Manual on
FRAMEWORK FOR RIVER HEALTH ASSESSMENT IN THAILAND

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AIT
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Content

Preface

This manual has been developed by researchers from the Asian Institute of Technology (AIT) as part of project that sought to develop a river health assessment framework for Thailand. The project was supported by CGIAR's Programme on Water, Land and Ecosystem (Greater Mekong) and Australian Aid.

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Background and context

Through out the history of humankind, rivers have always been the lifeline of any civilization. The trend continues till today. However, because of contemporary socioeconomic development, this lifeline of civilization has been facing burgeoning threats from several quarters—unsustainable water withdrawals, pollution, and habitat deterioration, among others. Improving the health of river is, therefore gaining increasing international prominence, and becoming a prime mandate of governments all over the globe. An important precursor to improving river health is establishing a framework to assess the river health, which can be then used to measure the effect of any remedial measures that are put into place to improve the river health. Traditionally the assessment of river health has been based solely on the measurement of physical, chemical and some biological characteristics. While these measurements may be effective in regulating effluent discharges and protecting humans, they are not very useful for large-scale management of catchments or for assessing whether river ecosystems are being protected. There is, therefore, a need for a more holistic assessment framework that encompasses the relevant dimensions of river health and is able to present an accurate view of the overall river health situation.

In late 2014, the Asian Institute of Technology (AIT), in collaboration with the Thai Water Partnership (TWP), and the Pollution Control Department (PCD) of Thailand's Ministry of Natural Resources and Environment embarked on a research for development project on ***"Developing an operational framework for river health assessment in the Mekong River Basin"***. The project was carried out over three years (2014-2017). It sought to plug existing knowledge gaps by developing a holistic river health assessment framework—capable of addressing a variety of dimensions of river health. This document presents this framework.

Scope of the framework

The scope of this framework for river health assessment comprises the river and its surrounding ecosystem.

Philosophy for the development of the framework

While the objective of various river health assessment frameworks may be the same, the design philosophies adopted in the development may differ. Design philosophies are crucial for stakeholders to understand the rationale behind developing a framework. For this river health assessment framework, the project team's design philosophy is to foster large-scale operationalization. In order to do so, the framework is designed to be:

1. **Scientifically sound:** The framework is built on scientific principles and studies. The objective is not to arrive at a scientifically elaborate framework. Such frameworks are difficult to implement on a consistent basis. Instead, the objective here is to develop an operational framework that is scientifically sound.

2. **Generic but still able to reflect local conditions:** Different river basins in Thailand have different topographies, features, and anthropogenic influences. The framework is, therefore, designed to be generic so that it be can be applied in any river basin in Thailand yet specific enough to capture site-specific conditions (non-generic).

3. **Manageable:** A conscious effort is made to keep the number of dimensions, indicators and variables to a small number so as to ensure that the river health assessment activity is not onerous for the user. However, it is also ensured that all relevant areas of river health assessment, as applicable in Thailand, are considered in the framework.

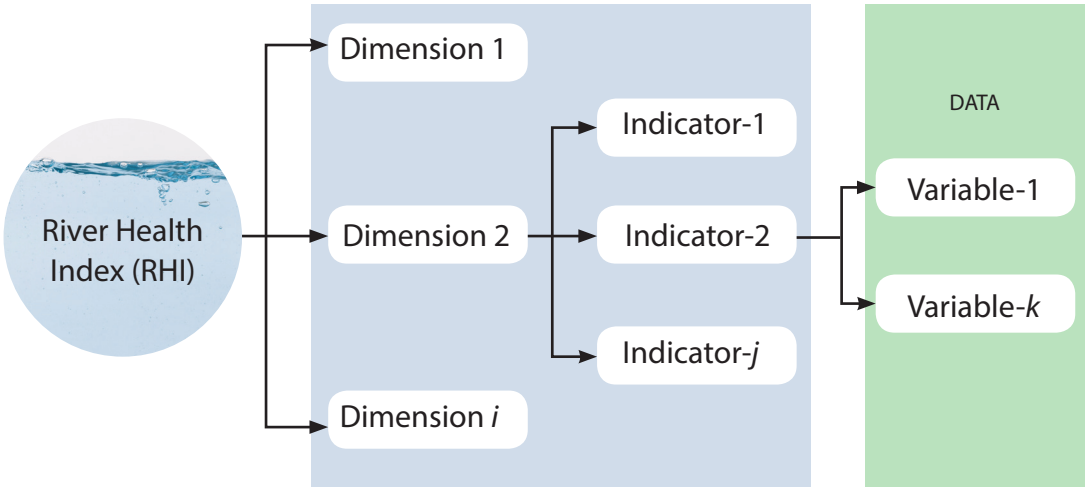
4. **Easy to use:** While the framework has a scientific basis, care is taken to minimise the use of technical jargon and calculations to arrive at the river health index. Furthermore, as far as possible simple, yet effective, variables and indicators are proposed in the framework.

5. **Scalable:** It is expected that this framework will be used to assess the river health in all basins of Thailand. Hence, the generic part of the framework is developed to capture the main issues and challenges facing the country.

Structure of the framework

The structure of the framework is presented in Figure 1. The various elements of the framework are described hereafter:

1. **River health Index (RHI):** This is the end-product of the river health assessment. The river health index is a number taking a value between the range 1 and 5. The interpretation of each of these values is presented in Table 1.



i, j and k are the number of dimensions, indicators for each dimension, and variables for each indicator respectively

Figure 1: *Schematic of the basin-scale river health assessment framework*

Table 1: *Interpretation of the river health index (RHI)*

Very Poor  RHI (<1.5)	The river cannot sustain its biological, physical and water quality characteristics, and is affected by extremely high level of disturbances. The river cannot provide efficient goods and services to people. The people in the river do not support river conservation interventions.
Poor  RHI (1.5-2.5)	The river can sustain only a few of its characteristics, and is affected by very high level of disturbances. The river can provide only a limited level of efficient goods and services to people. The people in the river basin have less capacity to support river conservation interventions.
Good  RHI (2.5-3.5)	The river can sustain only half of its characteristics, and is affected by moderate level of disturbances. The river can provide modest level of efficient goods and services to people. The people in the river basin have a medium capacity to support river conservation.
Very Good  RHI (3.5-4.5)	Most of river's characteristics are maintained. The river is affected by low level of disturbances. It can provide a high level of efficient goods and services to people. The people in the river basin have a high capacity to support river conservation interventions.
Excellent  RHI (>4.5)	Most of river's characteristics can be maintained. The river is affected by very low level of disturbances. It can provide very high level of efficient goods and services to people. The people in the river basin have a very high level of coping capacity to support river conservation.

2. **Dimensions**: Dimensions refer to the various components of river health as applicable to the river and its surrounding ecosystem. Each dimension is unique and looks at a different aspect of river health.

3. **Indicators:** Indicators are used to represent the dimensions of river health. The aim of the indicators is to capture all the necessary points of interest within a particular dimension. Dimensions could be represented by any number of indicators.

4. **Variables:** Variables are used to quantify the indicators. These are essentially the elements that are assigned mathematical values in order to foster quantification. An indicator could be represented by more than one variable if required.

The framework has two shaded portions. The portion shaded in blue—dimensions and indicators—is the generic part of the framework that can be applied in any basin. However, it is also important that the framework should be able to reflect site-specific nuances. The portion shaded in green—variables—is meant for this purpose. Hence, while the dimensions and indicators may remain the same in every basin, the choice of variables may differ to account for local influences on river health.

Overview of the assessment framework

Figure 2 presents the river health assessment system developed by the project. The system has four dimensions of river health—biological, physical habitat, water quality and socioeconomics. Ten indicators have been used to represent the four dimensions.

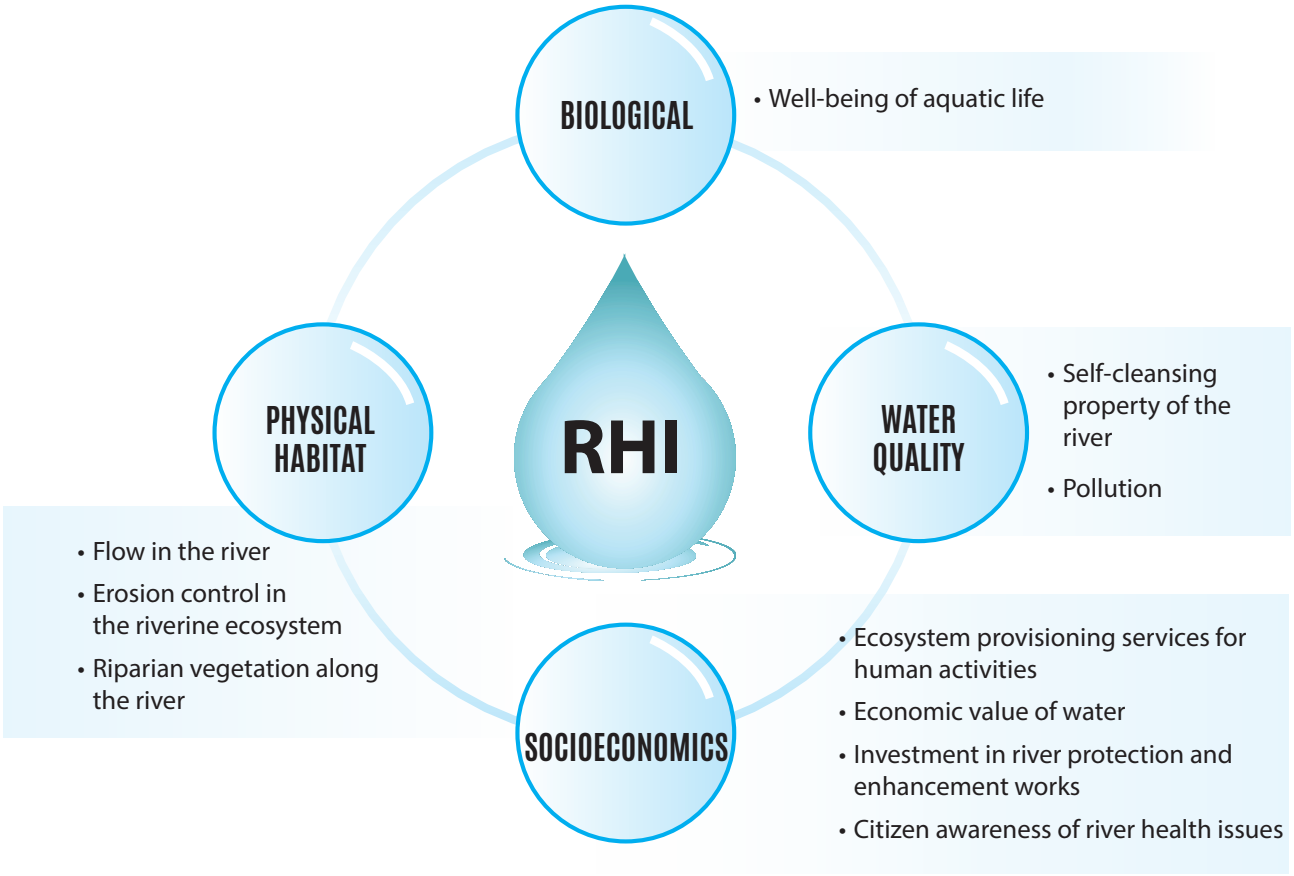


Figure 2: *River health assessment framework developed by the project*

Provided hereafter is a detailed description of each dimension of the river health assessment framework.

BIOLOGICAL DIMENSION

Scope of investigation: The assessment under this dimension evaluates the ability of river to support aquatic life and sustain the state of river ecosystem. It is impossible to take stock of all aquatic life. Hence, the assessment should look to target the more locally significant aquatic species.

Under this dimension one indicator (Indicator 1) is proposed.

Indicator 1:
Well-being of aquatic life

What are its implications for river health?

Well-being in this context refers to the ability of aquatic life to thrive naturally. Well-being of the major aquatic species is at the heart of river health.

Suggested variable	How to calculate?
1a: Long-term consistency in natural fish catch (%)	$\frac{\text{Inland fisheries catch in the study period}}{\text{Average long-term (e.g. 10 years) inland fisheries catch}} \times 100$

Thresholds for Variable1a

Long-term consistency in natural fish catch (%)	Score
0-40	1
40-60	2
60-80	3
80-90	4
>90	5

Other potential variables:

1b. Fish loss component (%)	$\frac{\text{No. of fish species existing in the study period}}{\text{No. of fish species existing in historical period*}} \times 100$
1c. Loss of indigenous/endangered species (%)	$\frac{\text{No. of indigenous/endangered species in the study period}}{\text{No. of indigenous/endangered species in historical period*}} \times 100$

**e.g. 10 years before*

Physical Habitat Dimension

Scope of investigation: The assessment under this dimension evaluates the physical features of the river and its surrounding ecosystem. This assessment is important because the surrounding ecosystem complements the functioning of a river and any disturbance in it will certainly impact the river health. Sediment plays a vital role in determining in-stream habitat of the river, thereby effecting the nature and population of aquatic species

Under this dimension three indicators (Indicator 2, Indicator 3 and Indicator 4) are proposed.

Indicator 2:
Flow in the river

What are its implications for river health?

Flow in the rivers have a direct effect on various environmental (e.g. instream habitat, type and variety of aquatic species, etc.), socioeconomical (design of water-related structures, navigation, etc.), and water management (water allocation for competing users) aspects of the river.

Suggested variables	How to calculate?
2a: Long-term stability in flow (%)	$100 - \frac{\text{AAF (study period) - AAF (historic period*)}}{\text{AAF (historic period*)}} \times 100$ *AAF = Average annual flow* **e.g. 10 years before*
2b. Assurance that environmental flow is available (%)	$\frac{\text{Average annual flow in dry season}}{\text{40\% of average annual flow}} \times 100$

Thresholds for Variable 2a

Long-term stability in flow (%)	Score
0-10	1
10-20	2
20-40	3
40-60	4
>60	5

Thresholds for Variable 2b

Assurance that environmental flow is available (%)	Score
0-10	1
10-20	2
20-30	3
30-40	4
>40	5

Other potential variables:

2c. Long-term stability in dry season flow (%)

$$100 - \frac{\text{DSF (study period) - DSF (historic period*)}}{\text{DSF (historic period*)}} \times 100$$

DSF: Dry season flow **e.g. 10 years before*

2d. Assurance that ecological water demand is met (%)

$$\frac{\text{Average annual flow in dry season}}{\text{Average ecological demand}} \times 100$$

Indicator 3:
Erosion control in the riverine ecosystem

What are its implications for river health?

This indicator takes stock of the sediment flow into the river.

Suggested variable	How to calculate?
3a: Pervious area in river floodplain (%)	$\frac{\text{Floodplain area - impervious area in floodplain}}{\text{Floodplain area}} \times 100$

Thresholds for Variable 3a

Pervious area in river floodplain (%)	Score
0-85	1
85-90	2
90-95	3
95-99	4
>99	5

Other potential variable:

3b. Green area in the river floodplain (%)	$\frac{\text{Green area in floodplain}}{\text{Floodplain area}} \times 100$

Indicator 4:
Riparian vegetation zone along the river

What are its implications for river health?

Riparian areas provide critical habitat for wildlife. By acting as buffers between upland areas and open water, they help filter pollutants such as nutrients and sediment.

Suggested variables	How to calculate?
4a: Width of the riparian zone at sampling points (m)	Average width of riparian vegetation in the sampling zone
4b. Longitudinal continuity of riparian zone	Visual inspection to estimate how much of the sampling zone is covered by riparian vegetation buffer

Thresholds for Variable 4a

Width of the riparian zone at sampling points (m)	Score
0	1
1-5	2
6-44	3
45	4
>45	5

Thresholds for Variable 4b

Longitudinal continuity of riparian zone (m)	Score
Very sparse, isolated or scattered	1
Regularly spaced	2
Occasional clumps	3
Semi-continuous	4
Continuous	5

Other potential variables:

4c. Presence of degradation in the riparian zone	Visual inspection in sampling zone
4d. Presence of alien and aggressive species of plants in the riparian zone	Visual inspection

WATER QUALITY DIMENSION

Scope of investigation: The assessment under this dimension evaluates the raw water quality in the river. It seeks to capture the ability of the river to withstand natural disturbances in water quality through its self-cleansing properties as well as the pollution parameters that the river is subjected to.

Under this dimension two indicator (Indicator 5 and Indicator 6) are proposed.

Indicator 5:
Self-cleansing property of the river

What are its implications for river health?

Every river should have some natural ability to respond to the disturbances in water quality that may occur from time to time. The healthier the river, the better these properties are.

Suggested variable	How to calculate?
5a: Concentration of Dissolved Oxygen (mg/L)	With the help of a Dissolved Oxygen (DO) meter. A direct reading of the DO concentrations can be obtained using this meter.

Thresholds for Variable 5a

Score	DO (mg/L)
1	0-2
2	2-3
3	3-4
4	4-6
5	>6

Other potential variable:

5b. Biochemical Oxygen Demand (mg/L)	Laboratory test

Indicator 6:
Pollution

What are its implications for river health?

A river faces pollution from several quarters – agriculture, domestic, industrial, etc. Pollution has a serious impact on the quality of water as well as the life supported by the river.

Suggested variable	How to calculate?
6a: Total Phosphorous (mg/L)	Laboratory test

Thresholds for Variable 6a

Total Phosphorus (mg/L)	Score
>0.13	1
0.104-0.13	2
0.077-0.104	3
0.05-0.077	4
0-0.05	5

Other potential variables:

6b. Total Nitrogen (mg/L)	Laboratory test
6c. Heavy metals concentration (mg/L)	Laboratory test

SOCIOECONOMIC DIMENSION

Scope of investigation: The assessment under this dimension evaluates the river's ability to provide ecosystem services for its dependents. It also examines the endeavors made by the users of the ecosystem to preserve and protect the river from damaging forces.

Under this dimension four indicator (Indicator 7, Indicator 8, Indicator 9 and Indicator 10) are proposed.

Indicator 7:
Ecosystem provisioning services for human activities

What are its implications for river health?

Every river provides some form of provisioning services to its users. A heathy river is expected to provide the full range of provisioning services.

Suggested variables	How to calculate?
7a: Sustainable utilization rate of surface water for various purposes (%)	$\frac{\text{Long-term AAF* - Total surface water use}}{\text{Long-term AAF*}} \times 100$ *AAF = Average annual flow*
7b: Sustainable utilization rate of groundwater for various purposes (%)	$\frac{\text{Available groundwater volume - Total groundwater use}}{\text{Available groundwater volume}} \times 100$

Thresholds for Variable 7a

Sustainable utilization rate of surface water (%)	Score
<45	1
45-55	2
55-65	3
65-80	4
>80	5

Threshold for Variable 7b

Sustainable utilization rate of groundwater (%)	Score
<30	1
30-40	2
40-50	3
50-60	4
>60	5

Other potential variables:

7c. Number and type of ecosystem services available for human activities	Visual inspection and field survey
7d. Water utilization rate (%)	$\frac{\text{Total available water volume - Total water use}}{\text{Total available water volume}} \times 100$

Indicator 8:
Economic value of water

What are its implications for river health?

Water is a finite resource, and cannot be taken for granted. One of the ways to evaluate if water is being productively utilized is to estimate the monetary value associated with its use for various purposes.

Suggested variables	How to calculate?
8a: Agricultural water productivity (USD/m³) *This includes aquaculture and fish productivity*	$\frac{\text{Agricultural revenue of the river basin}}{\text{Agricultural water use in the basin}}$
8b: Non-agricultural water productivity (USD/m³)	$\frac{\text{Non-agricultural revenue in the basin}}{\text{Non-agricultural water use in the basin}}$

Thresholds for Variable 8a

Agricultural water productivity (USD/m³)	Score
0-0.1	1
0.1-0.2	2
0.2-0.35	3
0.35-1	4
>1	5

Threshold for Variable 8b

Non-agricultural water productivity (USD/m³)	Score
0-2.1	1
2.1-5.5	2
5.5-20	3
20-50	4
>50	5

Other potential variable:

8c. Recreational productivity (USD/m³)	$\frac{\text{Recreational revenue from the river}}{\text{Water set aside for recreation}}$

Indicator 9:
Investment in river protection and enhancement works

What are its implications for river health?

Rivers have a natural ability for restoration. However, when the level of disturbance it is subjected to crosses its natural threshold, there will be a need for human interventions to maintain its ecosystem goods and services.

Suggested variable	How to calculate?
9a: Per capita Gross Provincial Product (USD)	$\frac{\text{Gross provincial income of the river basin}}{\text{Population in the basin}}$

Thresholds for Variable 9a

Per capita Gross Provincial Product (USD)	Score
0-635	1
635-1,025	2
1,025-4,035	3
4,035-12,475	4
>12,475	5

Other potential variables:

9b. Investment in river restoration works (USD)	Direct data can be procured from national/local governments
9c. Number of plans/policies for river restoration	Direct data can be procured from national/local governments
9d. Contribution from corporate social responsibility for river restoration works (USD)	Direct data can be procured from national/local governments

Indicator 10:
Citizen awareness of river health issues

What are its implications for river health?

In order to truly achieve sustainability of river health, citizen engagement and their support is imperative.

Suggested variable	How to calculate?
10a: Average schooling years of residents (years)	Self-explanatory

Thresholds for Variable 10a

Average schooling years of residents (years)	Score
0-6.2	1
6.3-8.5	2
8.6-9.7	3
9.8-11	4
>11	5

Other potential variables:

10b. Number of awareness campaigns on river health aspects.	Self-explanatory
10c. Number of voluntary organizations working on river protection and restoration.	Self-explanatory

Calculation of the River Health Index

1. Choose the appropriate variables to quantify the indicators of the RHI.
2. Collect the data required for each variable.
3. Based on the magnitude of the data for each variable, assign the variable a score between 1 and 5, as per the thresholds provided.
4. Calculate the score for each indicator by averaging those variable scores that contribute to the indicator.
5. Calculate the score for each dimension by averaging those indicator scores that contribute to the dimension.
6. Average the dimension scores to arrive at the river health index.
7. Use Table 1 to interpret the river health index.

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