ENVIRONMENTAL FLOW ASSESSMENT USING MULTIPLE DATA-DRIVEN NUMERICAL MODELS ON AQUATIC HABITANTS OF THE SELANGOR RIVER BASIN, MALAYSIA

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of this thesis presented to the Senate of Universiti Putra in fulfilment of the requirement of the degree of Doctor of Philosophy

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Chair : Nor Rohaizah binti Jamil, PhD
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Rivers are essential ecosystems that provide freshwater and support biodiversity, but they are under threat from human activities such as pollution, channelization, abstraction, and damming. This study aims to assess the environmental flow of the Sg. Selangor River, which is necessary for the sustainability of aquatic ecosystems. The Sg. Selangor River basin in Malaysia is a crucial water resource, supplying water to over 60% of the population in the state of Selangor and the Federal Territory of Kuala Lumpur. The mean annual rainfall ranges from 2400 – 3000 mm, with a distinct wet season during the SWM (April-May) and NEM (Oct-Dec), while dry season in Jan-Mar and June-Sept. Although the basin receives abundant rainfall, drought is still a frequently occurring phenomenon. Various types of data analysis approaches and modelling techniques were adopted in this study, where both primary and long-term historical hydrological datasets were used. The water flow data analyzed covers a length of 60 years (1960 to 2020). The study utilizes hydrological and habitat simulation methods, including the Flow Duration Curve-Environmental Management Class (FDC-EMC), Indicator Hydrologic Alteration (IHA), Water Quality Index (WQI), and hydraulic-ecological simulation using PHABSIM and SEFA models. The Water Quality Index (WQI) scores for the river is 84.3 and 85.3 for normal flow and high flow condition, respectively which indicate a clean condition in the regulated system. Meanwhile, the Flow Duration Curve-Environmental Management Class (FDC-EMC) analysis of the 60 years' historical flow data suggested Sg. Selangor River be managed under EMC class C, with min-max flow values of 3.35 - 98.09 m^3/s for optimum environmental flow requirement. The IHA analysis results that the minimum amount of flow or 99.9% exceedance flow in the pre-impact period is 0.69 m^3/s, while for the post-impact period is 6.16 m^3/s. In addition, the results suggest that the river flow is highly regulated by the dam operation, which affects the environmental flow maintenance and may not meet the required environmental flow requirements due to the constant rate of dam release. The particle size analysis reveals that the river bed is dominated by sandy gravel and sands ranging between 0.18 to 4.00 mm, and the upper section near the dam is dominated by gravel and large sands, indicating active erosive flow. The habitat suitability criteria for *Hampala macrolepidota*, a native fish species, are used to define the inputs for the hydraulic-ecological simulation. The results indicated the HSC for the species' depth preference fell within 0.7 to 1.05 m as suggested by SEFA, while an exact value of 1.14 m was suggested by PHABSIM. Likewise, the velocity preferred by the species ranged between 0.6 to 0.9 m/s or the exact value of 0.786 m/s, as suggested by SEFA and PHABSIM respectively. However, this amount differs in various sampling stations. The flows amount of 6.2 m^3/s, 14.5 m^3/s, 2.5 m^3/s, and 3.5 m^3/s are needed in stations 2 to 5, respectively. Both PHABSIM and SEFA models provide reliable estimations of environmental flow, with SEFA suggesting an interval of Environmental Flow Allocation for better management flexibility and defining acceptable objectives to all stakeholders in the Sg. Selangor River. The findings of this study could contribute to the development of sustainable river basin management plans and improve the management of water resources in the Sg. Selangor River basin.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi kepeluan untuk ijazah Doktor Falsafah

PENILAIAN ALIRAN ALAM SEKITAR MENGGUNAKAN MODEL NUMERIK BERBILANG DATA TERHADAP PENGHUNI AKUATIK LEMBANGAN SUNGAI SELANGOR, MALAYSIA

Oleh

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Sungai adalah suatu ekosistem yang penting, berfungsi untuk membekalkan bekalan air bersih serta menyokong biodiversiti. Namun, sungai mengalami ancaman daripada aktiviti manusia misalnya pencemaran, aktiviti penyaluran dan pengambilan air serta pembinaan empangan. Oleh itu, kajian ini bertujuan untuk menilai aliran persekitaran di Sungai Selangor sebagai suatu keperluan kelestarian terhadap ekosistem hidupan akuatik. Lembangan Sungai Selangor di Malaysia adalah penting untuk membekalkan sumber dan bekalan air kepada lebih daripada 60% populasi penduduk di negeri Selangor dan juga di wilayah Kuala Lumpur. Bacaan purata tahunan hujan adalah dalam rangka 2400-3000 mm dengan musim hujan yang berbeza iaitu semasa monson barat daya (April-Mei) dan monson timur laut (Okt-Dis), manakala musim kemarau pada Jan-Mac dan Jun-Sept. Walaupun lembangan sungai meneriman taburan hujan yang tinggi, musim kemarau juga merupakan fenomena yang kerap berlaku. Pelbagai jenis pendekatan analisis data dan teknik pemodelan telah diaplikasikan dalam kajian ini, di mana kedua-dua set data iaitu data primier dan set data hidrologi jangka masa Panjang telah digunakan. Data aliran air ini dianalisis untuk tempoh masa 60 tahun (1960 hingga 2020). Kajian ini memanfaatkan kaedah simulasi hidrologi dan habitat termasuk Kelas Pengurusan Keluk-Environmental Tempoh Aliran (FDC-EMC), Penunjuk Perubahan Hidrologi (IHA), Indeks Kualiti Air (WQI), dan simulasi hidraulik-ekologi menggunakan model PHABSIM dan SEFA. Skor Indeks Kualiti Air (WQI) bagi sungai ialah 84.3 dan 85.3 untuk keadaan aliran normal dan aliran tinggi untuk menunjukkan keadaan sungai bersih dalam sistem yang terkawal. Sementara itu, analisis Keluk Tempoh Aliran-Kelas Pengurusan Alam Sekitar (FDC-EMC) bagi data aliran sejarah 60 tahun menunjukkan Sungai Selangor perlu diuruskan dibawah kelas C EMC dengan nilai aliran min-maks 3.35 - 98.09 m^3/s untuk keperluan aliran persekitaran optimum. Analisis IHA mendapati jumlah aliran minimum atau aliran melebihi 99.9% dalam tempoh pra-impak ialah 0.69 m^3/s, manakala bagi tempoh pasca-impak ialah 6.16 m^3/s. Tambahan pula, keputusan menunjukkan bahawa aliran sungai dikawal oleh operasi empangan, yang menjejaskan penyelenggaraan aliran alam sekitar dan mungkin tidak memenuhi keperluan aliran alam sekitar yang diperlukan disebabkan oleh kadar pelepasan empangan yang berterusan. Analisis saiz zarah pula menunjukkan bahawa dasar sungai didominasi oleh batu kerikil berpasir dan pasir antara saiz 0.18 hingga 4.00 mm manakala di bahagian atas berhampiran empangan didominasi oleh batu kerikil dan pasir besar. Hal ini membuktikan berlaku aliran hakisan yang aktif. Kriteria kesesuaian habitat untuk Hampala macrolepidota iaitu sejenis spesies ikan asli telah digunakan sebagai input bagi simulasi hidraulik-ekologi. Keputusan menunjukkan HSC untuk kesesuaian kedalaman spesies berada dalam lingkungan 0.7 hingga 1.05 m seperti yang dicadangkan oleh SEFA, manakala nilai 1.14 m pula dicadangkan oleh PHABSIM. Selain itu, halaju yang bersesuaian oleh spesies tersebut adalah antara 0.6 hingga 0.9 m/s atau nilai tepatnya adalah 0.786 m/s, seperti yang telah dicadangkan oleh SEFA dan PHABSIM. Namun begitu, nilai ini berbeza pada setiap stesen persampelan. Nilai aliran iaitu 6.2 m^3/s, 14.5 m^3/s, 2.5 m^3/s, dan 3.5 m^3/s direkod pada stesen 2 hingga 5. Kedua-dua model PHABSIM dan SEFA telah menyediakan anggaran aliran alam sekitar yang boleh dipercayai. SEFA mencadangkan selang Peruntukan Aliran Alam Sekitar untuk pengurusan yang lebih baik dan fleksebiliti serta menentukan objektif yang boleh diterima oleh semua pihak berkepentingan di Sungai Selangor. Dapatan kajian ini boleh menyumbang kepada pembangunan pelan pengurusan lembangan sungai yang mampan dan menambah baik pengurusan sumber air di lembangan Sungai Selangor.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

E-Flow	Environmental Flow
EFA	Environmental Flow Assessment
NEM	Northeast Monsoon
SWM	Southwest Monsoon
IBWT	Inter Basin Water Transfer
UTES	Underground Thermal Energy Storage
WFD	Water Framework Directorate
GES	Good Ecological Status
GEP	Good Ecological Potential
EFA	Environmental Flow Assessment
PHABSIM	Physical Habitat Simulation Model
RHYHABSIM	River Hydraulic and Habitat Simulation Method
RHABSIM	Riverine Habitat Simulation Model
SEFA	System for Environmental Flow Analysis
IFIM	Instream Flow Incremental Methodology
BBM	Building Block Methodology
DRIFT	Downstream Response to Imposed Flow Transformation
ELOHA	Ecological Limits of Hydrologic Alteration
USFWS	United States Fish and Wildlife Service
IFG	Instream Flow Group
CAMS	Catchment Abstraction Management Strategies
RAM	Resources Assessment and Management
NSPSF	North Selangor Peat Swamp Forests
DO	Dissolved Oxygen

EC	Electrical Conductivity
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
AN	Ammoniacal Nitrogen
WQI	Water Quality Index
WQV	Water Quality Variables
DOE	Department of Environment
DID	Department of Irrigation and Drainage
SIDO	Sub Index Dissolved Oxygen
NWQI	National Water Quality Index
GEFC	Global Environmental Flow Calculator
IHA	Indicators of Hydrological Alteration
LWR	Length Weight Relationship
NWQS	National Water Quality Standard
APHA	American Public Health Association
HDPE	High Density Poly Ethylene
FDC	Flow Duration Curve
EMC	Environmental Management Class
DRM	Desktop Reserve Model
EFC	Environmental Flow Components
WSL	Water Surface Level
HSI	Habitat Suitability Index
HSC	Habitat Suitability Criteria
HSCs	Habitat Suitability Curves

WSL	Water Surface Level
WUA	Weighted Usable Area
AWS	Area Weighted Suitability
CSI	Combined Suitability Index
GAM	Generalized Additive Model
MK	Mann-Kendal
LC	Least Concern
DD	Data Deficient
MCM	Million Cubic Meters
CD	Coefficient of Dispersion
DF	Deviation Factor
GSD	Grain Size Distribution
PSD	Particle Size Distribution
CCA	Canonical Correspondence Analysis
MSL	Mean Sea Level
VDF	Velocity Distribution Factor
SZF	Stage Zero Flow
SI	Suitability Index
Sg.	Sungai
GIS	Geographical Information System
H. macrolepidota	Hampala macrolepidota
NWRP	National Water Resource Policy
NAWABS	National Water Balance System
IRBM	Integrated River Basin Management

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Freshwater is a vital resource for living beings and ecosystems that should be measured as a prerequisite for sustainable development (Kalvani et al., 2019). These resources are under increasing threat from human anthropogenic activities, both in terms of consumptive and non-consumptive use. The increasing demands for water are causing substantial flow alterations in rivers across the world. Flow alterations are directly linked to impacts on the physical and chemical properties and processes of rivers and consequent ecological changes (Linnansaari et al., 2013).

As the competing demands vary for water, most rivers in the world are used in many ways. Dams and reservoirs are constructed for several uses, such as to enable water diversion for irrigation, hydropower generation, and mitigating drought and flood disasters. The benefits may be very crucial for some stakeholders. Still, these developmental activities threaten the river's riparian ecosystems and ecological character by altering the river flow. As a result, it causes negative impacts on the livelihood of people dependent on ecosystem services. The negative implications for the affected people may relate to the loss of fisheries, health, nutrition, economic loss, and social and cultural dislocation (IUCN Vietnam, 2005).

The current and projected water demand increment have caused intensified and complex conflicts among river development as water and energy resources and their conservation as biologically diverse ecosystems (Tharme, 2003). It causes stress on river ecosystems, biodiversity and human. So, water managers and policymakers face extreme challenges in providing an affordable and reliable water supply to meet worldwide demand (Sanderson et al., 2012). Therefore, large and small dams are constructed to meet the drinking water supply, irrigation, flood control, energy generation, and other human demands (Tharme, 2003). Approximately two large dams were built daily worldwide during the second half of the 20th century. The number of these dams has risen to more than 47,000, and additional 800,000 smaller dams by the year 2000, which block the world's river flow, and the numbers are increasing (Richter & Thomas, 2007; Schmutz & Sendzimir, 2018). Besides all these benefits, dams can cause interruption to natural flow regimes that have extensive impacts, including alterations in pristine hydrological dynamics, changes in biological production, spreading of biodiversity in space and time, and changes in services and functions of aquatic ecosystems (Agostinho, et al., 2008). As a result, the continuous decline of river ecosystems and loss of biodiversity are extensive.

Government agencies and stakeholders have accepted river restoration as a vital supplement to natural resources management and conservation (Wohl et al., 2005). However, restoring the pre-damming condition of a dammed river is impossible. Nevertheless, any efforts to improve the ecological conditions are called mitigation measures (Schmutz & Sendzimir, 2018). Conservation and management of large rivers to protect aquatic ecosystems and biodiversity is a relatively new task. Along the rivers, these systems are characterized by high habitat dissimilarities and species richness, which may be distinguished by large-scale fish migrations called ecological phenomena. On the other hand, the large size of riverine ecosystems is also caused by obstructing the implementation of conservation plans. Therefore, there is a consensus in the conservation community that plans and policies should be scale-appropriated (Arthington et al., 2004).

The amount and time of freshwater flows and levels required to sustain aquatic ecosystems that can support human cultures, economies, sustainable livelihoods, and wellbeing are called environmental flow or E-Flow (FAO, 2019; Liu et al., 2016). Moreover, the term Environmental Flow is defined by The Brisbane Declaration (2007) as "*Environmental flow describes the quantity, quality and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems"* (Brisbane Declaration, 2007). This definition spans the twin responsibilities of management, to balance the use and the protection of the water resource, i.e. it seeks to provide the flows that will protect ecosystems and the human use of those ecosystems. All water in excess of the Environmental Flow is the utilizable or "allocable" water that resource managers can allocate and divert to agricultural, industrial and domestic activities (FAO, 2019). Water has an economic value and should be exploited for the benefit of people, their subsistence and economic welfare. The environmental flow (e-flow) concept is at the core of many countries' water management strategies for the river system. Investigation of e-flow requirements for rivers of some countries is essential because of diminished flows and the creation of dry beds in many rivers in dry seasons. Knowledge of e-flow is necessary for understanding any river restoration and resuscitation task. E-flow is the water needed in a watercourse to maintain healthy ecosystems (Akter, 2010). Since rivers are the most important parts of the Environment, thus with the degradation of the Environment, rivers and their flow which are called Environmental flows, are also get affected. The ecological processes that are related to river flow and other features are providing goods, such as; the production of food and fiber, water purification, and other marketable goods; and services such as; flood mitigation and recreational activities (Arthington et al., 2004; Dyson et al., 2008).

The same concept was targeted by an older term called "instream flow", but nowadays, scientists prefer to use "environmental flow", as it covers a broader view of what should be assessed. Historical instream flow is mainly concerned with the physical environment of limited species. However, environmental flow assessment is a process trying to implement the Brisbane declaration into specific estimates of environmental water needed for ecosystem and human well-being. It will decide; whether to conserve an amount of water in the flow for environmental uses, if yes, how much, and when; whether the negative impacts of an existing project on a stream or flow can be mitigated or not by releasing the environmental flows or restricting water withdrawals; how can the existing water projects be modified to improve the environmental conditions, whether to construct a new water project or not, if so, how? (Williams et al., 2019).

Despite the positive environmental impacts such as green energy production, groundwater recharge, and many more of large dams, it has been amongst the most drastic issue that threatens natural flow regimes and dependent ecosystems (Jayasiri et al., 2017; King & Brown, 2018). Moreover, environmental flow is essential for sharing benefits, poverty reduction, and sustainable development, but water allocation for environmental uses is still challenging. Construction and investment in water resources infrastructures such as dams and reservoirs for water storage, irrigation, flood control and others are vital for economic growth. However, their improper plan, design, and operation can impact the volume, pattern, and flow quality, which can degrade the downstream ecosystems and communities. At the same time, aquatic life depends on the quality and quantity of the flowing water. Any changes in the flow may result in significant changes in ecosystem processes and services. Therefore, all stakeholders need to grab their attention to downstream impacts to achieve sustainable development (Hirji & Davis, 2009). It is also projected that climate change can affect the supply and demand of water resources, which can also impact the water for the environment. For example, the estuarine processes which depend on freshwater environmental flow will be affected by the saltwater intrusion due to sea-level rise. In some countries, climate change adaptation relies on building dams and reservoirs to secure against increased variability of rainfall and runoff. However, it will further increase the risk of adverse impacts in the downstream ecosystems unless the impacts are properly assessed and managed (Hirji & Davis, 2009).

In such a situation, ecosystems lying downstream will be under the threat of losing their functions. Therefore, releasing a sufficient amount of flow is vital to the downstream to maintain ecosystem sustainability (Jayasiri et al., 2017), and it is of most importance to assess the environmental flow of a river to ensure the sustainability of downstream communities, ecosystems, and fish life in the river. There are more than 200 methods for assessing the environmental flow of a river (O'Keefe & Tom, 2009). The most beneficial methods are grouped into four categories: hydrological, hydraulic rating, habitat simulation, and holistic methodologies (Tharme, 2003).

1.2 Problem Statement

Humans' life without rivers is not possible. Humans rely strongly on rivers from their inhabitants on the earth's surface, as the rivers provide them with drink, food, and sites for settlement. In addition, humans have relied on rivers for cleaning, waste removal and decomposition, transportation, commerce, and recreation (Karr & Chu, 2000). The global concerns over the need for sustainable water management have increased due to the rapid water change and food insecurity over the last two decades. Rapid population growth, economic development, climate change, and other causes are among the main drivers of water availability and use alteration. They result in the risk of extreme high and low flows, flow regimes and water quality alteration, and surpassing water demands from the renewable water supply (Pahl-wostl et al., 2013).

The natural flow regimes of the river are heavily modified and altered by damming as 50,000 large dams, and an estimated 80,000 smaller dams have been built during the last century, generating low flows and grabbing the high flood pulses. In addition, the increasing demand for irrigation, hydropower generation, and the growing population's domestic and industrial use leads to reduced river discharge. Furthermore, climate change also contributes to the changes in flow regimes, as the decrease is seen in many rivers worldwide (Dutta et al., 2017). One of the most significant environmental challenge of the 21st century is having enough water for human usage without compromising the related ecosystems. Compared to the year 2000, the agriculture sector will need 70% more water by 2050 so that enough food will be provided for a population of more than 9 Billion (Pastor et al., 2014).

During the last three decades, the very rapid development of Malaysia is leading to many folds' increase in urbanization in major cities. Along with this, industrialization and agricultural expansion have also rapidly turned land use of primary forests into cash crops and industrial, commercial, and urban centers. As a result of these developments, the river systems are stressed and reached the carrying capacity of water supply, and become vulnerable to water stress and droughts. The concentration of pollutants, due to the agricultural, industrial, commercial, and transportation activities, has reached their limits, especially during the low flow conditions, and many rivers have become polluted, some of which are not rehabilitable (Chan et al., 2003). The significant changes to the hydrological and hydraulic characteristics of catchments are due to the urban areas' paved areas. Therefore, flash floods' frequency is increasing yearly (Hasan et al., 2019). On the other hand, rapid flow and disturbance of hydrological characteristics also lead to droughts and water deficit that causes freshwater shortages in many parts of the country (Huang et al., 2016).

1.3 Research Objectives

The main objective of this study is to assess the flow released from the Sg. Selangor dam and its relationship with the relevant aquatic ecosystems downstream of the Sg. Selangor dam, and recommend an amount of flow that is necessary for the sustainability of the targeted fish species which is *Hampala macrolepidota*. To accomplish this goal, the following specific objectives have been fulfilled:

1. To assess the environmental flow requirements of Sg. Selangor River for physical habitat based on the hydrological index methods.

2. To estimate the physical habitat preference and water quality condition for targeted fish species in different flow regimes setting.

3. To determine the optimum environmental flow and physical habitat preference of the target fish species in the Sg. Selangor River based on the physical habitat simulation method.

1.4 Research Questions

During the study, the following specific questions aroused from the above problem statement and following the research objectives will be answered:

1. What amount of flow is needed in the Selangor River for river sustainability?

2. What is the habitat preference and water quality requirement for targeted fish species?

3. What is the amount of optimum flow to sustain the downstream ecosystems and ensure the growth of targeted fish species?

1.5 Scope and Limitation of Study

The study aims to investigate the amount of environmental flow that needs to be released from the Sg. Selangor dam to conserve and sustain the downstream aquatic ecosystems. The study has focused on evaluating the high and low flows of the Sg. Selangor river under certain flow variations in different seasons downstream of the Sg. Selangor dam. Furthermore, this study integrates hydrological and habitat simulation methods and results from various modelling software such as; GEFC, IHA, PHABSIM, and SEFA to recommend the optimum e-flow through various aspects. For this purpose, the historical hydrological data and the data collected from Seven sampling stations during normal and high flows condition are used. Thus, this study will provide valuable insights into the impacts of Sg. Selangor dam on the streamflow and its targeted fish species, which can help in the re-operation of the dam to sustain the downstream aquatic ecosystems.

The limitation of this study is missing a fieldwork and sampling in low flow conditions. As the initial plan for the sampling and fieldwork was designed for all three flow conditions, but unfortunately due to the COVID-19 situations and movement control orders, we were not able to implement our initial plan of three fieldworks. The rainfall data analyzed for the climatic conditions of the river basin is only for 15 years which is relevant to post impact period and there is no long-term and complete set of data available from any station in the study area, however it is not affecting the findings of this study. Moreover, the fish data analyzed in this study is minimal which creates issues in plotting habitat suitability curves, therefore, it is recommended for other studies to conduct fish sampling in all flow conditions.

1.6 Significance of Study

Flow regime alteration, water extraction, and water infrastructures have resulted in the decline of the riverine and wetland habitats and the loss of freshwater biodiversity that has led to the field of environmental flow (Arthington et al., 2018). The emerging field of environmental flow has many achievements as a protection approach to rehabilitate ecosystem services, ecological integrity, and aquatic biodiversity by managing freshwater flow regimes (Arthington, 2020; Arthington et al., 2018). Environmental flow assessment is essential in understanding the significant impacts of reservoirs and dams on aquatic biota and ecosystems by determining the rivers' flow regime. The significant impacts of reservoirs and dams on flow regimes can be concluded as a decrease in high flow magnitude and an increase in low flow magnitudes through time. In addition, the frequency of high flow and low flow variability can also be reduced; however, their duration will be increased (Zhang et al., 2015).

One of the proposed approaches to mitigate the adverse environmental impacts of dams is the reoperation of the dam while controlling the magnitude and timing of flow releases for environmental conservation. For achieving this goal, environmental flow is among the proposed approaches. The restoration of crucial ecosystem processes needed for aquatic biodiversity can be achieved by mimicking natural flow dynamics by controlling the timing, quality, and quantity of water released from the dam. However, on the other hand, the allocation of water for environmental uses is a highly disputed process around the world (Hirji & Davis, 2009), especially in developing countries (Tegos et al., 2009). Moreover, the rapid expansion of dam construction around the world is closely followed by the research progress of e-flow, which aims to ensure the minimum flow for critical habitats below the large dams for at least a single species (Hao et al., 2021). As a result, many methods have been established to study e-flows. The hydrological and habitat simulation methodologies are adopted for this study. It assesses environmental flow based on a detailed analysis of quantity and suitability of instream physical habitat, primarily targeted fish species (Tegos et al., 2017).

REFERENCES

Abdullah, F. (2012). Ecology of Fishes in Tasek Bera, Pahang, Malaysia. University of Malaya.

Abidin, A. Z. (1986). The reproductive biology of a tropical cyprinid, Hampala macrolepidota (Van Hasselt), from Zoo Negara Lake, Kuala Lumpur, Malaysia. Journal of Fish Biology, 29(3), 381–391. https://doi.org/10.1111/j.1095-8649.1986.tb04954.x

Abowei, J. F. N. (2010). Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. Advance Journal of Food Science and Technology, 2(1), 36–40.

Abrahão, R., Carvalho, M., Da Silva, W. R., Machado, T. T. V., Gadelha, C. L. M., & Hernandez, M. I. M. (2007). Use of index analysis to evaluate the water quality of a stream receiving industrial effluents. Water SA, 33(4), 459–465. https://doi.org/10.4314/wsa.v33i4.52940

Acreman, M. (2016). Environmental flows—basics for novices. Wiley Interdisciplinary Reviews: Water, 3(5), 622–628. https://doi.org/10.1002/wat2.1160

Acreman, M., & Dunbar, M. J. (2004). Defining environmental river flow requirements - A review. Hydrology and Earth System Sciences, 8(5), 861–876. https://doi.org/10.5194/hess-8-861-2004

Agostinho, A. A., Pelicice, F. M., & Gomes, L. C. (2008). Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. Brazilian Journal of Biology, 68(4), 1119–1132.

Ahmad, A. K., Mohd Sham, O., Shukor, M. N., Awenk, E.-R., & Shuhaimi-Othman, O. (2011). Ecological Factors Affecting Fish Diversity and Density in Sungkai Wildlife Reserve, Perak, Malaysia. The Zoologist, 9(January 2011), 78–84.

Aini, N. (2016). Physical Habitat Assessment for Dominant Freshwater Fish Species in Galas River Basin, Kelantan, Malaysia. Universiti Putra Malaysia.

Akter, J. (2010). Environmental flow assessment for the ganges river. Dhaka: Department of Water Resources Engineering, Bangladesh University of Engineering and Technology.

Ali, R. O., & Abubaker, S. R. (2019). Trend analysis using mann-kendall, sen's slope estimator test and innovative trend analysis method in Yangtze river basin, China: review. International Journal of Engineering &Technology, 8(2), 110–119. https://doi.org/10.14419/ijet.v7i4.29591

Alsalahi, M. A., Latif, M. T., Ali, M. M., Magam, S. M., Wahid, N. B. A., Khan, M. F., & Suratman, S. (2014). Distribution of surfactants along the estuarine area of Selangor River, Malaysia. Marine Pollution Bulletin, 80(1–2), 344–350. https://doi.org/10.1016/j.marpolbul.2013.12.019

Amponsah-Dacosta, F., & Mathada, H. (2017). Study of Sand Mining and Related Environmental Problems along the Nzhelele River in Limpopo Province of South Africa. Mine Water and Circular Economy. Mine Water and Circular Economy, 1259–1266.

Ardura, A., Planes, S., & Garcia-Vazquez, E. (2011). Beyond biodiversity: Fish metagenomes. PLoS ONE, 6(8). https://doi.org/10.1371/journal.pone.0022592

Arévalo-Mejía, R., Leblois, E., Salinas-Tapia, H., Mastachi-Loza, C. A., Bâ, K. M., & Díaz-Delgado, C. (2020). A baseline assessment of hydrologic alteration degree for the Mexican catchments at gauged rivers (2016). Science of the Total Environment, 729(4). https://doi.org/10.1016/j.scitotenv.2020.139041

Arias-González, J. E., Acosta-González, G., Membrillo, N., Garza-Pérez, J. R., & Castro-Pérez, J. M. (2012). Predicting spatially explicit coral reef fish abundance, richness and Shannon-Weaver index from habitat characteristics. Biodiversity and Conservation, 21(1), 115–130. https://doi.org/10.1007/s10531-011-0169-y

Arthington, A. H., King, J. M., O’Keeffe, J. H., Bunn, S. E., Day, J. A., Pusey, B. J., Bluhdorn, D. R., & Tharme, R. (1992). Development of an holistic approach for assessing environmental flow requirements of riverine ecosystems. Proceedings of an International Seminar and Workshop on Water Allocation for the Environment, 69(January), 76. The Centre for Water Policy Research, University of New England: Armidale. P. 69-76.

Arthington, A. H. (2020). Environmental Flows: History of Assessment Methods, Ecosystem Frameworks and Global Uptake. Treatise on Geomorphology, 1277–1295. https://doi.org/10.1016/b978-0-12-409548-9.12450-9

Arthington, A. H., Bhaduri, A., Bunn, S. E., Jackson, S. E., Tharme, R. E., Tickner, D., Young, B., Acreman, M., Baker, N., Capon, S., Horne, A. C., Kendy, E., McClain, M. E., Poff, N. L., Richter, B. D., & Ward, S. (2018). The Brisbane Declaration and Global Action Agenda on Environmental Flows (2018). Frontiers in Environmental Science, 6(JUL), 1–15. https://doi.org/10.3389/fenvs.2018.00045

Arthington, A. H., Naiman, R. J., McClain, M. E., & Nilsson, C. (2010). Preserving the biodiversity and ecological services of rivers: New challenges and research opportunities. Freshwater Biology, 55(1), 1–16. https://doi.org/10.1111/j.1365-2427.2009.02340.x

Arthington, A. H., Rall, J. L., Kennard, M. J., & Pusey, B. J. (2003). Environmental flow requirements of fish in Lesotho Rivers using the drift methodology. River Research and Applications, 19(5–6), 641–666. https://doi.org/10.1002/rra.728

Arthington, A. H., Tharme, R. E., Brizga, S. O., Pusey, B. J., & Kennard, M. J. (2004). Environmental flow assessment with emphasis on holistic methodologies. Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, 2(February 2016), 37–65. https://doi.org/10.1002/rra.728

Asabonga, M., Cecilia, B., Mpundu, M. C., & Vincent, N. M. D. (2016). The physical and environmental impacts of sand mining. Transactions of the Royal Society of South Africa, 72(1), 1–5. https://doi.org/10.1080/0035919X.2016.1209701

Azmai, M. N. A., Ghani, I. F. A., Lokman, M. I. N., Halim, M. R. A., Ahmad, A., Zakaria, Z. A., Zain, K. M., Ahmad, M. F., Naser, M. A. M., & Ismail, A. (2020). Fishes of North Selangor Peat Swamp Forest.

Azmon, E. (1961). Field method for sieve analysis of sand. Journal of Sedimentary Research, 31(4), 631–633.

Bašić, T., Britton, J. R., Rice, S. P., & G. Pledger, A. (2017). Impacts of gravel jetting on the composition of fish spawning substrates: Implications for river restoration and fisheries management. Ecological Engineering, 107, 71–81. https://doi.org/10.1016/j.ecoleng.2017.06.057

Ballinger, A., & Lake, P. S. (2006). Energy and nutrient fluxes from rivers and streams into terrestrial food webs. Marine and Freshwater Research, 57(1), 15-28.

Beisel, J. N., & Moreteau, J. C. (1997). A simple formula for calculating the lower limit of Shannon's diversity index. Ecological Modelling, 99(2–3), 289–292. https://doi.org/10.1016/S0304-3800(97)01954-6

Benyahya, L., Caissie, D., St-Hilaire, A., Ouarda, T. B. M. J., & Bobée, B. (2007). A Review of Statistical Water Temperature Models. Canadian Water Resources Journal, 32(3), 179–192. https://doi.org/10.4296/cwrj3203179

Bernhardt, E. S., Palmer, M. A., Allan, J. D., Alexander, G., Barnas, K., Brooks, S., … Sudduth, E. (2005). Synthesizing U.S. River Restoration Efforts. Policy Forum, 308(April), 636–638.

Best, J. (2019). Anthropogenic stresses on the world's big rivers. Nature Geoscience, 12(1), 7–21. https://doi.org/10.1038/s41561-018-0262-x

Beuselinck, L., Govers, G., Poesen, J., Degraer, G., & Froyen, L. (1998). Grain-size analysis by laser diffractometry: Comparison with the sieve-pipette method. Catena, 32(3–4), 193–208. https://doi.org/10.1016/S0341-8162(98)00051-4

Bibi, F., & Ali, Z. (2013). Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. Journal of Animal and Plant Sciences, 23(2), 469–474.

Bilotta, G. S., & Brazier, R. E. (2008). Understanding the influence of suspended solids on water quality and aquatic biota. Water Research, 42(12), 2849–2861. https://doi.org/10.1016/j.watres.2008.03.018

Blott, S. J., & Pye, K. (2001). Gradistat: A grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surface Processes and Landforms, 26(11), 1237–1248. https://doi.org/10.1002/esp.261

Bond, N. R., Grigg, N., Roberts, J., McGinness, H., Nielsen, D., O'Brien, M., Overton, I., Pollino, C., Reid, J. R. W., & Stratford, D. (2018). Assessment of environmental flow scenarios using state-and-transition models. Freshwater Biology, 63(8), 804–816. https://doi.org/10.1111/fwb.13060

Booker, D. J., & Dunbar, M. J. (2004). Application of physical habitat simulation (PHABSIM) modelling to modified urban river channels. River Research and Applications, 20(2), 167–183. https://doi.org/10.1002/rra.742

Bovee, K. D., Lamb, B. L., Bartholow, J. M., Stalnaker, C. B., Taylor, J., & Henriksen, J. (1998). Stream habitat analysis using the instream flow incremental methodology. In USGS/BRD-Information and Technology Report (1st ed.). Fort Colins: U.S. Geological Survey.

Boyles, W. (1997). Chemical oxygen demand. Technical Information Series, Booklet,(9), 24.

Brandt, S. A. (2000). Classification of geomorphological effects downstream of dams. Catena, 40(4), 375–401. https://doi.org/10.1016/S0341-8162(00)00093-X

Brisbane Declaration. (2007). The Brisbane Declaration. 10th International River Symposium and International Environmental Flows Conference, 3-6 Sept. 2007, 1–7.

Brizga, S. O., Arthington, A. H., Choy, S. C., Kennard, M. J., Mackay, S. J., Pusey, B. J., & Werren, G. L. (2002). Benchmarking, a 'top-down'methodology for assessing environmental flows in Australian rivers. Proceedings of the International Conference on Environmental Flows for River Systems, Southern Waters, University of Cape Town, South Africa, 53(9), 1689–1699.

Brookes, A., & Gregory, K. J. (1983). An Assessment of River Channelization in England and Wales. The Science of the Total Environment, 27, 97–111.

Brosse, S., Beauchard, O., Blanchet, S., Dürr, H. H., Grenouillet, G., Hugueny, B., Lauzeral, C., Leprieur, F., Tedesco, P. A., Villeger, S., & Oberdorff, T. (2013). Fish-SPRICH: A database of freshwater fish species richness throughout the World. Hydrobiologia, 700(1), 343–349. https://doi.org/10.1007/s10750-012-1242-6

Brown, C., Pemberton, C., Birkhead, A., Bok, A., Boucher, C., Dollar, E., Harding, W., Kamish, W., King, J., Paxton, B., & Ractliffe, S. (2006). In support of water-resource planning - Highlighting key management issues using DRIFT: A case study. Water SA, 32(2), 181–191. https://doi.org/10.4314/wsa.v32i2.5258

Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. (1970). A water quality index-do we dare. Water and Sewage Works, 117(10).

Bunn, S. E., & Arthington, A. H. (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management, 30(4), 492–507. https://doi.org/10.1007/s00267-002-2737-0

Bunn, S., Kennard, M., & Jackson, S. (2019). Environmental Water Management in the Indo-Pacific: An Australian Perspective. Canberra: Australian Water Partnership.

Camara, M., Jamil, N. R. B., & Abdullah, F. B. (2020b). Variations of water quality in the monitoring network of a tropical river. Global Journal of Environmental Science and Management, 6(1), 85–96. https://doi.org/10.22034/gjesm.2020.01.07

Camara, M., Jamil, N. R., Abdullah, A. F. Bin, Hashim, R. binti, & Aliyu, A. G. (2020a). Economic and efficiency based optimisation of water quality monitoring network for land use impact assessment. Science of the Total Environment, 737(5). https://doi.org/10.1016/j.scitotenv.2020.139800

Carriquiry, J. D., Sánchez, A., & Camacho-Ibar, V. F. (2001). Sedimentation in the northern Gulf of California after cessation of the Colorado River discharge. Sedimentary Geology, 144(1–2), 37–62. https://doi.org/10.1016/S0037-0738(01)00134-8

Chan, N. W., Abdullah, A. L., Ibrahim, A. L., & Ghazali, S. (2003). River pollution and restoration towards sustainable water resources management. Society, Space and Environment in a Globalized World: Challenges and Prospects, (July 2015), 208–219.

Chang, H. H. (2008). River Morphology and River Channel Changes. Transactions of Tianjin University, 15(1), 254–262. https://doi.org/10.1007/s12209-008-0045-3

Cheetham, M. D., Keene, A. F., Bush, R. T., Sullivan, L. A., & Erskine, W. D. (2008). A comparison of grain-size analysis methods for sand-dominated fluvial sediments. Sedimentology, 55(6), 1905–1913. https://doi.org/10.1111/j.1365-3091.2008.00972.x

Chen, X., Yan, Y., Fu, R., Dou, X., & Zhang, E. (2008). Sediment transport from the Yangtze River, China, into the sea over the Post-Three Gorge Dam Period: A discussion. Quaternary International, 186(1), 55–64. https://doi.org/10.1016/j.quaint.2007.10.003

Chicharo, L., Müller, F., & Fohrer, N. (2015). Ecosystem services and river basin ecohydrology. In Ecosystem Services and River Basin Ecohydrology (1st ed.). https://doi.org/10.1007/978-94-017-9846-4

Claessens, L., Hopkinson, C., Rastetter, E., & Vallino, J. (2006). Effect of historical changes in land use and climate on the water budget of an urbanizing watershed. Water Resources Research, 42(3), 1–13. https://doi.org/10.1029/2005WR004131

Clergue, B., Amiaud, B., Pervanchon, F., Lasserre-Joulin, F., & Plantureux, S. (2005). Biodiversity: Function and Assessment in Agricultural Areas: A Review. Agronomy for Sustainable Development, 23(2005), 407–418. https://doi.org/10.1051/agro

Corbacho, C., & Sánchez, J. M. (2001). Patterns of species richness and introduced species in native freshwater fish faunas of a mediterranean-type basin: The Guadiana river (Southwest Iberian Peninsula). River Research and Applications, 17(6), 699–707. https://doi.org/10.1002/rrr.631

Cox, B. A. (2003). A review of currently available in-stream water-quality models and their applicability for simulating dissolved oxygen in lowland rivers. The Science of the Total Environment, 314–316(03), 335–377. https://doi.org/10.1016/S0048-9697(03)00063-9

Davies, B. R., Thoms, M., & Meador, M. (1992). An assessment of the ecological impacts of inter-basin water transfers, and their threats to river basin integrity and conservation. Aquatic Conservation: Marine and Freshwater Ecosystems, 2(February), 325–349.

Debels, P., Figueroa, R., Urrutia, R., Barra, R., & Niell, X. (2005). Evaluation of water quality in the Chillán River (Central Chile) using physicochemical parameters and a modified Water Quality Index. Environmental Monitoring and Assessment, 110(1–3), 301–322. https://doi.org/10.1007/s10661-005-8064-1

Demeke, A., & Tassew, A. (2016). A review on water quality and its impact on Fish health. International Journal of Fauna and Biological Studies, 3(1), 21–31.

Department of Environment & Science. (2018). Background information on water quality measurements using in situ water quality instruments 1 Purpose and scope. Retrieved from https://environment.des.qld.gov.au/__data/assets/pdf_file/0028/90793/physical-and-chemical-assesssment-background-information-on-water-quality-measurements-using-in-situ-water-quality-instruments.pdf

Devesa-Rey, R., Díaz-Fierros, F., & Barral, M. T. (2010). Trace metals in river bed sediments: An assessment of their partitioning and bioavailability by using multivariate exploratory analysis. Journal of Environmental Management, 91(12), 2471–2477. https://doi.org/10.1016/j.jenvman.2010.06.024

Devi, P. A., Padmavathy, P., Aanand, S., & Aruljothi, K. (2017). Review on water quality parameters in freshwater cage fish culture. International Journal of Applied Research, 3(5), 114–120. Retrieved from https://www.researchgate.net/publication/316874865

DeWeber, J. T., & Wagner, T. (2014). A regional neural network ensemble for predicting mean daily river water temperature. Journal of Hydrology, 517(May), 187–200. https://doi.org/10.1016/j.jhydrol.2014.05.035

Di Stefano, C., Ferro, V., & Mirabile, S. (2010). Comparison between grain-size analyses using laser diffraction and sedimentation methods. Biosystems Engineering, 106(2), 205–215. https://doi.org/10.1016/j.biosystemseng.2010.03.013

DID. (2009). Study on the River Water Quality Trends and Indexes in Peninsular Malaysia. Kuala Lumpur.

DOE. (2010). Malaysia Environmental Quality Report 2010. In Malaysia Environmental Quality Report.

Dogan, E., Ates, A., Yilmaz, E. C., & Eren, B. (2008). Application of Artificial Neural Networks to Estimate Wastewater Treatment Plant Inlet Biochemical Oxygen Demand. 27(7), 439–446. https://doi.org/10.1002/ep

Dubey, A., Singh, O., Shekhar, S., & Pohshna, C. (2019). Assessment of Environmental Flow Requirement using Environmental Management Classes-Flow Duration Curve for Narmada River. International Journal of Current Microbiology and Applied Sciences, 8(01), 891–897. https://doi.org/10.20546/ijcmas.2019.801.096

Dudgeon, D. (2000). The Ecology of Tropical Asian Rivers And Streams in Relation to Biodiversity Conservation. Annual Reviews Ecological Systems, 31, 239–263.

Duncan, E., Kleinman, P. J., & Sharpley, A. N. (2012). Eutrophication of Lakes and Rivers. ELS. John Wiley & Sons, Ltd: Chichester, (February), 1–8. https://doi.org/10.1002/9780470015902.a0003249.pub2

Dutta, V., Sharma, U., & Kumar, R. (2017). Assessment of river ecosystems and environmental flows: Role of flow regimes and physical habitat variables. Climate Change and Environmental Sustainability, 5(1), 20–34. https://doi.org/10.5958/2320-642x.2017.00002.3

Dyson, M., Bergkamp, G., & Scanlon, J. (2008). Flow - The essentials of environmental flows. In IUCN, Gland, Switzerland. Gland, Switzerland.

Ekka, A., Pande, S., Jiang, Y., & Zaag, P. van der. (2020). Anthropogenic modifications and river ecosystem services: A landscape perspective. Water (Switzerland), 12(10), 1–21. https://doi.org/10.3390/w12102706

Elosegi, A., Díez, J., & Mutz, M. (2010). Effects of hydromorphological integrity on biodiversity and functioning of river ecosystems. Hydrobiologia, 657(1), 199–215. https://doi.org/10.1007/s10750-009-0083-4

Elvira, B., & Almodóvar, A. (2001). Freshwater fish introductions in Spain: Facts and figures at the beginning of the 21st century. Journal of Fish Biology, 59(SUPPL. A), 323–331. https://doi.org/10.1006/jfbi.2001.1753

FAO. (2019). Incorporating environmental flows into “water stress” indicator 6.4.2 - Guidelines for a minimum standard method for global reporting. Retrieved from https://www.unwater.org/publications/incorporating-environmental-flows-into-water-stress-indicator-6-4-2/

Farahani, H., & Bayazidi, S. (2018). Modeling the assessment of socio-economical and environmental impacts of sand mining on local communities: A case study of Villages Tatao River Bank in North-western part of Iran. Resources Policy, 55(November 2017), 87–95. https://doi.org/10.1016/j.resourpol.2017.11.001

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., Helkowski, J. H., Holloway, T., Howard, E. A., Kucharik, C. J., Monfreda, C., Patz, J. A., Prentice, I. C., Ramankutty, N., & Snyder, P. K. (2005). Global consequences of land use. Science, 309(5734), 570–574. https://doi.org/10.1126/science.1111772

Fulazzaky, M. A., Seong, T. W., & Masirin, M. I. M. (2010). Assessment of water quality status for the selangor river in Malaysia. Water, Air, and Soil Pollution, 205(1–4), 63–77. https://doi.org/10.1007/s11270-009-0056-2

Gamito, S. (2010). Caution is needed when applying Margalef diversity index. Ecological Indicators, 10(2), 550–551. https://doi.org/10.1016/j.ecolind.2009.07.006

Gavriletea, M. D. (2017). Environmental impacts of sand exploitation. Analysis of sand market. Sustainability (Switzerland), 9(7). https://doi.org/10.3390/su9071118

Gazzaz, N. M., Yusoff, M. K., Aris, A. Z., Juahir, H., & Ramli, M. F. (2012). Artificial neural network modeling of the water quality index for Kinta River (Malaysia) using water quality variables as predictors. Marine Pollution Bulletin, 64(11), 2409–2420. https://doi.org/10.1016/j.marpolbul.2012.08.005

Gazzaz, N. M., Yusoff, M. K., Ramli, M. F., Aris, A. Z., & Juahir, H. (2012). Characterization of spatial patterns in river water quality using chemometric pattern recognition techniques. Marine Pollution Bulletin, 64(4), 688–698. https://doi.org/10.1016/j.marpolbul.2012.01.032

Ghani, A. A., Ali, R., Zakaria, N. A., Hasan, Z. A., Chang, C. K., & Ahamad, M. S. S. (2010). A temporal change study of the Muda River system over 22 years. International Journal of River Basin Management, 8(1), 25–37. https://doi.org/10.1080/15715121003715040

Gleeson, T., & Richter, B. (2018). How much groundwater can we pump and protect environmental flows through time? Presumptive standards for conjunctive management of aquifers and rivers. River Research and Applications, 34(1), 83–92. https://doi.org/10.1002/rra.3185

Grant, E. H. C., Lynch, H. J., Muneepeerakul, R., Arunachalam, M., Rodriguez-Iturbe, I., & Fagan, W. F. (2012). Interbasin Water Transfer, Riverine Connectivity, and Spatial Controls on Fish Biodiversity. PLoS ONE, 7(3), 1–7.

Grantham, T. E., Viers, J. H., & Moyle, P. B. (2014). Systematic screening of dams for environmental flow assessment and implementation. BioScience, 64(11), 1006–1018. https://doi.org/10.1093/biosci/biu159

Griffiths, D., Mcgonigle, C., & Quinn, R. (2014). Climate and species richness patterns of freshwater fish in North America and Europe. Journal of Biogeography, 41(3), 452–463. https://doi.org/10.1111/jbi.12216

Guan, L., Tong, Y., Li, J., Wu, S., & Li, D. (2019). An online surface water COD measurement method based on multi-source spectral feature-level fusion. RSC Advances, 9(March), 11296–11304. https://doi.org/10.1039/C8RA10089F

Gupta, A. Das. (2008). Implication of environmental flows in river basin management. Physics and Chemistry of the Earth, 33(5), 298–303. https://doi.org/10.1016/j.pce.2008.02.004

Gupta, Neha, Yadav, K. K., Kumar, V., & Singh, D. (2013). Assessment of physicochemical properties of Yamuna River in Agra City. International Journal of ChemTech Research, 5(1), 528–531.

Gupta, Nidhi, Pandey, P., & Hussain, J. (2017). Effect of physicochemical and biological parameters on the quality of river water of Narmada, Madhya Pradesh, India. Water Science, 31(1), 11–23. https://doi.org/10.1016/j.wsj.2017.03.002

Hach, C. C., Klein Jr, R. L., & Gibbs, C. R. (1997). Biochemical Oxygen Demand. Tech. Monogr, 7.

Haghighi, A. T., Marttila, H., & Kløve, B. (2014). Development of a new index to assess river regime impacts after dam construction. Global and Planetary Change, 122, 186–196. https://doi.org/10.1016/j.gloplacha.2014.08.019

Hanna, D. E., Tomscha, S. A., Ouellet Dallaire, C., & Bennett, E. M. (2018). A review of riverine ecosystem service quantification: Research gaps and recommendations. Journal of Applied Ecology, 55(3), 1299-1311. DOI: 10.1111/1365-2664.13045

Hammer, O. (2001). PAleontological STatistics version 4.06. In Technology (Vol. 1).

Hao, Z., Rallings, A. M., Espinoza, V., Luo, P., Duan, W., Peng, Q., Gao, Y., & Viers, J. H. (2021). Flowing from East to West: A bibliometric analysis of recent advances in environmental flow science in China. Ecological Indicators, 125(January), 107358. https://doi.org/10.1016/j.ecolind.2021.107358

Haroon, M., & Unnisa, S. A. (2016). Performance and Evaluation of Sewage Treatment Plant Based on UASB. World Journal of Environmental Biosciences, 5(1), 1–9.

Hasan, H. H. Bin. (2017). Environmental Flow Assessment of High Gradient River System Using Integrated Habitat Simulation Method. Universiti Putra Malaysia.

Hasan, H. H., Razali, S. F. M., Zaki, A. Z. I. A., & Hamzah, F. M. (2019). Integrated hydrological-hydraulic model for flood simulation in tropical urban catchment. Sustainability (Switzerland), 11(23), 1–24. https://doi.org/10.3390/su11236700

Hashim, R., Azlan, M. R. P., Mohd Zainuddin, W. M. A., Jusoh, S. A., & Md Sah, A. S. R. (2015). Fish Distribution and Composition of Kelantan River Systems, Kelantan, Malaysia. Applied Mechanics and Materials, 747, 294–297. https://doi.org/10.4028/www.scientific.net/amm.747.294

Hashim, Z. H., Zainuddin, R. Y., & Mansor, M. (2012). Fish Checklist of Perak River , Malaysia. 8(3), 408–413.

Hayes, D. S., Brändle, J. M., Seliger, C., Zeiringer, B., Ferreira, T., & Schmutz, S. (2018). Advancing towards functional environmental flows for temperate floodplain rivers. Science of the Total Environment, 633, 1089–1104. https://doi.org/10.1016/j.scitotenv.2018.03.221

Hezri, A. A., & Hasan, M. N. (2006). Towards sustainable development? The evolution of environmental policy in Malaysia. Natural Resources Forum, 30(1), 37–50. https://doi.org/10.1111/j.1477-8947.2006.00156.x

Hirji, R., & Davis, R. (2009). Environmental Flows in Water Resources Policies, Plans, and Projects: Findings and Recommendations. In Environmental Flows in Water Resources Policies, Plans, and Projects. https://doi.org/10.1596/978-0-8213-7940-0

Hong, D., & Hong, K. A. (2016). Drought Identification, Monitoring and Forcasting for Selangor River Basin. International Journal of U- and e- Service, Science and Technology, 9(3), 53–66. https://doi.org/10.14257/ijunesst.2016.9.3.07

Hong, J. L., & Hong, K. A. (2016). Flow Forecasting For Selangor River Using Artificial Neural Network Models to Improve Reservoir Operation Efficiency. International Journal of Hybrid Information Technology, 9(7), 89–106. https://doi.org/10.14257/ijhit.2016.9.7.10

Horton, R. K. (1965). An index number system for rating water quality. J Water Pollut Control Fed, 37(3), 300–306.

Hossain, M. A., Mir, S. I., & Nasly, M. A. (2013). Water Quality Index: an Indicator of Surface Water Pollution in Eastern part of Peninsular Malaysia. Research Journal of Recent Sciences, 2(10), 10–17.

Huang, Y. F., Ang, J. T., Tiong, Y. J., Mirzaei, M., & Amin, M. Z. M. (2016). Drought Forecasting using SPI and EDI under RCP-8.5 Climate Change Scenarios for Langat River Basin, Malaysia. Procedia Engineering, 154, 710–717. https://doi.org/10.1016/j.proeng.2016.07.573

Im, D., Choi, S. U., & Choi, B. (2018). Physical habitat simulation for a fish community using the ANFIS method. Ecological Informatics, 43(September), 73–83. https://doi.org/10.1016/j.ecoinf.2017.09.001

Ismail, N. (2014). Issues and Problems towards the Sustainable Dam Management System in Malaysia. International Journal of Innovation, Management and Technology, 5(6). https://doi.org/10.7763/ijimt.2014.v5.549

IUCN Vietnam. (2005). Environmental Flows: Rapid Environmental Flow Assessment for the Huong River Basin, Central Vietnam. In IUCN Vietnam, Hanoi, Vietnam.

Jain, S. K. (2012). Assessment of environmental flow requirements. Hydrological Processes, 26(22), 3472–3476. https://doi.org/10.1002/hyp.9455

Jamil, N. R., Ibrahim, Z. Z., Hairan M. H., Kardani, N. F., Ibrahim A., Samad, N. M., Redzuan, N. H., Nazir N., & Shamsuri, S., (2022). A Systematic Review of Environmental Flow Assessment Strategies at NAWABS Study Area (NAWABS Development Phase 1). Water Resources Publication Series (No. 25), Kuala Lumpur: Department of Irrigation and Drainage Malaysia.

Jayasiri, M. J. G. C. N., Dayawansa, N. D. K., & Gunawardena, E. R. N. (2017). Assessment of Environmental Flow Release from Deduru Oya Reservoir to Mitigate Possible Impacts on Downstream Ecosystem. Tropical Agricultural Research, 28(3), 298–311. https://doi.org/10.4038/tar.v28i3.8233

Jindal, R., & Sharma, C. (2011). Studies on water quality of Sutlej River around Ludhiana with reference to physicochemical parameters. Environmental

Monitoring and Assessment, 174(1–4), 417–425. https://doi.org/10.1007/s10661-010-1466-8

Jingan, S., Jiupai, N. I., Chaofu, W., & Deti, X. (2005). Land use change and its corresponding ecological responses: a review. Journal of Geographical Sciences, 15(3), 305. https://doi.org/10.1360/gs050305

Johnson, M. F., Thorne, C. R., Castro, J. M., Kondolf, G. M., Mazzacano, C. S., Rood, S. B., & Westbrook, C. (2020). Biomic river restoration: A new focus for river management. River Research and Applications, 36(1), 3–12. https://doi.org/10.1002/rra.3529

Jouanneau, S., Recoules, L., Durand, M. J., Boukabache, A., Picot, V., Primault, Y., Lakel, A., Sengelin, M., Barillon, B., & Thouand, G. (2014). Methods for assessing biochemical oxygen demand (BOD): A review. Water Research, 49(November), 62–82. https://doi.org/http://dx.doi.org/10.1016/j.watres.2013.10.066

Jowett, I., Payne, T. R., & Milhous, R. T. (2019). SEFA: System for Environmental Flow Analysis. Retrieved from http://sefa.co.nz/

Juan, A., Gori, A., & Sebastian, A. (2020). Comparing floodplain evolution in channelized and unchannelized urban watersheds in Houston, Texas. Journal of Flood Risk Management, 13(2), 1–19. https://doi.org/10.1111/jfr3.12604

Jung, S. H., & Choi, S.-U. (2015). Prediction of composite suitability index for physical habitat simulations using the ANFIS method. Applied Soft Computing Journal, 34(May), 502–512. https://doi.org/10.1016/j.asoc.2015.05.028

Käiro, K., Haldna, M., Timm, H., & Virro, T. (2017). The effect of channelization on the biological quality of lowland streams using macroinvertebrates as proxies. Hydrobiologia, 794(1), 167–177. https://doi.org/10.1007/s10750-017-3091-9

Kalvani, S. R., Sharaai, A. H., Manaf, L. A., & Hamidian, A. (2019). Assessing ground and surface water scarcity indices using ground and surface water footprints in the Tehran Province of Iran. Applied Ecology and Environmental Research, 17(2), 4985–4997. https://doi.org/10.15666/aeer/1702

Karakoyun, Y., Dönmez, A. H., & Yumurtacı, Z. (2018). Comparison of environmental flow assessment methods with a case study on a runoff river–type hydropower plant using hydrological methods. Environmental Monitoring and Assessment, 190(12), 722.

Karr, J. R., & Chu, E. W. (2000). Sustaining living rivers. Hydrobiologia, 422–423, 1–14. https://doi.org/10.1023/a:1017097611303

Kayaalp, N., Ersahin, M. E., Ozgun, H., Koyuncu, I., & Cumali, K. (2010). A new approach for chemical oxygen demand (COD) measurement at high salinity and low organic matter samples. Environmental Science and Pollution Research, 17(May), 1547–1552. https://doi.org/10.1007/s11356-010-0341-z

Kemp, P., Sear, D., Collins, A., Naden, P., & Jones, I. (2011). The impacts of fine sediment on riverine fish. Hydrological Processes, 25(11), 1800–1821. https://doi.org/10.1002/hyp.7940

Khalil, B., Ouarda, T. B. M. J., & St-Hilaire, A. (2011). Estimation of water quality characteristics at ungauged sites using artificial neural networks and canonical correlation analysis. Journal of Hydrology, 405(3–4), 277–287. https://doi.org/10.1016/j.jhydrol.2011.05.024

Kim, B. R., Shin, J., Guevarra, R. B., Lee, J. H., Kim, D. W., Seol, K. H., Lee, J. H., Kim, H. B., & Isaacson, R. E. (2017). Deciphering diversity indices for a better understanding of microbial communities. Journal of Microbiology and Biotechnology, 27(12), 2089–2093. https://doi.org/10.4014/jmb.1709.09027

King, J., Brown, C., & Sabet, H. (2003). A scenario-based holistic approach to environmental flow assessments for rivers. River Research and Applications, 19(5-6), 619–639. https://doi.org/10.1002/rra.709

King, J. M., & Brown, C. (2018). Environmental flow assessments are not realizing their potential as an aid to basin planning. Frontiers in Environmental Science, 6(OCT), 113. https://doi.org/10.3389/fenvs.2018.00113

Kondolf, G. M. (2006). River restoration and meanders. Ecology and Society, 11(2). https://doi.org/10.5751/ES-01795-110242

Kuriqi, A., Pinheiro, A. N., Sordo-Ward, A., & Garrote, L. (2019). Flow regime aspects in determining environmental flows and maximising energy production at run-of-river hydropower plants. Applied Energy, 256(October). https://doi.org/10.1016/j.apenergy.2019.113980

Kusin, F. M., Muhammad, S. N., Zahar, M. S. M., & Madzin, Z. (2016). Integrated River Basin Management: incorporating the use of abandoned mining pool and implication on water quality status. Desalination and Water Treatment, 57(60), 29126–29136. https://doi.org/10.1080/19443994.2016.1168132

Kuusisto, E. (1996). Chapter 12 - Hydrological Measurements. In J. Bartram & R. Ballance (Eds.), Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes (1st ed.). London: E&FN Spon, an imprint of Chapman & Hall, 2–6 Boundary Row, London SE1 8HN, UK.

Larned, S. T., Datry, T., Arscott, D. B., & Tockner, K. (2010). Emerging concepts in temporary-river ecology. Freshwater Biology, 55(4), 717–738. https://doi.org/10.1111/j.1365-2427.2009.02322.x

Latrubesse, E. M., Arima, E., Ferreira, M. E., Nogueira, S. H., Wittmann, F., Dias, M. S., Dagosta, F. C. P., & Bayer, M. (2019). Fostering water resource governance and conservation in the Brazilian Cerrado biome. Conservation Science and Practice, 1(5), 1–8. https://doi.org/10.1111/csp2.77

Lee, A. H., & Nikraz, H. (2015). BOD: COD Ration as an Indicator for River Pollution. International Proceedings of Chemical, Biological and Environmental Engineering, 88(1), 12–16. https://doi.org/10.7763/IPCBEE

Lehner, B., Liermann, C. R., Revenga, C., Vörömsmarty, C., Fekete, B., Crouzet, P., Doll, P., Endejan, M., Frenken, K., Magome, J., Nilsson, C., Robertson, J. C., Rodel, R., Sindorf, N., & Wisser, D. (2011). High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. Frontiers in Ecology and the Environment, 9(9), 494–502. https://doi.org/10.1890/100125

Leong, K. H., Tan, L. L. B., & Mustafa, A. M. (2007). Contamination levels of selected organochlorine and organophosphate pesticides in the Selangor River , Malaysia between 2002 and 2003. Chemosphere, 66(October), 1153–1159. https://doi.org/10.1016/j.chemosphere.2006.06.009

Lessard, J. L., & Hayes, D. B. (2003). Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. River Research and Applications, 19(7), 721–732. https://doi.org/10.1002/rra.713

Leuven, R. S. E. W., Hendriks, A. J., Huijbregts, M. A. J., Lenders, H. J. R., Matthews, J., & Velde, G. V. D. (2011). Differences in sensitivity of native and exotic fish species to changes in river temperature. Current Zoology, 57(6), 852-862.

Li, D., Xu, X., Li, Z., Wang, T., & Wang, C. (2020). Detection methods of ammonia nitrogen in water: A review. Trends in Analytical Chemistry, 127(April), 1–16. https://doi.org/10.1016/j.trac.2020.115890

Li, X., Zhang, K., Gu, P., Feng, H., Yin, Y., Chen, W., & Cheng, B. (2021). Changes in precipitation extremes in the Yangtze River Basin during 1960 – 2019 and the association with global warming , ENSO , and local effects. Science of the Total Environment, 760(144244). https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.144244

Lin, Y. P., Hong, N. M., Wu, P. J., Wu, C. F., & Verburg, P. H. (2007). Impacts of land use change scenarios on hydrology and land use patterns in the Wu-Tu watershed in Northern Taiwan. Landscape and Urban Planning, 80(August), 111–126. https://doi.org/10.1016/j.landurbplan.2006.06.007

Linnansaari, T., Monk, W. A., Baird, D. J., & Curry, R. A. Review of approaches and methods to assess Environmental Flows across Canada and internationally., VII Canadian Science Advisory Secretariat 75 (2013).

Liu, J., Liu, Q., & Yang, H. (2016). Assessing water scarcity by simultaneously considering environmental flow requirements, water quantity, and water quality. Ecological Indicators, 60, 434–441. https://doi.org/http://dx.doi.org/10.1016/j.ecolind.2015.07.019

Lorenz, C. M., Dijk, G. M. Van, Hattum, A. G. M. Van, & Cofino, W. P. (1997). Concepts in river ecology: Implications for indicator development. Regulated Rivers: Research and Management, 13(6), 501–516. https://doi.org/10.1002/(sici)1099-1646(199711/12)13:6<501::aid-rrr479>3.0.co;2-1

Lv, Y., Jiang, Y., Hu, W., Cao, M., & Mao, Y. (2020). A review of the effects of tunnel excavation on the hydrology, ecology, and environment in karst areas: Current status, challenges, and perspectives. Journal of Hydrology, 586(March). https://doi.org/10.1016/j.jhydrol.2020.124891

Maddock, I. (1999). The importance of physical habitat assessment for evaluating river health. Freshwater Biology, 41(2), 373–391. https://doi.org/10.1046/j.1365-2427.1999.00437.x

Makmur, S., Arfiati, D., Bintoro, G., Ekawati, A. W., & Subagdja, S. (2019). Gill net selectivity, length at first capture and length at first gonad maturity on Hampala macrolepidota (Kuhl & Van Hasselt, 1823) in Ranau Lake, Indonesia. IOP Conference Series: Earth and Environmental Science, 348(1). https://doi.org/10.1088/1755-1315/348/1/012006

Marschke, M., Rousseau, J.-F., Beckwith, L., & Arragon, L. Van. (2021). Displaced Sand, Displaced People: Examining the Livelihood Impacts of Sand Mining in Cambodia. Paris.

Martin, D. M., Labadie, J. W., & Poff, N. L. (2015). Incorporating social preferences into the ecological limits of hydrologic alteration (ELOHA): A case study in the Yampa-White River basin, Colorado. Freshwater Biology, 60(9), 1890–1900. https://doi.org/10.1111/fwb.12619

McCleskey, R. B., Kirk Nordstrom, D., & Ryan, J. N. (2011). Electrical conductivity method for natural waters. Applied Geochemistry, 26(SUPPL.), 227–229. https://doi.org/10.1016/j.apgeochem.2011.03.110

McCleskey, R. B., Nordstrom, D. K., Ryan, J. N., & Ball, J. W. (2012). A new method of calculating electrical conductivity with applications to natural waters. Geochimica et Cosmochimica Acta, 77, 369–382. https://doi.org/10.1016/j.gca.2011.10.031

Meador, M. R. (1992). Inter-basin Water Transfer : Ecological Concerns Inter-basin Water Transfer : Ecological Concerns. Fisheries, 17(2), 37–41.

https://doi.org/http://dx.doi.org/10.1577/1548-8446(1992)017<0017:IWTEC>2.0.CO;2

Mezger, G., De Stefano, L., & Tánago, M. G. del. (2019). Assessing the Establishment and Implementation of Environmental Flows in Spain. Environmental Management, 64(6), 721–735. https://doi.org/10.1007/s00267-019-01222-2

Mielach, C., Schinegger, R., Schmutz, S., Galie, A., Isfan, F., Tanase, I., Bopa, B., Gasparetto, D., Saccardo, I., Cesca, M., Rechberger, A., Talker, H., Santl, S., Conaric, N., & Smolar, N. Z. (2012). Comparative Analysis of Methodologies for the Implementation of Environmental Flows according to the WFD. In Preserving Water Bodies Ecosystems.

Mohsin, A. K. M., Jee, A. K., & Hoklai, H. (1977). A list of freshwater fishes of Selangor. Malaysian Applied Biology, 6(1), 75–78.

Mohtar, W. H. M. W., Bassa, S. A., & Porhemmat, M. (2017). Grain size analysis of surface fluvial sediments in rivers in Kelantan, Malaysia. Sains Malaysiana, 46(5), 685–693. https://doi.org/10.17576/jsm-2017-4605-02

Morris, E. K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., Meiners, T., Muller, C., Obermaier, E., Prati, D., Socher, S. A., Sonnemann, I., Waschke, N., Wubet, T., Wurst, S., & Rillig, M. C. (2014). Choosing and using diversity indices: Insights for ecological applications from the German Biodiversity Exploratories. Ecology and Evolution, 4(18), 3514–3524. https://doi.org/10.1002/ece3.1155

Morrison, G., Fatoki, O. S., Persson, L., & Ekberg, A. (2001). Assessment of the impact of point source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma River - pH, electrical conductivity, oxygen- demanding substance (COD) and nutrients. Water SA, 27(4), 475–480. https://doi.org/10.4314/wsa.v27i4.4960

Mouillot, D., & Leprêtre, A. (1999). A comparison of species diversity estimators. Researches on Population Ecology, 41(2), 203–215. https://doi.org/10.1007/s101440050024

Mrozińska, N., Glińska-Lewczuk, K., Burandt, P., Kobus, S., Gotkiewicz, W., Szymańska, M., Bakowska, M., & Obolewski, K. (2018). Water quality as an indicator of stream restoration effects-A case study of the Kwacza River restoration project. Water (Switzerland), 10(9), 1–19. https://doi.org/10.3390/w10091249

Muñoz-Mas, R., Papadaki, C., Martínez-Capel, F., Zogaris, S., Ntoanidis, L., & Dimitriou, E. (2016). Generalized additive and fuzzy models in environmental flow assessment: A comparison employing the West Balkan trout (Salmo farioides; Karaman, 1938). Ecological Engineering, 91(March), 365–377. https://doi.org/10.1016/j.ecoleng.2016.03.009

Murchie, K. J., Hair, K. P. E., Pullen, C. E., Redpath, T. D., Stephens, H. R., & Cooke, S. J. (2008). Fish Response to Modified Flow Regimes in Regulated Rivers: Research Methods, Effects and Opportunities. River Research and Applications, 24(January), 197–217. https://doi.org/10.1002/rra

Nikghalb, S., Shokoohi, A., Singh, V. P., & Yu, R. (2016). Ecological Regime versus Minimum Environmental Flow: Comparison of Results for a River in a Semi Mediterranean Region. Water Resources Management, 30(9), 4969–4984. https://doi.org/10.1007/s11269-016-1488-2

Nilsson, C., & Berggren, K. (2000). Alterations of riparian ecosystems caused by river regulation. BioScience, 50(9), 783–792. https://doi.org/10.1641/0006-3568(2000)050[0783:AORECB]2.0.CO;2

Norris, R. H., & Thoms, M. C. (1999). What is river health? Freshwater Biology, 41(2), 197–209. https://doi.org/10.1046/j.1365-2427.1999.00425.x

Nurandani, H., Winardi, N. D., & Vito, E. S. B. (2020). Analysis of The Impact of Industrial Activities Towards River Vacancy Viewed from BODS , CODS , and TSS Using The QUAL2KW Software Method Approach (Case Study : Klampok River , Semarang District). E3S Web of Conferences, 04008. https://doi.org/https://doi.org/10.1051/e3sconf/202020204008

Nurhidayu, S., Azhar, M., & Shafuan, F. H. M. (2015). Long-term sediment pattern of the Selangor river basin, Malaysia impacted by land-use and climate changes. River Basin Decision Support System, Malaysia, (June), 1–5. The Hague, the Netherlands: IAHR World Congress.

O'Keefe, J., & Tom, L. Q. (2009). Keeping rivers alive. In WWF (Vol. 613). Retrieved from http://www.india-seminar.com/2010/613/613_nachiket_&_jagdish.htm

Pahl-wostl, C., Palmer, M., & Richards, K. (2013). Enhancing water security for the benefits of humans and nature — the role of governance. Current Opinion in Environmental Sustainability, 5, 676–684.

Palmer, M. A., Bernhardt, E. S., Allan, J. D., Lake, P. S., Alexander, G., Brooks, S., Carr, J., Clayton, S., Dahm, C. N., Shah, J. F., Galat, D. L., Loss, S. G., Goodwin, P., Hart, D. D., Hassett, B., Jenkinson, R., Kondolf, G. M., Lave, R., Meyer, J. L., O'Donnell, T. K., Pagano, L., & Sudduth, E. (2005). Standards for ecologically successful river restoration. Journal of Applied Ecology, 42(2), 208–217. https://doi.org/10.1111/j.1365-2664.2005.01004.x

Palmer, M., & Ruhi, A. (2019). Linkages between flow regime, biota, and ecosystem processes: Implications for river restoration. Science, 365(6459). https://doi.org/10.1126/science.aaw2087

Palmer, Margaret A., Lettenmaier, D. P., Poff, N. L., Postel, S. L., Richter, B., & Warner, R. (2009). Climate change and river ecosystems: Protection and adaptation options. Environmental Management, 44(6), 1053–1068. https://doi.org/10.1007/s00267-009-9329-1

Pan, B., Yuan, J., Zhang, X., Wang, Z., Chen, J., Lu, J., Yang, W., Li, Z., Zhao, N., & Xu, M. (2016). A review of ecological restoration techniques in fluvial rivers. International Journal of Sediment Research, 31(2), 110–119. https://doi.org/10.1016/j.ijsrc.2016.03.001

Pastor, A. V., Ludwig, F., Biemans, H., Hoff, H., & Kabat, P. (2014). Accounting for environmental flow requirements in global water assessments. Hydrology and Earth System Sciences, 18(12), 5041–5059. https://doi.org/10.5194/hess-18-5041-2014

Patil, P. N., Sawant, D. V., & Deshmukh, R. N. (2012). Physico-chemical parameters for testing of water, a review paper. International Journal of Environmental Sciences, 3(3), 1194–1207.

Payne, T. R., & Jowett, I. G. (2013). SEFA-Computer software system for environmental flow analysis based on the instream flow incremental methodology. 32. Retrieved from http://sefa.co.nz/documents/sefa_overview.pdf

Pinto, R., Patrício, J., Baeta, A., Fath, B. D., Neto, J. M., & Marques, J. C. (2009). Review and evaluation of estuarine biotic indices to assess benthic condition. Ecological Indicators, 9(1), 1–25. https://doi.org/10.1016/j.ecolind.2008.01.005

Pitlick, J., Mueller, E. R., Segura, C., Cress, R., & Torizzo, M. (2007). Relation between flow, surface-layer armoring and sediment transport in gravel-bed rivers. Earth Surface Processes and Landforms, 33(October), 192–209. https://doi.org/10.1002/esp.1607

Poff, N. L. R., Tharme, R. E., & Arthington, A. H. (2017). Evolution of Environmental Flows Assessment Science, Principles, and Methodologies. In A. C. Horne, J. A. Webb, M. J. Stewardson, B. Richter, & M. Acreman (Eds.), Water for the Environment: From Policy and Science to Implementation and Management (pp. 203–236). https://doi.org/10.1016/B978-0-12-803907-6.00011-5

Poff, N. L., Richter, B. D., Arthington, A. H., Bunn, S. E., Naiman, R. J., Kendy, E., Acreman, M., Apse, C., Bledsoe, B. P., Freeman, M. C., Henriksen, J., Jacobson, R. B., Kennen, J. G., Merritt, D. M., O'Keeffe, J. H., Olden, J. D., Rogers, K., Tharme, R. E., & Warner, A. (2010). The ecological limits of hydrologic alteration (ELOHA): A new framework for developing regional environmental flow standards. Freshwater Biology, 55(1), 147–170. https://doi.org/10.1111/j.1365-2427.2009.02204.x

Praskievicz, S., & Luo, C. (2020). Assessment of flow–ecology relationships for environmental flow standards: a synthesis focused on the southeast USA.

Hydrological Sciences Journal, 65(4), 571–582. https://doi.org/10.1080/02626667.2020.1714051

Prowse, T. D., & Culp, J. M. (2003). Ice breakup: A neglected factor in river ecology. Canadian Journal of Civil Engineering, 30(1), 128–144. https://doi.org/10.1139/l02-040

Puckridge, J. T., Sheldon, F., Walker, K. F., & Boulton, A. J. (1998). Flow variablility and the ecology of large rivers. Marine Freshwater Resource, 49, 55–72. https://doi.org/10.1071/MF94161

Rameshkumar, S., Radhakrishnan, K., Aanand, S., & Rajaram, R. (2019). Influence of physicochemical water quality on aquatic macrophyte diversity in seasonal wetlands. Applied Water Science, 9(1), 1–8. https://doi.org/10.1007/s13201-018-0888-2

Rawat, M., Dookia, S., & Sivaperuman, C. (2015). Aquatic Ecosystem: Biodiversity, Ecology and Conservation (1st ed.). https://doi.org/10.1007/978-81-322-2178-4

Rhoads, B. L. (2020). The Vertical Dimension of Rivers: Longitudinal Profiles, Profile Adjustments, and Step-Pool Morphology. In B. L. Rhoads (Ed.), River Dynamics: Geomorphology to Support Management (pp. 294–318). https://doi.org/DOI: 10.1017/9781108164108.013

Rice, S., & Church, M. (1998). Grain size along two gravel-bed rivers: Statistical variation, spatial pattern and sedimentary links. Earth Surface Processes and Landforms, 23(4), 345–363. https://doi.org/10.1002/(SICI)1096-9837(199804)23:4<345::AID-ESP850>3.0.CO;2-B

Richter, B.D., Baumgartner, J. V., Jennifer, P., & Braun, D. P. (1996). A method for assessing hydrologic alteration within ecosystems | Un metro para evaluar alteraciones hidrologicas dentro de ecosistemas. Conservation Biology, 10(4), 1163–1174. https://doi.org/10.1046/j.1523-1739.1996.10041163.x

Richter, B., Baumgartner, J., Wigington, R., & Braun, D. (1997). How much water does a river need? Freshwater biology, 37(1), 231-249.

Richter, Brian D., Baumgartner, J. V., Braun, D. P., & Powell, J. (1998). A spatial assessment of hydrologic alteration within a river network. River Research and Applications, 14(4), 329–340. https://doi.org/10.1002/(sici)1099-1646(199807/08)14:4<329::aid-rrr505>3.0.co;2-e

Richter, Brian D., & Thomas, G. A. (2007). Restoring environmental flows by modifying dam operations. Ecology and Society, 12(1). https://doi.org/10.5751/ES-02014-120112

Rossi, L., Krejci, V., Rauch, W., Kreikenbaum, S., Fankhauser, R., & Gujer, W. (2005). Stochastic modeling of total suspended solids (TSS) in urban areas during rain events. Water Research, 39(17), 4188–4196. https://doi.org/10.1016/j.watres.2005.07.041

Rožić, M., Cerjan-Stefanović, Š., Kurajica, S., Vančina, V., & Hodžić, E. (2000). Ammoniacal nitrogen removal from water by treatment with clays and zeolites. Water Research, 34(14), 3675–3681. https://doi.org/10.1016/S0043-1354(00)00113-5

Ruesink, J. L. (2005). Global Analysis of Factors Affecting the Outcome of Freshwater Fish Introductions. Conservation Biology, 19(1), 56–65. https://doi.org/10.1111/j.1523-1739.2005.00289.x

Rügner, H., Schwientek, M., Beckingham, B., Kuch, B., & Grathwohl, P. (2013). Turbidity as a proxy for total suspended solids (TSS) and particle facilitated pollutant transport in catchments. Environmental Earth Sciences, 69(2), 373–380. https://doi.org/10.1007/s12665-013-2307-1

Rukmana, D., Salman, D., Alimuddin, I., & Arsyad. (2020). Economic and environmental impacts of sand mining activities at sadang river Pinrang Regency, South Sulawesi. IOP Conference Series: Earth and Environmental Science, 575(1). https://doi.org/10.1088/1755-1315/575/1/012043

Saimy, I. S., & Yusof, N. A. M. (2013). The Need for Better Water Policy and Governance in Malaysia. Procedia - Social and Behavioral Sciences, 81, 371–375. https://doi.org/10.1016/j.sbspro.2013.06.445

Salas, F., Marcos, C., Neto, J. M., Patrício, J., Pérez-Ruzafa, A., & Marques, J. C. (2006). User-friendly guide for using benthic ecological indicators in coastal and marine quality assessment. Ocean and Coastal Management, 49(5–6), 308–331. https://doi.org/10.1016/j.ocecoaman.2006.03.001

Sanderson, J. S., Rowan, N., Wilding, T., Bledsoe, B. P., Miller, W. J., & Poff, N. L. (2012). Getting to Scale with Environmental Flow Assessment: The Watershed Flow Evaluation Tool. River Research and Applications, 28(June), 1369–1377. https://doi.org/10.1002/rra.1542

Sarkar, A., & Pandey, P. (2015). River Water Quality Modelling Using Artificial Neural Network Technique. Aquatic Procedia, 4(Icwrcoe), 1070–1077. https://doi.org/10.1016/j.aqpro.2015.02.135

Scarf, F. (1995). River Discharge Measurement by Current Meter. Hydrological Procedure No. 15. Drainage and Irrigation Department. Ministry of Agriculture, Malaysia. Edition 2.

Schmutz, S., & Sendzimir, J. (2018). Riverine Ecosystem Management. In J. Huisman (Ed.), Springer Open. https://doi.org/10.1007/978-3-319-73250-3

Seyam, M., & Othman, F. (2014). Long-term variation analysis of a tropical river's annual streamflow regime over a 50-year period. Theoretical and Applied Climatology, 121(July), 71–85. https://doi.org/10.1007/s00704-014-1225-9

Sharma, U. (2019). Effective framework for Environmental-flows estimation for data deficient Indian rivers. Journal of Applied and Natural Science, 11(2), 545–555. https://doi.org/10.31018/jans.v11i2.2116

Sincero, A. P., & Sincero, G. A. (2003). Physical – Chemical Treatment of Water and Wastewater Physical – Chemical Treatment of Water. In CRC Press New York (1st ed.). New York: IWA Publishing.

Smakhtin, V., & Anputhas, M. (2006). An Assessment of Environmental Flow Requirements of Indian River Basins. In International Water Management Institute (Vol. 107). Colombo.

Smakhtin, V. U., & Eriyagama, N. (2008). Developing a software package for global desktop assessment of environmental flows. Environmental Modelling and Software, 23(12), 1396–1406. https://doi.org/10.1016/j.envsoft.2008.04.002

Soukhaphon, A., Baird, I. G., & Hogan, Z. S. (2021). The impacts of hydropower dams in the Mekong River Basin: A review. Water, 13(3), 265. https://doi.org/10.3390/w13030265

Soulivongsa, L., Tengjaroenkul, B., Patawang, I., & Neeratanaphan, L. (2021). Cytogenetic, Serum Liver Enzymes and Liver Cell Pathology of the Hampala barb Fish (Hampala macrolepidota) Affected by Toxic Elements in the Contaminated Nam Kok River near the Sepon Gold–Copper ine, Lao PDR. International Journal of Environmental Research and Public Health, 18(11). https://doi.org/10.3390/ijerph18115854

Spence, R., & Hickley, P. (2000). The use of PHABSIM in the management of water resources and fisheries in England and Wales. Ecological Engineering, 16(1), 153–158. https://doi.org/10.1016/S0925-8574(00)00099-9

Stonestrom, D. A., Scanlon, B. R., & Zhang, L. (2009). Introduction to special section on impacts of land use change on water resources. Water Resources Research, 45(7), 1–3. https://doi.org/10.1029/2009WR007937

Strayer, D. L., Beighley, R. E., Thompson, L. C., Brooks, S., Nilsson, C., Pinay, G., & Naiman, R. J. (2003). Effects of land cover on stream ecosystems: Roles of empirical models and scaling issues. Ecosystems, 6(5), 407–423. https://doi.org/10.1007/s10021-002-0170-0

Su, G., Logez, M., Xu, J., Tao, S., Villéger, S., & Brosse, S. (2021). Human impacts on global freshwater fish biodiversity. Science, 371(6531), 835–838. https://doi.org/10.1126/science.abd3369

Sun, Q., Miao, C., Duan, Q., Ashouri, H., Sorooshian, S., & Hsu, K. L. (2018). A Review of Global Precipitation Data Sets: Data Sources, Estimation, and Intercomparisons. Reviews of Geophysics, 56(1), 79–107. https://doi.org/10.1002/2017RG000574

Supriatna, J. (2018). Biodiversity Indexes: Value and Evaluation Purposes. E3S Web of Conferences, 48, 1–4. https://doi.org/10.1051/e3sconf/20184801001

Suryaningsih, S., Sukmaningrum, S., Amurwanto, A., & Rofiqoh, A. A. (2021). Reproductive characters of hampala fish (hampala macrolepidota kuhl & Van Hasselt, 1823), correlation with body length. IOP Conference Series: Earth and Environmental Science, 819(1). https://doi.org/10.1088/1755-1315/819/1/012013

Sutton, R., & Morris, C. (2004). Instream Flow Assessment Big Timber Creek , Idaho. Colorado.

Switzer, A. D., & Pile, J. (2015). Grain Size Analaysis. In I. Shennan, A. J. Long, & B. P. Horton (Eds.), Handbook of Sea Level Research (1st ed., pp. 331–346). West Sussex: John Wiley & Sons Ltd.

Szarek-Gwiazda, E., Ciszewski, D., & Kownacki, A. (2023). The Effects of Channelization with Low In-Stream Barriers on Macroinvertebrate Communities of Mountain Rivers. Water, 15(6), 1059. https://doi.org/10.3390/w15061059

Tao, H., Bobaker, A. M., Ramal, M. M., Yaseen, Z. M., Hossain, M. S., & Shahid, S. (2019). Determination of biochemical oxygen demand and dissolved oxygen for semi-arid river environment: application of soft computing models. Environmental Science and Pollution Research, 26(1), 923–937. https://doi.org/10.1007/s11356-018-3663-x

Tare, V., Gurjar, S. K., Mohanta, H., Kapoor, V., Modi, A., Mathur, R. P., & Sinha, R. (2017). Eco-geomorphological approach for environmental flows assessment in monsoon-driven highland rivers: A case study of Upper Ganga, India. Journal of Hydrology: Regional Studies, 13(July), 110–121. https://doi.org/10.1016/j.ejrh.2017.07.005

Tedesco, P. A., Beauchard, O., Bigorne, R., Blanchet, S., Buisson, L., Conti, L., Cornu, J. F., Dias, M. S., Grenouillet, G., Hugueny, B., Jezequel, C., Leprieur, F., Brosse, S., & Oberdorff, T. (2017). Data Descriptor: A global database on freshwater fish species occurrence in drainage basins. Scientific Data, 4(October), 1–6. https://doi.org/10.1038/sdata.2017.141

Tegos, A., Schlüter, W., Gibbons, N., Katselis, Y., & Efstratiadis, A. (2018). Assessment of Environmental Flows from complexity to parsimony-lessons from Lesotho. Water (Switzerland), 10(10), 1–17. https://doi.org/10.3390/w10101293

Tegos, M., Nalbantis, I., & Tegos, A. (2017). Environmental flow assessment through integrated approaches. European Water, 60, 167–173.

Tegos, Miltiades, Nalbantis, I., & Tegos, A. (2017). Environmental flow assessment through integrated approaches. European Water, 60, 167–173.

Tharme, R. E. (2003). A global perspective on environmental flow assessment: Emerging trends in the development and application of environmental flow methodologies for rivers. River Research and Applications, 19(5–6), 397–441. https://doi.org/10.1002/rra.736

The Nature Conservancy. (2009). Indicators of Hydrologic Alteration (IHA) User's Manual Version 7.1. In The Nature Conservancy.

Thompson, G. G., & Withers, P. C. (2003). Effect of species richness and relative abundance on the shape of the species accumulation curve. Austral Ecology, 28(4), 355–360. https://doi.org/10.1046/j.1442-9993.2003.01294.x

Tikadar, K. K., Kunda, M., & Mazumder, S. K. (2021). Diversity of fishery resources and catch efficiency of fishing gears in Gorai River, Bangladesh. Heliyon, 7(12). https://doi.org/10.1016/j.heliyon.2021.e08478

Timpe, K., & Kaplan, D. (2017). The changing hydrology of a dammed Amazon. Science Advances, 3(11), 1–14. https://doi.org/10.1126/sciadv.1700611

Ting, W. H. T., Tan, I. A. W., Salleh, S. F., & Wahab, N. A. (2018). Application of water hyacinth (Eichhornia crassipes) for phytoremediation of ammoniacal nitrogen: A review. Journal of Water Process Engineering, 22(October 2017), 239–249. https://doi.org/10.1016/j.jwpe.2018.02.011

USEPA. (2020). Conductivity. Retrieved October 15, 2020, from United States Environmental Protection Agency website: https://archive.epa.gov/water/archive/web/html/vms59.html#:~:text=Conductivity is measured in micromhos,50 to 1500 µmhos%2Fcm

Van Vliet, M. T. H., Franssen, W. H. P., Yearsley, J. R., Ludwig, F., Haddeland, I., Lettenmaier, D. P., & Kabat, P. (2013). Global river discharge and water temperature under climate change. Global Environmental Change, 23(2), 450–464. https://doi.org/10.1016/j.gloenvcha.2012.11.002

Verma, A., Wei, X., & Kusiak, A. (2013). Predicting the total suspended solids in wastewater: A data-mining approach. Engineering Applications of Artificial Intelligence, 26(4), 1366–1372. https://doi.org/10.1016/j.engappai.2012.08.015

Waddle, T. (2001). PHABSIM for Windows User's Manual and Exercises. In US Geological Survey (Vol. 01–340). https://doi.org/https://doi.org/10.3133/ofr2001340

Wang, Y., Wang, D., Lewis, Q. W., Wu, J., & Huang, F. (2017). A framework to assess the cumulative impacts of dams on hydrological regime: A case study of the Yangtze River. Hydrological Processes, 31(17), 3045–3055. https://doi.org/10.1002/hyp.11239

Ward, J. V., & Stanford, J. A. (1995). Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers:

Research & Management, 11(1), 105–119. https://doi.org/10.1002/rrr.3450110109

Warsa, A., Tjahjo, D. W. H., & Astuti, I. P. (2019). Monofilament Gillnet Selectivity for Hampala Barb (Hampala macrolepidota) Management at Ir. H. Djuanda Reservoir-West Java. Omni-Akuatika, 15(1), 66–74.

Warwick, C. (2012). “Sustainable” water abstraction: Catchment abstraction management strategies in England and Wales. Water Policy, 14(4), 647–667. https://doi.org/10.2166/wp.2011.116

Weber-Scannell, P. K., & Duffy, L. K. (2007). Effects of total dissolved solids on aquatic organisms: A review of literature and recommendation for salmonid species. American Journal of Environmental Sciences, 3(1), 1–6. https://doi.org/10.3844/ajessp.2007.1.6

Weng, T. K., & Mokhtar, M. Bin. (2009). An appropriate institutional framework towards integrated water resources management in Pahang River Basin, Malaysia. European Journal of Scientific Research, 27(4), 536–547.

Wetzel, R. G. (2001). Limnology, Third Edition (2001) (Third). London: Academic Press.

Williams, J. G., Moyle, P. B., Webb, J. A., & Kondolf, G. M. (2019). Environmental Flow Assessment Methods and Applications. In Willey Blackwell (1st ed., Vol. 1). West Sussex.

Wohl, E., Angermeier, P. L., Bledsoe, B., Kondolf, G. M., MacDonnell, L., Merritt, D. M., … Tarboton, D. (2005). River restoration. Water Resources Research, 41(10), 1–12. https://doi.org/10.1029/2005WR003985

Wohl, E., Lane, S. N., & Wilcox, A. C. (2015). The science and practice of river restoration. Water Resources Research, 51(January), 5974–5997. https://doi.org/doi:10.1002/ 2014WR016874

Wood, P. J., & Armitage, P. D. (1997). Biological effects of fine sediment in the lotic environment. Environmental Management, 21(2), 203–217. https://doi.org/10.1007/s002679900019

Woolsey, S., Capelli, F., Gonser, T., Hoehn, E., Hostmann, M., Junker, B., … Peter, A. (2007). A strategy to assess river restoration success. Freshwater Biology, 52(4), 752–769. https://doi.org/10.1111/j.1365-2427.2007.01740.x

Wu, H., Chen, J., Xu, J., Zeng, G., Sang, L., Liu, Q., Yin, Z., Dai, J., Yin, D., Liang, J., & Ye, S. (2019). Effects of dam construction on biodiversity: A review. Journal of Cleaner Production, 221(3), 480–489. https://doi.org/10.1016/j.jclepro.2019.03.001

Yang, F. R., Lee, C. H., Kung, W. J., & Yeh, H. F. (2009). The impact of tunneling construction on the hydrogeological environment of “Tseng-Wen Reservoir

Transbasin Diversion Project” in Taiwan. Engineering Geology, 103(1–2), 39–58. https://doi.org/10.1016/j.enggeo.2008.07.012

Yang, H. F., Yang, S. L., Xu, K. H., Milliman, J. D., Wang, H., Yang, Z., Chen, Z., & Zhang, C. Y. (2018). Human impacts on sediment in the Yangtze River: A review and new perspectives. Global and Planetary Change, 162(January), 8–17. https://doi.org/10.1016/j.gloplacha.2018.01.001

Yin, X. A., Yang, Z., Zhang, E., Xu, Z., Cai, Y., & Yang, W. (2018). A New Method of Assessing Environmental Flows in Channelized Urban Rivers. Engineering, 4(5), 590–596. https://doi.org/10.1016/j.eng.2018.08.006

Yoshida, Y., Lee, H. S., Trung, B. H., Tran, H. D., Lall, M. K., Kakar, K., & Xuan, T. D. (2020). Impacts of mainstream hydropower dams on fisheries and agriculture in lower Mekong Basin. Sustainability, 12(6), 2408. doi:10.3390/su12062408

Yonggui, Y., Shi, X., Wang, H., Yue, C., Chen, S., Liu, Y., Hu, L., & Qiao, S. (2014). Effects of dams on water and sediment delivery to the sea by the Huanghe (Yellow River): The special role of Water-Sediment Modulation. Anthropocene, 3(March), 72–82. https://doi.org/10.1016/j.ancene.2014.03.001

Yue, T. X., Ma, S. N., Wu, S. X., & Zhan, J. Y. (2007). Comparative analyses of the scaling diversity index and its applicability. International Journal of Remote Sensing, 28(7), 1611–1623. https://doi.org/10.1080/01431160600887714

Zaimes, G. N., Gounaridis, D., & Symenonakis, E. (2019). Assessing the impact of dams on riparian and deltaic vegetation using remotely-sensed vegetation indices and Random Forests modelling. Ecological indicators, 103, 630-641. https://doi.org/10.1016/j.ecolind.2019.04.047

Zainudin, Z. Benchmarking river water quality in Malaysia., Jurutera 12–15 (2010).

Zeng, Q., Qin, L., & Li, X. (2015). The potential impact of an inter-basin water transfer project on nutrients (nitrogen and phosphorous) and chlorophyll a of the receiving water system. Science of the Total Environment, 536(July), 675–686. https://doi.org/10.1016/j.scitotenv.2015.07.042

Zhang, L., Yuan, B., Yin, X., & Zhao, Y. (2019). The influence of channel morphological changes on environmental flow requirements in urban rivers. Water (Switzerland), 11(9), 1–13. https://doi.org/10.3390/w11091800

Zhang, Y., Zhai, X., Shao, Q., & Yan, Z. (2015). Assessing temporal and spatial alterations of flow regimes in the regulated Huai River Basin, China. Journal of Hydrology, 529(P1), 384–397. https://doi.org/10.1016/j.jhydrol.2015.08.001

Zhang, Z., Balay, J. W., Bertoldi, K. M., & Macoy, P. O. (2016). Assessment of Water Capacity and Availability from Unregulated Stream Flows Based in Ecological Limits of Hydrologic Alteration (ELOHA) Environmental Flow Standards. River Research and Applications, 32(October), 1469–1480. https://doi.org/10.1002/rra.2979

Zhou, J., Agichtein, E., & Kallumadi, S. (2020). Diversifying Multi-aspect Search Results Using Simpson's Diversity Index. International Conference on Information and Knowledge Management, Proceedings, (October), 2345–2348. https://doi.org/10.1145/3340531.3412163

Zhuang, W. (2016). Eco-environmental impact of inter-basin water transfer projects: a review. Environmental Science and Pollution Research, 23(December), 12867–12879. https://doi.org/10.1007/s11356-016-6854-3