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Hydro morphological assessment using the habitat survey method of Pandurucan River in San Jose, Occidental Mindoro

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ABSTRACT

Describing the physical characteristics and natural processes of a river system required field investigation and site survey. The River Habitat Survey (RHS) was developed to guide water managers to provide technical descriptions of the river ecosystem useful in the conservation and rehabilitation of the riverside habitats. The survey was conducted to assess the hydro morphological features of the river to provide substantial evidence for the corrective measures applicable to the river. This study employed the procedures suggested by RHS to present the habitat quality assessment and habitat modification scores that describe the present diversity and ecology of Pandurucan River in San Jose, Occidental Mindoro. The Habitat Quality Assessment (HQA) scores reflected that the river has poor diversity and naturalness, as shown by the physical features of the channel, bed, and riverbank. The high value of the Habitat Modification Score showed that the river is severely modified by the existing land use, structures, and development in the river, describing the present ecology in the river. The study further proved that rehabilitation strategies must be prioritized in the objective of reviving the Pandurucan River.

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1. INTRODUCTION

Characterizing the physical features of rivers and evaluating the river habitat quality is becoming a popular approach to support river management. Hydro morphology is used to describe the characteristics and processes of the river ecosystem (European Commission, 2000) and supports the assessment of the biological components; biotic elements affecting the richness of the river; the nutrient and organic matter storage, and the aquatic life processes (Vaughan et al., 2009; Elosegi et al., 2010; Elosegi and Sabater, 2013). Therefore, hydro morphological assessment aims to evaluate and classify all the existing hydrological and geomorphological features of the river to assess the condition (Belleti et al., 2015). While approaches to an effective river management system raise pressing issues for many water managers and policymakers, the choice of sustainable river management depends on the quality of information and expert decisions. Most of the failure occurs in the inability to characterize the physical structures of the river and present the chemical and biological factors affecting the river system. In the attempt to conduct a sound hydro-morphological assessment, the conduct of the River Habitat System (RHS) is important. RHS can determine the type of aquatic biological communities present in the river, the land use and land pattern, and the type of river, describing the river flow, channel bed, and slope. The approach is based on data collection on a 500m stretch of the river channel, considering the grid reference, slope, geology, height of the sources, and distance from source, in-stream features of the channels, and riverbank (Environment Agency, 1997b; Fox et al., 1998).

There are various methods introduced to carry out a hydro morphological assessment for river restoration, ranging from the spatial configuration of the physical habitats to broader river condition assessments, biological assessment methods; conceptual approaches on the holistic, representative, and multiple practices; and multivariate and multimeric approaches (Raven et al., 2002; Fernández et al., 2011, Fryirs et al., 2008; Karr and Chu, 2000; Tharme, 2003; Gostner, 2012). A common approach in hydro-morphological assessment is the RHS, which focuses on the physical structure of the river using the systematic collection of the physical structure of the watercourse of the river channel. RHS is carried out using a standard field survey method, a computer database as an appropriate method for assessing habitat quality, and a system for describing the extent of artificial channel modification (Raven et al., 1997, 1998).

RHS was first used in the United Kingdom to determine the physical quality of rivers as the main data for the environmental assessment and catchment planning; the method was recommended for further refinement to consider the robustness of the data, such as the habitat requirements and impact of channel modification (Raven et al., 2000). A study of Buffagni and Kemp (2002) conducted the RHS using a survey method in determining the type of flows, substrate, and the characteristics of the wetted channel; the study revealed the average number of flow types per site increased between 1.0 to 2.2, while the substrate types were close to 1.0. The RHS was also used in characterizing the Douro basin in Portuguese Land using the ordination, classification techniques, and the 10-spot checks, and discovered factors affecting the river corridor are dependent on typological characteristics (Cortes et al., 2008). Further, RHS investigated the 500-meter length of the river considering the hydrologic conditions, land-use, and the riparian habitat structure; the assessment showed 82-76% channel attributes and 87-98% of channel and bank features (Raven et al., 2010). Moreover, the study of Urošev et al. (2009) applied RHS in classifying the river habitat quality of Golijska, Moravica, and Jerma basins in Serbia; the study revealed that the Habitat Quality Assessment (HQA) index of Moravica and Jerma has higher habitat diversity with lower values of Habitat Modification Score (HMS). Further, RHS, utilizing the HMS and HQA indices, was used in three small lowland rivers in Poland: Zielawa, Zwoleńka, and Zagożdżonk; the study revealed that the values were dependent on the seasons and were greatly affected by the level of vegetation and the number of species observed in the river channels, with 5% maximal value (Kiraga, 2020). Another usability of RHS was presented in forecasting the effects of Zielawa River restoration between the selected stretch of the river; the study found that the use of variants and indices can increase the ecological class from Class V to Class IV (Kiraga and Popek, 2014). Another study on the RHS was applied in classifying the ecological condition of Wardynka River using the HQA and HMS indices; the 48 HQA index and 3 HMS index revealed that the river has a type 4 class, having moderate environmental condition (Spieczyński et al., 2014). The use of drones and photographic data was recently developed as a strategy to carry out RHS and provided an opportunity to upscale the habitat classification and monitor the river system in a more precise and accurate manner (Woodget et al., 2017). RHS using HQA and HMS were used in assessing the river channels of the Wardynka river and Kanał Habdziński of North-western and central Poland; analysis of the study revealed numerical values of 68 HQA score and 19 HMS for Wardynka, identified moderate (Class 3) ecological status; while 33 HQA and 28 HMS determined in Kanał Habdziński classified as Class 4 or poor ecological status (Brysiewicz and Czerniejewski, 2019).

Literature has stated the usefulness of the River Habitat Survey in assessing and classifying the physical structures of the river system as basic information for river management. The ability of the HQA and HMS indices in describing the characteristics of the river was used in this study. The data acquired from the catchment delineation served as the input data in the score sheets and was compared to the applicable standards. The results of the study can provide important information for the conservation project and river basin management plans of Pandurucan River. The river connects the coastal barangays to the proper town and is generally used for recreational purposes. Part of the rehabilitation plan for the river is the investigation of the physical, biological, and environmental factors affecting the river ecosystem. The assessment of water quality has already been conducted and revealed poor water quality (Enriquez, Tanhueco, 2022). In the attempt to determine the factors affecting the causes of contamination, this study aims to present the physical structures of the river, including the characteristics of the surrounding environment. This study presented a hydro-morphological assessment approach in describing the character of chemical and biological sampling points used for assessing water quality.

2. METHODOLOGY

2.1. Design

This study focused on the application of the River Habitat Survey (HRS) as a structured survey technique in characterizing a river (Raven et al., 1997, 1998b). The approach was adopted to collect data from field observations such as the substrate, flow, erosion, deposition features in the channels, morphological and vegetation structure on the banks, and the land use in the surrounding environment.

2.2. Study Area

Pandurucan River is considered one of the important rivers in the province of Occidental Mindoro (Candelario, 2009). The river plays an important role in connecting barangays to the town and was categorized as Type B or recreational waters by the Department of Environment and Natural Resources (2023). The upstream region is surrounded by mountains and agricultural areas; the middle stream seats through Brgy. Labangan is surrounded by semi-commercial and agricultural areas, while the downstream region is surrounded by commercial and residential areas. The study considered a 500-meter stretch of the River from the Pandurucan Bridge to the downstream region of the river.

A field survey was conducted to gather all the needed data to describe the physical characteristics of the river. Table 1 shows the type of data and sources from which the data were taken, while Image 1 shows the transects considered in the study area.

Table 1. Type of data for hydro morphological assessment.

TYPE OF DATA	SOURCES OF DATA	QUALITY OF DATA
Geomorphological characteristics	QGIS Catchment Delineation (Enriquez, 2022)	Catchment Area: $3{,}605.10\ ha$ Drainage Area: $5367.33m^2$
Elevation-DEM	ArcGIS Field Survey	5m x 5m resolution Walkthrough analysis
Channel slope	QGIS Catchment Delineation (Enriquez, 2022)	Slope: 0.21891°

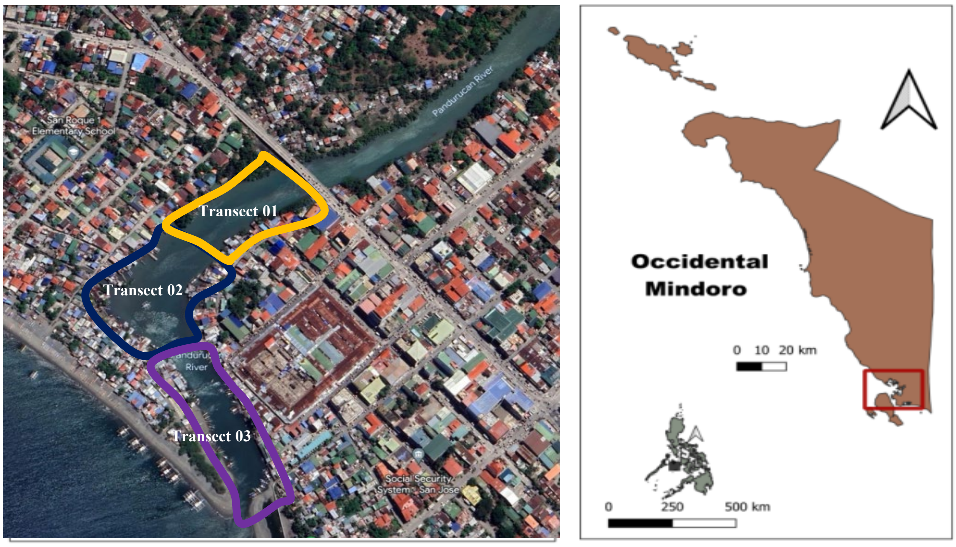

Image 1. Study area

2.3. Hydro Morphological Data

The hydro morphological assessment was carried out considering the Physical Habitat Survey, riparian habitat assessment, and morphological assessment. The physical habitat assessment includes the physical observation of the river to determine the in-stream habitats or microhabitats. A walk-through analysis and photograph were used to determine the land use in the study area and other channel features. The field/site investigation was carried out to validate the data gathered. The riparian habitat described the riverbed system, types of revetment/protection present/, riverbank profiles, and the type of vegetation. Lastly, the morphological assessment approach focused on the framework of river conditions and the assessment needed for the restoration design. The data to present the morphological conditions, such as the catchment area, slope, and length, were provided by the catchment delineation process in QGIS.

2.4. Habitat Quality Assessment (HQA) Score

HQA is an indicator of the global diversity of habitat, considering the natural characteristics of the study area, such as flow types, channel floor, and deposition features in the channel, and is presented with scores given to each characteristic. The HQA indices, where a score of 10 indicates a very small number of features and a score of 80 represents a high degree of natural characteristics, were adopted in this study (Uroševet al., 2009; Ferreira et al., 2011).

2.5. Habitat Modification Score (HMS)

HMS quantifies the presence and influence of anthropogenic modifications, such as the presence of hydraulic /water structures in the river system: bank reinforcement, modified bank profile, dams, piers, culverts, and bridges. The modifications were scored according to the presence or absence (0-100 score) of HMS Rules version 2018 were adopted in the study [Table 2].

Table 2. HMS classification and description (Naura, 2014).

HM CLASSIFICATION	HMS DESCRIPTION	HMS SCORE
1	Pristine/semi-natural	0-16
2	Predominantly unmodified	17-199
3	Obviously modified	200-499
4	Significantly modified	500-1399
5	Severely modified	>1400

3. RESULTS

3.1. Basic Morphometric Data of the River

To characterize the 500-meter length of the river, two stations were considered as the river site investigation area. The first site is located near the Pandurucan Bridge, and the second station is located near the outlet of the river. The basic morphometric data obtained in the identified stations [Table 3].

Table 3. Basic morphometric data of the river.

TRANSECT	RIVER'S SURROUNDING AREA	LOCATION	ELEVATION (MEAN SEA LEVEL, m)	MAXIMUM DEPTH OF THE WATER (m)	BANK WIDTH (m)
1	Highly densely populated area	12'21'01N 121'03'35'E	5.0	1.08	67.88
2	Highly densely populated area	12'21'08N 121'03'37'E	4.5	0.85	89.45
3	Highly densely populated area	12'21'14'N 121'03'40'E	3.0	0.65	46.57

3.2. Water Depth and Width of the Riverbank

The depth of the water was determined by the average values of depth measured using a range pole during the field survey. The exact spot-check coordinates were determined using a GPS device, while the elevations of the sites were measured from the mean sea level with the help of Google Earth and calibrated through the GPS device. The bank top width was measured on site [Image 2].

Image 2. Field survey for the depth and width of the river bank

3.3. Spot Check Survey

Using the spot-check systems recommended by the River Habitat survey, the river was transected into three sections as shown in Figure 1, selected based on the flow and physical attributes of the river. In general, all transects were surrounded by highly dense and populated areas. The spot checks used in the study considered the hydro-morphological elements of the river, including the channel substrate, flow type, bank features, riverbed, and land use present.

Considering the three (3) transects used in the analysis, the following general information was drawn: the sites were part of the river, and there were no adverse conditions affecting the survey. The survey was conducted on a sunny day, a cloudy day and a day after rain at 9:00am. During the survey, the riverbed is partially visible, and the water is generally clear. The bottom is considered flat since the 500-meter stretch of the river lies on the lowest elevation. The flow of the water was characterized by shallow and fast flow with a distinct disturbed surface over the unconsolidated gravel-pebble substrate at Transect 1. As water flows into Transect 2, a slower flow along the unconsolidated riverbed was observed, accompanied by sediments, while the flow in Transect 3 was characterized by a slow-to-fast flow as it approaches the outlet of the river. In terms of the physical attributes of the river [Table 4].

Table 3. Results of the spot check survey

PARAMETERS	**RIVER HABITAT SURVEY SPOT-CHECK RESULTS**	
Physical attributes	**Left bank**	**Right bank**
Bank materials	Gravel/sand	Gravel/sand
Bank modifications	Reinforced bank	Reinforced bank
Bank features	Unvegetated point bar	Unvegetated point bar
Channel substrate	Gravel/pebble Sand Silt clay	
Flow type	Smooth and rippled	
Chanel modifications	No obvious modification on channel bed	
Channel features	Unvegetated mid-channel bars	
Bank top land use and vegetation structure		
Land use within 5m of left bank top	Suburban/urban development	
Left bank top (structure within 1.0m)	Complex	
Left bank-face	Complex	
Right bank-face	Complex	
Land use within 5m of the right bank top	Complex	

3.4. Channel Substrate and Flow Type

The physical attributes of the river defined the existing environment, affecting the natural processes of the river. It was observed that the left and right banks of the river are covered with coarse gravel and pebbles, especially in Transect 1. Silt and sand substrates were observed along Transect 2, and Transect 3 was characterized by sand, as it is closely located near the mouth of the ocean. Some bank modifications observed in the river were the presence of concrete, riprap, and gabions, and piles of wood. While the bank features are described as an unvegetated point bar due to the unconsolidated riverbed material with distinguishing low flow and shallow slope into the water and characterized by sediment transported with the stream flow. Further, the channel substrate was determined by the collected fragments in the range pole and by analyzing the size. In general, the collected substrates were a combination of pebbles, sand, silt clay. No obvious modifications on the channel bed were observed, and the channel features were characterized by unconsolidated riverbed material [Image 3].

Image 3. Channel substrate and flow type

3.5. Land Use and Existing Structures Present on the Riverbank of the Pandurucan River

After characterizing the channel beds and substrate, the present land use and land cover surrounding the river were analyzed. The survey considered the land use and existing structures on the left and right banks of the river [Image 4].

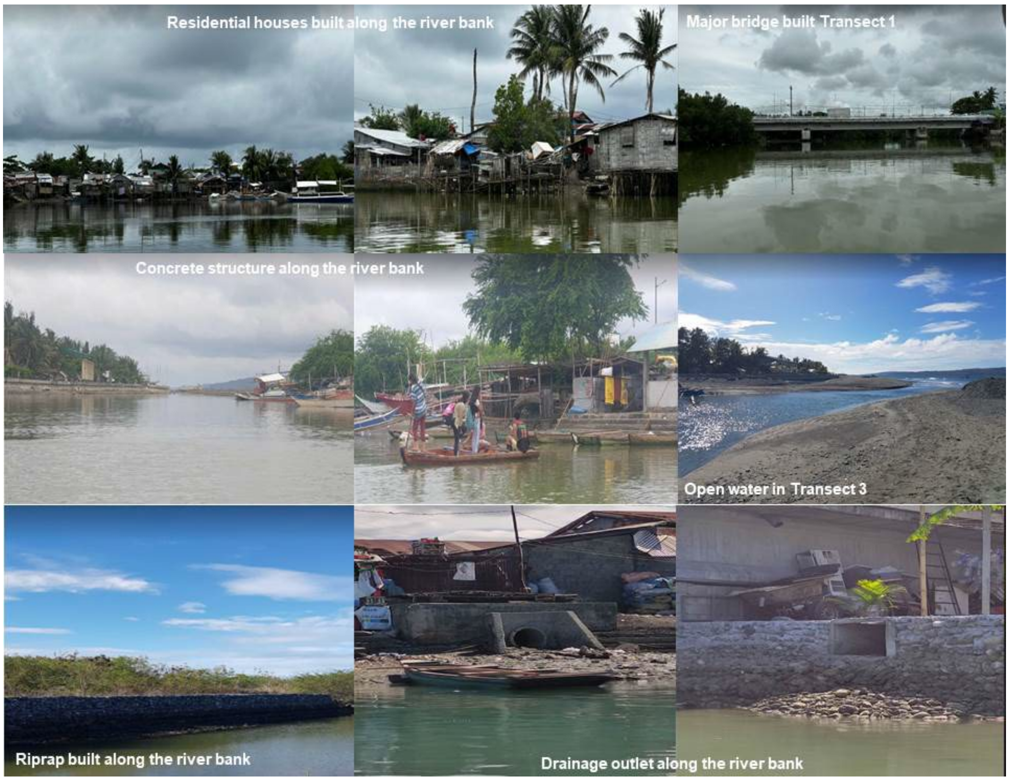

Image 4. Land use and existing structures present on the riverbank of the Pandurucan River

3.6. Type of Vegetation Present in the Study Area

Based on the collected information, within the 1.0-meter to 5.0-meter left and right banks, the presence of residential houses and commercial structures was present. The residential houses are usually made up of light materials with columns submerged in the river water. The presence of the Pandurucan Bridge is considered a major structure affecting the hydro morphological activities. The San Jose Public Market and a seawall structure were situated along the riverside. There were drainage outlets directly facing the river. The presence of natural open water in Transect 3 makes the area useful for the docking of boats from the nearby island. In conclusion, the congested houses and structures present described the complexity of the riverbank, as many activities were concentrated on the existing land-use.

Further, the channel vegetation type described the functional habitat provided for other living organisms in the river. Some of the features were categorized as free-floating from the presence of fallen leaves in Transect 1; amphibious from the mangrove trees arranged along the riverbank; submerged fine leaves from the long leafy plants observed; and the filamentous algae stacked on the stones and boulders along the riverbank [Image 5].

Image 5. Types of vegetation present in the study area.

The field observation conducted in this study provided an in-depth description of the existing vegetation along the selected stretch of the Pandurucan River. The results showed varying vegetation features classified as bare, uniform, simple, and complex. Bare features were observed along portions of the riverbank lacking any type of vegetation. The uniform features were characterized by the presence of mangrove and aroma trees arranged in linear formations. The simple features referred to sections of the riverbank with a single type of tree, while complex features represented areas containing a diversity of vegetation types.

3.7. Habitat Quality Score

Considering all the results of the field observation and analysis of the present features of the Pandurucan River, all data were placed in the Habitat Survey application, and a corresponding value for the HQA was generated. Result shows the scores obtained from each category of the River Habitat Survey considered in the study [Table 4].

Table 4. Habitat Quality Score

CATEGORIES	TRANSECT 1	TRANSECT 2	TRANSECT 3
Flow type	6	1	10
Channel substrates	10	10	5
Channel features	1	0	0
Bank features	4	2	3
Point bars	2	2	
In-stream channels	1	0	0
Land use within 50m	4	4	4
Trees and associated features	2	1	1
Object of special importance	1	1	2
HQA Score	**39**	**29**	**35**

The results of the table showed the hydro morphological features of the study area with HQA scores of 39, 29, and 35 for Transect 1, 2, and 3, respectively. Notably, the scores are lower than 80, indicating the river transects have low diversity and naturalness. The condition can be attributed to the high population density and extensive infrastructure development that may have influenced the ecological quality of the selected stretch of the river. The lowest HQA score was observed in Transect 2, where a public market and residential houses, and other concrete structures were built. The next lowest score was observed in Transect 3, characterized by the presence of a seawall and residential houses. The presence of aroma trees along the riverbanks helped improve the natural water quality. The highest HQA score was obtained by Transect 1, despite being surrounded by residential houses; the presence of mangrove trees and other types of vegetation provided an opportunity for living organisms to survive.

3.8. Habitat Modification Score

During the field observation, all types of modifications present in the study area were recorded and documented. The HMS was carried out by assessing the presence and absence of artificial objects such as pipeline weirs, bridges, dams, and others. The assessment also included the investigation of any type of modification implemented in the bank profile, bank reinforcement, embankment, and other. As the number of modifications increases, the HMS also increases, describing the hydro morphological transformations affecting the natural processes of the river.

Result reflects the HMS Score obtained by the transects of the river used in the analysis, considering all types of modifications present in the study area. The overall score of 2,290 indicates that the river is severely modified. The presence of concrete structures such as the Pandurucan Bridge and seawall, gabions and riprap, and other bank modifications contributed to the high value of HMS. The presence of extensive modifications clearly demonstrated that the natural habitat of living organisms in the river is greatly affected [Table 5].

Table 5. Results of the habitat modification score

CATEGORIES	SPOT-CHECK	HMS SCORE	NUMBER OF OCCURRENCES	SCORE
Channel modifications	Culverts	200	6	1,200
Bank material	Concrete	40	2	80
	Gabions	40	2	80
	Riprap	40	1	40
Bank modification	Reinforced concrete	40	4	160
	Channel substrate	200	2	400
	Embankment	20	4	80
	Bridge	250	1	250
			Total Score	**2,290**

4. DISCUSSION

This study presented technical information on how to assess the habitat in the river system, taking into consideration the ecological conditions for river restoration and rehabilitation. As river management becomes a pressing issue for many water managers, the need for a substantial evaluation of the ecological system must be carried out to understand how the natural characteristics and processes in the river are affected by natural and human-induced activities.

The hydro morphological assessment conducted in the Pandurucan River considered the key physical attributes such as the riverbed, channels, riverbanks, and all other types of modifications existing in the study area that collectively influence the river flow, channel bed, and slope. The use of the RHS and the HMS, and HQA provided values derived from the field investigation and reconnaissance survey. The results revealed that the Pandurucan River demonstrated low habitat diversity and was heavily modified. The HQA of 39, 25, and 35 specifically shows the poor ecological diversity that requires attention for restoration and rehabilitation (Kiraga, 2020). Similar studies, such as Olveira et al. (2004) and Urošev et al. (2009), showed the ability of the HQA and HMS in providing valuable inputs in the conservation project and river basin management plan by evaluating the ecological conditions of the rivers.

The RHS, originally used in European countries, has gained popularity in many countries in the world. The approach provided an opportunity for this study to conduct an in-depth analysis of the ecological condition of the Pandurucan River. However, the limitations of the study were concentrated only on a 500-meter stretch of the river that might not capture the variability of the entire river such as the seasonal variation and changes in the hydraulic conductivity, substrate type and composition, and other depositional features in the riverine (Ferreira, et.al, 2001; Raven, et.al, 2009a; Raven, et.al, 2009b).

The study showed that as the degree of modification increases, HMS also increases, indicating the substantial changes in the natural anthropology of the river system. The HMS score summarizes the structural changes present in the river (Costa and Vieria, 2021) and can present the consequences of alterations on the bed and margins of the river. In general, higher HQA and lower HMS signify a healthy river system (Urošev et al., 2009; Raven et al., 1997). Therefore, the HQA and HMS indices become a powerful tool in review restoration efforts, quantifying and prioritizing interventions to improve the naturalness of the river habitat (Kiraga, 2020; Kiraga, 2014).

5. CONCLUSION

This study successfully used the River Habitat Survey in presenting the hydro morphological characteristics of the Pandurucan River. The use of the survey categories allowed a detailed assessment of the river's channel, bed, banks, substrate, flow type, land use, and the vegetation of the river system. The field investigation and ocular inspection provided substantial information to carry out the objective of the study

The HQA scores obtained in the analysis showed that the river exhibits poor diversity and has less opportunity for living organisms to thrive. While the listing of all types of modification provided an HMS score of 2, 290 described that the river is severely modified due to the extensive impacts of human activities and land development. The results of the evaluation provided essential information for the local government authorities to make sound decisions and develop a framework for river restoration and rehabilitation efforts.

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