THE ALTERNATIVE OF DRAINAGE CONSTRUCTION TECHNOLOGY SELECTION BY USING *ANALYTICAL HIERARCHY PROCESS* METHOD

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Abstract: The drainage channel is one of the complementary buildings on the road segment in requiring one of the technical requirements for road infrastructure. The road drainage channels in general are open channels using gravity to drain surface water or inundation to the channel. The distribution of flow in the drainage channel to this channel follows the contours of the highway so that the water will flow easily following gravity. The Several alternatives selection of drainage development technologies include elbow drainage, parallel, grid iron, natural and radial. The problem found that some factor considered in selection the right technology are the construction budget, construction period, material supply, and construction process affecting the selection process become complicated. The purpose of this study is to determine the dominant criteria required in considering the selection of drainage construction technology in Banda Aceh and to determine the proper alternative using Analytical Hierarchy Process (AHP) method. After distributing questionnaires to 16 respondents, the research found that the dominant criterion is the construction period as the score 0.66. According to the respondents, the construction period become the most vital criteria since the assessment of criteria variable relate to the limitation in complete all drainage proposed. This study founds that the best alternative in selecting drainage construction technology is "parallel drainage" as the score 4.96. Therefore, this study recommends the use of "parallel drainage" as a priority in the drainage construction Banda Aceh by considering construction budget, construction period, material supply and construction process.
Keywords: AHP; drainage; technology

Abstrak: Saluran drainase merupakan salah satu bangunan pelengkap pada ruas jalan dalam memenuhi salah satu persyaratan teknis prasarana jalan. Pada umumnya saluran drainase jalan merupakan saluran terbuka yang menggunakan gaya gravitasi untuk mengalirkan air limbah ke *outlet*. Distribusi aliran di saluran drainase ke *outlet* ini mengikuti kontur jalan raya sehingga air limbah akan lebih mudah mengalir secara gravitasi. Beberapa alternatif pemilihan teknologi pembangunan drainase antara lain adalah drainase elbow, parallel, gridiron, natural dan radial. Persoalannya, beberapa faktor yang perlu dipertimbangkan dalam memilih teknologi yang tepat, biaya pembangunan, waktu konstruksi, ketersediaan material, dan proses pembangunan sehingga pilihan menjadi rumit. Tujuan dari penelitian ini adalah untuk menentukan kriteria dominan yang perlu diperhatikan dalam pemilihan teknologi pembangunan drainase di Kota Banda Aceh dan menentukan alternatif yang tepat melalui metode

Analytical Hierarchy Process (AHP). Setelah menyebarkan kuesioner kepada 16 responden, penelitian menemukan bahwa kriteria yang dominan adalah waktu pengerjaan dengan bobot tertinggi (0,66). Menurut responden, waktu konstruksi merupakan kriteria yang paling penting karena keterbatasan dalam menyelesaikan seluruh usulan pembangunan drainase perlu dipertimbangkan. Studi ini menemukan bahwa alternatif terbaik dalam memilih teknologi pembangunan drainase adalah "drainase paralel" yang memperoleh nilai kinerja tertinggi sebesar 4,96. Oleh karena itu, penelitian ini merekomendasikan penggunaan "drainase paralel" sebagai prioritas dalam pembangunan drainase di Kota Banda Aceh dengan pertimbangan biaya. waktu konstruksi, ketersediaan material, dan proses pembangunan.
Kata kunci: AHP; drainase; teknologi

Introduction

The high population growth and the settlement construction improvement in the line with the supporting facilitation are not supported by drainage system development. One of the impacts is the improvement of surface water and the reduction of water quality infiltrating to the ground, it affects inundation/flood in the rainy season and becomes the drought risk in the dry season (Muliawati and Mardyanto, 2015).

The flood in the urban area becomes one of the main issues in all over the world influencing significant impacts to the population and environment. The effective flood management requires the proper design of urban drainage system. It is crucial because the drainage function is vital in influencing significantly the flood damage and distribution (Yin, et. al., 2020).

The general drainage concept applied in almost of the world is conventional drainage concept. This concept have been comprehensively evaluated. The paradigm of the concept is the rainfall will be disposed to the river/drainage channel. If all of the rainfall is drained to the river without infiltrating to the ground, it will be vital impact for the rivers will overload the capacities. The rivers will overflow and affect the inundation (Muliawati and Mardyanto, 2015).

The inundation impacts the economic and social losses. However, the government budget limit impacts that the comprehensive drainage system improvement cannot be applied. It is required the priority in effective drainage system improvement to avoid the inundation (Suprapto, et al., 2016).

Several drainage system improvement including river and drainage channel normalization or channel improvement can only overcome the drainage problem for the short period. It is required the drainage problem management which is not only for short period but also integrated (Muliawati and Mardyanto, 2015).

The inundation problem solving cannot be applied comprehensively. It is required the study in determining the priority of drainage channel improvement based on social and economic losses caused by the inundation impact. So that the drainage channel improvement applied is more effective and capable in minimizing the losses of the inundation (Suprapto, et al., 2016).

The performance assessment of sustainable urban drainage system involve several criteria and it is crucial in decision making of urban sustainable development (Yang & Zhang, 2020).

One of the relevant method calculating the consistency value in determining the criteria priority level is Analytical Hierarchy Process Method (Munthafa and Mubarok, 2017).

According to Panchal & Shrivastava (2021), Ransikarbum, et al. (2021), Analytical Hierarchy Process (AHP) supports in solving the complex problems in different simple criteria. The criteria is given by scaling as the relative interest. The complex problem is the problem depending on many factors (Verma & Patel, 2021).

The proper technology selection of drainage construction is required to consider several criteria including construction budget, construction period, material supply, and construction process by using type decision making method. The prevalent decision making method applied is Analytical Hierarchy Process (AHP). It is a analysis method by making the proper decision and considering all comprehensive criteria in determining the priority scale (Julita, 2016).

The technology selection alternatives of drainage construction reviewed are elbow, parallel, grid iron, natural and radial drainages. The drainage channel is constructed as the field condition and surrounding area (Kitsikoudis, et al., 2021). The drainage can be constructed in the various system type to obtain the optimal output such as elbow system, parallel system, grid iron system, natural system, and radial system.

The background of the study was how to determine the dominant criteria in considering the technology selection of drainage construction in Banda Aceh and which alternative is proper in selecting the technology of drainage construction by using AHP Method. The research aimed to determine the dominant criteria considered in selecting the technology of drainage construction in Banda Aceh and to determine the proper alternative in selecting the technology of drainage construction by using AHP method.

Literature Study
Drainage System

Drainage is defined as the water construction series in reducing and or disposing the water surplus from an area/land, so that the area can be use optimally. Drainage is also meant as the application in managing the groundwater quality in the relation to salinity (Alriansyah, et al., 2019, and Fairizi, 2015).

The drainage system is general defined as the science in learning the application to dispose the water surplus in the context of specific use (Hasmar, 2012). The similar opinions was also delivered by Jia, et al. (2021).

According to Rurung, et al. (2019), the drainage system is a system to drain the rainfall and surface runoff. There are 2 types of drainage systems including conventional drainage system and environmentally friendly drainage system (Eco-drainage) i.e. the infiltration well (Ellafi, et al., 2021).

Drainage System Type

According to Alriansyah, et al. (2019) and Fairizi (2015), a drainage channel is constructed as the field condition and the surrounding area. The drainage can be constructed in the various system types to obtain the optimal output as:

1. Elbow, the network system that is constructed in the higher topography area than the river. The river become the last drainage system located in the middle of the urban.
2. Parallel, the main network system which is located parallel to the secondary channel. It has many secondary channels. If there is the urban development, the channel will be improved.
3. Grid iron, the network system that the river is located in the urban side. The secondary channels are previously collected in the collector channels.
4. Natural, the network system which is similar to elbow network system. The river load for natural network system is higher.
5. Radial, the network system which is located in the hilly area. The channel pattern is scatter to all directions.

Analytical Hierarchy Process (AHP) Method

Analytical Hierarchy Process (AHP) is a decision supporting method developed by Thomas L. Saaty. According to Verma & Patel (2021), hierarchy is defined as a representation of a complex problem in the multilevel structure in which the first level is objective, followed by factor, criteria, sub criteria an others factors to the last level of the alternatives.

The AHP method is applied as the problem solving method compared to other methods due to the below arguments (Munthafa & Mubarok, 2017):

1. Hierarchy structuring, as the consequence of the selected criteria, to the deep sub criteria.
2. Calculating the validity to inconsistence tolerance limit as the selected criteria and alternative by the decision makers. Calculating the output endurance of decision making sensitivity analysis..

According to Munthafa & Mubarok (2017), the benefit of AHP method are applied the analysis method. The analysis benefits are:

1. Unity, AHP creating the complex and unstructured problems becomes flexible and easy to be understood.

2. Complexity, AHP solves the complex problems by using system approach and deductive integration.
3. Interdependence, AHP can be used in independent elements and it is not required the linear correlation.
4. Hierarchy Structuring, AHP representing the natural consideration tends in grouping the system elements to the different levels from each similar elements level.
5. Measurement, AHP provides measurement scale and method in finding the priority.
6. Synthesis, AHP directs to all arguments to how desirable each alternative is.
7. Trade Off, AHP considers the factors relative priority on the system until the decision maker is capable in selecting the best alternative based on the objective.
8. Judgement and Consensus, AHP does not require a consensus but it combine the different assessment output.
9. Process Repetition, AHP is capable to create the decision maker in screening the definition of a problem and developing the assessment and their comprehension by using repetition.

Kinanti (2018) mentioned that Analytical Hierarchy Process (AHP) method is one of decision making methods described graphically so it is easy to be comprehended by all parties involved in decision making process. The assessment steps in AHP method are:

1. The assessment of criteria and alternative element. After the problem is decomposition, there are two steps in the assessment or comparing the elements. It compares inter criteria and inter alternative for each criteria. Inter criteria comparison is carried out to determine the level for each criteria. This assessment is performed to find the importance of a alternatives reviewed from the specific criteria.
2. Creating pair matrix for each criteria and alternative. It compares every element to other element in every hierarchy level in pairs to determine the element interest level value in qualitative judgment. The assessment scale is used to qualify the qualitative judgment to determine judgment value in the number (quantitative). The values of relative comparison are processed in determining the relative level from all alternatives.
3. Determining priority value. It is applied to identified the scale of a criteria based on relatively advanced idea of matrix algebra and calculating the scale as the element of eigenvector associated to maximum eigenvector of a matrix. The value of eigenvector is obtained by using the formula in Equation 1 below.

$$\text{Wi} = \sqrt{\text{ai1.\,ai2.\,aij}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

Description:
Wi = Eigenvector criteria I

ai1 = Comparison of criteria I interest level to criteria 1
ai2 = Comparison of criteria I interest level to criteria 2
aij = Comparison of criteria I interest level to criteria j
n = Total criteria

The matrix obtained is eigenvector or criteria scale. The criteria scale is determined based on the below formula in Equation 2.

$$xi = \frac{Wi}{\sum Wi} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(2)$$

The highest value of eigenvalue (λmax) is obtained from equation (2) continue to be substituted to the ekemudian disubsitusikan to equation 3 below.

$$\lambda maks = \Sigma aij. xij \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(3)$$

Description:
λmaks = Maximum eigen vaue
aij = comparison of criteria i to criteria j of interest level
xij = Eigenvector in each criteria I to criteria j

4. Scale Consistency Test

Consistency assessment from a matrix is based on the maximum eigenvalue, the inconsistency is produced from the comparison matrix can be minimized. The formula to calculate consistency index can be summarized in Equation 4 below.

$$CI = \frac{\lambda maks - n}{n - 1} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(4)$$

Description:
CI = Consistency index
λmaks = Maximum eigen value
n = Matrix size

Consistency index is changed to inconsistency ratio and divided by Random Indeks (RI). The output describes that the higher matrix size, the higher inconsistency resulted. The random index value can be explained in table 1 below.

Table 1. Random Index Value

Matrix Size	*1.2*	*3*	*4*	*5*	*6*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Random Index	*0.58*	*0.9*	*1.12*	*1.24*	*1.32*	*1.41*	*1.45*	*0*	*0.58*	*0.9*	*1.12*	*1.24*	*0.58*

Source: Kinanti (2018)

Based on table 1 above, the comparison between CI and RI of a matrix is defined as Consistency Rasio (CR) described in Equation 5 below.

$$CR = \frac{CI}{RI} \leq 0.1\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(5)$$

Description:
CR   =   Consistency Rasio
CI   =   Consistency Index
RI   =   Random Index

5. Alternative Performance Matrix

Alternative performance matrix is the representative of criteria compliance level of an alternative as the output of the multiple between criteria level and alternative performance score. The process of alternative performance scoring is carried out by using proportional method by comparing the performance variable values resulted by every proposal, the scale score is 1 to 9 (Munthafa & Mubarok, 2017).

Research Methodology
Research Location

The study was carried out in several location in Banda Aceh including Gampong Doy located in Ulee Kareng Sub-district, the location is not connected to primary and secondary drainage channel. The upstream and downstream conditions are not clear so that the surface water can not be disposed. The other location is Kampung Keramat located in kuta Alam Sub-District, and Kopelma Darussalam located in Syiah Kuala Sub-district in which the drainage water flows to the roads because the drainage capacity is overflow the capacity.

Existing Drainage Condition

The existing drainage condition in Banda Aceh is generally applied the trapezium type made of the ground. This channel is required the large space and applied to dispose the rainfall, domestic liquid waste, and irrigation water. The figure 1 describes the construction on one of the drainage channels in Banda Aceh.

Figure 1. Drainage Costruction

Data Collection and Processing

A study is required a systematical and organized research flowchart design. It is used to find out the relevant output research.

The primary data of the research was collected directly from the field observation by distributing the questionnaire to 16 respondents selected using purposive sampling. The respondent selection is carried out by using the consideration that the respondents have skill and competency in drainage channel construction.

The respondents selected were from PUPR Banda Aceh Institution (1 respondent), Perkim Banda Aceh Institution (1 respondent), Bappeda Banda Aceh (1 respondent), Watering Banda Aceh Institution (1 respondent), Statistical Center Institution of Banda Aceh (1 respondent), BMKG Banda Aceh (1 respondent), and the lecturer of Civil Engineering Faculty Muhammadiyah Aceh University (2 hydrology lecturer as respondents and 2 structural lecturer as respondents). The research flowchart is described as below.
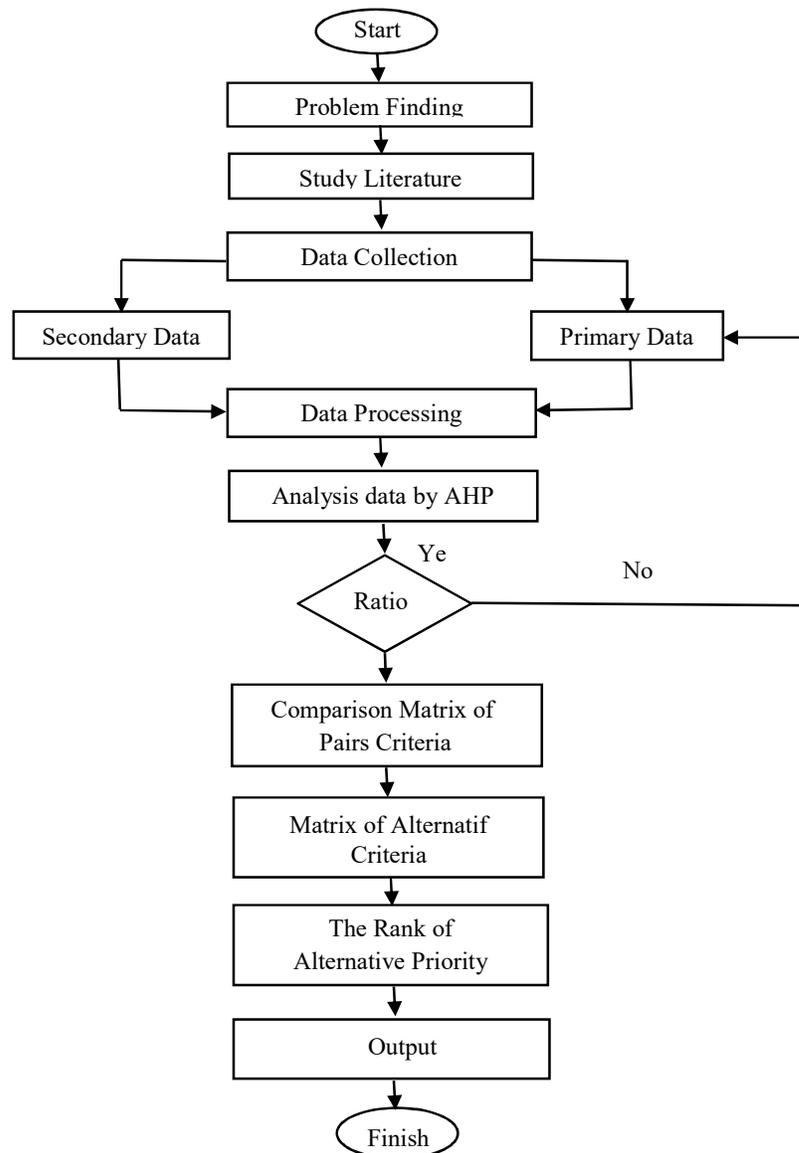
Figure 2. Research Flowchart

Validity and Reliability Test

　　Al Hayyan, et al. (2021) mentioned that validity test is applied in measuring whether valid or not of the questionnaire. It means that if the questionnaire question is capable in expressing a measurement indicator, the questionnaire is valid. Validity test is carried out by compared the r table of degree of freedom (df) = n-k, to alpha 0.1 which is n as total samples and k total items. If r counted > r table meaning that the question item is valid (Bai & Qian, 2021).

　　Reliability test is the tools to measure the questionnaire as the indicator of variable on construct. The questionnaire will be reliable if the respondent answer

is consistent meaning that the value of cronbach alpha > 0.60 (Al Hayyan, et al., 2021 and Bai & Qian, 2021).

Data Analysis

After data processing, it continues to data analysis by using Analytical Hierarchy Process (AHP) Method. It compiles a hierarchy structure described by figure 3 below:
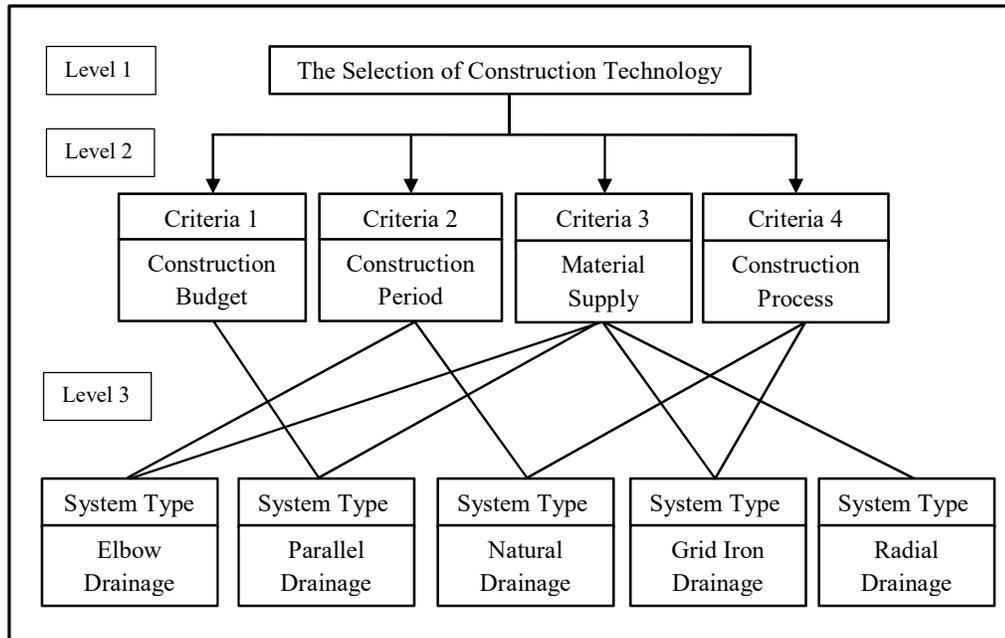
Figure 3. AHP Hierarchy System

Result and Discussion
Descriptive Analysis

Descriptive analysis is used to determine the characteristics of respondent, answer assessment frequency, and mean of each variable in describing research problem solving. Respondent characteristic is divided into gender, age group and occupation. This characteristic is grouped to prove that the respondents are competent in the have skill in the study.

The respondent characteristic based on gender showed that from the total of 16 respondents, there were 11 males or 69% and 5 females or 31%. The respondent characteristic based on age group explained that 30-39 years old were 8 respondents or 50%, 40-49 years old were 6 respondents or 37.50%. While >50 years old were only 2 respondents or 12.50%. The respondent characteristic based on occupation described that from the total of 16 respondents, the most were lecturers as 4 respondents with the similar total frequency which were 2 respondents from each and the rest represented by 1 respondents of each other institution.

Validity and Reliability Test

The output of validity test mentioned that each value of the criteria variable statement was higher than r table which is 0.661. it is summarized that the test is valid. The output of questionnaire criteria variable is reliable for the mean value of the criteria variable is 0.892. It is reliable since the coefficient variable > Cronbach Alpha coefficient (> 0.6).

Comparison Matrix of Pairs Criteria

The criteria scale was carried out based on respondent perception (stakeholders) interviewed. This process aimed to find the interest scale of each criteria. In compiling the criteria scale, the survey data obtained and respondents' answers were established comparison matrix of pairs, then calculating eigenvector and relative scale of each criteria as perception of criteria scale value of each respondent. Then being continued by averaging the value of criteria scale from 16 respondents to find the total criteria scale. The pair compilation matrix calculation of each respondent was described in table 2 below.

Table 2. The Pair Comparison Matrix inter Criteria for Respondent of structural Lecturer of Civil Engineering Faculty Unmuha (R-1)

Criteria	Criteria				Eigen Vector (Wi)	Criteria Scale (xi)	Eigen Value (λmaks)
	A	B	C	D			
A	1	0.14	0.20	0.20	0.27	0.04	0.01
B	7	1	7	9	4.58	0.66	3.02
C	5	0.14	1	9	1.58	0.23	0.36
D	5	0.11	0.11	1	0.49	0.07	0.03
					6.92	1.00	3.43
						CI	0.07
						CR	0.08

Based on table 2 above, It is obtained the Eigen Vector, criteria scale, and Eigen Value. Then it is calculated the consistency index (CI) and consistency ratio (CR) as 0.07 < 0.1 meaning that the perception of respondent answer is consistent.

The construction period criteria (B) have the highest scale with the average value is 0.66. The second criteria is material supply (C) as 0.23, the third criteria is construction process (D) as 0.07, and the last one is construction budget (A) as 0.04.

Alternative Performance Matrix of Drainage Construction

The assessment process of drainage construction alternative performance describes that Pi value is higher and will be as the first rank in the determination priority scale of drainage construction in Banda Aceh. The output of multiplying both alternative performance score and every criteria scale found that drainage

construction alternative is parallel which the highest alternative performance value is 4.96. It will be the first priority in drainage construction in Banda Aceh.

The natural drainage alternative will be the last priority since alternative performance value is 1.95. The output (OP) of multiplying both of each alternative performance score (PS) and drainage construction alternative can be detail explained in table 3.

Table 3. Determination of Drainage Construction Alternative Performance Matric in Banda Aceh for Respondent for Structural Lecturer of Civil Engineering Faculty Unmuha (R-1)

Drainage Alternative	Criteria Type							
	Construction Budget		Period Construction		Material Suppy		Construction Process	
	Criteria 0.03		Criteria 0.62		Criteria 0.26		Criteria 0.09	
	PS	OP	PS	OP	PS	OP	PS	OP
Elbow Drainage	2	0.06	2	1.24	2	0.52	2	8
Parallel Drainage	8	0.24	8	4.96	8	2.08	8	2
Grid Iron Drainage	5	0.15	5	3.10	5	1.30	5	0.45
Natural Drainage	1	0.03	1	0.62	1	0.26	1	0.09
Radial	4	0.12	4	2.48	4	1.04	4	0.36

Conclusion

The selection criteria of the stakeholder in Banda Aceh is period construction. It is proved by the highest score as 0.66. The stakeholders tent to observe that construction period as the more vital criteria. Because the assessment of criteria variable relate to the limitation in complete all drainage proposed.

The proper alternative in selection of drainage construction technology is parallel drainage. It is proved by the highest score as 4.96. The parallel drainage will be the first priority in drainage construction in Banda Aceh. This technology selects since the area used is relative flat and the drainage channel is parallel with the different direction between the channels. So that the channel can improve ad the urban development.

Acknowledgment

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