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Research paper

Watershed Sustainability Index for Langat UNESCO HELP River Basin, Malaysia

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Abstract

The study on Watershed Sustainability Index (WSI) has been conducted to analyst the environmental condition in the area incorporating ecological baseline and socio-economic conditions. WSI is an integrated indicator based on basin Hydrology, Environment, Life and Policy (HELP) state condition. It is suitable to be applied in the Langat River Basin in Malaysia which has similar catchment area (up to 2,350 km^2) and is one of the UNESCO HELP River Basin since 2004. The WSI analysis which uses a pressure–state–response function based on basin HELP Indicator was done for Langat River Basin by using relevant available 5 years data for the period of 2009 to 2013. It is found that Langat River Basin is having WSI value of 0.68 which falls under the category of medium sustainability (between 0.5-0.8). Based on the maximum value (i.e. 1) or high sustainability (i.e. WSI value more than 0.8) it can be said that Langat is in the good side in term of sustainability. Few management aspects need to be improved and maintained well to be more sustainable. The assessment provides Langat River Basin with more information that is crucial in managing the basin through the adoption of UNESCO's HELP Framework.

Keywords: *index; Langat; river basin; sustainability; watershed.*

1. Introduction

The Langat River Basin in Malaysia has been recognized as one of the UNESCO HELP River Basin since 2004 (during the implementation phase of HELP) and was classified as Evolving HELP Basin, out of 91 catchments from 67 countries in the world. This initiative led by the Institute for Environment and Development (LESTARI) of Universiti Kebangsaan Malaysia (UKM). The Langat river basin is located in the mid-western part of Peninsular Malaysia and lays across two states and one federal territory i.e. Selangor State, Negeri Sembilan State and the Putrajaya Federal Government Administrative Centre [1].

HELP is a cross cutting and transdisciplinary initiative of the UNESCO led by the International Hydrological Programme (IHP). HELP has created a new approach to integrated catchment management through a framework for water law and policy experts, water resource managers and water scientists to work together on water-related problems [2]. The objectives of HELP are to deliver social, economic and environmental benefits to stakeholders through sustainable and appropriate use of water by directing hydrological science towards improved integrated catchment management basins and also implementation of research through collaborations between scientists, managers and stakeholders [3].

Langat River Basin is small but it has inherited numerous problems of a large river basin. The river plays an important role in conservation, agriculture and potable water supply yet it faces threat from rapid development in the industry sectors and urbanization in the basin.

Since its acknowledgement as HELP Basin in 2004 till a decade of its acknowledgement in 2014, the status of Langat River Basin is static as an Evolving HELP Basin. Although various initiatives have been done in order to improve the current status of Langat River Basin and to increase its sustainability, and some achievements have also been made in bringing Langat into the national and international arena, however there are still lot of things to be done to make sure all initiatives and achievements will have more positive impact to the public and community at large. Sustainable efforts and commitments are very important and need to be further strengthened in order to sustain the water resources management in this basin. Hence a study on Watershed Sustainability Index (WSI) at the catchment level for Langat River Basin was conducted by [4-5]. These studies were more focusing on Micro WSI analyses at certain areas of Langat. The continuation study of WSI which is focusing on overall area of Langat River Basin was again conducted by [1] and the analysis and results of the study is presenting in this paper.

2. Watershed Sustainability Index

The Watershed Sustainability Index (WSI) is an integrated indicator which uses a pressure–state–response function based on basin Hydrology, Environment, Life and Policy (HELP) state condition [6]. It is an index developed to measure the sustainability of a specific watershed over a period of time. This index system incorporates the elements of hydrologic, environmental, life and policy issues. Several issues impact the water sustainability of a river basin. Among them are the social, economic, and environmental aspects. However, they are often treated separately and not as an integrated, dynamic process.

In order to integrate the hydrologic, environmental, life and policy issues, as well as the existing pressures and policy responses in one quantitative, dynamic, and aggregated indicator, a watershed sustainability index (WSI), which uses a pressure–state–response function, is applied in this research. It includes gathering, describing and assessing relevant socio-economic data.

WSI has applied to a 2,200 km^2 UNESCO HELP Demonstration Basin in Brazil i.e. SF Verdadeiro by [6]. In this study, WSI is applied to the Langat River Basin in Malaysia which has similar catchment area (up to 2,350 km^2) and is one of the UNESCO HELP River Basin. Hence, WSI is suitable to be applied in this River Basin [7-8].

By using the HELP component for WSI analysis at catchment level, the output of this study will be in line with the HELP objectives i.e to deliver social, economic and environmental benefit to stakeholders through sustainable and appropriate use of water by directing hydrological science towards improved integrated catchment management basins and also implementation of research in collaboration between scientists, managers and stakeholders.

3. Methodology

3.1. Study Area

The Langat River Basin is located adjacent to the highly developed Klang Valley metropolitan in Peninsular Malaysia. Administratively, it encompasses two states and a federal territory as mentioned above. In Selangor it spans the districts of Sepang, Hulu Langat and Kuala Langat. In Negeri Sembilan, it spans four mukim (sub district) of the western portion of the district of Seremban, viz. Seremban, Labu, Lenggeng and Setul. Fig. 1 shows the location of Langat River Basin and other HELP River Basin in the world and Fig. 2 shows Map of Study Area in Langat River Basin.

The Langat River Basin is currently the fastest developing area in the country as a number of large scale social-economic projects are either currently taking shape or are already completed in the basin, such as Multimedia Super Corridor, Putrajaya, Cyberjaya, Kuala Lumpur International Airport, Formula One Grand Prix Circuit at Sepang, Malaysian BioValley, Institutions of Higher Learning and Training Centers etc.

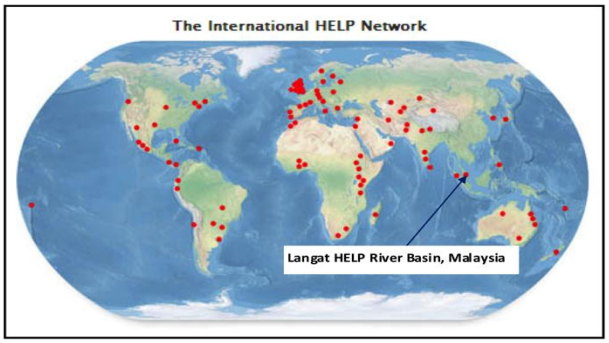

Fig. 1: Location of Langat River Basin among HELP River Basin Networks in the World [3]

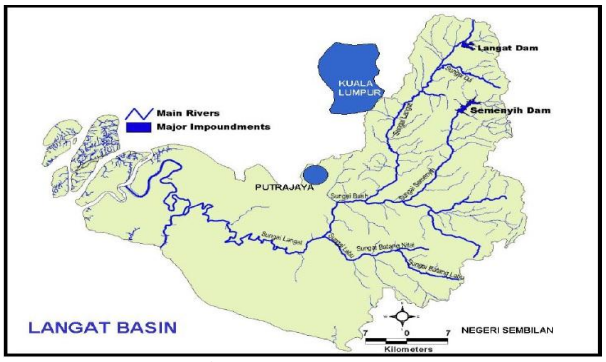

Fig. 2: Map of Study Area Langat River Basin [9]

Langat River Basin is an important water catchment area and a source of hydropower (two reservoirs and eight water treatment plants), providing raw water supply and other amenities to approximately more than 1.59 million people in this basin [10]. The area is facing rapid development in terms of urbanization, industrialization, road network and agriculture. During the last two decades, considerable forest areas have been converted to other landuse leaving only 803.8km^2 of forest cover in 2000. This scenario of extensive land conversion from agriculture use to urban-industrial commercial landscape in particular has brought humans into conflict of harmony with the river environment, and increases the degree of pollution into the river channels.

3.2. WSI Application

This study aimed to conduct the WSI assessment for Langat River Basin based on the available data for the period of 2009 to 2013. WSI assessment covers the aspect of Pressure, State and Response for each of the HELP elements using a set of predefine parameters as shown in Table 1. In conducting this assessment, some modifications were applied to the parameter due to lacks of available data. However, this modification was made with the best intention to best reflect the needed element in the assessment.

To each combination of indicators and parameters, a value between 0 and 1 is assigned. Each parameter receives a score 0; 0.25; 0.50; 0.75 or 1. A value of 0.25 is assigned to poorer levels, and 1.00 to optimum condition. The individual score of each parameter will be used to assess each correspondent element and finally derived the WSI of the basin.

Table 1: Indicators and parameters of the WSI [6]

Indicators	Pressure	State	Response
	Parameters		
Hydrology	Variation in the basin's per capita water availability in the period analyzed	Basin per capita water availability (long term average)	Improvement in water-use efficiency in the period analyzed
	Variation in the basin BOD5 in the period analyzed	Basin BOD5 (long term average)	Improvement in sewage treatment/disposal in the period analyzed
Environment	Basin's EPI (Rural and urban) in the period analyzed	Percent of basin area with natural vegetation	Evolution in basin conservation (percent of protected areas, BMPs) in the period analyzed
Life	Variation in the basin per capita income in the period analyzed	Basin HDI (weighted by county population)	Evolution in the basin HDI in the period analyzed
Policy	Variation in the basin HDI-Education in the period analyzed	Basin institutional capacity in IWRM	Evolution in the basin's IWRM expenditures in the period analyzed

The formula of WSI analysis that is used in this study is shown below:

$$WSI\ (0\text{-}1) = (H + E + L + P) / 4 \quad (1)$$

where H = Hydrology indicator (0-1), E = Environmental indicator (0-1), L = Livelihood indicator (0-1) and P = Policy indicator (0-1).

WSI < 0.5: Low
0.5 < WSI < 0.8: Medium
WSI > 0.8: High

4. WSI Status and Overall Results

4.1. Hydrology Indicator

The hydrology element of the index comprises of two components mainly the quantity and quality parameter of the water in the basin area. In the case of water quantity indicator, the study made a modification and adopted for the surface potable water available per capita in the basin. This modification was made because lack of data on the river flow and most of the water available for population are from potable sources. Taking into accounts the population growth in the basin during this period, the variation of basin per capita water availability was found to be -13%. While for the *State* aspect, the basin's per capita water availability was found to be 268 m^3/person year.
In the case of the water quality, pressure parameter correspond to the variation in the basin BOD5 (-27.7%), yielding a score of 1. The state parameter, basin BOD5 long term average was found about 7.5mg/L resulting in a score of 0.5. For response parameter, in the studied period of 5 years, there were some good initiative and improvement towards water efficiency and sewage treatment based on expert opinions giving a 0.5 score. The final score for water quantity and quality are 0.42 and 0.67 respectively. Hence, the overall Hydrology indicator value is the mean of water quantity and quality scores that is 0.553.

4.2. Environment Indicator

Similarly to Hydrology, Environment indicator is the mean average of state, pressure and response parameter. In the case of pressure parameter, the basin variation in agricultural area and urban population in the period of studied was -4.99 % and 15.44% respectively. The mean resulting in 5.22% Environmental Pressure Index. This is corresponding to an environmental pressure score of 0.75. In the case of environmental state, the basin has 26% of its natural vegetation covers in the year of 2013 which resulted in a score value of 0.75. Regarding response parameter that look into the evolution in basin conservation area, total area of 293 299 Ha is the conversation area by [11]. With The available law and policy that protected the areas from any development process, the conservation area is estimated to be the same in the period of studied. The score were assigning as 0.55. Therefore, the overall score is 0.75.

4.3. Life Indicator

The life-pressure indicator score in the basin was obtained from the variation in basin HDI-per capita income (GDP) over the long term period. However, since the data on basin level does not exist, the GDP for Malaysia as whole is used with the assumption it is similar to the basin's value. Based on the World Bank data [12-13], there was an increase of 44.8%, resulting in a score of 1 for this parameter. In the case of State life-indicator, the basin's HDI is assumed to be same as the national level HDI which found to be 0.779 in 2014 [14]. Over the period of the study, there were two reported HDI in 2009 and 2014 and the variation was found to be -6.03%. This resulted in the score 0.75 for response parameter. The overall Life score for the basin was 0.75.

4.4. Policy Indicator

The policy pressure score parameter (variation in the HDI – Education in the 5-year period) for the basin was 0% resulting in a parameter of 0.75. This is due to the unchanged in Education Index of HDI that contributed by constant mean years of schooling for above 25 years old and expected years of schooling. In the case of state parameter, there is a good range for basin institutional capacity in Water Resource Management in term of the legal and organizational within the period of studied, resulting in a score of 0.75. With regard to policy response parameter, the exact basin expenditure in water resource management initiatives is not available, thus replaced with a valid data from Department of Irrigation and Drainage that capture expenditure on Flood mitigation and management initiative as a reflection toward the basin WRM expenditure in the last 5 years. This has resulted in a score of 0.5. The overall policy indicator was the mean of the three policy parameters was 0.67.

4.5. Overall Watershed Sustainability

The WSI value is mean of the four HELP indicator using the Pressure-State-Response parameter. It is found that the overall WSI score for Langat River Basin is 0.68 as shown in Table 2 which represent near to optimum level of sustainability (maximum value is 1 and if it is less than 0.5 means there is bottleneck).
The analysis indicates that the concerning aspects are those related to the hydrology quantity and quality. However, this results includes several limitations, especially in obtaining real data that is localize to the basin level. This is a major constraint facing in conducting the WSI assessment and therefore requires modifications in term of projections and assumptions.

Table 2: Parameter Score and Watershed Sustainability Index for Langat River Basin for five years period (2009-2013)

Indicators		WSI				
		Pressure	State	Response	Average	Score
Hydrology	Quantity	0.25	0.25	0.75	0.42	0.55
	Quality	1	0.5	0.5	0.67	
Environment	EPI	0.75	0.75	0.75	0.75	0.75
Life	HDI	1	0.75	0.5	0.75	0.75
Policy	EDI	0.75	0.75	0.5	0.67	0.67
Result						0.68

Score ≤ 0.50: Bottleneck

5. Conclusion

Based on WSI analysis conducted during this study has shown quantitatively and qualitatively the sustainability value of the watershed in the Langat River Basin, Malaysia. The value of WSI for Langat River Basin is 0.68 (in the range of 0-1) and rating the basin's sustainability as "intermediate" or medium sustainability (between 0.5-0.8). There was no exact scale to measure this value, but based on the maximum value (i.e. 1) or high sustainability (WSI more than 0.8) it can be said Langat is in the good side in term of sustainability. A more thorough assessment can be conducted if there were more real data available and this shall be a focus in improving the management of Langat River Basin. The main watershed strengths were related to the Environment, life and Policy components. On the other hand, the weakness observed in the watershed was related to the Hydrology indicator, mainly due to water pollution issues. Overall, this value can be used as practical guide and management tool for water related stakeholders and community in the management of Langat River Basin. It is also very useful for improving the current level of Langat River Basin i.e. "Evolving" River Basin to become an "Operational" River Basin in the future under the framework of UNESCO-IHP HELP Network.

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