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DETERMINATION OF PRIORITY OF THE CONSTRUCTION OF IRRIGATION NETWORK

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Abstract

Development of the irrigation network is one of the factors that give the great impact to economic growth in Indonesia. The Indonesian government has the authority on this development. However, the handling of the irrigation network has not been maximum and cannot meet the expectations/needs during this time. This is because the limitation of government funding which is not in a good proportion to the increasing of the damage of the irrigation network from year to year and the priority scale is only based on the proposed community and the desire of some of the stakeholders. Therefore, a research is important to determine priority scale, which is appropriate to the real needs in the field. The method applied in this research was descriptive research by spread over the questioner to the stakeholders related to the development of the irrigation network and analyzed the data using Analytic Hierarchy Process (AHP). The location of the research was in Sidoarjo Regency that covers 10 locations. The analysis results showed the priority order execution of irrigation network development in accordance with the requirements of the irrigation network. It is expected that this method can be applied to the entire development of the irrigation networks and other infrastructures, therefore, limited government funds can be used efficiently and effectively.

Keywords: Irrigation, Network, Priority, Effective, Efficient

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Introduction

Science and Technology is one of the important factors that affecting the economic growth of a country. The rapid development of science and technology have an impact on the emergence of efforts to promote the acceleration of infrastructure development including irrigation network. The strategy on the development of adequate, appropriate and sustainable irrigation infrastructures urgently required in order to improve the national economy and food durability in Indonesia. Infrastructure provision is the duty and obligation of the government. The Ministry of National Development Planning (BAPPENAS) estimates that in order to achieve the targets of the infrastructure development specified in the National Medium-term Development Plan 2015 - 2019, the required fund approaches 5,452 trillion rupiahs, where the government is only able to provide 1,131 trillion rupiahs. Thus, there is a financing gap up to 4,321 trillion rupiahs. Regarding this big value of financing gap, the great effort must be done to keep the acceleration of sustainable infrastructure development for the welfare of Indonesian society. The assumption was that the experiences provided information to decision makers who were finding some ways for improving regional or country water resources system planning and analysis (Hermans, 2011).

According to the Standard Book of Planning Criteria of tertiary irrigation channel. (KP01), an irrigation system as one of the supporting components on the successful agricultural development has a very important role in supporting food durability especially national rice production. The availability of water resources that more limited and competitive as the impact of climate change will not only have a negative effect on economic and social life between the users in a sector but also will give impact to the quantity of the irrigation water allocation.

Maintenance of irrigation network is also very important in order to ensure continuity of irrigation water allocation. In the implementation of the construction of new irrigation network, rehabilitation, and maintenance of irrigation network system are still not well organized by the order or priority based on the technicalities of interests.

During this time, development of irrigation networks has been only considered by the discussion with the community, therefore the execution of the development is only based on the community desire whereas is not due to the real needs.

Consideration of the recommendation regarding this development has not used the accurate method, therefore incorrect decision still occurred. Based on this condition, a strategy is required, thus infrastructure development needs can be conducted in accordance with the real needs.

Literature reviews

Previous studies

Problems on the determination of the priority of the implementation of the construction project widely occurred in some areas. Therefore, this issue has been studied elsewhere, however, the focus study does not focus on the development of irrigation network, such as 1) Mulyawati (2013) who studied on "Determination of the Priority of the Activities of the Operation and Maintenance of Irrigation Area using the method of Analytic Hierarchy Process (AHP)". Commonly, there is a cut on the operation and maintenance activities; therefore, it is necessary to determine the priority scale based on each interest of working item according to AKNOP. 2) Supriyono (2013), conducted research on "Determination of the Priority Scale on Irrigation Network Performance based on the irrigation network Batujai, Gde Bongoh, and Sidemen in the district of Central Lombok". By applying AHP method, it could be found the category with less performance and the need to increase the personnel organization management and organization management of the association of the Farmers Water User.

The right strategy is important in order to determine the priority scale on the execution of irrigation network. This strategy is done by applying the AHP. By applying this process, it can be known the sequence of the development based on the real needs, properly, and the approached goals. AHP is a methodological approach, which implies structuring criteria of multiple options into a system hierarchy, including relative values of all criteria, comparing alternatives for each particular criterion and defining average importance of alternatives (Kholil, 2014).

The Analytical Hierarchy Process (AHP) was developed by Dr. Thomas L. Saaty from Wharton School of Business in the 1970s to organize information and judgment in selecting the most preferred alternative. Using AHP, an issue that will be solved is arranged in organized framework of thinking, thus it possible to be expressed to take effective decisions on the issue. Actually, as the decision maker, what we actually do is the result of the compilation of some decisions. The AHP method allows flexibility of the decision-making process and helps the decision makers to set the priorities, and to make the best decision taking into consideration both qualitative and quantitative aspects of decisions (Baric, 2014). The AHP is effective as a decision aid that can assist decisions makers in choosing the best alternative (Nachtnebel, 2015). The AHP is a convenient method in order to solve the kinds of problems (Koc and Burhan, 2015).

Definition of irrigation

According to the Government Regulation No. 20 year of 2006 about irrigation, irrigation is a work on providing, setting, and the disposal of irrigation water to support agriculture that the type is covering the surface irrigation, swamp irrigation, underground water irrigation, pumps irrigation, and ponds irrigation. According to the Government regulation of Sidoarjo district, Indonesia, 2009 about medium-term development plan in district of Sidoarjo year of 2010-2015, the function of irrigation is supporting the farmer productivity to improve agricultural production in the context of national food durability and society welfare, particularly farmers, which are realized through the sustainability of irrigation systems.

The order of irrigation area

The order of irrigation area is the arrangement of the lands that will be watered in some areas and distribution of the water by constructing the building to manage the distribution of water for each area, and also the construction of required channels and buildings to facilitate distribution and disposal of water. The water flowing from the river is distributed to the primary channel and then split up into the secondary channels. From this secondary channels, water is split up again into the tertiary channels through the splitter building or tertiary tap building.

Analytical Hierarchy Process (AHP) method (Saaty, 2008)

In order to make the decision, a person is often faced with various conditions, such as unique, uncertain long term and complex. Unique is when the problem does not have a precedent and may not be repeated again in the future. Uncertain is a condition when the factors expected to influence have the very low level of known or information. Long-term is the condition when the implications have far reached into the future and involve the sources of important business. Complex is when the decision making on the risk and time has a great contribution.

This AHP is a flexible model that provides an opportunity for individuals or groups to build ideas and define the problems by making their own assumptions and obtain the desired solutions from it.

The basic concept of AHP started by the identification of the various elements supporting the decision and give assessments on it based on the level of interests, preference or partisanship. These elements can be alternative actions, the criteria, and attributes that will be used to determine the priority or stages of a series of alternative decisions which will be decided.

The basic concept of the AHP are described as follows: 1) The arrangement of the hierarchy. The issue/problem that will be solved is reduced to their basic element. 2) Assessment of the criteria and alternative, make the comparison scale which is called as the fundamental scale revealed based on psychological research on the individual capacity to make a comparison in pairs of some elements that will be compared. 3) Determination of the priority. This is a pair wise comparison and relative comparisons of the values, then are processed to determine the relative ranking of all alternatives. 4) Logical consistency. All elements are grouped logically and rated consistently in accordance with logical criteria.

The completion by mathematical equation

There are 3 steps to determine the amount of weight started from the special case and simple to the common cases, as follows (Saaty, 1988):

Step 1:

W_i / W_j = a_{ij} (i,j =1,2,...,n)

W_i = input weight in row

W_j = input weight in column

Step 2:

W_i = a_{ij} W_j (i,j =1,2,...n)

for the common cases, the equation becomes:

$W_i = \frac{1}{n}\sum_{j=i}^{n} a_{ij} w_j$ (i,j =1,2,...,n)

W_i = average of $a_{i1}w_1,...,a_{in}w_n$

Step 3:

When the approximation of a_{ij} is good, it will tend to be close with the ration of W_i / W_j. If *n* also change, then it will be changed to λ *max*, then it can be obtained:

W_i = (i =1,2,...,n)

The horizontal processing intends to arrange the priority of the elements of the decision on each level of the decision hierarchy. According to Saaty (1988), its phases are as follows:

a. Multiplication of lines (z) with the equation:

$$Z_i = \sqrt[n]{\pi_{j=1} a_{ij}}$$

b. Calculation of priority vector or eigen vector:

$$eVP_1 = \frac{\sqrt[n]{\pi_{j=i}^{n} a_{ij}}}{\sum_{i=1}^{n}\sqrt{\pi_{j=i}^{n} a_{ij}}}$$

eVP_1 is the element of priority vector i

c. Calculation of maximum eigen value

VA = a_{ij} x VP, with VA = (V_{ai})

VB = VA / VP, with VB = (V_{bi})

$l_{max} = \frac{1}{n}\sum_{i=1}^{n} a_{ij}$ VB_i for i = 1,2,..., n

VA = VB = vector

d. Calculation of consistency index (CI)

The aim of this calculation is to know the consistency of the results that affect to the validity of the results. The equation is as follows:

$$CI = \frac{\lambda \max - n}{n-1}$$

To know whether CI with the certain value is quite good or not, it is necessary to know the criteria of the good ratio, i.e., when CR value $\leq$0.1. CR is defined as

$$CR = \frac{CI}{RI}$$

In AHP method, the group decides the decision of hierarchy structure containing *n* decision choices that suitable with the problems and the desired solution. Each individual decision maker (t) determine their relative preference ($ai^t_j = w_i / w_j$) to the pair of decision choices *I* and *j (ij=1,...,n)*, therefore matrix of A^t withan i^t_j element will be obtained.

for example:

$w^t = (w^t_1,...w^t_n)$ is the normalized weight vector, w^t_i / w^t_j equal to ai^t_j and w^t where this values can be obtained by solving the following eigen value:

$$A^t * w^t = \lambda_{\max}{}^t * w^t$$

where $\lambda_{\max}{}^t$ is the highest eigen value from A^t therefore $\Sigma_j w^t_j = and\ w^t_j \geq 0.$

The calculation of consistency ratio (CR) is to determine the inconsistency level from the preference of each decision maker.

$$CR = \frac{CI}{RI} = \frac{(\lambda_{\max} - n)/(n-1)}{RI}$$

Where, *CI* and *RI* are consistency index and inconsistency random index, respectively.

The inconsistency level cannot be accepted when the CR $\geq$ 0,1.

Basically, AHP method can be applied to proceed the data from one expert respondent. However, in the application, the assessment of the criteria and alternative is done by some multidisciplinary expert. Consequently, the consistency of the opinion from the experts need to be checked one by one. Then, the consistent opinion will be compiled by the following geometric:

$$\overline{XG} = \sqrt[n]{\prod_{i=1}^{n} X_i}$$ $\overline{XG}$ = geometric average

n = a number of respondents
Xi = the assessment from *i*-th respondent.

Methodology

The methodology applied in this research includes the study of literature, data collection, preparation and implementation of the decision model of AHP. This research is descriptive research to determine the priority Scale of Irrigation Network Development of Irrigation Office in Sidoarjo Regency year of 2015.

Materials and research location

The research location is the construction side of irrigation canals in Sidoarjo regency, Indonesia. The potential land area is 22,000 ha, comprising of 5,000 ha and 17,000 ha of sugarcane and rice lands, respectively. The planting area in the rainy and dry seasons reach 30,000 ha. The field area continues to decrease as a result of changes in the function of the field and is estimated down to be 13,544 ha in 2029. The research location was done on the irrigation project managed by Department of Irrigation in Sidoarjo Regency, Province of East Java, Indonesia, with a budget of less than Rp. 52,112,500,000. In the medium-term Development Plan in Sidoarjo Regency year of 2010-2015, currently, the handling of the irrigation network includes some of the program, i.e., maintenance, normalization, construction of dams and levee.

Based on data provided from the administration development of the Regional Secretariat Sidoarjo Regency, the number of the new irrigation construction project and rehabilitation in Sidoarjo Regency conducted in 2015 is as much as 318 project points. This research is restricted to the project with the value of each a maximum budget of 200 million rupiahs.

Data

Primary data

In this research, the primary data was collected through the direct survey on the field, interview process and spread over the questionnaire to the targets of this research. It is important to select the respondents who are believed to be able to give appropriate answers in the questioner to the research topic (Sugiyono, 2011). The sampling technique was conducted by purposive sampling.

Secondary data

This secondary data were collected from data on the related institutions, literature reviews, and data from the previous study related to this research, including general condition of the study area, service area, costs, benefits, and network conditions.

The formulation of rehabilitation of policy support systems (Saaty, 2008)

Priority scale was divided into 10 irrigation network development where each criteria is determine to four, i.e., service area, cost, benefit, and network conditions.

The criteria were drawn up in the form of the hierarchy as shown in the Fig. 1.

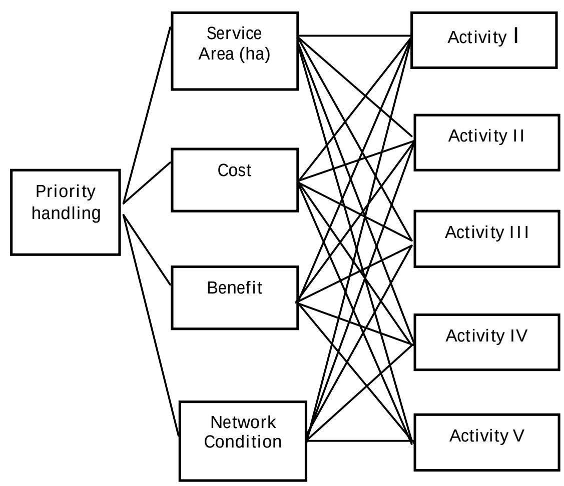

Fig. 1. System of policy support.

Data analysis

According to Saaty in Marimin (2004), the principles of AHP criteria and alternative were evaluated by comparison pairs for various problems using the scale of 1 to 9. Then, the weight value was given to the comparison criteria based on the perception and interest from the worst to the best levels. After weighing the both criteria and alternative, then analyzing by AHP method, therefore we can get the result which area will be ordered either prioritized or rehabilitated.

Analytical Hierarchy Process (AHP) analysis

AHP was applied to determine the alternative strategy that appropriates to the determination factor. This AHP method (Saaty, 1991) was conducted in the following steps: 1) Defining the problem and determining the desired solution. 2) Creating the structure of the hierarchy that started with a general purpose, followed by sub-objectives, the criteria and the possible alternative on the lowest criteria level. 3) Creating paired comparison matrix describing the relative contribution or the influence of each element against each objective or criteria that equivalent in it. 4) Performing the paired comparison, starting from the top of the hierarchical level that was intended to select the criteria, for example, it was given factor of X, then we took the element that will be compared, e.g., X_1, X_2, and X_3, therefore the order of the compared elements will be shown in Table 1.

Determination of the value of the relative interest between elements uses the scale of 1 to 9. When an element compared to itself, then it was given the value of 1. If *i*-element compared to the *j*-element gave a specific value, thus *j*-element compared to *i*-element has the opposite value.

Table 1. Examples of the paired comparison matrix.

Factor	X1	X2	X3
X1	1	2	5
X2	½	1	¼
X3	1/5	2	1

Results and Discussion

In the first step of the AHP analysis process is by tabulation of the results from respondents. Determination of the priority value of variables was done by creating a table of paired comparison influence as shown in Table 2 as follows:

Table 2. Matrix of comparison criteria between criteria.

Criteria	Service area (ha)	Cost	Benefit	Network condition
Service area (ha)	1	1	1	7
Cost	1	1	1	6
Benefit	1	1	1	9
Network condition	1/7	1/6	1/9	1

Then divided the value of each matrix elements by a number of the respective column. These results can be seen in Table 3.

Table 3. Calculation results of weight criteria.

Criteria	Weight Priority	Rank
Service area (ha)	0.3179	2
Cost	0.3159	3
Benefit	0.3217	1
Network Condition	0.0445	4

Then finding the value of Consistency Index (CI) and the value of Consistency Ratio (CR), as follows:

CI	(Lambda max-n)		/	N
	4.023	4	/	4 - 1
	0.023			
	0.008			

The value of Consistency Index (CI) =0.008 was obtained as follows:

CR	CI	/	IR
	0.008	/	0.9
	0.0088		

The results of CR value was 0.0088 which was less than 0.1, thus the value was accepted with IR = 0.9. The analyzed activities are shown in Table 4.

Table 4. Alternative Activities.

No	Code of Activities	Activities
1	A1	Lining of Gedangrowo Channel
2	A2	Normalization of Reformasi Channel
3	A3	Lining of Desa Suwaluh Channel
4	A4	Lining of Mangetan Kanal Channel
5	A5	Lining of Dusun Kesimbuk Irrigation Channel
6	A6	Lining of Purboyo II Desa Popoh Channel
7	A7	Rehabilitation of Desa Dukuhtengah Channel
8	A8	Rehabilitation of Ketawang Channel
9	A9	Rehabilitation of Kecamatan Candi Channel
10	A10	Sluice installation

Table 5. Comparison Matrix Inter Activities.

Code of Activities	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	1	9	1	7	4	1	8	1	5	1/5
A2	1/9	1	1/8	6	8	5	9	7	1/5	5
A3	1	8	1	9	1	1	1	1	5	1/5
A4	1/7	1/6	1/9	1	1	1	1	1	5	5
A5	1/4	1/8	1	1	1	1	1	1	1/5	5
A6	1	1/5	1	1	1	1	1	1	1/5	5
A7	1/8	1/9	1	1	1	1	1	1	5	5
A8	1	1/7	1	1	1	1	1	1	5	5
A9	1/5	5	1/5	1/5	5	5	1/5	1/5	1	5
A10	5	1/5	5	1/5	1/5	1/5	1/5	1/5	1/5	1

Next step is to know the weight of each of the activities using the comparison pair inter activities.

Table 6. Comparison matrix inter activities.

Code of Activities	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Weight Value
A1	0.1984	0.1984	0.1983	0.1983	0.1983	0.1983	0.1983	0.1983	0.1983	0.1983	0.1983
A2	0.1644	0.1644	0.1644	0.1644	0.1644	0.1645	0.1644	0.1645	0.1644	0.1644	0.1644
A3	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127
A4	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896	0.0896
A5	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831	0.0831
A6	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715	0.0715
A7	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154	0.1154
A8	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979	0.0979
A9	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281
A10	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389	0.0389

In the fourth iteration resulted in calculations as shown in Table 6 where the comparison of the multiplication pairs is nearly zero, therefore, it can be concluded that the calculation was enough to be taken as a result.

Thus, the matrix was resulted as shown in Table 7 with A1 (Plengsengan Gedangrowo Channel) is the activity with the highest weight.

Both Consistency Index (CI) and Consistency Ratio (CR) values were calculated according to the equation in AHP model. The results are shown as follows:

CI	(Lambda max-n)		/	N
	11.34	10	/	10 - 1
	1.34			
	0.15			

CR	CI	/	IR
	0.15	/	1.51
	0.0099		

CI and CR values were 0.15 and 0.0099, respectively. This CR value was less than 0.1, therefore the calculation was accepted with IR value of 1.51.

Next step is the calculation of weight for each criterion, i.e., service area, cost, benefit and network condition as shown in Table 8.

From the calculation, the global weight values could be obtained where the criteria affected on the determination of priority of the irrigation network development activities Public Works Department of Irrigation Sidoarjo Regency with the highest weight level to the lowest level as listed in Table 9.

Table 7. Weight of activities.

No	Code of Activities	Activities	Activities Weight
1	A1	Lining of Gedangrowo Channel	0.1983
2	A2	Normalization of Reformasi Channel	0.1644
3	A3	Lining of Desa Suwaluh Channel	0.1127
4	A4	Lining of Mangetan Kanal Channel	0.0896
5	A5	Lining of Dusun Kesimbuk Irrigation Channel	0.0831
6	A6	Lining of Purboyo II Desa Popoh Channel	0.0715
7	A7	Rehabilitation of Desa Dukuhtengah Channel	0.1154
8	A8	Rehabilitation of Ketawang Channel	0.0979
9	A9	Rehabilitation of Kecamatan Candi Channel	0.0281
10	A10	Sluice installation	0.0389

Table 8. Weight results.

	Service area (0,19463)	Cost (0,0041)	Benefit (0,1956)	Network Condition (0,0028)	Weight	Rank
A1	0.0325	0.0007	0.0327	0.0005	0.0663	1
A2	0.0298	0.0006	0.0300	0.0004	0.0608	2
A3	0.0220	0.0005	0.0221	0.0003	0.0449	4
A4	0.0131	0.0003	0.0132	0.0002	0.0268	7
A5	0.0102	0.0002	0.0103	0.0001	0.0208	10
A6	0.0127	0.0003	0.0128	0.0002	0.0261	9
A7	0.0129	0.0003	0.0131	0.0002	0.0265	8
A8	0.0159	0.0003	0.0160	0.0002	0.0325	6
A9	0.0180	0.0004	0.0181	0.0003	0.0368	5
A10	0.0272	0.0006	0.0274	0.0004	0.0556	3

Table 9. Results of activity weight priority.

Code of activities	Activities	Rank
A1	Lining of Gedangrowo Channel	1
A2	Normalization of Reformasi Channel	2
A10	Sluice installation	3
A3	Lining of Desa Suwaluh Channel	4
A9	Rehabilitation of Kecamatan Candi Channel	5
A8	Rehabilitation of Ketawang Channel	6
A4	Lining of Mangetan Kanal Channel	7
A7	Rehabilitation of Desa Dukuhtengah Channel	8
A6	Lining of Purboyo II Desa Popoh Channel	9
A5	Lining of Dusun Kesimbuk Irrigation Channel	10

Conclusion

According to the analysis results and discussion explained in the above, it can be concluded that the first priority on this irrigation network is Lining of Gedangrowo Channel while the last priority is Lining of Dusun Kesimbuk Irrigation Channel. There are some recommendations in order to get the better results, i.e., 1) Determination of priority scale on the handling of irrigation construction in some area in Indonesia is no longer based on the desire but based on the physical needed to the society interests by applying AHP. 2) This research should be continued with the addition of criteria to get the optimum results.

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