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A FRAMEWORK FOR CRITERIA WEIGHTING IN A SUSTAINABLE RIVER BASIN

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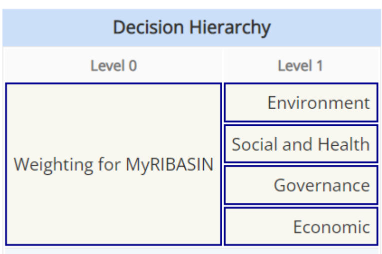
Graphical abstract



Abstract

River basin systems involve complex, diverse and dynamic nature. The Malaysia River Basin Sustainability Index (MyRIBASIN) monitors the sustainability status in river basin ecosystems by addressing multi-element involved in river basin systems. The study highlights a link between the multi-criteria in MyRIBASIN as a sound basis for measures design. The multi-criteria judgment aims to define the river basin performance from criteria indicators which Johor River Basin is a case study. The analytic hierarchy process (AHP) weighs four criteria for elements in the river basin: Environment, Social Awareness and Health, Governance and Economic. The group decision-making process is used to assess priorities based on the inputs from Malaysia's authorities and academicians. Results show that the weighting values for Environment criteria have the highest value, followed by Social and Health, Governance and Economic. The findings show the perception of respondents on the importance of basin conservation and community awareness.

Keywords: Analytical Hiierarchy Process; Weighting; River Basin; Sustainability

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1.0 INTRODUCTION

Sustainable river basin management is a complex system involving economic, social, and environmental factors. Various challenges associated with river basin management include misused governance, poorly implemented policies, lack of suitable data and over-exploitation of river resources [1](Srinivas et al., 2018). Freshwater resources are crucial for harmonizing socio-economic development growth and ecological security, which underline the importance of river basin management. However, water resources are increasingly under pressure due to population growth, declining groundwater and environmental water requirements [2](Touch et al., 2020). As a result, water scarcity has become a huge barrier to socio-economic growth and risk to the community in parts of the biospheres [3](Liu et al. 2017). Therefore, river basin management needs an integrative and comprehensive strategic approach by comprising diverse stakeholders' perceptions and conflicting criteria on sustainable management. The strategy includes Multi-Criteria Decision Making analysis (MCDM) analysis in determining stakeholders' views on river basin issues or elements.

Decision making on options or alternatives starts with recognizing the issues and identifying the objectives. The approach then focuses on the development of options and allocating variables involved in each option. The final phase assesses the best choice by comparing the options, defining indicators, assigning a weight to each and ranking them [4](Sugumaran and Sugumaran, 2007). Srinivas et al., 2018 [1] applied the Fuzzy hybridized-SWOT model to identify the best mechanism for sustainable river basin management policies. Stakeholders' views and geostatic approach have emphasized enforcing regulations on the disposal of heavy metals, developing hydropower, the adaptation of organic farming, education and participation of stakeholders, regulations on dams and barrages. The study by Ghobadi et al., 2021 [5] analyses water allocation for aquaculture purposes in Lorestan Province. The fuzzy AHP method was used to determine the potential rivers in Lorestan Province for aquacultures activity. Dung et al., 2021 [6] combined the AHP algorithm Geographic

Information System (GIS) to identify and assess the level at which various criteria affect flood risk in the Lam River basin. Therefore, MCDM has been widely applied for river basin planning.

Malaysia River Basin Sustainability Index (MyRIBASIN) has been developed to identify the performance of river basins based on set criteria and indicators. This study's overall objective is to highlight a link between the multi-criteria in MyRIBASIN as a sound basis for measures design. The multi-criteria judgment aims to define the river basin performance from criteria indicators which Johor River Basin is a case study. In our case, the AHP concept was carried out to identify the weightage of each element for MyRIBASIN development.

2.0 METHODOLOGY

2.1 Hierarchy Structural Map for MyRIBASIN Framework

Analytic Hierarchy Process (AHP) is a well-established mathematical structure of consistent matrices and their related right eigenvector's capability to produce approximate or true weights (Saaty, 1994)[7]. The elementary of the AHP is a set of maxims that cautiously limits the scope of the environmental problem [8](Saaty 1986). The AHP method connects alternatives or criteria concerning a criterion or pairwise mode. It converts individual perspectives into ratio scale weights that can be linked into a simple weighted score value. The hierarchy structure of the MyRIBASIN framework is illustrated in Figure 1, consisting of two levels, namely goal and main criteria. The four criteria listed in the study are environment, social and health, governance and economy.

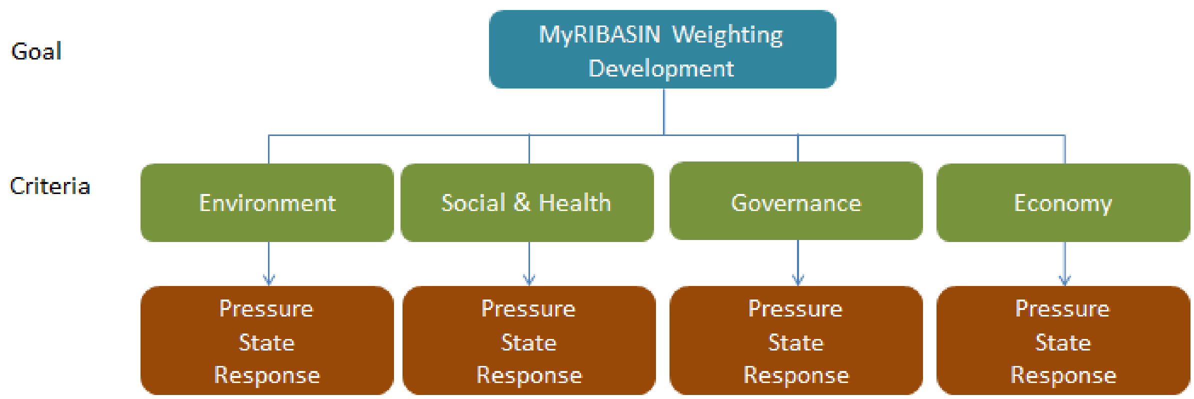

Figure 1. Malaysia River Basin Sustainability Index (MyRIBASIN) framework.

2.2 Determining weight values in AHP

The mathematics of the AHP is based on constructing a matrix that defines the attribute's weightage. The respondents are requested to indicate the importance of two elements through pairwise comparison. The comparison takes into account both governance and the sustainability components. A set of the scale was developed based on the approach introduced by Saaty (1986) [8]. Scale 1 to 9 is used to rate the importance of criteria, with one identifying as equally important and nine identifying as absolutely more important than other comparison criteria. A complete square matrix was generated to develop a set of local priorities. The priorities demonstrate the relative impact of the elements within its category and on an element in the level immediately above. The matrix was calculated using a set of eigenvectors using the geometric mean method (GMM). The framework for the GMM calculation is done by multiplying each element in each row and taking their nth root (Saaty, 1986)[8] (Figure 2). The results are then normalized to acquire the vectors of priorities. Finally, the Consistency Ratio (CR) needs to be calculated to determine the judgements' consistency relative to many samples of purely random judgements. Consistency in a method is important to provide information on how serious the violations of numerical occur. It is also important to identify the issue by seeking additional data or re-examining the assessment. Furthermore, the consistency ratio (CR) is computed. The value of CR should be 10% or less to make sure the pairwise comparison is acceptable. However, in some cases, 20% is still acceptable but never more (Saaty, 1985) [9].

The matrix	A1	A2	A3	A4	Eigenvector		Normalize Result
A1	$\frac{w1}{w1}$	$\frac{w1}{w2}$	$\frac{w1}{w3}$	$\frac{w1}{w4}$	$\sqrt[4]{\frac{w1}{w1} x \frac{w1}{w2} x \frac{w1}{w3} x \frac{w1}{w4}} =$	a	$^{a}/_{Total} =$ x1
A2	$\frac{w2}{w1}$	$\frac{w2}{w2}$	$\frac{w2}{w3}$	$\frac{w2}{w4}$	$\sqrt[4]{\frac{w2}{w1} x \frac{w2}{w2} x \frac{w2}{w3} x \frac{w2}{w4}} =$	b	$^{b}/_{Total} =$ x2
A3	$\frac{w3}{w1}$	$\frac{w3}{w2}$	$\frac{w3}{w3}$	$\frac{w3}{w4}$	$\sqrt[4]{\frac{w3}{w1} x \frac{w3}{w2} x \frac{w3}{w3} x \frac{w3}{w4}} =$	c	$^{c}/_{Total} =$ x3
A4	$\frac{w4}{w1}$	$\frac{w4}{w2}$	$\frac{w4}{w3}$	$\frac{w4}{w4}$	$\sqrt[4]{\frac{w4}{w1} x \frac{w4}{w2} x \frac{w4}{w3} x \frac{w4}{w4}} =$	d	$^{d}/_{Total} =$ x4
						Total	

Figure 2. Computing the eigenvector and normalizing result for developing priority.

2.3 AHP Analysis

The questionnaire was developed based on the main criteria listed in the hierarchy structure (**Figure 1)**. The main criteria were ranked according to the respondent's view on the criteria' importance. The pair-wise comparison responses were answered and analysed into AHP online system BPMSG [10](Goepel, 2018), and Figure 3 demonstrates the AHP structure for the study.

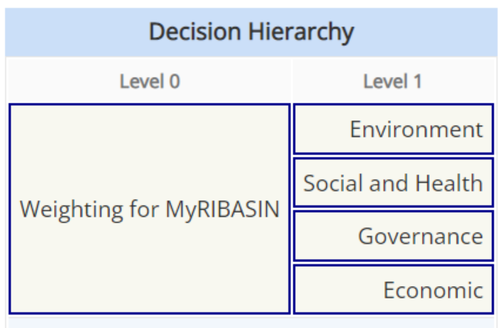

Figure 3. AHP structural in AHP online system BPMSG.

3.0 RESULTS AND DISCUSSION

3.1 Pairwise Comparisons

This section discusses the general result in the MyRIBASIN based weighting. The respondents were asked to rate the importance of the four criteria in the river basin, which are Environment, Social Awareness and Health, Governance and Economic, to obtain the weighting results. AHP online software tool, developed by Goepel, 2018 was used for the AHP analysis [10]. The result for weighting is shown in Figure 4. Results show that the weighting values for Environment criteria have the highest value, followed by Social and Health, Governance and Economic. The consistency ratio (CR) value is 3.7% which is less than 10%; thus, the pair-wise comparison is acceptable. The findings show the perception of respondents on the importance of basin conservation and community awareness.

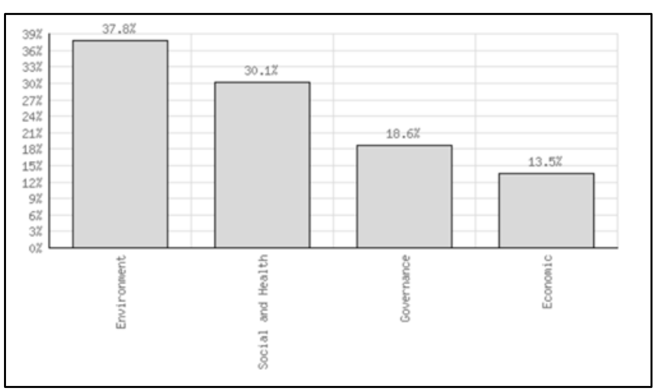

Figure 4. MyRIBASIN weighting result

3.2 Opinions of Respondents

The sub-criteria can justify the responses on the importance of environment criteria under the criteria. Under environment criteria, four main criteria included water quantity, flood risk, land-use change and water quality. Social and health criteria incorporated two sub-criteria: environmental behaviour and health Both governance and economic criteria have one sub-criteria. The high number of subcriteria in the main criteria may reduce the priorities of subcriteria in the main result. For example, subcriteria in the environment element will be divided by the number of subcriteria; thus, high priorities in the environment element increase the total priorities of the subcriteria.

The high priorities values on the environment may also explain by the growing issues on explicit evidence in Johor River Basin. Empirical evidence is believed to guide personal interests and values, which may have an unjustifiable influence on priority setting [11](Ottersen and Norheim, 2014). Water quantity, flood risk, water quality, and land-use change issues in environment criteria provide evidence-informed priority to the respondents. This rather compared with qualitative evidence in social and governance criteria, which tolerate subjective factors as evidence. For example, the respondents may highlight the the environment as a a key issue due to experience and knowledge on water quality deterioration and land-use change in the the Johor River Basin area. However, what is found as 'evidence' for one person may not be regarded as appropriate evidence by another, including subjective terms. In their responses, respondents focused on the aspects of evidence that they value most [12](Kapiriri, 2020).

Aside number of sub criteria and explicit evidence, the results shows the respondents sign of ecocentrism more than anthropocentrism value. Ecocentrism can be recognized as inherent value in all life forms and ecosystems themselves, including biodiversity [13](Washington et al., 2017). Anthropocentrism, oppositely values human as a centred of other life forms. Kopnina et al (2018) emphasize anthropocentrism based on utilitarianism and human self-interest [14]. Anthropocentrism has been condemned as insufficient to provide an ethic adequate for respecting and protecting the natural ecosystem [13](Washington et al., 2017). This further relates to economic perspectives, where anthropocentrism addresses the privileges humans above the rest of nature [14] (Kopnina et al, 2018), thus contributing to over exploitation of nature. Some environmental ethicists debate that critics on anthropocentrism are imprudent [15] (Kopnina et al, 2018b). Some of the arguments are anthropocentrism can be ambiguous by discriminate legitimate human interests. Moreover, since ecosystems provide life support for humans, anthropocentrism will be a powerful inspiration for environmental protection.

4.0 CONCLUSION

River basin systems face diverse competing needs from various economic activities such as manufacturing and agriculture. These include environmental challenge impacts from pollution and land-use change. An AHP methodology weighs the importance of four criteria in the MyRIBASIN framework as a sound basis for measures design. The result shows that environmental criteria have the highest value compared with other criteria. The result expresses the high discernment of environmental values by the respondents.

Acknowledgments

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