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Expert's Judgments on the Evaluation of the Concession Agreement's Annex on Environmental Factors of the Hydropower Projects in Lao PDR using AHP Approach

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Abstract: **To eliminate the gap of non-compliance for the Concession Agreement particularly an Annex on Environmental Obligations of the Hydropower Projects in Lao PDR, Ministry of Natural Resources and Environment to Lao PDR (MoNRE) has to monitor and judge on the Evaluation of the Concession Agreement's Annex on Environmental Factors of the Hydropower Project which approved by MoNRE to Lao PDR. Hydropower Projects Environmental Factor Compliance Monitoring is not only conducted in accordance with the mandate. It is also a promotion for the Environmental Obligations Implementation via granting an award to the most environmental friendly project. AHP is used to help Expert's Judgments on the Evaluation of the Concession Agreement's Annex on Environmental Factors of the Hydropower Project in Lao PDR, and to rank the best environmental friendly project among 3 case studied hydropower projects in ranges from 500-1000 MW by means of 5 main environmental criteria derived from Environmental Impact Assessment (EIA) reports as well as deriving some key indicators and parameters from approved Concession Agreement's Annex on Environmental Obligations, Environmental Monitoring Guideline and Checklist and interviewing 7 expertise skill inspectors from DESIA, MoNRE. The research's finding shall help projects to improve the future Environmental Obligations Compliance based on these performance factors. Also, an Applying AHP to Evaluate the Concession Agreement's Annex on Environmental Obligations of the Hydropower Project in Lao PDR shall contribute to research field of management science, environmental science, hydropower engineering and other related filed like social development.**

Keywords: **Concession Agreement (CA), Environmental Obligation, Environmental Compliance, AHP, Hydropower.**

I. INTRODUCTION

Lao People's Democratic Republic (Lao PDR), Ministerial Instruction on the Process of Environmental and Social Impact Assessment of the Investment Projects and Activities is made, referenced to Article 22 of the Law on Environmental Protection (Amended) No. 29/NA, dated 18 December 2012 [1]. This Ministerial Instruction was defined that the Project Developer shall apply the List of Investment Projects and Activities as the reference for the screening process to determine whether its proposed investment project and activities categorized into 2 groups namely: Group 1 which should conduct an Initial Environmental Examination Process and Group 2 which should conduct an Environmental and Social Impact Assessment Process [2]. Project developers shall submit the IEE reports to the local authorities of MoNRE called Provincial Department of Natural Resources and Environment and submit the EIA reports to MONRE. Generally, the Environmental Management and Monitoring Plan (EMMP) is a key required document to come together with the EIA report for consideration whether MoNRE will issue Environmental Compliance Certificate (ECC). Then, after getting

ECC, project developers particularly the hydropower projects developers shall prepare the Concession Agreement (CA) together with various Annexes, especially annex on Environmental Obligations [1], [3]. EMMP may include specific plans such as watershed management plan, biomass clearance plan, reservoir management plan, resettlement action plan, livelihood restoration plan etc., [5] which become site specific plan set in CA's Annex particularly Standard Environmental and Social Obligations (SESO). In Lao PDR, there are three form of monitoring for environmental compliance including monitoring by government, by external agencies and self-monitoring by project developers. The major issue in our research paper is monitoring by government.

Most countries around the global including Lao PDR have statutory requirements on EIA; however, the experience from Lao PDR shows that the legally required EIA has certain critical limitations [5]. Over the past 13 years, MoNRE of Lao PDR presently realized that this situation was not sustainable. In Lao PDR, hydropower projects are dealt with through concession agreements, and through this system MoNRE has been able to considerably improve and strengthen the environmental requirements. In 2009 MoNRE introduced what later developed into Standard Environmental and Social Obligations (SESO) for Hydropower Concession Agreements. The SESO is an annex to the concession agreement and it consists of three parts, the first part is general principles and obligations, the second part is a technical part on environmental mitigation measures, and the last part is about compensation and resettlement of the project affected persons. In addition, SESO in English version is already translated into Lao Version with the purpose of facilitating for the whole nation to understand [6].

The Project Owner shall design the measures and describe and present them in the relevant documents such as EIA and the Environmental Management and Monitoring Plans (construction phase, operational phase) and it is the Project Owner's responsibility that this is done properly and in a scientifically correct manner. Even though such technical documents have been approved by MoNRE, the adequacy, correctness and completeness of the Measures still remain the responsibility of the Project Owner.

Another stories regarding to evaluate hydropower project via SEA framework, In Mekong mainstream, SEA seeks to identify the potential opportunities and risks, as well as contribution of these proposed projects to regional development, by assessing alternative mainstream Mekong hydropower development strategies. In particular the SEA focuses on regional distribution of costs and benefits with respect to economic development, social equity and environmental protection. As such, the SEA supports the wider Basin Development Planning (BDP) process by complementing the MRC BDP assessment of basin-wide development scenarios with more in-depth analysis of power related and cross-sector development opportunities and risks of the proposed mainstream projects in the lower Basin [7]. An overview of Strategic Environmental Assessment in the Greater Mekong Subregion [8], during the past decade, the value of SEA has gained recognition in the GMS, reflected by supportive legal frameworks and its emerging use in development policy and planning processes. Lao PDR recently included provisions for SEA in its revised Environmental Protection Law and Thailand has begun drafting SEA legislation. Both Cambodia and Myanmar have recently shown interest in developing a legal basis for SEA. In the countries without a legal basis established, SEA has mainly been applied as capacity-building pilot exercises. The SEA engaged stakeholders from major development sectors in the PRC's Yunnan Province, the Lao PDR, and Thailand, who together identified environmental and social effects from the corridor.

II. LITURATURE REVIEW

A. Literature Review regarding AHP:

The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgements that represents, how much more, one element dominates another with respect to a given attribute. The judgements may be inconsistent, and how to measure inconsistency and improve the judgements, when possible to obtain better consistency is a concern of the AHP. The derived priority scales are synthesised by multiplying them by the priority of their parent nodes and adding for all such nodes [9]. It is also a brainstorming tool for experts and/or expertise skill staffs in evaluation of the legislation implementation i.e. Expert's Judgments on the Evaluation of the Concession Agreement's Annex on Environmental Factors of Hydropower Project. The grading is in range in between 1-9 shown in below Table I.

TABLE I: Grading Scale for Pairwise Comparisons

Saaty	Definition	Reciprocal
1	Equally important	1
3	Weakly more important	1/3
5	Fairly important	1/5
7	Strongly important	1/7
9	Absolutely important	9
2	The intermittent value between two adjacent scales	½
4		¼
6		1/6
8		1/8

The AHP method is comprised as following steps:

Step 1: Identify problem or goal, in our case is to find the most Environmental Compliance Project. The flowchart of AHP is shown in **Error! Reference source not found.**. Figure 1 divided in three layers: layer 1 is "Goal" is the most suitable environmental compliance hydropower project, the second layer 2 is "Factors" considered as criteria in our case studies. They are water quality (F1), watershed management plan (F2), reservoir management plan (F3), fish and fisheries (F4) and rehabilitation plan (F5). Finally, the third layer are alternatives project 1 (A1), project 2 (A2) and project 3 (A3).

Step 2: Pairwise comparison respect to each criterion (F1:F5). There are four sub- steps for this step as follow:

Step 2 (1): Pairwise comparison respected to each criterion (F1:F5) before field inspection.

Step 2 (2): Pairwise comparison respected to each criterion (F1:F5) after field inspection.

Step 2(3): Conducting pairwise comparison respected to each criterion (F1:F5) after field inspection. In addition, pairwise comparison matrix is shown as follow:

$[a_{11....}a^k_{1n}$

A =

$a_{n1....} a_{nn}]$,

where a_{13} is pairwise comparison between F1 and F3

Step 2 (c): Calculation of average weighting for each criterion (F1:F5).

Step 3: Ranking of weighted criteria (F1:F5).

Step 4: Calculation of Consistency Ratio (CR) to validate whether collected data are consistency. This step includes three sub steps as follow:

Step 4 (a) Calculation of eigenvalue λ_{max} through equation (1)

$\lambda_{max} = (A\ w_i / w_i) / n$ (eq. 1)

Step 4 (b) Calculation of Consistency Index (CI) through equation (2)

$CI = (\lambda_{max} - n) / (n-1)$ (eq. 2)

Step 4 (c) CR Calculation through equation (3)

$CR = CI/RI$ (eq. 3)

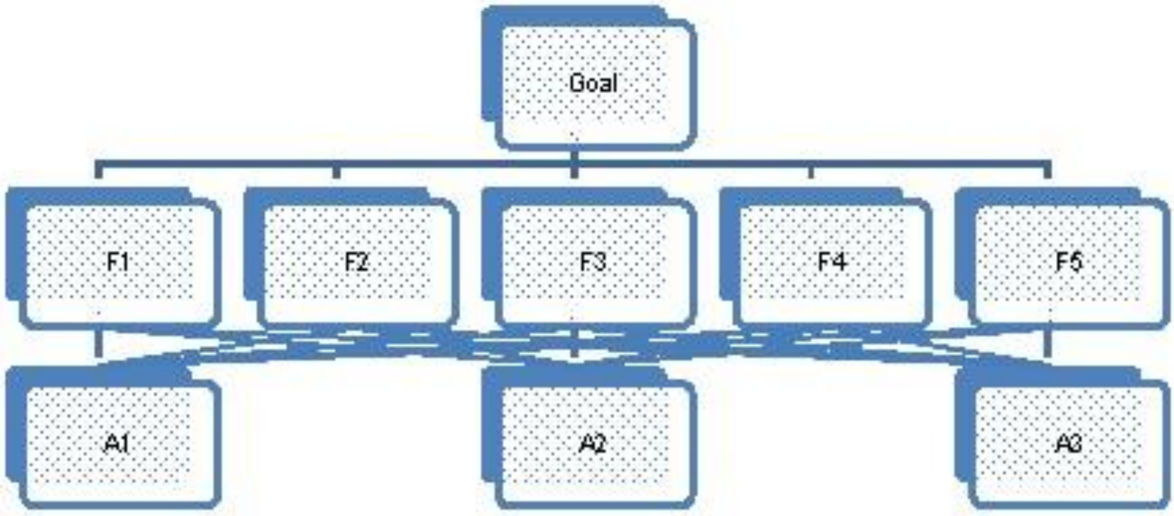

Fig. 1: Analytical Hierarchy Process to find the most Environmental Compliance Project.

Ajayi, K. T. and Olamide, O. O., 2014 [10] investigated power plant selection and location in Nigeria using AHP. They used 12 criteria including: (i) availability of fuel, (ii) electricity cost, (iii) capital cost, (iv) topography of installation site, (v) risk, (vi) fixed operating and maintenance cost, (vii) variable operating and maintenance cost, (viii) service life, (ix) efficiency (electrical) and (x) SO2 emission, (xi) CO2 emission, (xii) NO emission. The results reveal that more attention should be given to the development and construction of Biomass power plant technology in the south west, of coal power plant in the south east, of combined cycle natural gas (CCNG) power plant in the south-south, of wind power plant in the north east and of hydroelectric power plant in both the north west and the north central zones respectively. Due to various sources of energy such as combined cycle natural gas (CCNG), Steam, Natural gas, Coal Nuclear, Biomass, Hydro, Wind and Solar (Ajayi, K. T. and Olamide, O. O., 2014), so, different power plants can optimally be located at different regions.

M. Rosso et al., 2014 [11] aimed to integrate multicriteria evaluation-AHP and stakeholders analysis for assessing the construction of hydropower plants in mountain areas basin of the Sesia Valley in Italy. He used 4 criteria explicitly: (i) Environmental, (ii) economic, (iii) technical and (iv) sociopolitical. The results of the work show that the methodology is able to grant participated decisions through a multi-stakeholders traceable and transparent assessment process, to highlight the important elements of the decision problem and to support the definition of future design guidelines. In other word, stakeholders groups technically able to define specific criteria in accordance with their professional mandates and experiences.

Priyabrata Adhikary et al.,[12] studied Selection of Hydro-Turbine Blade Material: Application of Fuzzy Logic (MCDA), the research finding is that from the very approximate data, the model is capable of generating reasonably accurate result. Their multi criteria decision analysis or fuzzy logic based computational approach to material science and engineering has the potential of making material science and engineering process more effective and efficient. This will, in effect, facilitates an appropriate management of human efforts as well as natural engineering or commercial materials and resources, particularly those that are susceptible to depletion.

Hosseini, S. et al., 2015 [13] fore sighted and estimated the risk of investing in the construction of power plants using AHP. He used 11 criteria namely: (i) Geographical location: influences of climate and weather conditions, (ii) Technical: having technical science, complexity of the technology used to obtain power quality, (iii) Economic: availability of fuel, fuel prices, the total cost of materials equipment and setup as well as maintenance and ground, (iv) Time: time to build, time start up or coming into orbit, useful life, (v) Administrative: office personnel to build, repair and maintenance, (vi) Environment: soil pollution, water, air, audio etc, (vii) Social and cultural rights: a positive impact on productivity, (viii) Political: sanctions and the arrival of new technologies, (ix) Cultural and natural heritage: damage, the area of land required, (x) Structural architecture: design art, (xi) The tourism: a positive impact on an attraction. Due to time constrain, various criteria may not suitable for small research. Some situation needs only mandatorily–related criteria such as environmental criteria for environmental obligations implementation. It also could save time and money in doing efficient research.

Thomas L. Saaty, 2001 [14] studied Decision-Making with the AHP: Why is The Principal Eigenvector Necessary research finding shown that the principal eigenvector of a matrix is a necessary representation of the priorities derived from a positive reciprocal pairwise comparison consistent or near consistent matrix. A positive reciprocal n by n consistent matrix $W = (w_{ij})$ satisfies the relation $w_{ik} = w_{ij}\ w_{jk.}$

Research finding of "Decision-making with the AHP: Why is the principal eigenvector necessary" shown that if inconsistency is allowed in a positive reciprocal pairwise comparison matrix (which we have shown it must), the principal eigenvector is necessary for representing the priorities associated with that matrix, providing that the inconsistency is less than or equal to a desired value [15]. he also mentioned three ways and illustrated two of them, as to how to improve the consistency of judgments and transform an inconsistent matrix to a near consistent one [16].

B. Literature Review regarding Fuzzy AHP:

However, although this research focuses on AHP method, some desired Fuzzy Analytic Hierarchy Process (FAHP) literatures also reviewed.

Pin-Yu Chu et al. [17], applied fuzzy AHP to integrating decisions of members in the technical committee using 4 criteria mainly: (i) Scientific & Technological merit, (ii) project execution. The results indicate that scientific & technology merit criterion (0.389) is most important considered in overall technical committees. Besides that, the project execution (0.260) is more important criteria than potential benefits (0.204). In addition, the paper reveals results: (1) the fuzzy AHP is an appropriate method in multi-criteria R&D projects selection; (2) the crisp judgment matrix is suitable to integrate subject judgments of technical committee.

Oliver Meixner, [18] studied fuzzy AHP and group decision analysis and its application for the evaluation of energy sources of energy via 5 criteria namely (i) Cost: price of a certain energy source, estimated as Euros per kWh (production cost of electricity), (ii) Availability of an energy source: for some energy sources (like wind or solar energy) we have to consider reduced availability depending on climatic and geographic conditions. Other energy sources are more or less available continuously (like coal or natural gas), (iii) Climate: environmental impacts of energy sources operationalized via CO2-equivalents per kWh, (iv) Degree of dependency: dependency of a nation on foreign deliverers; via this criterion we tried to include the possible lack of different raw materials within a country, which are necessary for energy production, e.g. crude oil, natural gas or coal and (v) Utilizability: refers to the fields of application of a specific energy source; mainly connected with the question of centralized vs. decentralized energy production. Therefore, author decided to use the geometric mean also for lower bound l_{ij} and upper bound u_{ij} which delivers satisfying fuzzy group weightings. Geometric mean operations are commonly used within the application of the AHP for aggregating group decisions (Davis, 1994, 52).

Yu-Cheng Tang, 2011 [19] researched an Application of the FAHP to the lead-free equipment selection decision with seven criteria mainly: (1) Acquisition cost of equipment and parts , (ii) Compatibility, (iii) Response and maintenance time, (iv) Education and training, (v) Equipment size and pollution control. Some of the results of pairwise comparison is that C2 is an important criterion to be considered when DMs make decisions.

Yu-Cheng Tang and Malcolm J. Beynon, 2005 [20] studied an Application and Development of a FAHP within a Capital Investment Study. After discussion with the DM concerning the nature of the application, he decided to restrict the number of criteria to five areas namely: (i) equipment, (ii) comfort (C1), (iii) safety (C3), (iv) image (C4), and (v) price (C5) respect to five types of cars or five alternatives: (i) Proton Persona (A1), (ii) Honda New Civic (A2), (iii) Vauxhall Merit (A3), (iv) Volkswagen Polo (A4), and (v) Daewoo Lanos (A5). The final results show that the most preferred car is the Honda, then Volkswagen, the Vauxhall, the Daewoo and the Proton which is least preferred car in the Decision Makers' mind. From the comparison between the criteria found that the first two preferred criteria out of five criteria are safety and price. This meant that the DM cares about the cost (car price) and safety more than other criteria. From an author point of view, the more certainty of information the less fuzziness results.

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III. RESEARCH METHODOLOGY

Research methodologies in our case comprise two stages as follow:

A. Data Collection Technique:

The data for this study is obtained by collecting primary and secondary data.

1. Primary data obtained by conducting interviews 7 DESIA technical staffs via questionnaires who have ever worked for the government's environmental management unit (EMU) at hydropower project fields.
2. Secondary data is the data mainly obtained from documents such as EIA reports including annex on environmental obligation.
3. Due to a political issue, name of hydropower projects in this research is preserved.

B. Data analysis:

This study used AHP analysis and some stakeholder analysis technique.

IV. RESULTS AND DISSCUSSION

A. Evaluation of Factors Field Inspection:

TABLE II: Judgment Based on Personal Preference after Field Inspection from 7 Inspector's Perspectives

Factors	F1	F2	F3	F4	F5
F1	1.00	0.57	1.33	1.33	1.00
F2	1.75	1.00	0.67	1.67	0.25
F3	0.75	1.50	1.00	0.60	0.78
F4	0.75	0.60	1.67	1.00	1.00
F5	1.00	4.00	1.29	1.00	1.00

TABLE II (a): Average Weight Value for Each Column

	F1	F2	F3	F4	F5	Average
F1	0.19	0.07	0.22	0.24	0.25	0.20
F2	0.33	0.13	0.11	0.30	0.06	0.19
F3	0.14	0.20	0.17	0.11	0.19	0.16
F4	0.14	0.08	0.28	0.18	0.25	0.19
F5	0.19	0.52	0.22	0.18	0.25	0.27

TABLE II (b): Ranking of Weighted Criteria

Each criteria	Weight	Ranking
Water Quality	0.20	2.00
watershed management plan	0.19	3.00
reservoir management plan	0.16	5.00
fish and fisheries	0.19	4.00
rehabilitation plan	0.27	1.00

TABLE II (c): Consistency Ratio of Data collected after Field Inspections

		finding λmax from eigenvalue		
		λmax = (A wi / wi) / n	=	5.45
		Consistency Index (CI)		
CI	:	CI = (λmax -n) / (n-1)	=	0.11
		Consistency Ratio (CR)		
		CR = CI / RI	=	0.10
		N	=	5.00
		RI:	=	1.12

After that, these below tables will demonstrate degree of importance based on personal preference after field inspection from 7 inspector's perspectives with respect to each factors: water quality, watershed management plan, reservoir management plan, fish and fisheries and rehabilitation plan separately.

TABLE III: Factor 1: Water Quality

	A1	A2	A3
A1	1.00	1.13	1.29
A2	0.89	1.00	0.43
A3	0.78	2.33	1.00

TABLE III (a): Ranking of Weighted Alternative with respect to Water Quality

Alternatives	Weighing	ranking
A1	0.37	2.00
A2	0.24	3.00
A3	0.39	1.00

λmax	=	3.11
CI = (λmax -n) / (n-1)	=	0.05
CR = CI / RI	=	0.09
n	=	3.00
RI:	=	0.58

TABLE IV: Factor 2: Watershed Management Plan

Alternatives	A1	A2	A3
A1	1.00	1.60	1.14
A2	0.63	1.00	1.00
A3	0.88	1.00	1.00

TABLE IV (a): Ranking of Weighted Alternative with respect to Watershed Management Plan

Alternatives	Weighing	Ranking
A1	0.40	1.00
A2	0.28	3.00
A3	0.32	2.00

λmax = (A wi / wi) / n	=	3.07
CI = (λmax -n) / (n-1)	=	0.04
CR = CI / RI	=	0.06
n	=	3.00
RI:	=	0.58

TABLE V: Factor 3: Reservoir Management Plan

Alternatives	A1	A2	A3
A1	1.00	1.00	1.14
A2	1.00	1.00	1.00
A3	0.88	1.00	1.00

TABLE V (a): Ranking of Weighted Alternative with respect to Reservoir Management Plan

Alternatives	Weighing	Ranking
A1	0.35	1.00
A2	0.33	2.00
A3	0.32	3.00

λmax = (A wi / wi) / n	=	3.08
CI = (λmax -n) / (n-1)	=	0.04
CR = CI / RI	=	0.07
N	=	3.00
RI:	=	0.58

TABLE VI: Factor 4: Fish and Fisheries

Alternatives	A1	A2	A3
A1	1.00	0.86	1.14
A2	1.17	1.00	1.25
A3	0.88	0.80	1.00

TABLE VI (a): Ranking of Weighted Alternative with respect to Fish and Fisheries

Alternatives	Weighing	Ranking
A1	0.33	2.00
A2	0.38	1.00
A3	0.29	3.00

λmax = (A wi / wi) / n	=	3.16
CI = (λmax -n) / (n-1)	=	0.08
CR = CI / RI	=	0.14
N	=	3.00
RI:	=	0.58

TABLE VII: Final Results for Each Alternative

Alternative	Weighted score	ranking
A1	0.36	1.00
A2	0.31	3.00
A3	0.33	2.00

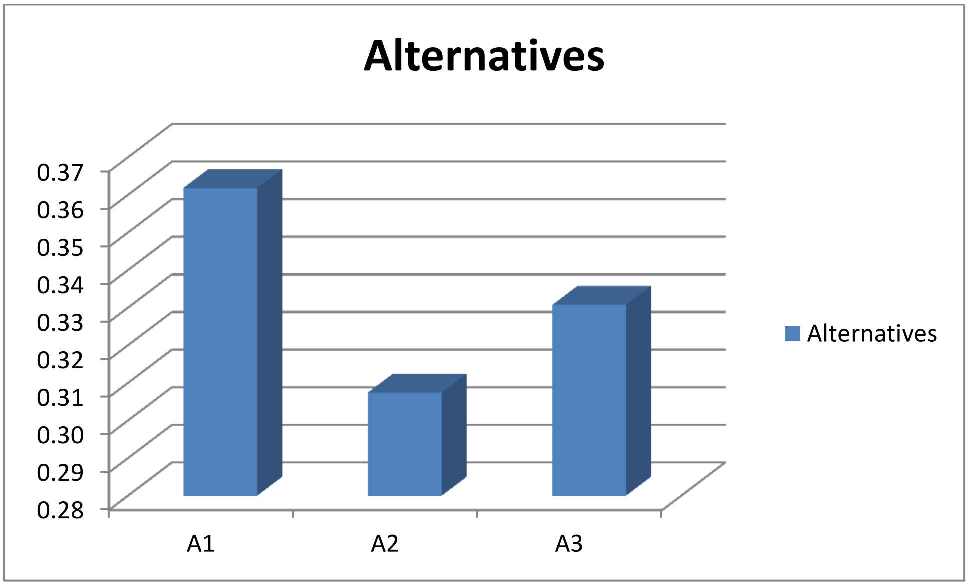

Fig N: Overall Result for Each alternative by Bar Chart

B. Discussion:

After field inspection and data entering into AHP process, the overall result revealed that alternative 1 (A1) is the front runner with a value of 0.36; then A3 came in the second with a value of 0.33, while the late comer is A2 with a value of 0.31. However, different alternative has different competency i.e., A2 has highlighted first rank respect to factor fish and fisheries (F4) with a value of 0.38. A1 has the best point at reservoir management plan (F3) with value of 0.35 while A3 is the front runner at Water Quality (F1) with value of 0.39.

V. CONCLUSION

The Finding Implied That Most Of Inspector Prioritized To F5 Because Of Timing Of Inspection Is In Transition Period Between Ending Of Construction Phase And Starting Operation Phase. After Ahp Analysis, The Overall Result Shown That Different Alternative Has Different Competency I.E., A2 Ranked As The First Runner With Respect To Factor Of Fish And Fisheries (F4). Finally, Ahp Analysis's Result Revealed That Alternative (A1) Is The Front Runner; Then A3 Came In The Second, While The Late Comer Is A2.

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