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Implementation of Fuzzy Delphi & Topsis Methods in Determining Priority Locations for Fiber to the Home Network Deployment

Journal of Electrical Systems

Abstract: - The study tested the fuzzy Delphi and TOPSIS methods to obtain the dominant criteria that management needs to consider in prioritizing FTTH construction locations. The weighting is obtained from the fuzzy Delphi scores from the data processing of questionnaires distributed to 9 expert respondents who have been selected based on their experience in FTTH. The research results in13 criterias along with weight values that meet the fuzzy Delphi criteria with a threshold value ≤ 0.2 and a consensus value of experts >75%. These criteria include: population (0.9111), number of registered customers (0.9111), purchasing power (0.900), analysis of operating areas (0.8815), business and office areas (0.8704), port occupancy (0. 8630), ARPU Value (0.8296), Core Backbone (0.8074), Customer Loyalty (0.8000), Port Availability (0.7815), Licensing (0.7778), Government Special Requirements (0.7704), and Competitor Service Delivery (0.5667). The ten criteria that were agreed to be the most dominant in terms of influence were tested using the TOPSIS method and resulted in five priority locations for FTTH network development, namely STO Mattoangin (0.6331), STO Bone (0.4808), STO Sinjai (0.4529), STO Selayar (0.4455) and STO Pangkep (0.4450).

Keywords: Fuzzy Delphi, Fiber Optic , TOPSIS, Telecommunication.

I. INTRODUCTION

The high demand for broadband internet services from year to year in Witel Makassar is shown by the high occupancy of development ports. Based on the data from 2020 to 2022, the occupancy of FTTH development ports in Witel Makassar tends to increase. At the end of 2022, the top 5 areas with the highest port occupancy are:

1. Antang location (76% occupancy),
2. Selayar location (75% occupancy),
3. Town Hall location (74% occupancy),
4. Mattoangin location (73% occupancy),
5. Panakkukang site (71% occupancy).

A snapshot of port utilization in each area is shown in Figure 1.1.

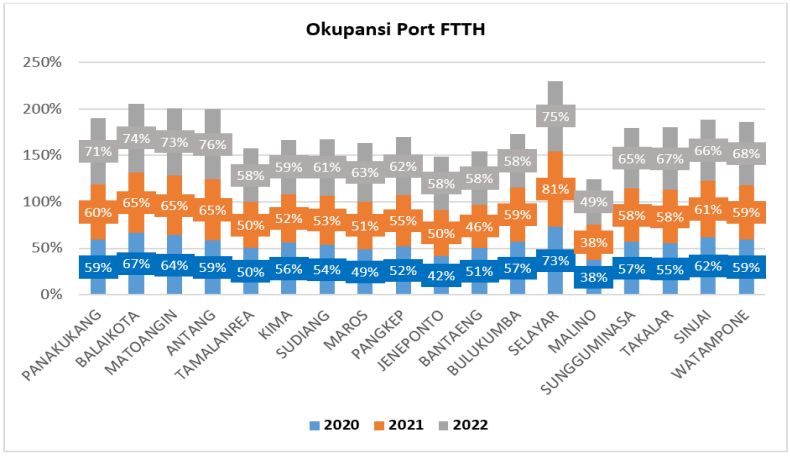

Figure 1.1 Occupancy of Development Port in 2020 to 2022 (Source: Internal Data, Year 2020-2022)

A high percentage of port occupancy indicates the limited availability of ports that can be sold. High occupancy also indicates that demand and internet usage in the area is very high. The indicators in Figure 1.1 are a sign to prepare a new development proposal to maintain the availability of production equipment in the territory. To maintain the availability of production equipment at occupancy below 70%, Witel Makassar must immediately propose port construction in the form of a List of Project (LoP). Each territory (18 STO offices) will propose the development in accordance with the needs and sales targets that have been set in each territory.

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One FTTH development cycle usually consists of a planning phase, procurement phase, installation phase and project completion phase. In this study, researchers will show the business process of the planning phase and installation phase.

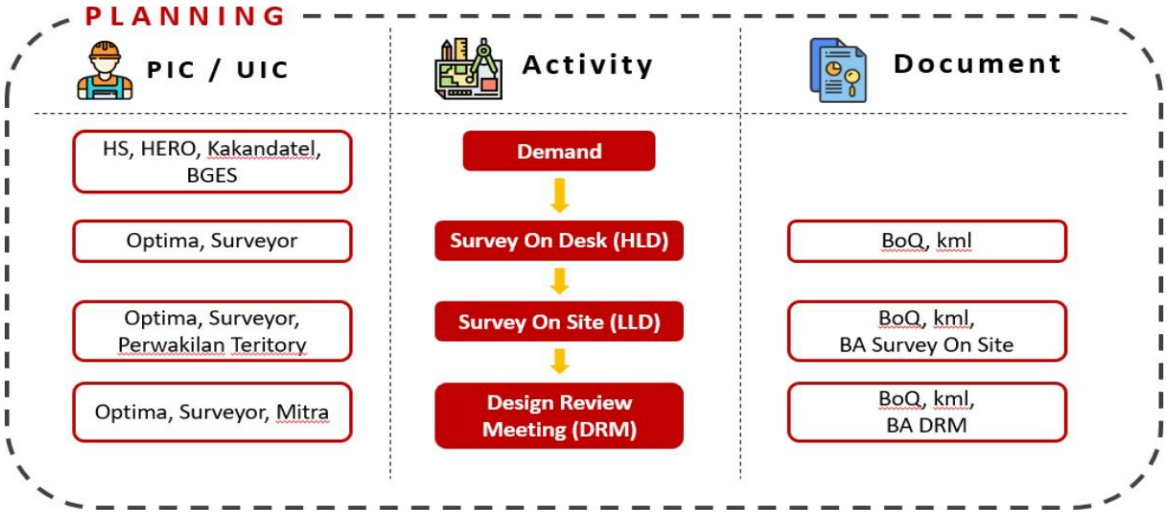


Figure 1.2 Business Process Planning FTTH Witel Makassar
(Source: Internal Data, Unit Construction 2022)

Good planning will result in more effective FTTH development and create efficiencies that ultimately improve the best customer experience and provide good profits to the company. In this phase, territory leaders will provide development proposals in the form of demand and clusters according to the needs and urgency in their respective areas. Furthermore, it will be surveyed and carried out a design review with the relevant units. After the phase in Figure 1.2, the next is the procurement process for selecting construction partners, followed by the installation phase. The business process in the installation phase is described in the process flow in Figure 1.3.

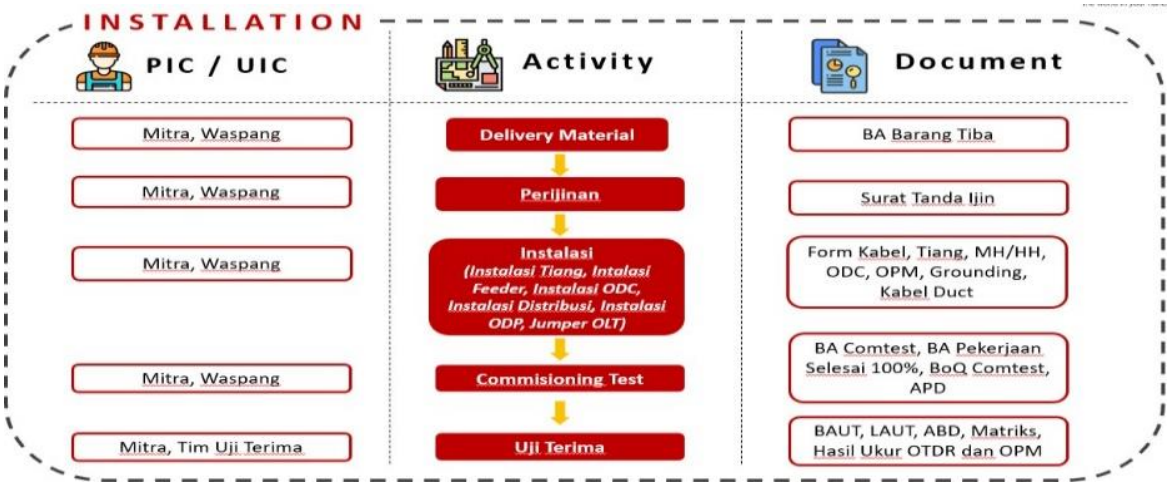


Figure 1.3 Business Process of FTTH Installation Witel Makassar
(Source: Internal Data, construction unit 2022)

After the partner selection process is carried out in the next logistics unit is the FTTH installation phase. There are development partners, security guards and also the acceptance test team which are PT Telkom organics. Have a letter of assignment to oversee and ensure the FTTH project runs well in the field.

Based on some of the business process explanations above, it is clear that the planning process that begins with the List of Project (LoP) proposal data is the beginning to determine how much the project value will be. Figure 1.4 shows the proposed data for the consumer segment development port that has been collected from 2020-2022 from the optima & construction supervisory unit:

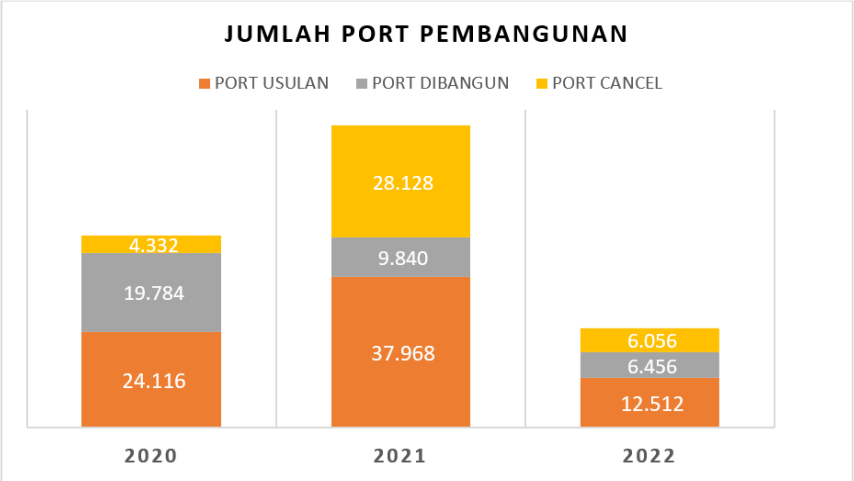


Figure 1.4 Consumer FTTH Development Port Profile
(Source: Internal Data, 2020-2022)

In Figure 1.4, it is obtained that in 2020 there are 18% or around 4,332 ports dropped, 74% or 29,128 ports dropped and in 2022 there are 48% or 6,056 ports canceled. Port cancel is a proposal for FTTH development from territories in Witel Makassar that cannot be fulfilled or approved for development because it does not match the investment feasibility criteria based on the standards applied at Telkom Regional VII, namely ≤ Rp. 1,200,000 per port. The proposed port development that is not approved can certainly have an impact on the achievement of sales realization against the high sales target in each area. Based on the results of coordination with the territory leader, in this condition each territory will be asked to evaluate the LoP. The options given can be to change the design, by reviewing the demand in the proposal, changing the design or replacing it with another LoP proposal. The validation of LoP data is what researchers propose can be reviewed by determining agreed criteria and becoming a guideline in assessing LoP proposals at Witel Makassar. So that it does not cause LoP which may be high in CAPEX per port but in the assessment of other non-financial aspects it turns out that it is possible to do.

The number of LoP proposals will have an impact on the absorption of Regional VII CAPEX, especially in Witel Makassar every year. The proposed project list also has an impact on the company's revenue and profit, especially Witel Makassar. Below is an overview of the CAPEX profile for the construction of the Fiber Optic To The Home (FTTH) network from 2020-2022.

Based on the results of coordination with the marketing unit, together with the territory team, not all of the proposed development loops will be fulfilled. Although the micro demand survey has obtained more specific demand results and boundaries have been made. The financial factor, namely CAPEX per port, is a consideration factor for the approval of the proposed project.

From the background of this problem, the researcher is interested in raising the topic and proposing to conduct research to identify and determine the dominant criteria that are influential in assessing the Fiber To The Home (FTTH) construction project list. That is to test a method that can later be used by the construction unit and senior leaders and management of Witel Makassar as a method to provide other considerations in assessing the proposed LoP FTTH that has been collected and proposed by the territory leaders from a different perspective. That assessing a project in addition to financial aspects also requires consideration of non-financial aspects. By standardizing the implementation of this method, all territory leaders can be facilitated in analyzing their LoP planning proposals. So that they can justify each proposal with supporting data and appropriate scientific studies.

The results of the literature study identify what factors / criteria are likely to influence management in approving a project. Project execution and complexity are influenced by management decisions. This factor is stated by Kermanshachiaet et al., 2016, Ahmadiet et al., 2017; Rumeser and Emsley (2019) and Schultzet et al., 2019. Another factor that influences project decision making is the aspect of laws and regulations, where the level of policy incentives and regulations affects the effectiveness of project implementation, this factor is concluded by research by Kivilaet et al., 2017 and Romasheva and Ilinova (2019). Changes in legal and regulatory policies, institutional complexity can arise in a project (Bosch-Rekveldt et al., 2011; Heet al., 2015). Even in conditions where regulations and laws do not change, conflicts can occur in projects (Li et al., 2015; Floricel et al., 2016). Other factors will be the subject of group discussions involving experts who have experience in FTTH construction.

By involving experts as respondents in a study, this method is very popular, namely the delphi method, but this method has several weaknesses such as a process that is too long and repetitive causing the data to be incomplete

and imprecise. With the fuzzy delphi method, only a small sample is needed and objective and reasonable results are obtained. In addition to saving the time and cost required to collect the opinions of experts through group discussions, but also the opinions of experts will also be expressed adequately without being distorted (Hsu and Yang, 2000, Ishikawa et al., 1993, Kuo and Chen, 2008, Murry et al., 1985).

To determine other factors, a method involving experts is needed to collect and classify qualified expert knowledge in natural language using questionnaires with feedback and reviews from them (Sayari, Yaghoobi, & Ghanaatpishe, 2014). This method is known as fuzzy delphi. This method ensures validity and verifies elements through expert opinion and consensus (Mohamad, Embi, & Nordin, 2015).

II. MATERIALS AND METHODOLOGY

STUDY AREA:

Source: Data Internal

The scope of this research is limited to the object of research only in the Telkom Witel Makassar area on Fiber To The Home (FTTH) infrastructure development in the Consumer segment. The enterprise, business and government and wholesale segments are not included in the scope of the study. Not all criteria obtained were tested in this study. Researchers limited the most dominant criteria based on the test results. The alternative locations that were selected were limited to the Makassar Witel operating area, namely 18 Automatic Telephone Center (STO) locations.

This research uses the method of collecting the selection of criteria in this study obtained based on literature studies and then evaluated and selected through surveys and feedback based on the fuzzy delphi method with experts who have been determined according to their abilities and experience while working at PT Telkom. The data that has been collected will become a reference as an indicator in the selection of priority FTTH development locations. This decision making is done by combining the fuzzy delphi and topsis methods according to predetermined criteria and giving an order based on a priority scale.

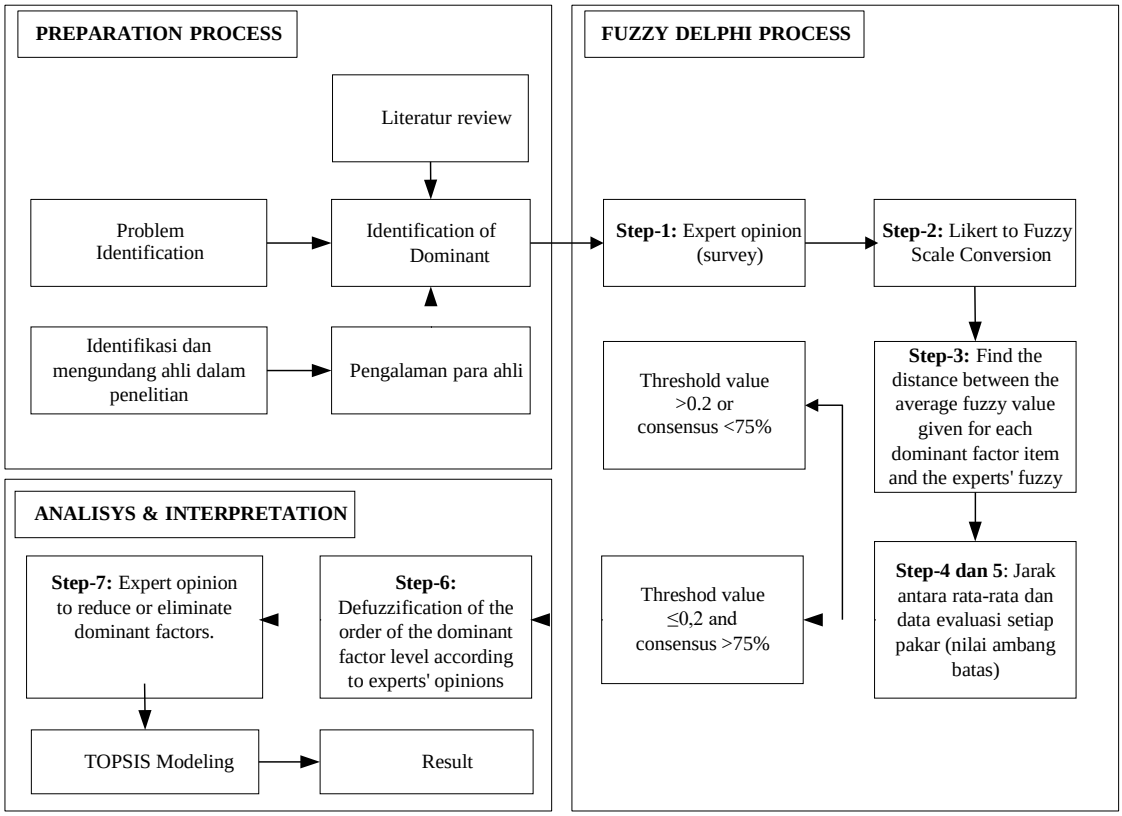


Figure 3.1 Flowchart of FTTH Development Priority Location Determination (Source: Chan et al., 2011)

Data Collection with Fuzzy DELPHI Method

In this stage of the preparation process, non-financial criteria are obtained from the results of literature studies and also observation results from interviews with experts in the field. The output at this stage is to get non-financial factors that can dominantly influence management considerations in making decisions to support the proposed List of Projects at Witel Makassar.

In Table 3.1 is a reference that has criteria for factors that influence a project decision. Table 3.1 Criteria that Influence Decisions.

No	Criteria	Source
1	Micro Demand	Results of initial interviews and field data
2	Port Occupancy Data	Results of initial interviews and field data
3	Competitors	Results of initial interviews and field data
4	Target Sales	Results of initial interviews and field data
5	Regional Potential Analysis	Results of initial interviews and field data
6	Backbone Infrastructure (Feeder, OLT)	Results of initial interviews and field data
7	*Laws & Regulation*	Kivila et al., (2017) and Romasheva and Ilinova (2019)
8	*Management Decisions*	Kermanshachia et al., (2016), Ahmadi et al., (2017); Rumeser and Emsley (2019) and Schultz et al., (2019)

(Source: Results of field research and *literature review*, 2022-2023)

After obtaining several criteria as in Table 3.1, then these non-financial criteria will be tested again by giving a questionnaire to experts. The questionnaire is compiled and consists of several statements systematically where experts will fill in each statement with a Likert scale of 1 to 7. The results of this questionnaire are then processed using formula tools in Ms. Excel which will be converted into *fuzzy* delphi until it meets the *threshold* value and consensus as required in *fuzzy* delphi to determine which criteria are valid and invalid.

Referring to the literature review regarding the steps and implementation of the survey or distribution of questionnaires, the data was then obtained using the *fuzzy* delphi method. This study used ten experts/respondents with the following criteria:

1. Respondents are organic employees of PT Telkom with Regional VII work locations and also Witel Makassar.
2. Represent the team that has an interest in the planning, engineering, deployment, maintenance and use of the results of FTTH development.
3. Have work experience above 10 years.
4. Have very specific and in-depth knowledge of FTTH construction development.

The selection of experts was based on previous studies where 5 to 15 experts were selected if there was high uniformity among the experts. The number of respondents can reach 10 to 50 experts (Jones, Twiss, 1987). Another study also concluded that the number of experts in fuzzy Delphi does not need to be large because there is no strong relationship between the number of experts and the quality of the decisions produced (Ocampo, Ebisa, Ombe, 2018).

A total of nine people were selected to represent all stakeholders in providing an assessment of the dominant factors influencing the decision to determine the priority location of FTTH development. The list and profiles of the experts are listed in Table 3.1.

Table 3.2 List of Experts

No.	Name	Position	Work Experience
1	Ant...	OSM Planning, Engineering & Deployment Reg VII	>10 Years
2	Ris...	MGR Access New FTTH & Modernization Deployment	>10 Years
3	Fan...	Kakandatel Gowa	>10 Years
4	Ded...	MGR Access Optima & DAMAN	>10 Years
5	Asr...	MGR Operaton BGES, WAN, WIFI	>10 Years
6	Chr...	MGR Access CAPEX QE & Performance	>10 Years
7	Muh...	MGR Access Optima	>10 Years
8	Ham...	Kakandatel Maros	>10 Years
9	Feb...	MGR Sales Promotion & Pricing	>10 Years

Stages of Fuzzy DELPHI Method

The criteria proposed to respondents are based on the results of the literature review and also field surveys. The following are the non-financial criteria that will be tested:

a. Micro Demand
b. Port Occupancy Data
c. Competitors
d. Target Sales
e. Operation Area Analysis
f. Laws & Regulations
g. Backbone Infrastructure (Feeder, OLT)
h. Management decisions.

To test the above criteria, there are several guidelines using the fuzzy Delphi method.

Guidelines based on research results from Jamil et., al 2017 are described as follows.

Step 1: The survey was distributed to the experts as respondents. Agreement with the selected experts on the assessment criteria for the variables to be measured using linguistic variables.

Step 2: Transform linguistic variables into triangular fuzzy numbers. Below is a table showing the changes in linguistic variables to the fuzzy scale.

Table 3.3 Fuzzy Scale

	Likert Scale	Fuzzy Scale
Strongly disagree	1	(0.0, 0.0, 0.1)
Disagree	2	(0.0, 0.1, 0.3)
Somewhat disagree	3	(0.1, 0.3, 0.5)

	Likert Scale	Fuzzy Scale
Neutral	4	(0.3, 0.5, 0.7)
Somewhat agree	5	(0.5, 0.7, 0.9)
Agree	6	(0.7, 0.9, 1.0)
Strongly agree	7	(0.9, 1.0, 1.0)

Step 3: Convert Likert scale into Delphi *fuzzy* number scale. Calculate the distance between the average r valuesij (Chen 2000) by using the Vertex method, which is the distance between two fuzzy numbers m = (m1, m2, m3) and n = (n1, n2, n3) using the formula:

$$d(\check{m},\check{n}) = \sqrt{\frac{1}{3}\left[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2\right]}$$

Step 4 and 5: Next determine the "d" value (*Threshold value*). If the threshold value obtained is (d < 0.2), it means that there is agreement among experts on an item that has been assessed. But on the contrary, if the threshold value is (d > 0.2), it means that there are different views among experts on the items that have been assessed (Cheng and Lin, 2002). Expert consensus can also be achieved when the percentage of consensus has reached 75% (Murry & Hammons, 1995; Chu & Hwang, 2008).

Step 6: Data analysis is carried out through the *defuzzification process*, this step aims to determine the final *fuzzy* score from the values obtained from experts or respondents. The value can be obtained using the equation: A = (1/3)*(m1 + m2 + m3).

Step 7: The order of criteria for dominant factors influencing decision-making decisions, which is the result of the evaluation of all expert opinions, is reported to the experts and then consulted with the experts to get a decision on whether to reduce or eliminate the criteria.

In this fuzzy delphi process, interviews and one-on-one discussions with experts are conducted online through the *zoom meeting* media. This condition is because the experts are in different locations and have a high enough busyness that it is quite difficult if the discussion is carried out offline. This condition is in line with research from previous researchers who stated that one of the other benefits of the delphi method is its flexibility which can be done using internet media (Steinert, 2009).

en surface water samples were collected from river, lake, bori for throughout the year for different three seasons post-monsoon 2019, pre-monsoon 2020 and during monsoon 2020. Each sampling location was recorded with Global Positioning System (GPS).Samples were collected in two liter High Density Polyethylene (HDPE) containers. pH, EC were measured on the spot immediately after the collection of water samples. Total Dissolved Solids, Calcium, Magnesium, Total hardness, Turbidity, Sulphate, Chloride, Lead, Chromium, Arsenic, Ferrous, Copper, and Zinc were analyzed using standard prescribed methods (APHA 1998). Samples for BOD analysis were collected in separate 300 ml BOD bottles and oxygen was fixed immediately.

TOPSIS Modeling

After testing using the *fuzzy* delphi method, then proceed with determining alternative locations that are prioritized for FTTH network development with alternative Automatic Telephone Center (STO) locations as in Table 3.4.

Table 3.4 Alternative STO Locations

Alternative	Location Name
Alternative- 1	STO Pangkep
Alternative- 2	STO Maros
Alternative- 3	STO Tamalanrea
Alternative- 4	STO Antang
Alternative- 5	STO Kima
Alternative- 6	STO Sudiang
Alternative- 7	STO Panakkukang
Alternative- 8	STO City Hall
Alternative- 9	STO Mattoangin

Alternative	Location Name
Alternative- 10	STO Sungguminasa
Alternative- 11	STO Malino
Alternative- 12	STO Takalar
Alternative- 13	STO Jeneponto
Alternative- 14	STO Bantaeng
Alternative- 15	STO Bulukumba
Alternative- 16	STO Selayar
Alternative- 17	STO Bone
Alternative- 18	STO Sinjai

The next process is to determine the ranking of alternative FTTH infrastructure development locations using the *topsis* method, using the following stages:

1. Create a decision matrix. The input data for criteria uses the results of the previous method.
2. Calculating the normalized decision matrix equation 2.1 of the decision matrix.
3. Calculating the weighted normalized decision matrix equation 2.2 from the normalized decision matrix with the input weight of each criterion obtained from the previous method.
4. Calculating the positive ideal solution value and negative ideal solution equation 2.3 of the weighted normalized decision matrix.
5. Calculate the distance of each alternative to the positive ideal solution and negative ideal equation 2.4. An alternative is preferred if
6. Has the smallest distance value to the positive ideal solution, and vice versa has the largest distance value to the negative ideal solution.
7. Calculating the preference value for each alternative equation 2.5 from the distance of each alternative to the positive ideal and negative ideal solutions.
8. Ranking alternatives based on the preference value of each alternative. Alternatives with a greater preference value indicate that the alternative is more preferred.

III. DISCUSSION

To compile the questionnaire in this study according to Sugiono (2012) variables are tools set by researchers for analysis. So that before the questionnaire is made, the definition of variables is obtained as in Table 4.1.

Table 4.1 Non-financial criteria to be tested

No.	Criteria	Sub Criteria	Statement
1	Micro Demand	A. Total Population	The number of residents in a territory is one of the factors considering the construction of FTTH in a territory.
2		B. Business and OfficeArea	Business and office areas are one of the consideration factors for the construction of FTTH in a territory.
3		C. Purchasing Power	The purchasing power of the community is one of the factors considering the construction of FTTH in a territory.
4	Port Occupancy	A. Availability port	Port availability is one of the considerations for building FTTH in a territory.
5		B. Port Occupancy	High port occupancy is one of the factors for building FTTH in a territory.
6	Similar Competitors	A. Competitor ServicePrice	The lower price of competitors' services is one of the factors for building FTTH in a territory.
7		B. Competitor After Sales	Fast after sales of competitors is one of the factors for the construction of FTTH in a territory.
8		C. Competitor ServiceDelivery	Competitors' fast service delivery is one of the factors for building FTTH in a territory.

No.	Criteria	Sub Criteria	Statement
9	Taget Sales	A. Number of registeredcustomers	The high number of Indohome customer registrations is one of the factors for the construction of FTTH in a territory.
10		B. ARPU Value	High ARPU value is one of the factors for building FTTH in a territory.
11		C. Customer Loyalty	Loyalty of Indihome customers in a territory is one of the factors for the construction of FTTH
12	Operation Area Analysis	A. Operation AreaAnalysis	The Regional Potential Analysis (ADO) profile is one of the factors for the construction of FTTH in a territory.
13	Laws & Regulation	A. Licensing	The existence of licenses from PTSP, City Public Works, Provincial Public Works and Balai Public Works is one of the factors for the construction of FTTH in a territory.
14	Backbone Infrastructure	A. Core Backbone	The existence of backbone cores (Core in ODC, Core in OLT) that are idle and can be used is one of the factors for building FTTH in a territory.
15		B. Link Budget CoreUplink	The appropriate link budget required is one of the factors for building FTTH in a territory.
16		C. Core Backbone Quality	Measurement results and good Core backbone quality are one of the factors for the construction of FTTH in a territory.
17	Management Decision	A. Special request of theGovernment	The existence of special requests from the central and local governments is one of the factors for management to decide that FTTH can be built in a territory.
18		B. Telkom and Government Cooperation Commitment	The existence of a long-term cooperation commitment between Telkom and the central government and or local government is one of the factors for the construction of FTTH in a territory.

From the identification of criteria and sub criteria in Table 4.1 from the results of interviews with experts, the researchers then compiled a questionnaire and adjusted it to the method to be used, namely fuzzy delphi.

IV. RESULTS

This scale supports research (Cicchetti et al., 1985; Preston and Colman, 2000; Weng, 2004) which will then be converted to *fuzzy* delphi with the help of formulas that have been made in Ms Excel. The results of the questionnaire will then be displayed in Table 4.2.

Table 4.2 Delphi Questionnaire Results in Likert

EXPERT	CRITERIA																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	6	7	6	7	5	4	4	4	6	7	6	7	6	5	5	6	5	5
2	6	6	7	5	6	4	4	4	6	6	6	6	6	6	5	6	6	6
3	6	6	6	2	6	2	5	5	7	7	7	7	6	6	4	4	6	7
4	7	7	6	6	5	4	4	4	7	3	4	6	4	4	4	3	5	3
5	6	7	6	5	6	4	3	3	6	6	6	5	7	6	7	6	6	6
6	7	6	6	6	6	4	4	4	6	7	7	6	5	6	4	3	5	4
7	7	7	7	6	7	6	6	5	6	6	4	6	6	6	7	6	6	6
8	7	6	6	7	7	5	5	5	7	7	7	7	6	6	6	6	4	5
9	6	4	7	7	7	2	3	5	7	5	5	6	4	6	5	4	6	6

(Source: Results of data processing *fuzzy* Delphi Ms Excel)

Table 4.3 Triangular *Fuzzy Number* values and average *fuzzy* Delphi values (m1, m2 & m3)

EXPERT	CRITERIA																											
	1			2			3			4			5			6			7			8			9		
1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,5	0,7	0,9	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
2	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
3	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0	0,1	0,3	0,7	0,9	1	0	0,1	0,3	0,5	0,7	0,9	0,5	0,7	0,9	0,9	1	1
4	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,9	1	1
5	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,1	0,3	0,5	0,1	0,3	0,5	0,7	0,9	1
6	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
7	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1
8	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,9	1	1	0,5	0,7	0,9	0,5	0,7	0,9	0,5	0,7	0,9	0,9	1	1
9	0,7	0,9	1	0,3	0,5	0,7	0,9	1	1	0,9	1	1	0,9	1	1	0	0,1	0,3	0,1	0,3	0,5	0,5	0,7	0,9	0,9	1	1
Average	**0,79**	**0,94**	**1,00**	**0,74**	**0,90**	**0,97**	**0,77**	**0,93**	**1,00**	**0,64**	**0,80**	**0,90**	**0,72**	**0,89**	**0,98**	**0,30**	**0,48**	**0,67**	**0,34**	**0,54**	**0,73**	**0,37**	**0,57**	**0,77**	**0,79**	**0,94**	**1,00**
	m1	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**

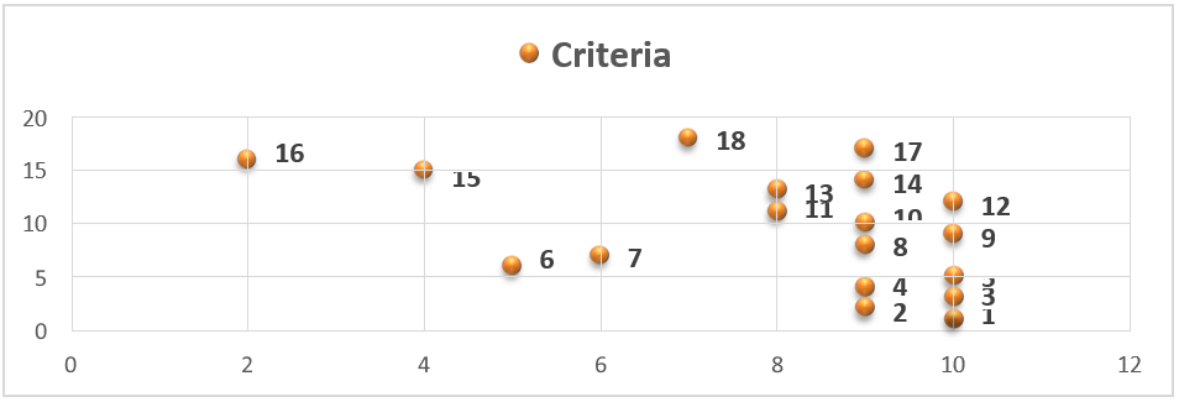
EXPERT	CRITERIA																											
	10			11			12			13			14			15			16			17			18		
1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,5	0,7	0,9	0,7	0,9	1	0,5	0,7	0,9	0,5	0,7	0,9
2	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1
3	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1	0,9	1	1
4	0,1	0,3	0,5	0,3	0,5	0,7	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,1	0,3	0,5	0,5	0,7	0,9	0,1	0,3	0,5
5	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1
6	0,9	1	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,1	0,3	0,5	0,5	0,7	0,9	0,3	0,5	0,7
7	0,7	0,9	1	0,3	0,5	0,7	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1
8	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,5	0,7	0,9
9	0,5	0,7	0,9	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,7	0,9	1	0,5	0,7	0,9	0,3	0,5	0,7	0,7	0,9	1	0,7	0,9	1
Average	**0,70**	**0,86**	**0,93**	**0,66**	**0,82**	**0,92**	**0,74**	**0,91**	**0,99**	**0,61**	**0,80**	**0,92**	**0,63**	**0,83**	**0,96**	**0,54**	**0,72**	**0,87**	**0,48**	**0,68**	**0,82**	**0,59**	**0,79**	**0,93**	**0,57**	**0,76**	**0,89**
	m1	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**	**m1**	**m2**	**m3**

(Source: Results of data processing *fuzzy* delphi Ms Excel)

Table 4.4 The *d* value *(Threshold Value)*

EXPERT	CRITERIA																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0,0679	0,1385	0,0509	0,2679	0,2412	0,0401	0,0612	0,1018	0,0679	0,1966	0,1129	0,1268	0,1367	0,1637	0,0476	0,3122	0,1079	0,0685
2	0,0679	0,0421	0,1018	0,1302	0,0280	0,0401	0,0612	0,1018	0,0679	0,0801	0,1129	0,0301	0,1367	0,0889	0,0476	0,3122	0,1446	0,1978
3	0,0679	0,0421	0,0509	0,9942	0,0280	0,5542	0,2450	0,2037	0,0849	0,1966	0,2399	0,1268	0,1367	0,0889	0,3116	0,2389	0,1446	0,3304
4	0,0849	0,1385	0,0509	0,1450	0,2412	0,0401	0,0612	0,1018	0,0849	0,7851	0,4420	0,0301	0,4143	0,4620	0,3116	0,5423	0,1079	0,6568
5	0,0679	0,1385	0,0509	0,1302	0,0280	0,0401	0,3662	0,4073	0,0679	0,0801	0,1129	0,2690	0,2718	0,0889	0,3702	0,3122	0,1446	0,1978
6	0,0849	0,0421	0,0509	0,1450	0,0280	0,0401	0,0612	0,1018	0,0679	0,1966	0,2399	0,0301	0,1209	0,0889	0,3116	0,5423	0,1079	0,3531
7	0,0849	0,1385	0,1018	0,1450	0,1529	0,5854	0,4896	0,2037	0,0679	0,0801	0,4420	0,0301	0,1367	0,0889	0,3702	0,3122	0,1446	0,1978
8	0,0849	0,0421	0,0509	0,2679	0,1529	0,3423	0,2450	0,2037	0,0849	0,1966	0,2399	0,1268	0,1367	0,0889	0,2397	0,3122	0,4071	0,0685
9	0,0679	0,5449	0,1018	0,2679	0,1529	0,5542	0,3662	0,2037	0,0849	0,1966	0,1533	0,0301	0,4143	0,0889	0,0476	0,2389	0,1446	0,1978
Average d	**0,0754**	**0,1408**	**0,0679**	**0,2770**	**0,1170**	**0,2485**	**0,2174**	**0,1810**	**0,0754**	**0,2232**	**0,2329**	**0,0889**	**0,2116**	**0,1387**	**0,2286**	**0,3470**	**0,1615**	**0,2521**

Table 4.5 Consensus value of experts (%)



(Source: Results of data processing *fuzzy* delphi Ms Excel)

Table 4.6 *Defuzzification* Process

EXPERT	Criteria																											
	1			2			3			4			5			6			7			8			9		
1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,5	0,7	0,9	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
2	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
3	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0	0,1	0,3	0,7	0,9	1	0	0,1	0,3	0,5	0,7	0,9	0,5	0,7	0,9	0,9	1	1
4	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,9	1	1
5	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,1	0,3	0,5	0,1	0,3	0,5	0,7	0,9	1
6	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1
7	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1
8	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,9	1	1	0,5	0,7	0,9	0,5	0,7	0,9	0,5	0,7	0,9	0,9	1	1
9	0,7	0,9	1	0,3	0,5	0,7	0,9	1	1	0,9	1	1	0,9	1	1	0	0,1	0,3	0,1	0,3	0,5	0,5	0,7	0,9	0,9	1	1
FUZZY EVALUATION PROCESS																												
Average m	0,79	0,94	1,00	0,74	0,90	0,97	0,77	0,93	1,00	0,64	0,80	0,90	0,72	0,89	0,98	0,30	0,48	0,67	0,34	0,54	0,73	0,37	0,57	0,77	0,79	0,94	1,00
	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3
Average fuzzy score	0,9111			0,8704			0,9000			0,7815			0,8630			0,4815			0,5407			0,5667			0,9111		

EXPERT	Criteria																											
	10			11			12			13			14			15			16			17			18				
1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,5	0,7	0,9	0,7	0,9	1	0,5	0,7	0,9	0,5	0,7	0,9	
2	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	
3	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,7	0,9	1	0,9	1	1	
4	0,1	0,3	0,5	0,3	0,5	0,7	0,7	0,9	1	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0,1	0,3	0,5	0,5	0,7	0,9	0,1	0,3	0,5	
5	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,9	1	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	
6	0,9	1	1	0,9	1	1	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,1	0,3	0,5	0,5	0,7	0,9	0,3	0,5	0,7	
7	0,7	0,9	1	0,3	0,5	0,7	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	
8	0,9	1	1	0,9	1	1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,3	0,5	0,7	0,5	0,7	0,9	
9	0,5	0,7	0,9	0,5	0,7	0,9	0,7	0,9	1	0,3	0,5	0,7	0,7	0,9	1	0,5	0,7	0,9	0,3	0,5	0,7	0,7	0,9	1	0,7	0,9	1	
FUZZY EVALUATION PROCESS																												
Average m	0,70	0,86	0,93	0,66	0,82	0,92	0,74	0,91	0,99	0,61	0,80	0,92	0,63	0,83	0,96	0,54	0,72	0,87	0,48	0,68	0,82	0,59	0,79	0,93	0,57	0,76	0,89	
	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	
Average fuzzy score	0,8296			0,8000			0,8815			0,7778			0,8074			0,7111			0,6593			0,7704			0,7370		

(Source: Results of data processing *fuzzy* delphi Ms Excel)

Table 4.7 Fuzzy Score (A)

No	Kriteria	Syarat Triangular Fuzzy Numbers		Syarat Fuzy Evaluation Proses				Kesimpulan Ahli
		Nilai Threshold (d)	Konsensus (%)	m1	m2	m3	Skor Fuzzy (A)	
1	Jumlah Penduduk	0,0754	100%	0,7889	0,9444	1,0000	0,9111	TERIMA
2	Area Bisnis dan Perkantoran	0,1408	90%	0,7444	0,9000	0,9667	0,8704	TERIMA
3	Daya Beli	0,0679	100%	0,7667	0,9333	1,0000	0,9000	TERIMA
4	Availability port	0,2770	90%	0,6444	0,8000	0,9000	0,7815	TERIMA
5	Okupansi Port	0,1170	100%	0,7222	0,8889	0,9778	0,8630	TERIMA
6	Harga Layanan Kompetitor	0,2485	50%	0,3000	0,4778	0,6667	0,4815	TOLAK
7	After Sales Kompetitor	0,2174	60%	0,3444	0,5444	0,7333	0,5407	TOLAK
8	Delivery Layanan Kmpetitor	0,1810	90%	0,3667	0,5667	0,7667	0,5667	TERIMA
9	Jumlah Pelanggan teregister	0,0754	100%	0,7889	0,9444	1,0000	0,9111	TERIMA
10	Nilai ARPU	0,2232	90%	0,7000	0,8556	0,9333	0,8296	TERIMA
11	Loyalitas Pelanggan	0,2329	80%	0,6556	0,8222	0,9222	0,8000	TERIMA
12	Analisa Daerah Operasi	0,0889	100%	0,7444	0,9111	0,9889	0,8815	TERIMA
13	Perijinan	0,2116	80%	0,6111	0,8000	0,9222	0,7778	TERIMA
14	Core Backbone	0,1387	90%	0,6333	0,8333	0,9556	0,8074	TERIMA
15	Link Budget Core Uplink	0,2286	40%	0,5444	0,7222	0,8667	0,7111	TOLAK
16	Kualitas Core Backbone	0,3470	20%	0,4778	0,6778	0,8222	0,6593	TOLAK
17	Permintaan khusus Pemerintah	0,1615	90%	0,5889	0,7889	0,9333	0,7704	TERIMA
18	Komitment Kerjasama Telkom dan Pemerintah	0,2521	70%	0,5667	0,7556	0,8889	0,7370	TOLAK

(Source: Results of data processing *fuzzy* delphi Ms Excel)

Table 4.8 Order of Criteria

No	Kriteria	Syarat Triangular Fuzzy Numbers		Syarat Fuzzy Evaluation Process				Kesepakatan Ahli	Ranking
		Nilai Threshold, d	Konsensus (%)	m1	m2	m3	Skor Fuzzy (A)		
1	Jumlah Penduduk	0,0754	100%	0,7889	0,9444	1,0000	0,9111	TERIMA	1
2	Jumlah Pelanggan teregister	0,0754	100%	0,7889	0,9444	1,0000	0,9111	TERIMA	2
3	Daya Beli	0,0679	100%	0,7667	0,9333	1,0000	0,9000	TERIMA	3
4	Analisa Potensi Daerah	0,0889	100%	0,7444	0,9111	0,9889	0,8815	TERIMA	4
5	Area Bisnis dan Perkantoran	0,1408	90%	0,7444	0,9000	0,9667	0,8704	TERIMA	5
6	Okupansi Port	0,1170	100%	0,7222	0,8889	0,9778	0,8630	TERIMA	6
7	Nilai ARPU	0,2232	90%	0,7000	0,8556	0,9333	0,8296	TERIMA	7
8	Core Backbone	0,1387	90%	0,6333	0,8333	0,9556	0,8074	TERIMA	8
9	Loyalitas Pelanggan	0,2329	80%	0,6556	0,8222	0,9222	0,8000	TERIMA	9
10	Availability port	0,2770	90%	0,6444	0,8000	0,9000	0,7815	TERIMA	10
11	Perijinan	0,2116	80%	0,6111	0,8000	0,9222	0,7778	TERIMA	11
12	Permintaan khusus Pemerintah	0,1615	90%	0,5889	0,7889	0,9333	0,7704	TERIMA	12
13	Komitment Kerjasama Telkom dan Pemerintah	0,2521	70%	0,5667	0,7556	0,8889	0,7370	TOLAK	
14	Link Budget Core Uplink	0,2286	40%	0,5444	0,7222	0,8667	0,7111	TOLAK	
15	Kualitas Core Backbone	0,3470	20%	0,4778	0,6778	0,8222	0,6593	TOLAK	
16	Delivery Layanan Kmpetitor	0,1810	90%	0,3667	0,5667	0,7667	0,5667	TERIMA	13
17	After Sales Kompetitor	0,2174	60%	0,3444	0,5444	0,7333	0,5407	TOLAK	
18	Harga Layanan Kompetitor	0,2485	50%	0,3000	0,4778	0,6667	0,4815	TOLAK	

(Source: Results of data processing *fuzzy* delphi Ms Excel)

In the delphi process as described in the research results above, one round of questionnaire filling was carried out by each expert. In the process of fuzzy delphi method (Chang et al., 2011), the threshold value

≤ 0.2 and consensus > 75% on each criterion have been obtained. As sorted in Table 4.7. There are 5 criteria that are rejected because the five criteria have consensus < 75% and some have a *threshold value* > 0.2. Meanwhile, 13 criteria in Table 4.7 are accepted as shown by meeting the threshold value ≤ 0.2 and consensus > 75%.

Based on the data in Table 4.8, it has answered the objectives of the research as described in Chapter 1, namely how to determine and find what non-financial criteria are dominant in determining the priority location of FTTH network construction at Telkom Witel Makassar. *Laws & regulations criteria* based on the research of Kivila et al.

(2017) and Romasheva and Ilinova (2019) did not become influential criteria in FTTH network construction after being tested in this study. Meanwhile, the criteria for *management decisions* in the research of Kermanshachia et al., (2016), Ahmadi et al., (2017); Rumeser and Emsley (2019) and Schultz et al., (2019) are agreed by experts as one of the non-financial factors that have a dominant influence after being tested in this study.

The 13 criteria that meet the requirements in fuzzy delphi and sorted from the most dominant level are shown in Table 4.9.

Table 4.9 Criteria for Expert Agreement Results

No	Criteria	Triangular Terms		FuzzyScore (A)	Expert Agreement	Ranking
		Value Threshold, d	Consensus (%)			
1	Total Population	0,0754	100%	0,9111	ACCEPT	1
2	Number of registered customers	0,0754	100%	0,9111	ACCEPT	2
3	Purchasing Power	0,0679	100%	0,9000	ACCEPT	3
4	Operation Area Analysis	0,0889	100%	0,8815	ACCEPT	4
5	Business and Office Area	0,1408	90%	0,8704	ACCEPT	5
6	Port Occupancy	0,1170	100%	0,8630	ACCEPT	6
7	ARPU Value	0,2232	90%	0,8296	ACCEPT	7
8	Core Backbone	0,1387	90%	0,8074	ACCEPT	8
9	Customer Loyalty	0,2329	80%	0,8000	ACCEPT	9
10	Availability port	0,2770	90%	0,7815	ACCEPT	10
11	Licensing	0,2116	80%	0,7778	ACCEPT	11
12	Government special requests	0,1615	90%	0,7704	ACCEPT	12
13	Competitor Service Delivery	0,1810	90%	0,5667	ACCEPT	13

(Source: Results of data processing *fuzzy* delphi Ms Excel)

In Table 4.9 all accepted criteria must fulfill two conditions in fuzzy delphi. If one of them is not met then that criterion will be rejected. The threshold value d is achieved at ≤ 0.2 and the consensus values of the experts on each criterion are all above 75%, so the criteria are acceptable. The population and number of registered customers criteria have the same threshold value and 100% consensus value. Which means that all experts in this study agree that these criteria have a very big influence in considering the construction of FTTH networks in a territory / area.

By using the fuzzy delphi method, the weight value of each criterion is produced as in Table 4.9. The weight of each criterion is obtained from the fuzzy score (A). The weight value obtained has answered the second research objective in this study, namely how to get the weight value of each criterion that has been agreed upon by the experts. The weight value will be used as a value in calculating the priority order of FTTH development locations using the TOPSIS method.

It starts by creating a decision matrix between alternative STO locations and criteria agreed upon by experts in the fuzzy delphi method. The decision matrix is shown in Table 4.10.

Table 4.10 Decision Matrix D

BOBOT (Fuzzy Delphi Score)	0,9111	0,9111	0,9000	0,8815	0,8704	0,8630	0,8296	0,8074	0,8000	0,7815
	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Cost	Cost	Cost
Alternatives/Criteria	Total Population	Number of Customers registered	Purchasing Power	Potential Analysis Regional	Business and Office	Port Occupancy (%)	ARPU Value	Core Backbone	Customer Loyalty (Data Churn)	Availability port
STO Pangkep	345.775	118	308.000	78	300	62	295.449	10	7	2.444
STO Maros	391.774	112	280.000	77	250	63	268.004	12	16	2.859
STO Tamalanrea	103.332	327	276.000	80	330	58	266.320	16	37	8.739
STO Antang	11.000	347	305.000	88	460	76	264.471	20	24	2.806
STO Kima	650	98	260.000	87	250	59	249.008	16	5	2.003
STO Sudiang	40.300	389	270.000	90	500	61	257.936	20	34	8.394
STO Panakkukang	147.000	126	274.000	90	650	71	262.491	26	92	11.525
STO Balaikota	646.200	200	242.000	89	750	74	232.172	22	53	7.217
STO Mattoangin	789.800	254	1.034.000	90	450	73	992.793	20	52	8.046
STO Sungguminasa	7.800	534	260.000	90	760	65	249.587	24	68	11.931
STO Malino	26.300	7	270.000	70	30	49	258.727	4	1	551
STO Takalar	300.853	80	276.000	90	160	67	264.338	14	7	1.836
STO Jeneponto	401.610	76	289.000	89	300	58	277.183	20	4	1.948
STO Bantaeng	196.716	51	305.000	86	450	58	292.314	22	4	2.218
STO Bulukumba	437.607	86	285.000	85	540	58	273.379	18	7	4.189
STO Selayar	137.071	26	346.000	90	567	75	332.190	10	3	721
STO Bone	801.775	106	288.000	87	670	68	275.804	16	24	4.693
STO Sinjai	259.478	50	313.000	90	690	66	300.072	12	5	1.645
Dividers	1.600.047	926	1.568.706	365	2.099	275	1.499.850	75	151	24.901

(Source: Results of data processing *fuzzy* delphi Ms Excel, equation 2.3)

The agreed criteria are compared with alternative STO locations. The data in Table 4.10 is internal data that has been collected in the field in the form of primary and secondary data. The data may change at any time. While the weight value is obtained from the results of data processing in the fuzzy delphi method (Table 4.9 *fuzzy* score column).

Table 4.11 Normalized Decision Matrix

	KRITERIA									
ALTERNATIF	0,2161	0,1275	0,1963	0,2136	0,1429	0,2252	0,1970	0,1335	0,0464	0,0981
	0,2449	0,1210	0,1785	0,2109	0,1191	0,2288	0,1787	0,1602	0,1060	0,1148
	0,0646	0,3532	0,1759	0,2191	0,1572	0,2106	0,1776	0,2136	0,2452	0,3510
	0,0069	0,3749	0,1944	0,2410	0,2191	0,2760	0,1763	0,2670	0,1590	0,1127
	0,0004	0,1059	0,1657	0,2382	0,1191	0,2143	0,1660	0,2136	0,0331	0,0804
	0,0252	0,4202	0,1721	0,2465	0,2382	0,2215	0,1720	0,2670	0,2253	0,3371
	0,0919	0,1361	0,1747	0,2465	0,3096	0,2579	0,1750	0,3471	0,6096	0,4628
	0,4039	0,2161	0,1543	0,2437	0,3572	0,2688	0,1548	0,2937	0,3512	0,2898
	0,4936	0,2744	0,6591	0,2465	0,2143	0,2651	0,6619	0,2670	0,3446	0,3231
	0,0049	0,5769	0,1657	0,2465	0,3620	0,2361	0,1664	0,3204	0,4506	0,4791
	0,0164	0,0076	0,1721	0,1917	0,0143	0,1780	0,1725	0,0534	0,0066	0,0221
	0,1880	0,0864	0,1759	0,2465	0,0762	0,2433	0,1762	0,1869	0,0464	0,0737
	0,2510	0,0821	0,1842	0,2437	0,1429	0,2106	0,1848	0,2670	0,0265	0,0782
	0,1229	0,0551	0,1944	0,2355	0,2143	0,2106	0,1949	0,2937	0,0265	0,0891
	0,2735	0,0929	0,1817	0,2328	0,2572	0,2106	0,1823	0,2403	0,0464	0,1682
	0,0857	0,0281	0,2206	0,2465	0,2701	0,2724	0,2215	0,1335	0,0199	0,0290
	0,5011	0,1145	0,1836	0,2382	0,3191	0,2470	0,1839	0,2136	0,1590	0,1885
	0,1622	0,0540	0,1995	0,2465	0,3287	0,2397	0,2001	0,1602	0,0331	0,0661

(Source: TOPSIS Ms Excel data processing results, equation 2.4)

Table 4.12 Weighted Normalized Decision Matrix

	KRITERIA									
ALTERNATIF	0,1969	0,1161	0,1767	0,1883	0,1244	0,1943	0,1634	0,1078	0,0371	0,0767
	0,2231	0,1102	0,1606	0,1859	0,1036	0,1975	0,1482	0,1293	0,0848	0,0897
	0,0588	0,3218	0,1583	0,1931	0,1368	0,1818	0,1473	0,1724	0,1961	0,2743
	0,0063	0,3415	0,1750	0,2124	0,1907	0,2382	0,1463	0,2156	0,1272	0,0881
	0,0004	0,0965	0,1492	0,2100	0,1036	0,1849	0,1377	0,1724	0,0265	0,0629
	0,0229	0,3829	0,1549	0,2172	0,2073	0,1912	0,1427	0,2156	0,1802	0,2634
	0,0837	0,1240	0,1572	0,2172	0,2695	0,2225	0,1452	0,2802	0,4877	0,3617
	0,3680	0,1968	0,1388	0,2148	0,3109	0,2319	0,1284	0,2371	0,2810	0,2265
	0,4497	0,2500	0,5932	0,2172	0,1866	0,2288	0,5492	0,2156	0,2757	0,2525
	0,0044	0,5256	0,1492	0,2172	0,3151	0,2037	0,1381	0,2587	0,3605	0,3744
	0,0150	0,0069	0,1549	0,1690	0,0124	0,1536	0,1431	0,0431	0,0053	0,0173
	0,1713	0,0787	0,1583	0,2172	0,0663	0,2100	0,1462	0,1509	0,0371	0,0576
	0,2287	0,0748	0,1658	0,2148	0,1244	0,1818	0,1533	0,2156	0,0212	0,0611
	0,1120	0,0502	0,1750	0,2076	0,1866	0,1818	0,1617	0,2371	0,0212	0,0696
	0,2492	0,0846	0,1635	0,2052	0,2239	0,1818	0,1512	0,1940	0,0371	0,1315
	0,0781	0,0256	0,1985	0,2172	0,2351	0,2351	0,1837	0,1078	0,0159	0,0226
	0,4566	0,1043	0,1652	0,2100	0,2778	0,2131	0,1526	0,1724	0,1272	0,1473
	0,1478	0,0492	0,1796	0,2172	0,2861	0,2069	0,1660	0,1293	0,0265	0,0516

(Source: TOPSIS Ms Excel data processing results, equation 2.5)

In Table 4.12, the weighted normalized value will be obtained and the highest and lowest score values of each criterion will be obtained. Positive ideal solutions and negative ideal solutions are strongly influenced by how to define *costs* and *benefits for* each criterion. The PIS and NIS values are more clearly shown in Table 4.13.

Table 4.13 Positive Ideal Solution (PIS), and Negative Ideal Solution (NIS)

Kriteria	A+	A-
Jumlah Penduduk	0,4566	0,0004
Jumlah Pelanggan teregister	0,5256	0,0069
Daya Beli	0,5932	0,1388
Analisa Potensi Daerah	0,2172	0,1690
Area Bisnis dan Perkantoran	0,3151	0,0124
Okupansi Port	0,2382	0,1536
Nilai ARPU	0,5492	0,1284
Core Backbone	0,0431	0,2802
Loyalitas Pelanggan	0,0053	0,4877
Availability port	0,0173	0,3744

(Source: TOPSIS Ms Excel data processing results, equations 2.6 and 2.7)

If we look at Table 4.13 above, it is very clear that the difference in values A^+ on criteria with *cost* and *benefit* categories. As explained, the postitive ideal solution is obtained by selecting the highest value of each *benefit* category criterion. Whereas for criteria with the *cost* category *(core backbone*, customer loyalty and *port availability) the* value of the ideal solution is the opposite, namely the lowest value of the criteria. A^+ is the opposite, namely the lowest value of the criterion. Likewise, for the negative ideal solution in the *cost* category criteria, the value used is the highest value of these criteria. The PIS and NIS results are shown in Table 4.14 below.

Table 4.14 Distance of Positive Ideal Solution and Distance of Negative Ideal Solution

(Source: TOPSIS Ms Excel data processing results, equations 2.8 and 2.9)

The last process in the TOPSIS method is after determining the positive ideal distance and negative ideal distance to calculate the value of the ideal distance. RC^+. This value will determine the order of priority scale based on the highest value (shortest distance). i

To determine the value RC^+ Based on the above results, the priority order can be displayed in i Figure 4.1.

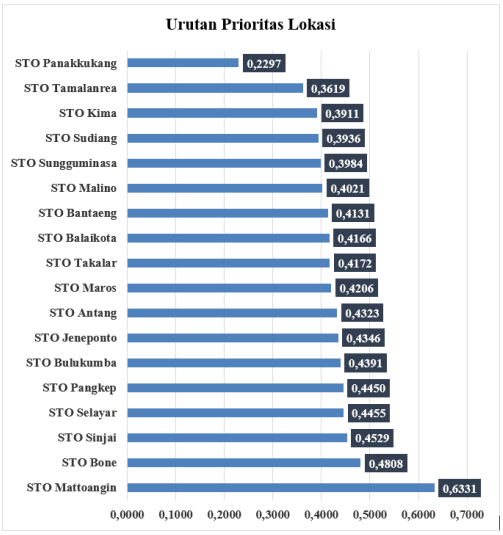


Figure 4.1 Priority Order of FTTH Development Location
(Source: TOPSIS Ms Excel data processing results, equation 2.10)

Based on Figure 4.1, the highest **V** value is STO Mattoangin, which means it is a priority location for the proposed FTTH network construction, after that STO Bone and STO Sinjai and STO Selayar. The last priority for FTTH network development is the location of STO Kima, STO Tamalanrea and STO Panakkukang.

V. CONCLUSION

After completing this entire research, which began with the results of literature review journals and data collection in the field in determining the dominant criteria that influence the priority location of *Fiber To The Home (FTTH)* development, the researcher concluded:

1. From a total of 18 non-financial criteria tested, 13 non-financial criteria were obtained that experts agreed based on the results of the fuzzy delphi method test had a dominant influence in determining the priority location of FTTH construction. Two requirements were met, namely *value threshold* ≤ 0.2 and expert

consensus >75% for each criterion tested. The criteria include population, number of registered customers**,** purchasing power**,** Analysis of Operating Areas**,** business and office areas, port occupancy**,** ARPU value, core backbone**,** customer loyalty**,** port *availability***,** licensing**,** government special requests and competitor service delivery.

2. The weight of each criterion obtained using the *fuzzy* delphi method is population **(0.9111)**, number of registered customers (0**.9111),** purchasing power (0.**900),** Analysis of Operating Areas (0**.8815),** Business and Office Areas **(0.8704)** port occupancy (0**.8630),** ARPU Value (0**.8296),** Core Backbone (0.**8074),** Customer Loyalty (0.**8000),** port *availability (0.***7815),** licensing (0.**7778),** government special requests (0.**7704)** and competitor service delivery (0.**5667)**.

The order of the five most prioritized locations for FTTH construction development with *fuzzy* delphi and TOPSIS methods in this study is Ten criteria agreed to be the most dominant influence were tested with the TOPSIS method and obtained five priority locations for FTTH network construction, namely STO Mattoangin (0.6331), STO Bone (0.4808), STO Sinjai (0.4529), STO Selayar (0.4455) and STO Pangkep (0.4450). The sequence of locations thereafter can be seen in more detail in Figure 4.1.

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