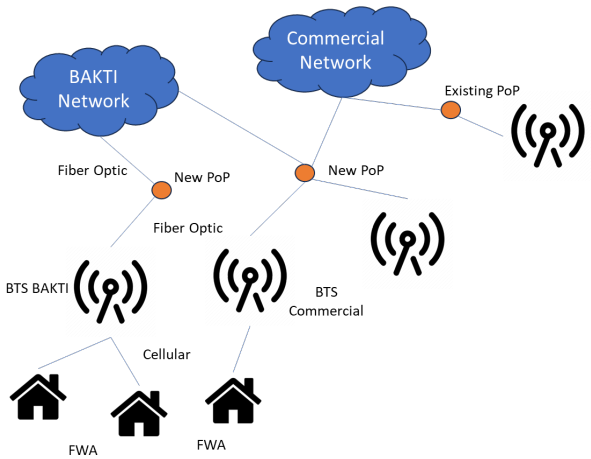

Figure 4. Network Illustration of Proposed Model

Table 2 explains the mapping between the previous considerations, its proposed solution, and the three-gap model mentioned in ITU. As for the compliance to the three-access gap model will be explained in Table 3.

Table 2. Comparison Between Proposed Model and Existing Model

Main Considerations	Existing Model	Proposed Model
Policy Effectiveness	The operating model is based on BAKTI standard, starting from initial roll-out, operations, monitoring, and maintenance. However, BAKTI does not have appropriate core competency and capability as a national-level telecom provider. Therefore, the outcomes of the programs often do not meet initial requirements and intentions.	BAKTI are still in charge of deploying the network until access level, but the operation and maintenance will be handled by a national-level telecom provider. On one hand, this will ensure the provider has sufficient resources to operate commercially in rural areas. On the other hand, the provider will have full responsibility and flexibility to operate and maintain the services in full accordance to their standard and characteristic.
Technological Advancement	Most of the current programs are satellite-based services, hence the quality of services is limited in terms of speed and latency.	The proposed model will use mobile cellular broadband technology in combination with Fixed Wireless Access solution. Both technologies will ensure people in rural to have both services, mobile and fixed broadband. FWA services will also provide the high-speed fixed broadband supported by mobile broadband technology and the simplest experience of initial implementation.
Economic Fluctuation	The current model lacks a clear exit strategy; hence the government needs to continuously spend money for ongoing locations. It means the budget for internet access services will continue to grow over the years with limited increase in terms of number of served locations.	The proposed model offers a new exit strategy by using the competency of professional and experienced telecom providers. It is expected that the exit strategy can be significantly faster when the commercial internet service is available in rural areas. Therefore, the O&M cost for existing locations can be cut short much earlier so it can be reallocated to other new locations. Although the initial cost for this model is higher than the current model, for overall duration it is expected to cost less.

Table 3. Parameters Comparison

Gap	Existing Model	Proposed Model
True Access Gap	Using satellite-based internet services Duration: 9 years	Using mobile broadband and FWA technology, providing similar internet services with higher speed rate and simple maintenance. Duration: 4 years
Smart Subsidy Zone	Using FWA for area which has commercial mobile broadband available Duration: 1 year	Using FWA only Duration: 1 year
Market Efficiency Gap	Above 10th years	Above fifth year

B. Evaluation Scenario

The evaluation scenario will be based on several assumptions on delivering internet access service to a fixed number of locations. The general assumptions will be explained in Table 4.

Table 4. General Assumptions

Parameter	Quantity	Unit	Description
Number of locations	1000	Locations	Number of planned locations to be delivered with internet services
MHz Requirement	625	MHz	The need of satellite spectrum to support internet services in ground segment programs.
Mbps Requirement	2000	Mbps	The need of internet speed to support internet services in CAPEX program
Distance between PoP	10	Km	Average distance between the nearest PoP to the new PoP for internet services
Average Child Branch per PoP	5		The number of branches each new PoP will have. Each branch will be connected to one BTS tower
Number of PoP	200	PoP	The number of PoP needed to fulfil the number of locations
Distance between PoP to BTS Tower	5	Km	Average distance between new PoP to BTS tower
FWA Child Branch per BTS	5		The number of branches each BTS will have. Each branch will be connected to one location
Number of BTS	200	unit	The number of BTS needed
WACC	5.7%		WACC for Telecom Providers per November 2023 (PWC, 2023)

Table 5. Cost Estimation

Program	Item	Description	Unit Price	Unit
AI EtE	Opex services	Including satellite services, ground segment, and O&M	50.000.000	IDR/location/month
AI EtE	OTC Installation	Initial cost for survey and installation	50.000.000	IDR/location
AI GS	Opex	Including ground segment and O&M	4.000.000	IDR/location/month
AI GS	OTC Installation	Initial cost for survey and installation	40.000.000	IDR/location
AI GS	LC1 Satellite services	External satellite services fee	17.432.045	IDR/MHz/month
AI BMN	LC2 Satellite services	External satellite services fee	6.069.682	IDR/Mbps/month
AI BMN	Opex	Includes O&M only	1.250.000	IDR/location/month
AI BMN	OTC Installation	Initial cost for survey and installation	30.000.000	IDR/location
FWA	OTC Installation	Delivery cost for modem	4.750	IDR/km
FWA	Opex services	Monthly plan	480.000	IDR/month
FWA	Opex modem	Monthly modem rental	30.528	IDR/month
Proposed Model	CAPEX Core PoP	FO from nearest PoP to new PoP, using 12 core armour	3.600.000	IDR/km
Proposed Model	OTC Installation PoP	Buried cable installation	50.000.000	IDR/km
Proposed Model	CAPEX Equipment + DC	New PoP building and equipment	480.000.000	IDR
Proposed Model	Opex Equipment + DC	New PoP building and equipment	20.000.000	IDR/month
Proposed Model	Opex PoP Backhaul	O&M for FO between PoP	13.065.000	IDR/month
Proposed Model	Opex BTS Backhaul	Managed service BTS backhaul	1.933.229	IDR/km/month/location
Proposed Model	Opex BTS & Tower	Using BAKTI's BTS infrastructure hence can be neglected.	0	IDR/month

There are three different scenarios to evaluate three different parameters separately. The first scenario will give each model a fixed number of locations to build. At the end of calculation, the NPV of each program's cost will be compared. The most efficient program will get a higher score in the latter analysis. The second scenario will be analysed based on calculation in the first

scenario. The objective of the second scenario is to find the maximum time allowed for the proposed model to trigger the market efficiency gap zone. This time duration then will be compared to one threshold parameter. This threshold parameter can be understood as the time a rural area needs to develop a digital lifestyle significantly higher. The third scenario will be based on calculation using a fixed available budget. The objective of the third scenario is to find the model which gives a higher number of locations to build. The calculation will be derived also from the first scenario.

All scenarios will share the same cost component. As for the cost component will be explained in Table 5.

1. First Scenario: Cost Efficiency

In the first scenario, the calculation uses a fixed number of locations. The number of locations that will be used is 1000 locations. From the calculation, the program with the highest cost is AI EtE and the lowest cost is AI BMN. AI Ete is the first program for internet access in BAKTI. The following programs (AI GS and BMN) were planned to reduce the deployment cost. Therefore, the result of calculation is in accordance with the initial intentions of internet access programs.

Using the general assumption, first we must estimate which of the current models will generate the lowest cost. Table 6 shows the comparison of cost estimation between the current model.

Table 6. Cost Comparison Between Current Model in Million Rupiah

Year	1	2	3	4	5	6	7	8	9	10
AI EtE	650,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	6,126
AI GS	218,740	178,740	178,740	178,740	178,740	178,740	178,740	178,740	178,740	6,126
AI BMN	190,672	160,672	160,672	160,672	160,672	160,672	160,672	160,672	160,672	6,126
NPV EtE	614,948	1,151,981	1,660,055	2,140,729	2,595,483	3,025,714	3,432,744	3,817,824	4,182,138	4,185,658
NPV GS	206,945	366,927	518,282	661,476	796,947	925,113	1,046,367	1,161,083	1,269,613	1,273,132
NPV BMN	**180,390**	**324,201**	**460,256**	**588,975**	**710,752**	**825,963**	**934,960**	**1,038,080**	**1,135,638**	**1,139,158**

Based on the Table IV.13, the lowest cost is generated by the AI BMN model. Therefore, for the next analysis we will use AI BMN as the reference for comparison analysis with the proposed model. After we estimate the cost for current model, then we must estimate the cost for our proposed model (see Table 7).

Table 7. Cost Estimation for Proposed Model in Million Rupiah

Component/ Year	1	2	3	4	5
CAPEX PoP	203,200	-	-		
OPEX PoP	74,130	74,130	74,130	74,130	
OPEX Backhaul	115,994	115,994	115,994	115,994	
CAPEX FWA	48				
OPEX FWA	6,126	6,126	6,126	6,126	6,126
Total Cost	399,498	196,250	196,250	196,250	6,126
NPV Proposed	**377,954**	**553,609**	**719,791**	**877,012**	**881,655**

The proposed model generates even lower cost than the AI BMN model. The proposed model records a NPV of IDR 881,7 billion, while AI BMN has IDR 1.139 trillion of NPV. It means the current model generates 29.2% more cost to build 1000 locations. Figure 5 shows the comparison of deployment costs.

2. Second Scenario: Exit Duration

Earlier in the first scenario, we have found that the NPV of the proposed model cost is at IDR 881,7 billion. This number has an equivalent value with the 6th or 7th year NPV from the current model. We use the NPV of AI BMN as the current model because it has the lowest cost. To be exact, the five years NPV of the proposed model is equivalent to the 6.5 years NPV of the current model. It means that the proposed model has 6.5 years as the maximum time threshold to allow rural locations to grow digital lifestyles properly so they are commercially attractive.

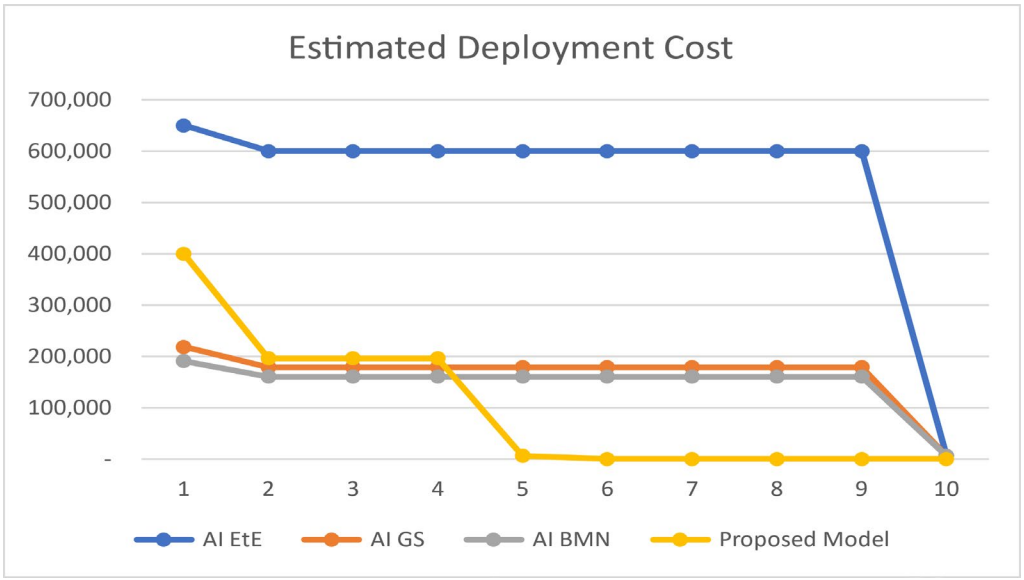

Figure 5. Comparison of Deployment Cost Between Current and Proposed Model

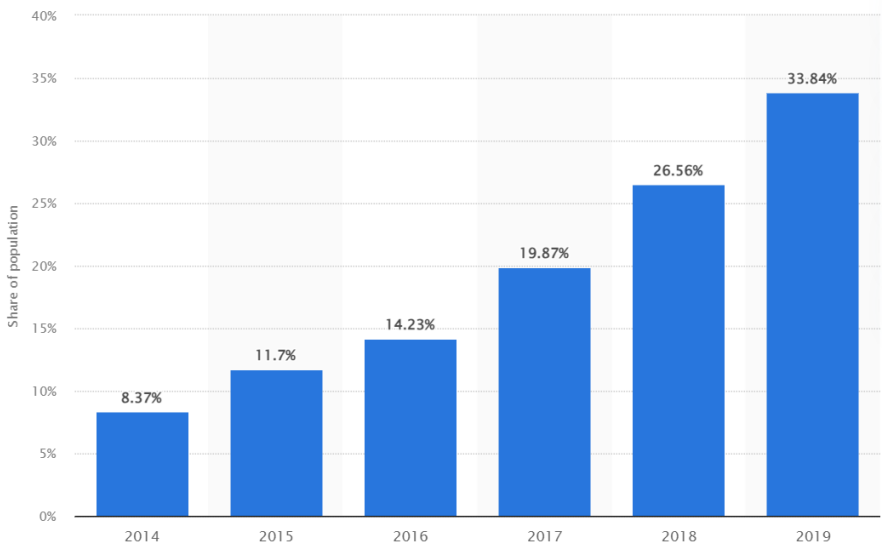

Figure 6. Rural Internet Penetration Rate in Indonesia

Figure 6 shows that historically in Indonesia the penetration rate in rural area grew about 4 times in a five-year interval (Statista, 2023). This number indicates that the internet user population also grew at high-rate. If compared with the maximum time threshold of 6.5 years, it indicates that the proposed model will have enough time to develop the rural area into the market efficiency gap zone.

3. Third Scenario: Number of Locations

For the third scenario, the average cost to build a location needs to be calculated first. In this regard, we can use the NPV of total cost in the first scenario for each model. The average cost per location for the current model is IDR 1,139 million, while the average cost of the proposed model is IDR 881.7 million. Hence, if given a budget of IDR 1 trillion, the current model can build about 878 locations, while the proposed model is able to build 256 more locations (1,134 locations).

Ensuring The Best Compliance Between Internet Access Schemes and Hypotheses Evaluation

The subsection contains the Quantitative Strategic Planning Matrix (QSPM) analysis, which evaluates strategic factors influencing the deployment of Internet access in rural areas of Indonesia. This analysis integrates internal and external factors identified through a SWOT analysis and quantifies them into a quantifiable framework. By assigning weights and attractiveness scores to each factor, the QSPM method enables us to objectively assess these factors' relative importance and potential impact. This approach allows us to understand the strategic actions necessary to enhance rural internet connectivity, providing valuable insights for decision-makers and stakeholders involved in this initiative. The resulting analysis will highlight the most influential factors and guide the strategic direction for effectively implementing rural internet access projects (see Table 8).

Table 8. Quantitative Strategic Planning Matrix

Key Factors	**Existing Model**			**Proposed Model**		
	W	**S**	**T**	**W**	**S**	**T**
Strengths						
Robust technological infrastructure	0.1	2	0.2	0.1	3	0.3
Effective government policies	0.15	2	0.3	0.15	3	0.45
Local community engagement	0.15	1	0.15	0.15	2	0.3
Digital literacy programs	0.05	1	0.05	0.05	2	0.1
Weaknesses						
Geographical challenges	0.2	2	0.4	0.2	2	0.4
Limited private sector participation	0.2	2	0.4	0.2	2	0.4
Inconsistent policy effectiveness	0.15	2	0.3	0.15	2	0.3
Sum Weights	*1*			*1*		
Opportunities						
Technological advancements	0.1	2	0.2	0.1	2	0.2
Increasing investment and funding	0.2	2	0.4	0.2	3	0.6
Growing demand for internet access	0.2	1	0.2	0.2	3	0.6
Threats						
Economic fluctuations	0.2	1	0.2	0.2	2	0.4
Rapid technological changes	0.15	2	0.3	0.15	2	0.3
Policy and regulatory challenges	0.15	2	0.3	0.15	2	0.3
Sum Weights	*1*			*1*		
Sum Total Attractiveness Score			3.4			4.65

W=weight [0.0,1.0], S=score [0,4], T=total

5. Conclusions and Recommendations

This study mainly aims to define a new and better model than the current model for deploying ICT infrastructure in rural areas. To be considered as the better model, the proposed model needs to cover parts of or all the challenges that need to be considered. After several analysis, discussion, and data collection, the key findings in this study are as following:

a. The proposed model generates better cost efficiency. The current model needs 29.2% more cost to build 1000 locations than the proposed model.
b. The proposed model has faster transition time from true access gap zone to market efficiency gap zone than the current model. This also means that the proposed model has enough time to accelerate the internet penetration rate in rural areas when given the same amount of cost as the current model.
c. The proposed model could build even more locations than the current model when given the same amount of cost. The proposed model could build 1.134 locations, while the current model could build 878 locations with IDR 1 trillion of budget.
d. The proposed model is considered to provide a better performance in several key indicators, such as;
    1. Robust technological infrastructure; the proposed model is considered to provide better performance of ICT infrastructure using advanced technology such as Fixed Wireless Access, Cellular Backhaul, and Fiber Optic backbone.
    2. Effective government policies; the proposed model is perceived to give better output in terms of cost efficiency and coverage of rural locations.
    3. Local community engagement; the proposed model will optimize the utilization of existing infrastructure and local providers/communities.
    4. Digital literacy program; the proposed model will give better opportunities and flexibilities to accommodate various digital-based programs.
    5. Increasing investment and funding; the wider coverage of rural internet services will create wider opportunities for both public and private investment.
    6. Growing demand for internet access; the rising of internet services availability will trigger the digital lifestyle, hence there will be more demand for further internet services.
    7. Economic fluctuations; better cost efficiency generated by the proposed model will serve a sustainable funding plan in the long term.
e. By using QSPM, the proposed model generates a better score than the current model. The score for the proposed model is 4.65, while the current model gets 3.4.

The recommendation and opportunities for future research in this study are as following;

a. Giving internet access to rural access is the first step for a digital lifestyle. Furthermore, using FWA as last mile technology offers high speed and reliable internet access. However, there is a need to continuously encourage people in rural villages to use the internet for increasing productivity and economic level.
b. There is a need for research on the ability and willingness to pay in rural areas, especially when the transition phase from BAKTI's program to commercial services will start. This research will help to ensure smooth transition to commercial internet services from BAKTI's program free of charge BAKTI's program.
c. The proposed model will heavily involve existing infrastructure both from commercial networks and other BAKTI's network. Therefore, we hope that BAKTI and the commercial network will synergize their deployment plan with this proposed model in terms of network node selection.

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