Channel Stability Assessment for Ayer Hitam Forest Reserve, Puchong, Malaysia

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Abstract: ***The consequence of soil acidity, human behaviors and other improvement are often linked with the changes of aquatic ecosystem water quality. Ayer Hiram is one of the most valued regions of lowland dipterocarp forest remaining in generally developed Selangor, Malaysia. The starting activities and de-gazettements execution have led to the deterioration of Main River in Ayer Hitam forest reserve. A case study using Ayer Hitam forest is aimed for such verification and validation to showcase the applicability of morphological assessment method on channel stability.Field sampling, laboratory analysis, statistical approach and verification process are used to achieve a stability index of channel or river and follow the standard of execution ranges from engineering field, geomorphology and statistical approach. The maximum depth was 0.89 m in cross section (3), however the minimum depth was 0.04 m in cross section(5) and the highest velocity was recorded in cross section (5) which 0.32 m/s and the lowest velocity recorded was 0.02 m/s in cross sections(2,7and8). Furthermore, the maximum discharge was 0.314 m^3/sin cross section (3) while the minimum discharge was 0.037 m^3/s measured in cross section(7). This research shows a better approach to assess river stability through hydro-morphological approach. The use of CSI and OSEPI index successfully elucidated the level of channel stability at Sungai Rasau, Selangor. CSI index shows that half of the cross section fall under stable category and another half fall under moderately unstable category. Meanwhile, all cross section falls under highly stable and moderately stable category for OSEPI index. This research can give a better understanding towards knowing channel stability of Sungai Rasa for a long run. The restoration and rehabilitation work could be performed by knowing the gap between stable and unstable channel behavior. The documentation of geomorphic data for Ayer Hiram forest reserve can benefit a lot of agencies towards conservation of river, riparian and aquatic life in the future.***

Keywords: Stability index of river Ayer Hiram, CSI, OSEPI, Malaysia

1. Introduction

For many major world rivers, failure and erosion of river banks due to environmental factors have raised concerns.A few approaches have been suggested to assess channel stability behaviour namely Physical Habitat assessment (PH), Riparian Habitat assessment (RH), Morphological assessment (M) and Hydrological Regime Alteration assessment (HRA). Baletti et al. (2014) provide an in-depth discussion on these 4 approaches by naming the key players for each technique.Puchong's Ayer Hitam forest reserve is one of the most valuable remaining lowland dipterocarp forest regions in greatly developed Selangor. In the beginning, the forest covered 4270 hectares and was gazetted as a forest reserve back in 1906(Rinaldi et al., 2013). Since then, it has suffered from a series of de-gazettements where now is left with only 1200 hectares. The opening activities and de-gazettements execution has led to the deterioration of Main River in Ayer Hitam forest reserve. The reserve is drained by three main rivers - Rasau, Biring, and Nasih. Nevertheless, Nasih and Biring rivers have been compromised severely by land expansion. It is a high time to re-visit the stability of Rasau River within the Ayer Hitam basin (Healey et al., 2012).

Methods of morphological assessment on river stability received numerous attentions recently. However, the consistency among this method is subject for further verification and validation. A case study using Ayer Hitam forest is proposed for such verification and validation to showcase the applicability of morphological assessment method on channel stabilityto achieve following objectives:

1) To measure the morphological and hydraulic data of Sungai Rasau at Ayer Hitam forest reserve
2) To evaluate the stability of Sungai Rasau using Morphological assessment approaches CSI and OSEPI.
3) To check the consistency of morphological assessment using different proposed index.
4) To evaluate the parameters which influence of both index.
5) This research can accord a better understanding towards knowing channel stability of Sungai Rasau for a long run. The restoration and rehabilitation work can be performed by knowing the gap between stable and unstable channel behaviour. The documentation of geomorphic data can benefit various agencies towards future conservation of river, riparian and aquatic life.

2. Materials and Method

2.1 Collection of plant material

In general, the present study is based on extensive field sampling and statistical analysis sequences. Therefore, the reliability and accuracy for each technique was set the highest priority. The field sampling involved three main themes which are river surveys, hydraulic geometry and hydraulic data as listed in Table 1. The study focused on the mixed sand-gravel bed river; thus the identification and classification of study site are crucial to correctly identify types of river (Harrelson et al., 1994, Bunte&Abt, 2001, Chen*et al*., 2006).

Table 1: Themes of Field Sampling

Data Theme		Types of Data	Data Category
River Surveys	River Classification Theme	Water Surface Slope (S_o) $Slope(\%) = \frac{\text{Rise}}{\text{Run}} \times 100$	Primary Data

		• Bed Material Sizes (d_{50})	
	Field Work	Cross-section of river (A) • Bed slope	
Hydraulic Geometry Data $Q = V * A$ Where, V is average river velocity and A is area for river's cross section.		• River width • River depth At-station measurement	Primary Data
Hydraulic Data Three readings are taken from the flow's left, right and middle in obtaining the stream's average velocity.		• Discharge (Q) • Velocity (V)	Primary Data

Figure 1: Data sheet aimed at completing basic stream channel data and aimed at completing channel stability (CSI)

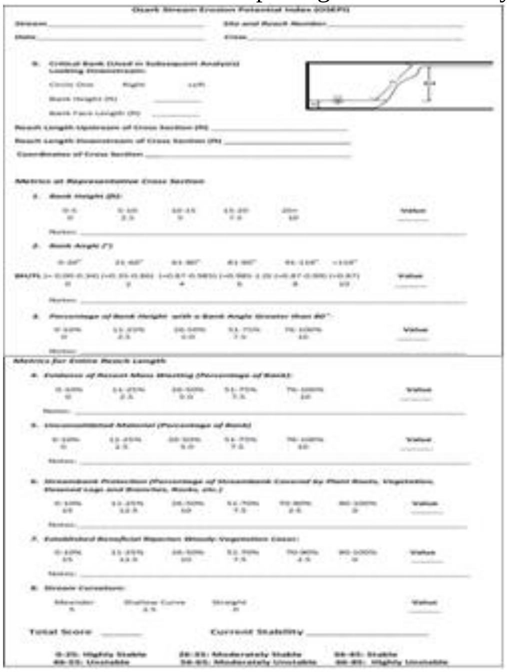

Figure 2: Data sheet to compile basic stream channel data and to complete Oklahoma Ozark streambank erosion potential index (OSEPI)

This study depicted the proposed conceptual work of how to analyse the stability index through channel stability index (CSI), The Oklahoma Ozark streambank erosion potential index (OSEPI) and Channel Condition and Stream Stability Index (CCSI) from the study area (Figure 1 and figure2).

3. Result

The chapter explains Rasau River assessment details of reach using Ozark Stream Erosion Potential Index (OSEPI), and Channel Stability Index (CSI).Each parameter in each index will be explained in details by inferring cross section number. The summary for each index is presented and the comparisons between these two indexes are made to observe the consistency among them. Prior to index assessment, the raw data are established comprising 5 themes namely cross section data, longitudinal elevation data, flow data, geometry and morphology data and bed material data. These 5 themes will be fixed into the CSI and OSEPI respectively. Table 2-3 show the parameterization for each index and the respective data theme to these indexes.

In CSI index, geometry and morphology data are predominant and profound in the morphologic assessment. The imagery data (e.g.: Photos) are crucial to establish the index as most of the parameters used qualitative judgment instead quantitative decision to obtain the final score.

Table 2: Mapping of Channel Stability Index (CSI) and Data Themes

No	CSI parameter	Data theme
1	Primary bed material	Bed material
2	Bed/bank protection	Geometry and morphology
3	Degree of incision	Cross section & longitudinal elevation
4	Degree of constriction	Cross section & longitudinal elevation
5	Streambank erosion	Geometry and morphology
6	Streambank instability	Geometry and morphology
7	Established riparian woody-vegetative	Geometry and morphology
8	Occurrence of bank accretion	Geometry and morphology
9	Stage of channel evolution model	Geometry and morphology

CS	Parameters									Index Score	Index Class
	1	2	3	4	5	6	7	8	9		
CS 1	2	0	4	0	LB 0 LB 0	LB 0 RB 0	LB 0 RB 0	LB 2 RB 2	0	10	stable
CS 2	1	0	3	1	LB 1 RB 1	LB 0 RB 0	LB 0 RB 0	LB 0 RB 0	0	7	Stable
CS 3	2	0	2	0	LB 0 RB 0	LB 0.5 RB 0.5	LB 0 RB 0	LB 0.5 RB 0.5	0	6	Stable
CS 4	1	0	2	0	LB 2 RB1	LB 0.5 RB 0.5	LB 0 RB 0	LB1.5 RB1.5	0	10	Moderat e Unstable
CS 5	1	0	4	0	LB 2 RB 2	LB 0.5 RB 0.5	LB 0 LB 0	LB 1 RB 1	0	12	Moderat e Unstable
CS6	3	0	3	1	LB 2 RB 2	LB 1.5 RB1.5	LB 0 RB 0	LB 1 RB 1	0	16	Moderat e Unstable
CS 7	3	0	3	3	LB 2 RB 2	LB 1 RB 1	LB 0 RB 0	LB 1 RB1	0	17	Moderat e Unstable
CS 8	3	0	2	0	LB 1 RB 1	LB 1 RB 1	LB 1 RB 1	LB 2 RB1	0	14	Moderat e Unstable

Table 3: Summary of Score Index at Rasau River using CSI approach LB = Left bank, RB = Right bank, CS=Cross Section

The parameters from 1 to 8 as followed areBank Height, Bank angle, Percentage of bank height with a bank angle greater than 80°, Evidence of recent mass wasting (percentage of bank), Unconsolidated material (percentage of bank), Streambank protection,Established beneficial riparian woody-vegetation cover and Stream curvature.

Table 4: Mapping of Ozark Stream Erosion Potential Index (OSEPI) and Data Themes

No	(OSEPI) parameter	Data theme
1	Bank Height	Geometry and morphology, Cross section & longitudinal elevation
2	Bank angle	Geometry and morphology, Cross section & longitudinal elevation
3	Percentage of bank height with a bank angle greater than 80°	Geometry and morphology, Cross section & longitudinal elevation
4	Evidence of recent mass wasting (percentage of bank)	Geometry and morphology
5	Unconsolidated material (percentage of bank)	Geometry and morphology
6	Streambank protection (percentage of streambank covered by plant roots, vegetation, downed logs and branches, rocks, etc.)	Geometry and morphology
7	Established beneficial riparian woody-vegetation cover	Geometry and morphology
8	Stream curvature	Geometry and morphology

OSEPI utilizes the river bank properties as an indicator to evaluate OSEPI. The bank angle is important to observe the channel stability and the cut-off of 80° ae taken into consideration for evaluation purpose (Table 4, 5, 6).

Table 5: Summary of Score Index at Rasau River using OSEPI approach (lift bank) (CS = Cross Section)

Cross section LB	Parameters 1	2	3	4	5	6	7	8	Index Score	Index Class
CS 1	5	0	0	2.5	0	0	2.5	0	10	Highly Stable
CS 2	2.5	0	0	2.5	2.5	0	0	2.5	10	Highly Stable
CS 3	2.5	0	0	2.5	0	0	2.5	2.5	10	Highly Stable
CS 4	0	0	0	2.5	2.5	2.5	2.5	2.5	12.5	Highly Stable
CS 5	2.5	0	0	2.5	2.5	2.5	2.5	2.5	15	Highly Stable
CS6	2.5	0	0	5	2.5	2.5	2.5	2.5	17.5	Highly Stable
CS 7	0	0	0	7.5	5	2.5	2.5	2.5	20	Highly Stable
CS 8	5	0	0	7.5	7.5	2.5	2.5	2.5	27.5	Moderately Stable

Table 6: Summary of Score Index at Rasau River using OSEPI approach (Right Bank) (CS = Cross Section)

Cross Section RB	Parameters 1	2	3	4	5	6	7	8	Index Score	Index Class
CS 1	5	0	0	2.5	0	0	2.5	0	10	Highly Stable
CS 2	2.5	0	0	2.5	2.5	0	0	2.5	10	Highly Stable
CS 3	2.5	0	0	2.5	0	0	2.5	2.5	10	Highly Stable
CS 4	0	0	0	2.5	2.5	2.5	2.5	2.5	12.5	Highly Stable
CS 5	2.5	0	0	2.5	2.5	2.5	2.5	2.5	15	Highly Stable
CS6	2.5	0	0	5	2.5	2.5	2.5	2.5	17.5	Highly Stable
CS 7	2.5	0	0	7.5	5	2.5	2.5	2.5	22,5	Highly Stable
CS 8	5	0	0	7.5	7.5	2.5	2.5	2.5	27.5	Moderately stable

Assessment of Rasau River using Channel Stability Index (CSI)

Channel stability index (CSI) comprised of nine (9) parameters namely streambank erosion,, bed/bank protection, established riparian woody-vegetative, primary bed material, degree of constriction, degree of incision, streambank instability, occurrence of bank accretion and stage of channel evolution model. By inferring cross number 1, those parameters is evaluated qualitatively and quantitatively.**Summary of Geometry Data and Geometry Data (Depth, Velocity, and Discharge)of the Rasau River is shown in table 7-8.**

Table 7: Summary of Geometry Data of the Rasau River

	Bank Height (BH)		Bank face length (FL)		River	Width Channel(W)		Diameter Streambed	Bank
	Left (m)	Right (m)	Left (m)	Right (m)	Stage(D)	W(m)	W_u(m)	Sediment(mm)	Gullies
Cross Section 1	3.5	3.6	13.5	13.5	0.29	9.85	9.66	2.84	None
Cross Section 2	2.4	2.8	11.5	11.8	0.32	8.9	12.4	119.66	None
Cross Section 3	1.6	2.2	15.5	17.5	0.61	12.4	6	8.61	None
Cross Section 4	0.2	0.6	13.4	19.0	0.13	6.0	6.0	81.98	None
Cross Section 5	2.2	1.6	17.5	15.5	0.04	6.0	5.85	246.9	None
Cross Section 6	1.9	2.6	11.5	12.5	0.42	5.85	8.3	3.22	None
Cross Section 7	1.2	2.2	11.4	9.6	0.26	8.3	8.5	3.78	None
Cross Section 8	0.6	3.0	12.5	10.0	0.39	8.5	9.0	4.35	None

Table 8: Summary of Geometry Data (Depth, Velocity, and Discharge) of the Rasau River

Cross Sections	Depth (m)	Velocity (m/s)	Discharge (m^3/s)
Cross Section 1	0.29	0.05	0.064
Cross Section 2	0.32	0.02	0.05
Cross Section 3	0.89	0.03	0.314
Cross Section 4	0.13	0.012	0.079
Cross Section 5	0.04	0. 32	0.086
Cross Section 6	0.42	0.03	0.074
Cross Section 7	0.26	0.02	0.037
Cross Section 8	0.39	0.02	0.06

4. Discussion

Based on geometry data which have been collected from Rasau River site. The maximum depth was 0.89 m in cross section (3) however the minimum depth was 0.04 m in cross section (5). The highest velocity was recorded in cross section (5) which was 0.32 m/s and the lowest velocity was 0.02 m/s in cross sections (2, 7 and 8). Farther more the maximum discharge was 0.13 m^3/s in cross section (3) while the minimum discharge was 0.037 m^3/s measured in cross section (7).

This research accord a better approach to assess river stability through hydro-morphological approach. The use of CSI and OSEPI index successfully elucidated the level of channel stability at Sungai Rasau, Selangor. CSI index shows that half of the cross section fall under stable category and another half fall under moderately unstable category. Meanwhile, all cross section fall under highly stable and moderately stable category for OSEPI index in Figure 5.1. From this figure, some inconsistencies are observed between these two indexes. There are few reasons for the inconsistencies:

Both indexes are using different set of rating score to categorize the level. CSI index rates the level to three while OSEPI rates the level to 6.It utilized different parameters in categorizing levels; therefore uniformity is a challenge to find.

Based on the summary table for CSI index (see Table 4.5), three parameters that give higher proportion towards instability namely degree of incision, degree of constriction and occurrence of fluvial deposition. The changes of this parameter will give high impact to the level of score. Correlation coefficients of these three parameters are high as well which signify the importance towards total score. Although both indexes cannot be directly compared to each other, however the level of reading depict the same intensity; as such dark blue colour in Figure 5.1 depicts the stable region, orange is for moderate unstable region and red is the highly unstable region. Nevertheless, the OSEPI shows consistency among the cross section where most of them are lie within stable region.Thus, authorities or policy makers may refer the outcome of this research to perform the rehabilitation work at specific cross section rather than looking at the whole stretch. As such, cross section at moderately unstable region must be given special attention should rehabilitation works are proposed in the future.

5. Conclusion

The recommendation of this research is given in point forms as follows:

Almost 80% of the parameters in the CSI and OSEPI index employed the observation method rather than computation method which can induce biased towards the total score. The use of empirical or semi-empirical equation is viable to produce such level of channel stability.These indexes are developed based on the case study in US. It is a high time for a new index appropriate for humid tropic region to be developed.The commonality among the index is very crucial so that different index will give same output to the organization of interest. The common state of reading / ranking should be implemented to eradicate the different interpretation (Figure 3).

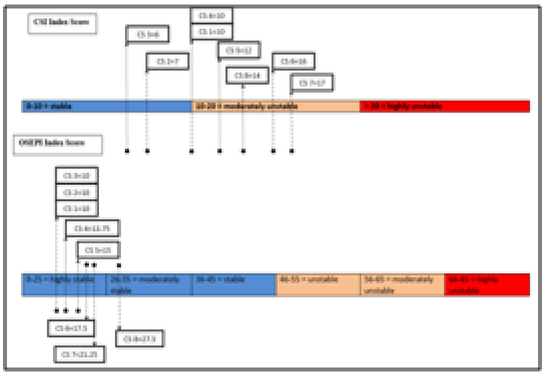

Figure 3: Distribution of each cross section andtheir associate indexes

6. Acknowledgment

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