湖南大学学报

JOURNAL OF HUNAN UNIVERSITY NATURAL SCIENCES

ISSN 1674-2974

2021 年 8 月 第 48 卷 第 8 期

VOL. 48, No. 8, AUGUST 2021

EI Compendex收录期刊

中国科学引文数据库来源期刊(CSCD)

Editorial Team

Journal of Hunan University Natural Sciences

湖南大学学报

ISSN 1674-2974

Vol 49, No 2 (2022)

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Articles

第 49 卷 第 2 期
2022 年 2 月

湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

Vol. 49 No. 2
February 2022

Open Access Article

Performance Index Model of River and Infrastructure

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Abstract: The study of river performance and infrastructure is not only conducted qualitatively. An instrument is needed to examine the object being observed quantitatively (usually with a minimum and maximum number scale interpretation). The review of the physical condition assessment for the river performance index and river infrastructure has not been developed based on a study of the variables that influence it. Therefore, this study aims to develop a mathematical model of the index of river performance and infrastructure as a decision support system for the integration of programs and activities related to river management. The research location was chosen based on the consideration that there has been no preparation of a performance index model in the Babon River. In this study, the authors use the Smart-PLS (Partial Least Square) application to analyze and narrow the variables and then re-analyze them using the Generalized Reduced Gradient (GRG) method to calculate non-linear equations. There are four variables, eight dimensions, and 51 (indicators) used, with the types of technical, spatial, social, and regulatory variables. Based on the PLS-SEM analysis, the results were narrowed into 4 (four) variables, 8 (eight) dimensions, and 51 (fifty one) indicators that were interrelated with one another. The GRG (Generalized Reduced Gradient) analysis with the solver in Microsoft Excel showed the most influential weights consisting of: technical variables, namely rivers (0.475) and flood problems (0.582); spatial variables, namely land use (0.418) and land cover (% Urban) (0.498); social variables, namely community activities (0.454), settlement density and socio-cultural conditions (0.289), and community participation (0.257); and regulation variables, namely law enforcement efforts (1.000). This research can be used for other watersheds with conditions or characteristics relatively similar to the Babon River. However, research related to this formulation on other watershed conditions still needs to be done.

Keywords: river, PLS, GRG, performance index, technical variables, spatial variables, social variables, regulation variables.

河流与基础设施绩效指标模型

摘要：河流性能和基础设施的研究不仅仅是定性的。需要一种仪器来定量地检查被观察的物体（通常使用最小和最大数字尺度解释）。对河流性能指数和河流基础设施的物理状况评估的审查尚未基于对影响它的变量的研究。因此，本研究旨在开发河流绩效和基础设施指数的数学模型，作为整合与河流管理相关的计划和活动的决策支持系统。研究地点的选择是基于巴邦河尚未建立性能指标模型的考虑。在本研究中，作者使用智能偏最小二乘（偏最小二

Received: November 26, 2021 / Revised: December 11, 2021 / Accepted: January 23, 2022 / Published: February 28, 2022

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乘）应用程序来分析和缩小变量，然后使用广义缩减梯度方法重新分析它们以计算非线性方程。使用了四个变量、八个维度和51个（指标），以及技术、空间、社会和监管变量的类型。基于偏最小二乘结构方程建模分析，将结果缩小为相互关联的4（4）个变量、8（8）个维度和51（51）个指标。使用微软峥求解器进行的广义缩减梯度分析显示影响最大的权重包括：技术变量，即河流（0.475）和洪水问题（0.582）；空间变量，即土地利用（0.418）和土地覆被（城市百分比）（0.498）；社会变量，即社区活动（0.454）、居住密度和社会文化条件（0.289）以及社区参与（0.257）；和监管变量，即执法力度（1.000）。本研究可用于其他条件或特征与巴邦河比较相似的流域。然而，在其他流域条件下与该公式相关的研究仍需进行。

关键词：河流、偏最小二乘法、广义缩减梯度、性能指标、技术变量、空间变量、社会变量、监管变量。

1. Introduction

The hydrological cycle is influenced by changes in watershed conditions from upstream to downstream, caused by human activities and developments over time. Human activities can affect land cover, affecting the process of rain, run-off, and infiltration. This condition results in a change in function in the upstream area, causing an increase in run-off water and a decrease in the amount of water absorbed through the infiltration process. Kurniawan et al. [1] in their research prove that the increase in population and human activities is directly proportional to the resistance or carrying capacity of the soil. This fact also affects the increase in the stability of the slope of the land. Development impacts shifting base flow indicators, especially on changes in intermittent rivers (rivers that have stable flow rates without being affected by climate or weather) to perennial rivers (rivers whose flow rates are affected by changes in climate or weather).

River performance measures the river's ability to carry out its functions. The performance of river infrastructure is a benchmark for its ability to carry out its functions. Various human activities can affect the river's performance and infrastructure along with the times. Several previous studies have examined river performance and infrastructure changes and their impacts separately, although river performance and infrastructure should be assessed as a whole.

The performance of rivers and river infrastructure can be measured both good and bad through a comprehensive review from upstream to downstream and various influential variables. Rivers and river infrastructure are a unit that supports each other both in terms of physical components and functions. For example, flooding in a river is caused by erosion in the upstream part. The eroded material is carried away by the current and subsequently causes a buildup of material (sedimentation) in the downstream area of the river. As a result of the sedimentation, the downstream river cannot function as a water diverter to the maximum, resulting in a flood overflow. In other words, in this case, the river performance becomes poor due to two influences, namely erosion in the upstream area and sedimentation in the downstream area, so various variables can influence that river performance [2]. This research was conducted to develop a mathematical model of the index of river performance and infrastructure as a decision support system for integrating programs and activities related to river management. Model development is done using SEM-PLS software.

2. Material and Method

2.1. Limitations of the Study

In this study, the author has several limitations as follows:

1. The location of this research is Babon River, Indonesia. The research location was chosen because there has been no preparation for a performance index model in the Babon River.
2. The performance appraisal concept method used in this study is a method that has generally been used in Indonesia, also known as the method of irrigation infrastructure performance appraisal.
3. The method used in this study is based on previous research, secondary data, and the suitability of regulatory variables. River assessment points are selected every 100 meters along 16.32 Km. The zero point in this study, the upstream river, refers to the Bendung Pucang Gading location, based on the BenchMark (BM) recording at the Pemali Juana River Basin Center.

4. Calculations of water allocation and river water quality were not used in this study.

2.2. Data Collection

The data collection method used in this study was a quantitative data collection method. The data used as material for analysis in this study were secondary data derived from data on river operations and maintenance at Pemali Juana River Basin Center with a review location of Babon River and data from questionnaires distributed to 1,200 respondents. These secondary data were grouped into four main classifications, namely:

2.3. Technical Variables

Physical variables (River Space Variables) consist of 1) River**;** 2) Inundation Problem**;** 3) River Infrastructure

2.2. Spatial Variables

Spatial variables consist of 1). Land Use and 2). Land Cover

2.3. Regulation Variables

Law/regulation variables consist of: 1) Law No. 17 of 2019 concerning Water Resources, 2) Government Regulation No. 42 of 2008 concerning Water Resources Management, 3) Latest Government Regulation No. 12 of 2021 concerning Amendments to Presidential Regulation No. 16 of 2018 concerning Government Procurement of Goods/Services, 4) Government Regulation No. 38 of 2011 concerning the river, 5) Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, 6) PUPR Ministerial Regulation 09/PRT/M/2015 concerning the Use of Water Resources, 7) PUPR Ministerial Decree No. 11/PRT/M/2015 concerning Guidelines for the Implementation of Activities of the Ministry of Public Works, which is the Authority of the Government and is carried out through Deconcentration and Assistance Tasks, 8) PUPR Ministerial Decree No. 04/PRT/M/2009 concerning Quality Management System (QMS), 9) Regulation of the Minister of Finance of the Republic of Indonesia No. 53/PMK.02/2014 dated March 17, 2014, concerning Standard for TA Input Fees. 2015, 10) SE Directory of SDA No. 05/SE/D/2016 concerning Guidelines for Operation and Maintenance of River Infrastructure and Maintenance, 11) Other Legal Basis relating to Water Resources.

2.4. Social Variables

Social variables consist of a) Community activities, b) Profile/socio-economic conditions of the community, and c) Community participation.

2.5. Research Concept Framework

Research concept chart is presented in Fig. 1:

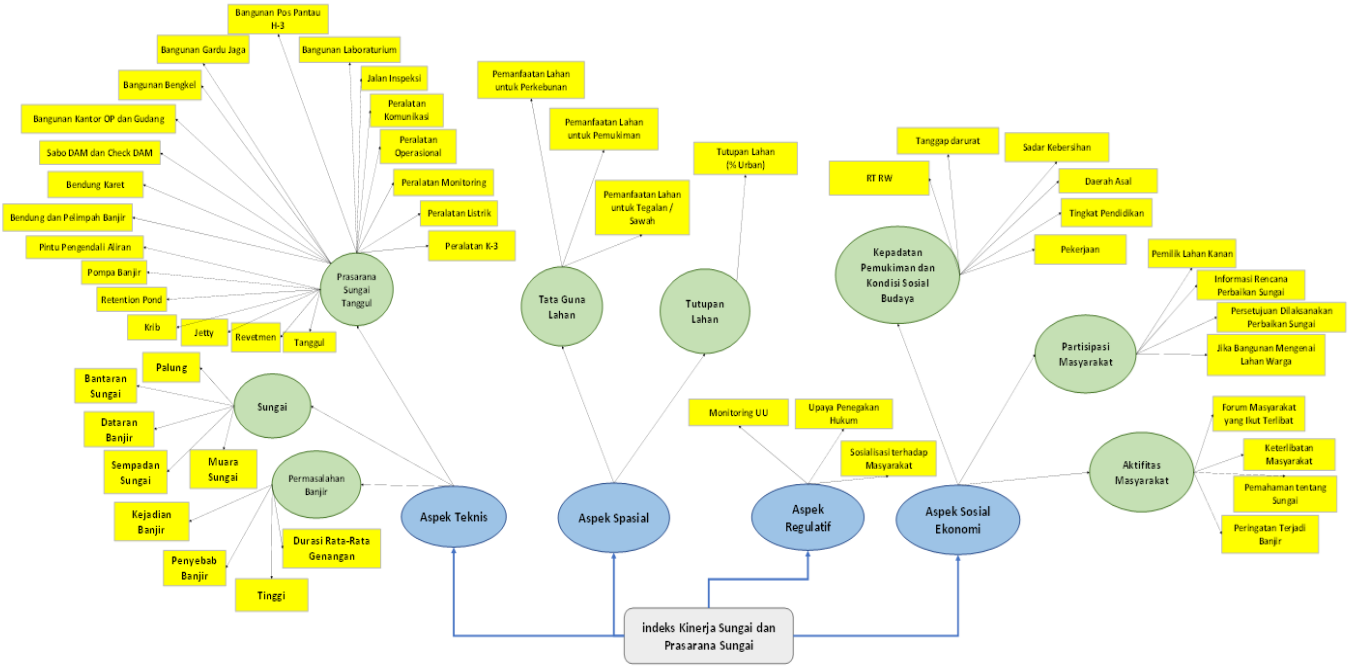

Fig. 1. Research concept chart

3. Results and Discussion

The index of river performance (case study in Babon River) was determined based on these four variables. Various appropriate studies supported each variable.

3.1. Research Variables

The variables in this research include 4 (four) variables, 8 (eight) dimensions, 51 indicators, namely: a) Technical variable; b) The dimensions of the research on the technical variable (T) are ***b.1.***) River (T_1): According to Hasyim [3], assessment is carried out on the river contained in the system are riverbed (t1.1), riverbanks ($t_{1.2}$), flood plains ($t_{1.3}$), river border ($t_{1.4}$), river mouth ($t_{1.5}$); ***b.2***) Inundation problems (T2) include flood events (T2.1), causes of flooding ($t_{2.2}$), inundation height ($t_{2.3}$), the average duration of inundation ($t_{2.4}$); ***b.3***) River infrastructure (T3) includes dike ($t_{3.1}$), revetment ($t_{3.2}$), jetty ($t_{3.3}$), groin ($t_{3.4}$), retention pond ($t_{3.5}$), flood pump ($t_{3.\ 6}$), flood control gate ($t_{3.7}$), flood weir and spillway ($t_{3.8}$), rubber weir ($t_{3.9}$), sabo dam and check dam ($t_{3.10}$), OP office building and logistics warehouse ($t_{3.11}$), workshop building ($t_{3.12}$), guard post building ($t_{3.13}$), monitoring post building ($t_{3.14}$), laboratory building ($t_{3.15}$), inspection road ($t_{3.16}$), communication equipment ($t_{3.17}$), operational equipment ($t_{3.18}$), monitoring and survey equipment ($t_{3.19}$), electrical equipment ($t_{3.20}$), OHS equipment ($t_{3.21}$); ***b.4***) Spacial variable; ***b.5***) The dimensions of the research on the spatial variable (S) are b.5.1.) Land use (S1) includes: Land Use for Plantations ($s_{4.1}$), Land Use for Settlements ($s_{4.2}$), River Utilization for Upland/Rice Fields ($s_{4.3}$); Land cover (% Urban) (S_2) or ($s_{5.1}$); and Regulation variable; ***b.6***) The dimensions of the research on the regulation variable (R) are: Monitoring UU ($r_{9.1}$); Law enforcement ($r_{9.2}$); and Socialization to the community ($r_{9.3}$); **b.7**) Social variable: The dimensions of research on social variables (So) are: b.7.1) Community activities (So1) include: Community Forum Involved ($so_{6.1}$), Community participation (e6.2), Understanding of rivers ($so_{6.3}$), Warning of flooding ($so_{6.4}$); b.7.2) Residential Density and Socio-Cultural Conditions (So2) include: RT RW (so7.1), flood emergency response (so7.2), awareness of cleanliness (so7.3), area of origin (so7.4), an education level (so7.5), work (so7.6); and b.7.3) Community participation (So3) includes: Land owners on the right and left of the river ($so_{8.1}$), Information on river improvement plans ($so_{\ 8.2}$), Approval for river improvement ($so_{\ 8.3}$), and if the building is on community land ($so_{\ 8.4}$).

Table 1 Data needs

Data Needs	**Description**
Technical variables	River measurement album (long and transverse images on the baboon river), field survey book on the baboon river, description book of Baboon River Hm, baboon river performance assessment for the 2017 academic year
Spatial variables	BIG data maps, topography
Regulation variables	Laws, ministerial regulations, etc.
Social variables on the dimensions of community activities	Interviews with 1,200 respondents at the Babon river location
Social variables on Settlement Density and Socio-Cultural Conditions	Interviews with 1,200 respondents at the Babon river location
Social variables of Community Participation	Interviews with 1,200 respondents at the Babon river location

3.2. River Infrastructure & Performance Index Model

The river performance and infrastructure condition was a unified system in which the value of function and usefulness became the reference parameter of evaluation. The value of functions and benefits becomes important because of the conditions in the field. It was also found that the operation and maintenance of the Babon River were carried out in stages, for example, sediment excavation, grass tripe, garbage cleaning, so that the value of functions and benefits have not been achieved.

The data obtained were secondary in technical data from BBWS Pemali Juana, 16.32 km long. Filtering of variables was done with the smart PLS-Partial Least Squares tool. Then an analysis was carried out using the GRG-Generalized Reduced Gradient method to solve the non-linear equation with objective-objective and constraint assumptions.

3.2.1. Statistical Analysis Using SEM PLS

This study aims to analyze the river performance index's technical, spatial, social, and regulation variables using the Partial Least Square (PLS) model with the SmartPLS program. Partial Least Square (PLS) is used because it is a powerful analytical method and is often referred to as soft modeling. It can eliminate the assumptions of the Ordinary Least Square (OLS) technique, such as the distribution of the residuals that does not need to have a multivariate normal distribution. In addition, in PLS, the sample does not have to be large. Moreover, the categorical, interval and ordinal measurement scales can be used in the same model [4]. The model developed in this study is shown in Fig. 1.

Based on the path diagram developed, it is known that the data obtained on several indicators have zero variance, so they cannot be included in the model. Some indicators are $s_{1.5}$ on the river dimension in the technical variables, $s_{3.1}$ to $s_{3.21}$ on the river infrastructure dimension in the technical variables, $e_{7.1}$ on the dimensions of settlement density and socio-cultural conditions in the social, and $r_{9.1}$ on the regulation variables.

The PLS results will be explained in detail as follows.

3.2.1.1. Evaluation of the Outer Model (Measurement Model)

The first evaluation of the outer model is convergent validity. An indicator is considered to meet convergent validity if it has an outer loading value > 0.7 [5].

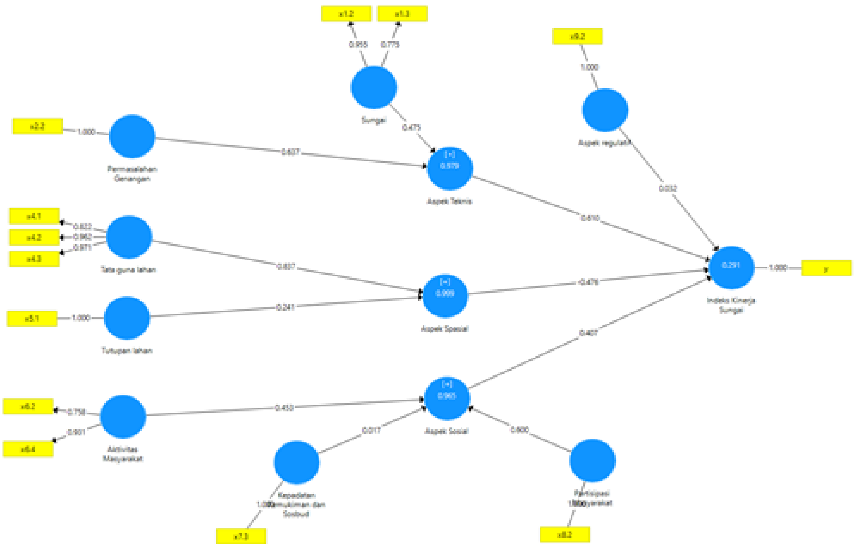

Fig. 2. The second round of measurement model analysis of technical variables, spatial variables, social variables, and regulation variables of the river performance index

Based on Fig. 2, it can be seen that all remaining indicators have an outer loading value greater than 0.7. Thus, each indicator in this study has met convergent validity so that indicators on technical variables, spatial variables, social variables, regulatory variables, and river performance indexes can be used for further analysis.

The second evaluation of the outer model is discriminant validity. Cross-loading values are used to measure the discriminant validity. An indicator is said to meet discriminant validity if the value of the cross-loading indicator on its constructs is the largest compared to other constructs. The following is the cross-loading value of each indicator on the dimensions and variables:

Table 3 The results of cross-loading values on the dimensions

	Community Activities	**River Performance Index**	**Residential density and socio-culture**	**Community Participation**	**Inundation Problems**	**River**	**Land Use**	**Land Cover**
$t_{1.2}$	-0.515	0.278	-0.198	-0.564	0.653	0.955	-0.262	-0.119
$t_{1.3}$	-0.103	0.365	-0.227	-0.103	0.222	0.775	-0.141	0.040
$t_{2.2}$	-0.687	0.119	-0.201	-0.709	1.000	0.574	-0.096	0.177
$s_{4.1}$	-0.090	0.753	0.036	0.063	-0.094	-0.135	0.822	0.482
$s_{4.2}$	-0.011	0.142	0.056	0.036	-0.096	-0.293	0.962	0.560
$s_{4.3}$	-0.048	0.170	0.046	0.017	-0.077	-0.251	0.971	0.589
$s_{5.1}$	-0.125	0.223	-0.107	-0.049	0.177	-0.076	0.592	1.000
$e_{6.2}$	0.758	-0.137	0.048	0.481	-0.212	-0.155	-0.154	-0.087
$e_{6.4}$	0.931	-0.147	0.182	0.715	-0.812	-0.492	0.015	-0.121
$e_{7.3}$	0.154	-0.062	1.000	0.188	-0.201	-0.231	0.050	-0.107
$e_{8.2}$	0.726	0.000	0.188	1.000	-0.709	-0.464	0.040	-0.049
y	-0.165	1.000	-0.062	0.000	0.119	0.341	0.367	0.223

Table 4 The results of cross-loading values on variables

	Social variables	**Spatial variables**	**Technical variables**	**Regulation variables**	**River Performance Index**
$t_{1.2}$	-0.615	-0.244	0.908	0.027	0.278
$t_{1.3}$	-0.138	-0.105	0.426	0.011	0.365
$t_{2.2}$	-0.820	-0.039	0.910	0.134	0.119
$s_{4.1}$	0.031	0.825	-0.132	0.155	0.753
$s_{4.2}$	0.042	0.931	-0.218	0.118	0.142
$s_{4.3}$	0.013	0.947	-0.189	0.125	0.170
$s_{5.1}$	-0.091	0.737	0.032	0.262	0.223
$e_{6.4}$	0.920	-0.018	-0.764	-0.090	-0.147
$e_{8.2}$	0.932	0.024	-0.701	-0.116	0.000
$r_{9.2}$	-0.111	0.185	0.089	1.000	0.129
y	-0.077	0.389	0.218	0.129	1.000

Based on Tables 3 and 4, it is known that the indicators that make up the dimensions of the river and the problem of inundation on the technical variables variable have the largest cross-loading value in the river dimension and inundation issues on the technical variables variable. It is the same as what happened to the variables of spatial variables, social variables, regulation variables, and river performance indexes with their respective dimensions. In other words, the cross-loading value of each indicator to its constructs is the largest compared to the other constructs. Thus, it can be said that the indicators used in this study have good discriminant validity in compiling their respective variables.

The last evaluation of the outer model is composite reliability. Composite reliability tests the value of the reliability of indicators on a construct. Constructs or variables are said to meet composite reliability if they have a composite reliability value of > 0.7. The following is the composite reliability value of each construct:

Table 5 The results of composite reliability value

	Composite Reliability
Community activities	0.837
Social variables	0.923
Spatial variables	0.921
Technical variables	0.905
Regulation variables	1.000
River performance index	1.000
Residential density and socio-culture	1.000
Community participation	1.000

Continuation of Table 5

Inundation problems	1.000
River	0.860
Land use	0.943
Land cover	1.000

Table 5 shows the composite reliability values for the technical variables with river dimension and inundation problems; spatial variables with the dimension of land use and land cover; social variables with the dimension of community activity, Residential density and socio-culture, and community participation; regulation variables, and river performance index with all of them more than 0.7. Thus, in the research model, each variable and dimension has met composite reliability.

3.2.1.2. Evaluation of the Inner Model (Structural Model)

The following is an image of the structural model developed in the analysis of technical variables, spatial variables, social variables, regulation variables of the river performance index.

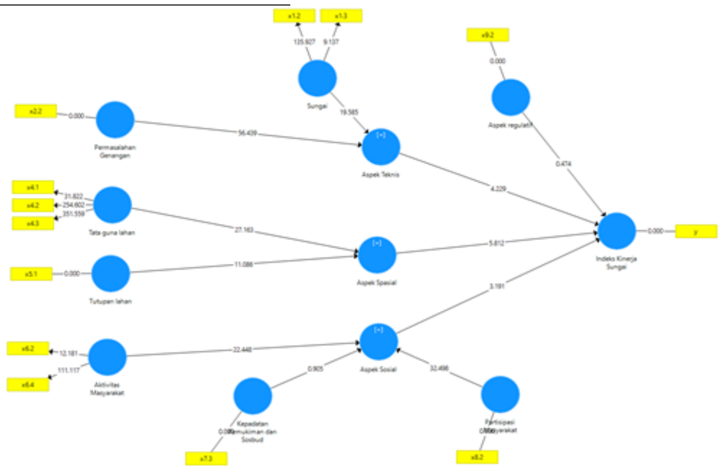

Fig. 3 Structural Model analysis of technical variables, spatial variables, social variables, regulation variables of the river performance index

The first evaluation of the inner model is seen from the R-Square value or the coefficient of determination. Based on data processing with PLS, the results of R-Square values are as follows:

Table 6 The results of R-square value

Variable	**R Square**
Social variables	0.965
Spatial variables	0.999
Technical variables	0.979
River Performance Index	0.291

The goodness of fit in the PLS model can be seen from the value of Q2. The value of Q2 has the same meaning as the coefficient of determination (R-square/R2) in the regression analysis. If the R2 value increases, the model can be said to fit the data more. From Table 6 above, it can be seen that the value of Q2 is as follows: R^2 on the technical variables variable is 0.978, meaning that the level of variation of the technical variable changes the river dimensions, and inundation problems can explain 97.8%. R2 on the spatial variable is 0.999, meaning that the variation of changes in the spatial variables defined by the dimensions of land use and land cover is 99.9%. R2 on the social variable is 0.970, meaning that the level of variation in the social variable change can be explained by the dimensions of community activity, settlement density and socio-cultural, and community participation is 97%. Meanwhile, the river performance index variable has an R2 of 0.262, which means the level of variation of changes in the river performance index variable that can be explained by the technical, spatial, social, and regulation variables is 72.7%.

The causality test is used to determine the level of significance of the river performance index's technical, spatial, social, and regulation variables. The influence between variables is statistically significant if the p-value <0.05. The following is the path coefficient value (original sample estimate) and the p-value in the inner model:

Table 7 The Results of Path dan P-Value Coefficients

	Original Sample (O)	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Community activities → social variables	0.453	0.020	22.448	0.000
Social variables→ river performance index	0.407	0.127	3.191	0.002
Spatial variables→ river performance index	-0.476	0.082	5.812	0.000
Technical variables→ river performance index	0.610	0.144	4.229	0.000
Regulation variables→ river performance index	0.032	0.068	0.474	0.636
Residential density and social-culture → social variables	0.017	0.019	0.905	0.366
Community participation → social variables	0.600	0.018	32.498	0.000
Inundation problems → technical variables	0.637	0.011	56.439	0.000
River → technical variables	0.475	0.024	19.585	0.000
Land use → spatial variables	0.837	0.031	27.163	0.000
Land cover → spatial variables	0.241	0.022	11.086	0.000

Based on Table 7 can be made, the mathematical equation as follows:

$IKS = 0.610 . IK_{Technical} - 0.476 . IK_{Spatial} + 0.453 . IK_{Social} + 0.032 . IK_{Regulation}$

where

Y = River Performance Index; X1 = Technical variables; X2 = Spatial variables; X3 = Social variables; X4 = Regulation variables.

3.2.1.3. Generalized Reduced Gradient (GRG)

The Generalized Reduced Gradient (GRG) method with the Solver tool in Microsoft Excel is used to find the respective weights. To make iterative modelling of these variables, dimensions, indicators, and boundary conditions are required as mentioned:

$1 \leq IK\ technical \leq 5$

$1 \leq IK\ spatial \leq 5$

$1 \leq IK\ social \leq 5$

$1 \leq IK\ regulation \leq 5$

$T_1 + T_2 = 1$

$S_1 + S_2 = 1$

$So_1 + So_2 + So_3 = 1$

$R_2 = 1$

$t_{1.2} + t_{1.3} + t_{2.2} = 1$

$s_{4.1} + s_{4.2} + s_{4.3} + s_{5.1} = 1$

$e_{6.2} + e_{6.4} + e_{7.3} + e_{8.2} = 1$

$r_{9.2} = 1$

$\alpha + \beta + \gamma + \delta = 1$

$1 \leq IKS \leq 5$

The Performance Index Model of River and Infrastructure is obtained by calculating the average index of technical, spatial, social, and regulation variables.

Technical Index Value :

$IK_{Technical} = 0.582 . T_1 + 0.418 . T_2$

$T_1 = 0.379 . t_{1.2} + 0.325 . t_{1.3}$

$T_2 = 0.296 . t_{2.2}$

Spatial Index Value :

$IK_{Spatial} = 0.502 . S_1 + 0.498 . S_2$

$S_1 = 0.394 . s_{4.1} + 0.189 . s_{4.2} + 0.200 . s_{4.3}$

$S_2 = 0.217 . s_{5.1}$

Social Index Value :

$IK_{Social} = 0.454 . So_1 + 0.289 . So_2 + 0.257 . So_3$

$So_1 = 0.330 . so_{6.2} + 0.241 . so_{6.4}$

$So_2 = 0.238 . so_{7.3}$

$So_3 = 0.191 . so_{8.2}$

Regulation Index Value :

$IK_{Regulation} = 1.000 . R_2$

$R_2 = 1.000 . r_{9.2}$

Value of Kurniawan Index :

$IKS = 0.338 . IK_{Technical} + 0.026 . IK_{Spatial} + 0.176 . IK_{Social} + 0.460 . IK_{Regulation}$

The magnitude of the Performance Index Model of River and Infrastructure in River of Babon using the above equation obtained the following results:

Technical Index Value :

$IK_{Technical} = 0.582 \times T_1 + 0.418 \times T_2$

$IK_{Technical} = 0.582 \times 2.687 + 0.418 \times 1.186$

$IK_{Technical} = 2.060$

Spatial Index Value :

$IK_{Spatial} = 0.502 \times S_1 + 0.498 \times S_2$

$IK_{Spatial} = 0.502 \times 2.200 + 0.498 \times 0.570$

$IK_{Spatial} = 1.388$

Social Index Value :

$IK_{Social} = 0.454 \times So_1 + 0.289 \times So_2 + 0.257 \times So_3$

$IK_{Social} = 0.454 \times 1.735 + 0.289 \times 0.460 + 0.257 \times 0.171$

$IK_{Social} = 0.965$

Regulation Index Value :

$IK_{Regulation} = 1.000 \times R_2$

$IK_{Regulation} = 1.000 \times 4.442$

$IK_{Regulation} = 4.442$

Value of Kurniawan Index :

$IKS = 0.338 \times IK_{Technical} + 0.026 \times IK_{Spatial} + 0.176 \times IK_{Social} + 0.460 \times IK_{Regulation}$

$IKS = 0.338 \times 2.060 + 0.026 \times 1.388 + 0.176 \times 0.965 + 0.460 \times 4.442$

$IKS = 2.944$

Therefore, the Performance Index Model of River and Infrastructure has a performance index of 2.944 or moderate performance.

The Performance Index Model of River and Infrastructure consists of four variables: technical, spatial, social, and regulation variables. The coefficient describes the magnitude of the influence of each variable, dimension, and indicator.

Table 8 The weighted value of river and infrastructure performance index

Num	Technical variables		Spatial variables		Social variables		Regulation variables	
1	T	0.338	S	0.026	So	0.176	R	0.460
2	T_1	0.582	S_1	0.502	So_1	0.454	R_2	1.000
3	T_2	0.418	S_2	0.498	So_2	0.289	$r_{9.2}$	1.000
4	$t_{1.2}$	0.379	$s_{4.1}$	0.394	So_3	0.257		
5	$t_{1.3}$	0.325	$s_{4.2}$	0.189	$so_{6.2}$	0.330		
6	$t_{2.2}$	0.296	$s_{4.3}$	0.200	$so_{6.4}$	0.241		
7			$s_{5.1}$	0.217	$so_{7.3}$	0.238		
					$so_{8.2}$	0.191		

Calibration is done by calculating the math equation of the index value through calculations with the field index value [6]. The difference between the two shows the relative error value. If the value is not greater than the specified error rate, the model can be accepted with compliance with the calibration requirements not exceeding the specified error magnitude. After twice re-calculation of solver, the Math Model of River and Infrastructure is finally done, with the biggest error value of 0.0082 and the smallest error value is 0. 0,000000002.

Index value validation will be carried out by testing the index model formula that has been generated at Dombo Sayung River. This validation must result in a statistically qualified value. This test uses the t-test by comparing the t-statistics with the t-table. The calculation results show the value of t-count (-1.656) < t-table (1.669). The H0 hypothesis is accepted, where the average river and infrastructure value has a performance index of 1.900.

3.2.2. Interpretation of the Use of the Kurniawan Index

According to [7], in watershed management, integrated programs and actions are needed based on: (1) utilization of natural resources (forest, land, and water) with due observance of environmental protection; (2) watershed management is multidisciplinary and cross-sectoral; (3) improvement of the community welfare; (4) integration begins in the planning of integrated watershed management. This finding aligns with [8], stating that activities improvement of sub-watershed performance can be made by improving planning and management land, reforestation activities, reforestation, and improvement of insightful land management conservation. Regarding the integration of these activities, these research results show and complement the relationship of each activity through the approach of technical variables, spatial variables, social variables, and regulatory variables. The variable approach is outlined in the Kurniawan Index (IK) model through mathematical equations with PLS-SEM analysis. IK is structured to see river benchmarks and river infrastructure.

Currently, several studies on technical and non-technical weights of infrastructure have been carried out. Suprayogi's [2] research shows the drainage index with a technical aspect weight of 0.73 and a non-technical aspect weight of 0.27. The Ministry of Public Works and Public Housing of the Republic of Indonesia (2015) has shown that the physical aspect weights 45%; productivity of cultivation and management weights 15%; supporting facilities and farmer associations weights 10%; and the documentation weights 5% for the surface irrigation infrastructure sector, through Ministerial Regulation Number 12/PRT/M/2015. Furthermore, a study was conducted to examine the polder system, with the final results showing a technical aspect with a weight of 0.53 and a non-technical aspect with a weight of 0.47 [9]. Purwantoro [10] conducted a similar study showing results of the physical aspect with a weight of 0.63; the social aspect with a weight of 0.27; and the regulation aspect with a weight of 0.10. Susilo [11] has also conducted a similar study on groundwater irrigation networks, with a physical aspect weight of 66.86%, social aspect by 8.56%, and management aspects by 24.58%. Previous research has shown that the physical or technical aspects tend to have the highest weights compared to non-technical or non-infrastructure aspects. The Kurniawan Index (IK) is slightly different from previous studies, with the weight for the regulation (46.00%), technical (33.80%), social (17.60%), and spatial (2.60%) variables. Several previous studies have studied variables that affect river performance separately. However, the performance of the river can only be determined by the condition of the river as a whole. River performance cannot be considered good or bad based only on one or two variables that affect the river. River performance can only be assessed after the river is reviewed and from upstream to downstream using all variables that affect river conditions.

3.2.3. Regulation Variables

The weight of the regulation variables is higher because the indicator review shows law enforcement related to public policies in the context of river performance and infrastructure policies that have been issued by authorized institutions and affect river performance both directly and indirectly. For example, the policy on determining the safe line of river borders will affect the river border's function where the river border should be avoided from the intervention of the surrounding community, such as settlements. According to Budiman [12], there is a common process, mutual support, and mutual strengthening in the relationship between public policy and law in the field of study of public policy formulation. Suggestions and input from residents should be considered in the river management process. In this process, public outreach was carried out to the entire community, especially those around the river and environmentalists. The implementation of public consultation is based on the Minister of the Environment Regulation Number 17 of 2012. The regulatory variables are so important that Ferreira *et al.* [13] have investigated the effect of hydrological regulation and land-use change on river morphology. This study showed that hydrological regulations and land-use changes could influence river morphology (related to river degradation). Based on the geomorphological point of view, river assessment cannot be done separately and requires the cooperation of all stakeholders.

3.2.3.1. Technical Variables (Physical Variables / River Space Variables)

This variable sees the discharge flowing in a river directly proportional to the wet cross-sectional area and the velocity of the flow. The flow velocity is not the same vertically and horizontally along the wet area, depending on the shape and roughness of the riverbed and river pattern. Water flows in rivers through the wet cross-section of the stream. The flow velocity varies along the channel body, depending on the shape, roughness, and flow pattern. According to [3, 14], it was found that the distribution of flow velocity on the cross-section of the Batang Lubuh river shows that the closer to the middle of the river, the higher the velocity value obtained.

On the other hand, the closer to the edge of the Batang Lubuh river channel, the lower the velocity value obtained; the channel wall influences this. From the side of the discharge flow during the flood in the study of Hasyim [3], which functionally interferes with the riverbanks, namely: on the right and left riverbanks, and perennials hinder the flow of flooding downstream. There are mining activities on the right and left of the riverbanks that result in erosion of riverbanks or embankments. This study refers to the research of Mokodongan *et al.* in Hasyim [3] on Riverbank maintenance as part of the maintenance of river space which helps accommodate and drain some of the floods. Therefore, all kinds of obstacles, such as perennials, must be cut down and not planted again on the banks. Mine pits near the toe of the embankment must be closed again at the bank level not to endanger the embankment's stability.

The weight of technical variables related to river conditions and infrastructure is very important in river management. According to Hasyim [3], the components of river maintenance are very important and must be maintained following the Real Figures for Operation and Maintenance Needs (AKNOP) compiled. This AKNOP is used for priority selection for handling existing problems. This condition refers to (1) Circular Letter of the Ministry of Public Works and Public Housing Number 12A/SE/D/2016 concerning Procedures for Preparation of Technical Recommendations for Licensing of Water Resources and Use of Water Resources at the Directorate General of Water Resources, (2) Circular Letter Director General of Natural Resources, Ministry of PUPR Number 05/SE/D/2016 concerning Guidelines for Operation and Maintenance of River Infrastructure and River Maintenance, and (3) Regulation of the Minister of Forestry of the Republic of Indonesia Number P.61/Menhut-II/2014 concerning monitoring and evaluation of management watershed.

3.2.3.2. Social Variables

Environmental management in these social variables is defined as the community's awareness to be involved in maintaining and or improving the environment so that the community can feel the benefits of the river. In using the river for human survival, each community group has different perceptions and changes from time to time according to their needs. Therefore, environmental management must be flexible [15]. The scope of environmental protection and management activities, especially rivers, by the participation of the surrounding community starts from the planning, utilization, control, maintenance, supervision, and law enforcement stages.

Kurniawan [15] states that there is a management effort in every business plan or activity that can cause significant impacts on the environment can accept it. River agencies must manage the effects of the existing activity stages, especially community perceptions. The management of the impact of public perception is carried out using socio-economic, institutional, and technological approaches. The socio-economic approach describes the socio-economic variables, the institutional approach determines the relevant institutions, and the technological approach describes the choice of technology used to control impacts. Furthermore, community participation has been stated in PP No. 22 of 2021 Article 160. The level of community participation in Babon River is in the medium category. The level of knowledge and perception is in the medium-high category, but the community's attitude is low-medium. Therefore, integrated river conservation by involving the surrounding community needs to be improved.

In this study, the author also discusses gender mainstreaming strategies to ensure that all levels of society can be involved in the development process to the benefit of development. Gender equality means that men and women can develop optimally without being constrained by gender. Meanwhile, gender justice means that men and women have different needs to be met. The forms of gender equality and justice include access, participation, control, and benefits. Gender mainstreaming in river management implementation consists of the planning, implementation, monitoring, and evaluation processes. It is hoped that all levels of society can carry out the development process. The government has mandated gender equality through Presidential Instruction No. 9 of 2020 concerning PUG in national development; Ministry of Home Affairs Regulation No. 15 of 2008 General Guidelines for the Implementation of Gender Equality in the Regions; Ministry of Home Affairs Regulation No. 67 of 2011; and Regulation of the Governor of Central Java Province No. 71 of 2017 concerning the Implementation of Gender Equality in Central Java.

3.2.3.3. Spatial Variables

The spatial review is a review that is based on the use of land use and the scope of land cover in the Baboon Watershed (DAS). The weight of the spatial variables within the watershed area (DAS) will change along with the area's development. In the hydrological cycle, changes in land use from open to closed will influence the run-off pattern [16]. Kurniawan [1] stated that development due to human activities and population growth is directly proportional to the load held by the soil. This increase will affect increasing the stability of the slope of the land. Regional development should also consider the hydrological boundaries of the watershed for land use spatial planning in the area. Of course, this development pattern must follow regulation variables in Regulation of the Minister of Agrarian Affairs and Spatial Planning/Head of the Indonesian National Land Agency No. 1 of 2018 concerning Guidelines for the Preparation of Provincial, Regency and City Spatial Plans.

3.3. Work Plan and Follow Up (WPFU)

WPFU is the preparation of programs or activities as guidelines for future implementation with a predetermined description, cost, and implementation time. The program or activity is structured to ensure integration and sustainability (specific). It can be measured (measurable) to determine priorities for handling operations and maintenance (achievable), following the policy on the physical level and the applicable river function (relevant), which is carried out within a certain period and can be updated as needed (timely). Furthermore, the Babon River IK value of 2,944 requires the preparation of an RKTL so that this value does not decrease for the next few years. The RKTL can be displayed as follows:

Table 9 WPFU of Babon River

Variable	Follow Up	Expectation
Technical Variables	Preparation of Real Figures for Operation and Maintenance Needs (AKNOP)	River management through submission of DIPA allocation runs according to AKNOP
Spatial Variables	Preparation of RTRW	Although it is challenging to maintain or reduce the percentage of land area covered, the project site changes after the infrastructure are built, and the return costs a lot.
Regulation Variables	Laws, ministerial regulations, etc	Regulations can be used as a reference for implementation & consequences of violations.
Social Variables	Socialization, public consultation, mass media, and others	Changes in knowledge, attitudes, and perceptions of rivers

4. Conclusion

The study of river performance & river infrastructure is qualitative. It needs an instrument to approach the object being observed into a quantitative measure (usually with a minimum & maximum number scale interpretation). The review of the physical condition assessment for the river performance index and river infrastructure has been developed based on this study. The Kurniawan Index (IK) model has been developed through mathematical equations with SEM PLS software to fill the current knowledge gap. The Kurniawan Index (IK) can be used as a decision support system to integrate programs and activities related to river management. Thus, it can be concluded that this IK can be used as a performance benchmark for preparing integrated programs and activities to improve the performance of rivers and river infrastructure in the watershed. Because of the limitation of this study, further research in other watersheds can be carried out because the IK mathematical model depends on the conditions or characteristics relatively similar to the Babon River. However, research related to this formulation on other watershed conditions still needs to be done.

References

[1] KURNIAWAN T., BISRI M., JUWONO P. T., and SUHARTANTO E. Review of the natural phenomenon and human intervention that affect the condition of river performance and infrastructure. *Journal of Southwest Jiaotong University*, 2021, 56(4), 7-15. https://doi.org/10.35741/issn.0258-2724.56.4.2

[2] SUPRAYOGI H., BISRI M., LIMANTARA L. M., and ANDAWAYANTI U. Service index modelling of urban drainage network. *International Journal of Geomate*, 2018, 15(50), 95-100. http://dx.doi.org/10.21660/2018.50.04204
[3] HASYIM F., KURNIAWAN T., SUROSO, and TRIHATMOKO E. Identifikasi skala prioritas pemeliharaan komponen sungai berdasarkan Analytic Hierarchy Process. Proceedings of the 38th Pertemuan Ilmiah Tahunan Himpunan Ahli Teknik Hidraulik Indonesia, Surabaya, 2021.
[4] SALUY A. B., & RAHARJO S. Effect of leadership, work motivation, and compensation for job satisfaction at work (Case Study at PT Agung Solusi Trans). *Saudi Journal of Business and Management Studies*, 2021, 6(8), 317-326. https://doi.org/10.36348/sjbms.2021.v06i08.005
[5] HAIR J. F., HULT G. T. M., RINGLE C. M., and SARSTEDT M. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) (2nd Ed.)*. Sage Publications, Wahington DC, 2017.
[6] JUWONO P. T., LIMANTARA L. M., and AMRIE S. The effect of land use change to the depth and area of inundation in the Bang sub-watershed-Malang-Indonesia. *International Journal of Geomate*, 2019, 16(53), 238-244. http://dx.doi.org/10.21660/2019.53.96946
[7] NITA A., DWI O. A., and RAMADHAN M. Pengaturan ideal tentang pengelolaan Daerah Aliran Sungai di Indonesia (Studi di Sungai Serang Kabupaten Kulon Progo). *Jurnal Hukum IUS QUIA IUSTUM*, 2020, 27(3), 592-614. https://journal.uii.ac.id/IUSTUM/article/view/16781
[8] SULASTRININGSIH H. S., & MURDIYANTO T. Monitoring dan evaluasi penggunaan lahan hulu Daerah Aliran Sungai Tondano Sulawesi Utara. *Proceedings of the 4th Seminar Nasional – Pengelolaan Pesisir dan Daerah Aliran Sungai*, Yogyakarta, 2018, p. 15.
[9] NOVIADRIANA D., ANDAWAYANTI U., JUWONO P. T., and SISINGGIH D. Index model of polder system using general reduced gradient. *International Journal of Innovative Technology and Exploring Engineering*, 2020, 9(5), 2278-3075. https://www.ijitee.org/wp-content/uploads/papers/v9i5/E2835039520.pdf
[10] PURWANTORO D. *Sabo Dam performance model index in Mount Merapi*. Komojoyo Press, Yogyakarta, 2021.
[11] SUSILO H., LIMANTARA L. M., SHOLICHIN M., and WAHYUNI S. Performance index model of groundwater irrigation systems. *Journal of Southwest Jiaotong University*, 2021, 56(5), 17-23. https://doi.org/10.35741/issn.0258-2724.56.5.2
[12] BUDIMAN S. Analisis hubungan antara hukum dan kebijakan publik: Studi pembentukan UU No 14 Tahun 2008. *Jurnal Ilmiah Kebijakan Hukum*, 2017, 11(2), 109-119. http://dx.doi.org/10.30641/kebijakan.2017.V11.109-119
[13] FERREIRA M. T., FERNANDES M. R., AGUIAR F. C., MARTINS M. J., and RIVAES R. Long-term human-generated alterations of Tagus River: effects of hydrological regulation and land-use changes in Distinct River Zones. *Catena*, 2020, 188, 104466. https://doi.org/10.1016/j.catena.2020.104466
[14] PUTRA W. A. Studi eksperimen distribusi kecepatan pada saluran lurus di Sungai Batang Lubuh. *Jurnal Mahasiswa Teknik Universitas Pasir Pengaraian*, 2016, 2(1), 1–10. https://media.neliti.com/media/publications/110569-ID-studi-experimen-distribusi-kecepatan-pad.pdf
[15] KURNIAWAN T., BISRI M., JUWONO P. T., SUHARTANTO E., and SARASTIKA T. Community participation in river conservation in the Babon River, Central Java. *Journal of Hunan University*, 2021, 48(10), 500-512. http://www.jonuns.com/index.php/journal/article/view/817
[16] NATAKUSUMAH D. K., PERMATASARI R., and ARWIN S. Pengaruh perubahan penggunaan lahan terhadap rezim hidrologi DAS (Studi kasus: DAS Komering). *Jurnal Teknik Sipil Institut Teknologi Bandung*, 2017, 24(1), 91-97. https://doi.org/10.5614/jts.2017.24.1.11

参考文

[1] KURNIAWAN T., BISRI M., JUWONO P. T., 和 SUHARTANTO E. 审查影响河流性能和基础设施状况的自然现象和人为干预。西南交通大学学报, 2021, 56(4), 7-15. https://doi.org/10.35741/issn.0258-2724.56.4.2
[2] SUPRAYOGI H., BISRI M., LIMANTARA L. M., 和 ANDAWAYANTI U. 城市排水管网服务指标建模。国际地质学杂志, 2018, 15(50), 95-100. http://dx.doi.org/10.21660/2018.50.04204
[3] HASYIM F., KURNIAWAN T., SUROSO, 和 TRIHATMOKO E. 根据层次分析法确定河流组成部分维护的优先级。印度尼西亚水利工程师协会第38届年度科学会议论文集，泗水, 2021.
[4] SALUY A. B., 和 RAHARJO S. 领导力、工作动机和工作满意度补偿的影响（至尊有限公司翻译解决方案的案例研究）。沙特商业与管理研究杂志, 2021, 6(8), 317-326. https://doi.org/10.36348/sjbms.2021.v06i08.005
[5] HAIR J. F., HULT G. T. M., RINGLE C. M., 和 SARSTEDT M. 偏最小二乘结构方程建模入门（第 2 版）。圣人出版物，华盛顿特区, 2017.
[6] JUWONO P. T., LIMANTARA L. M., 和 AMRIE S. 砰子流域-玛琅-印度尼西亚土地利用变化对淹没深度和面积的影响。国际地质学杂志, 2019, 16(53), 238-244. http://dx.doi.org/10.21660/2019.53.96946
[7] NITA A., DWI O. A., 和 RAMADHAN M. 印度尼西亚流域管理的理想环境（西朗河研究，库隆普罗戈摄政）。法律杂志 对，因为对, 2020, 27(3), 592-614. https://journal.uii.ac.id/IUSTUM/article/view/16781
[8] SULASTRININGSIH H. S., 和 MURDIYANTO T. 北苏拉威西省通达诺河流域上游土地利用监测与评价。第四届全国研讨会论文集——沿海和流域管理，日惹, 2018, 页。15.

[9] NOVIADRIANA D., ANDAWAYANTI U., JUWONO P. T., 和 SISINGGIH D. 使用一般缩减梯度的圩田系统指数模型。国际创新技术与探索工程杂志, 2020, 9(5), 2278-3075. https://www.ijitee.org/wp-content/uploads/papers/v9i5/E2835039520.pdf

[10] PURWANTORO D. 默拉皮山的萨博大坝性能模型指数。 科莫乔约出版社, 日惹, 2021.

[11] SUSILO H., LIMANTARA L. M., SHOLICHIN M., 和 WAHYUNI S. 地下水灌溉系统性能指标模型。西南交通大学学报, 2021, 56(5), 17-23. https://doi.org/10.35741/issn.0258-2724.56.5.2

[12] BUDIMAN S. 法律与公共政策的关系分析：2008年第14号法律的形成研究。法律政策科学杂志, 2017, 11(2), 109-119. http://dx.doi.org/10.30641/kebijakan.2017.V11.109-119

[13] FERREIRA M. T., FERNANDES M. R., AGUIAR F. C., MARTINS M. J., 和 RIVAES R. 塔霍河的长期人为改变：不同河流区域的水文调节和土地利用变化的影响。系列, 2020, 188, 104466. https://doi.org/10.1016/j.catena.2020.104466

[14] PUTRA W. A. 巴塘卢布河直河道流速分布试验研究。浇沙大学工科学生杂志, 2016, 2(1), 1–10. https://media.neliti.com/media/publications/110569-ID-studi-experimen-distribusi-kecepatan-pad.pdf

[15] KURNIAWAN T., BISRI M., JUWONO P. T., SUHARTANTO E., 和 SARASTIKA T. 社区参与中爪哇巴邦河的河流保护。湖南大学学报, 2021, 48(10), 500-512. http://www.jonuns.com/index.php/journal/article/view/817

[16] NATAKUSUMAH D. K., PERMATASARI R., 和 ARWIN S. 土地利用变化对流域水文状况的影响（案例研究：科梅林 流域）。万隆理工学院土木工程学报, 2017, 24(1), 91-97. https://doi.org/10.5614/jts.2017.24.1.11