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RESEARCH PAPER

Water Sensitive Approach in Assessing Project Feasibility Using the Adaptation of Life Cycle Assessment with Water Quality Index and Water Exploitation Index

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ABSTRACT

Life cycle assessment (LCA) is a valuable tool not only for analysing the environmental impact of a product but also for assisting in early-stage product development before incurring scaling-up costs. When validating a new process or project, it may be constrained to align with existing regulations or standards. Therefore, combining LCA with other applicable standards is essential to demonstrate the project's feasibility. In this regard, the water quality index (WQI) and Water Exploitation Index (WEI) provide additional information that reflects the overall water quality at a specific location and time. The objective of this study is to utilize the LCA framework in conjunction with the Malaysian WQI and WEI to protect the water quantity and water quality of the river. A negative change in the WQI score indicates that the current effluent from the process is degrading the river's classification, rendering it undesirable and necessitating a reduction in concentration. The findings demonstrate that the method for determining effluent requirements for a water treatment system is straightforward and replicable. Such an approach could be employed, for example, in an environmental impact analysis of a project to verify its viability.

KEYWORDS: *Life cycle assessment; Water quality index; Water exploitation index; Water sensitive approach; River management.*

1. Introduction

Due to population growth, resource shortages, ageing infrastructure, and degraded environments, many places around the world, especially cities, are dealing with complicated and linked concerns. These problems are made worse by the increasing unpredictability of the climate [1]. Cities that are sensitive to water, for instance, are the result of policies that support long-term sustainability, high standards of living, resilience, and prosperity. These policies include water supply, sanitation, flood control, and environmental protection. Many efforts have been made to implement water-sensitive practises in cities all over the world with a variety of social, institutional, and biophysical contexts since the concepts behind them were first introduced ten years ago. This perspective looks at practical applications of water sensitivity. It focuses on the lessons discovered in putting the practises for water-sensitive cities into practises over the previous ten years, and it outlines the research and action agendas that must be pursued over the following ten years to mainstream water-sensitive cities [1].

Water-sensitive strategies also consider water scarcity brought on by increasing water demand,

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diminishing water supplies, and increased water pollution as a result of fast population and economic growth. There is an urgent need to regulate demography and the economy while enforcing clear rules that apply equally everywhere to limit pollution, preserve aquifers, and save water, even though the efforts encourage the hasty adoption of nature-based solutions within an unrestricted population and economic expansion [2]. In terms of industrial development, a variety of ecological crises brought on by rapid urbanisation have negatively impacted many ecosystems and living conditions. Not that the sectors are not important in the context of economic expansion. Thus, Life Cycle Assessment is used as a method to evaluate the potential environmental impact of operations and materials utilised in a factory or facility while examining the impact of industry.

By locating the optimal process design choices with the least degree of environmental impact, life cycle assessment (LCA) aims to inform and assist decision-making regarding life cycle improvements [3]. According to the LCA approach [4], finding environmental hotspots in the system being studied shows which processes cause environmental problems and makes it possible to change those processes. In conclusion, the LCA is a process that helps to discover opportunities for improving a product's environmental outputs by looking at its potential environmental effects over the course of its life cycle [5].

A strong overall structure underpins LCA. The four-step approach was described by Fava et al. [6] and Consoli et al. [7] (Figure 1). The study's objective must be communicated to the target audience, which includes decision-makers, in the first phase [5]. The second phase's LCA study's boundary configuration is described in the research's scope. During this stage, the functional unit will be determined. As a point of reference for normalising input and output data, a functional unit is described. The process of inventory analysis involves compiling data about a system or product. Qualitative and quantitative data for the inventory should be gathered for each unit process assessed within the system limits.

The following action is to undertake a Life Cycle Impact Assessment (LCIA) to assess a product's environmental performance using a functional component of the LCA research. Mandatory and optional parts make up the LCIA phase, which is sometimes divided into two phases [5]. Classification of LCI results into the authorised effect categories and characterization of category indicator outcomes are both required by LCIA. To produce a single value output, normalisation and weighting techniques are used for optional parts. The results of the life cycle effect category analysis and the circularity evaluation are combined in the results interpretation step. The results, limitations, and recommendations made during the interpretation phase should be consistent with the stated purpose and scope [3].

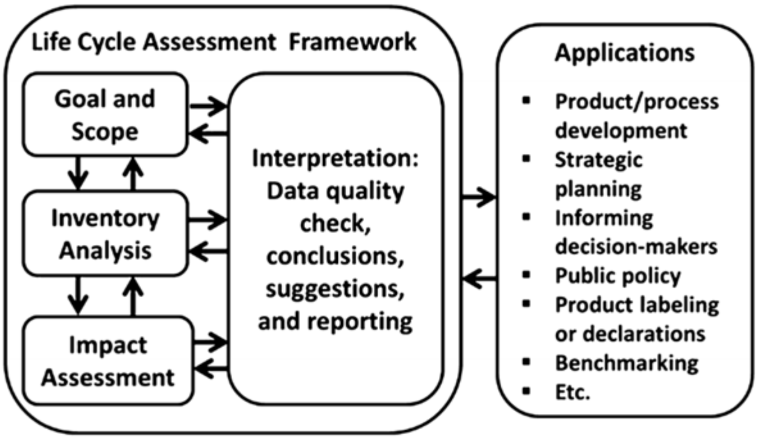


Fig. 1. Typical phases in life cycle assessment [6][7]

However, LCA has limitations, which could lead to criticism of LCA results. LCA relies on assumptions and scenarios as it assesses the reality in a simplified model. The scopes of studies might also vary; thus, one study might not contain effects or processes that another study does. Each study's scope, assumptions, and situations could be different, which could lead to a range of LCA findings. For non-experts in particular, these variations in LCA methodology and findings could be confusing. A huge number of resources is also needed to undertake an LCA study because such a large amount of data is needed. The study won't produce trustworthy results if the data collection is poor or there isn't enough data. Furthermore, it can be difficult to communicate the findings of an LCA study. Then, a more thorough analysis is needed to call attention to the variations and accentuate the advantages and disadvantages of the products, making it challenging for decision-makers to choose the best solutions [8]. LCA has been integrated with Life Cycle Costing (LCC) and Social Life Cycle Assessment (CLSA) to provide a better understanding of the study [9][10][11][12]. A study by Paes et al. [9] develops an example of a method to analyse municipal solid waste management systems (MSWMS) that integrates environmental and economic indicators using Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). The findings highlight that this approach is effective in establishing scenarios that can underpin adequate long-term planning of public policies in the MSW domain. LCA generally relates environmental impacts to a process or service rather than studying a geographic area [13]. In the sensitive areas such as watershed, more information needs to be added to understand their diversity and highlight their strengths and weaknesses in the context of watershed management. Xiaodan et al. [14] conducted a comprehensive integration of life cycle assessment (LCA) with risk assessment to evaluate the environmental impacts of human-made contaminants at a watershed level. A conceptual framework called "watershed life cycle assessment (WLCA) for pollutants" has been created in the study. This framework aims to depict the connections between sources and sinks of specific pollutants by incorporating biogeochemical processes at a watershed level, with the assistance of Geographic Information System (GIS). The study highlights that the integrated RA–LCIA of each hot spot can be mapped on the GIS platform of the watershed of interest. Contributions of different emission sources to the pollutants of interest and impact degree of the pollutants are quantified for ranking reduction or control priority of pollutants and emission sources in the watershed, which might be useful for environmental-quality based economic planning.

Additionally, the LCA analysis may be constrained when translated to adhere to regulations or laws already in place. As a result, more requirements must be added to LCA in order to determine whether a project plan is feasible. The status of river conditions can be ascertained using the Water Quality Index (WQI) and the Water Scarcity Index (WSI). Water quality can be measured using the water quality index (WQI) pattern. According to Naubi et al. [15], the water quality index (WQI) is helpful for figuring out whether river waters are suitable for various uses, including agriculture, aquaculture, and residential use. In order to reduce a large amount of data on water quality to a single value or index, aggregation techniques are used. Around the world, utilising regional water quality standards, the WQI technique has been used to quantify water quality (surface and subsurface) [16]. Numerous water quality indices have been created globally to evaluate river water quality. These indices are based on various standards for water quality. Al-Shujairi (2013) [17] proposed a WQI formula that contained seven water quality factors, while Meher et al. [18] evaluated water quality in Ganges rivers using more than 10 criteria. For the evaluation of the overall status of the river waters, the WQI Malaysia includes six parameters: dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), ammoniacal nitrogen (AN), and pH. Based on the aforementioned six factors, the WQI certified by the DOE (Equation 1) is determined [19]. Table 1 displays the WQI categorization that the Department of Environment Malaysia has authorised. According to the range of WQI values, five classes have been categorised [20][14].

Tab. 1. DOE Water Quality Index Classification [20]

Parameter	Unit	Class				
		I	II	III	IV	v
Ammoniacal Nitrogen	mg/l	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Biochemical Oxygen Demand	mg/l	<1	1-3	3-6	6-12	>12
Chemical Oxygen Demand	mg/l	<10	10-25	25-50	50-100	>100
Dissolved Oxygen	mg/l	>7	5-7	3-5	1-3	<1
pH	-	>7	6-7	5-6	<5	>5
Total Suspended Solid	mg/l	<25	25-50	50-150	150-300	>300

Water Quality Index (WQI)	>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

The Water Exploitation Index (WEI) measures the pressure put on local demands by the water supply. The phrase "Water Stress Index," which is based on the real ratio of water withdrawal to hydrological availability, was first used by Pfister et al. in 2009. Criticality ratio is a phrase that is frequently used to describe water shortages [21]. The Water Exploitation Index will be utilised throughout the study to ensure the consistency with the terminology adopted by the study in the Malaysia River Basin. WEI is defined as the difference between the long-term average freshwater resources and the mean annual total freshwater demand. It illustrates how the water resource is strained as a result of overall water demand. There are four different categories of water stress: non-stressed countries (a), low stress (10–20%), strained (20–40%), and severe (d) (40%) countries. The aforementioned threshold values/ranges are averages, and according to the EEA (2017) [22], areas with a water extraction index of greater than 20% are more likely to face severe water stress during a drought. As a result, there has been an increase in recent years in theorising on the idea of integrating/combining environmental assessment with other parts, such as circularity assessment. This is because existing indicators are looking for different viewpoints. The existing integration/combination models of the research can be summed up into two models if integration is defined as the process of bringing together more elements [23]. Hence, this study aims to integrate the Life Cycle Assessment (LCA), Water Quality Index (WQI), and Water Exploitation Index (WEI) to evaluate the effectiveness of this approach in establishing a correlation between LCA, water quality, and water quantity in a river.

2. Methodology

2.1 Overview of the production process and LCA

2.1.1 Goal and Scope

This LCA's main objective was the production of graphic paper. Paper manufacture and the production of chemical pulp are both incorporated in the manufacturing process. The LCA was developed to look into how producing graphic paper for newsprint affected the environment. As shown in Figures 2-4, three regions in the Johor River Basin and Selangor River Basin have been chosen as a case study in order to assess the project's viability. The pulp and paper (P&P) sector has a difficult time adhering to tight environmental laws and regulations [24]. P&P facilities typically generate enormous streams of effluent and use a lot of water [25]. P&P mills are divided into three main sections: making pulp, which is the process of converting raw materials into pulp; improving pulp quality; and producing the finished good [26]. Thus, with significant impact on water quantity and water quality, production of graphic paper has been seen as a good example to present the feasibility of the integration of LCA, WQI and WEI. Moreover, the locations were picked as the method's strongest points. Table 2 displays the water quality metrics for the three locations. It should be emphasised that the study used a baseline of varying sample times for measuring water quality metrics.

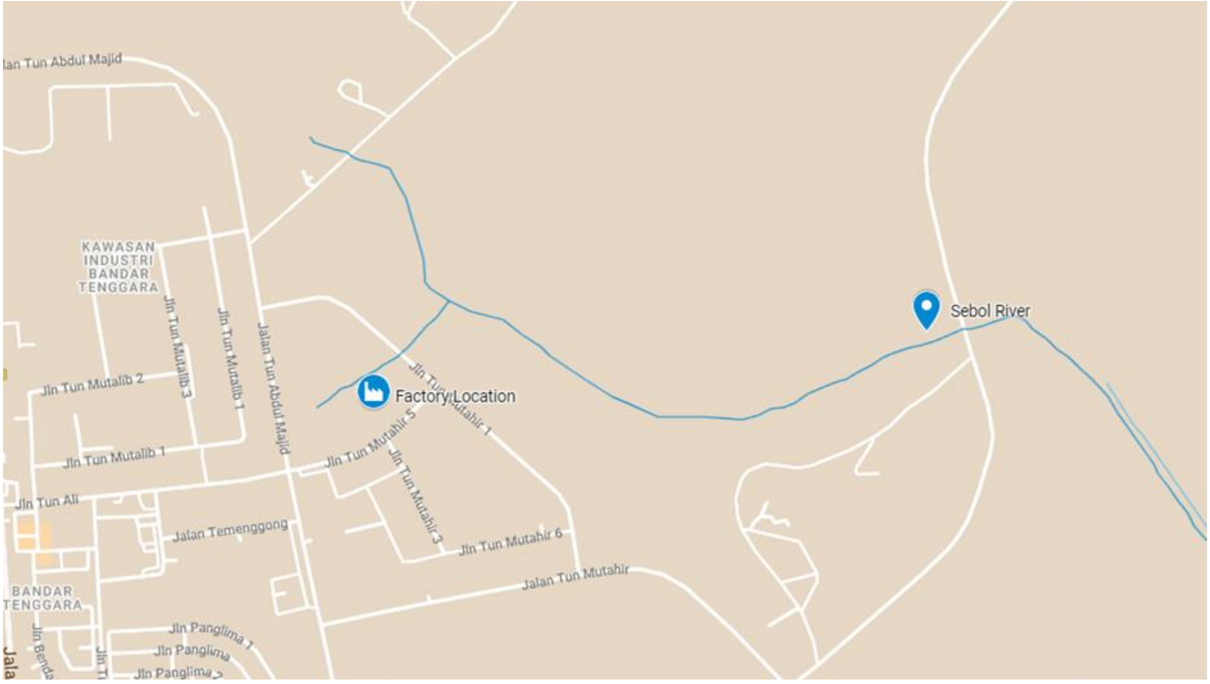


Fig. 2. Location 1: Location within sebol river area

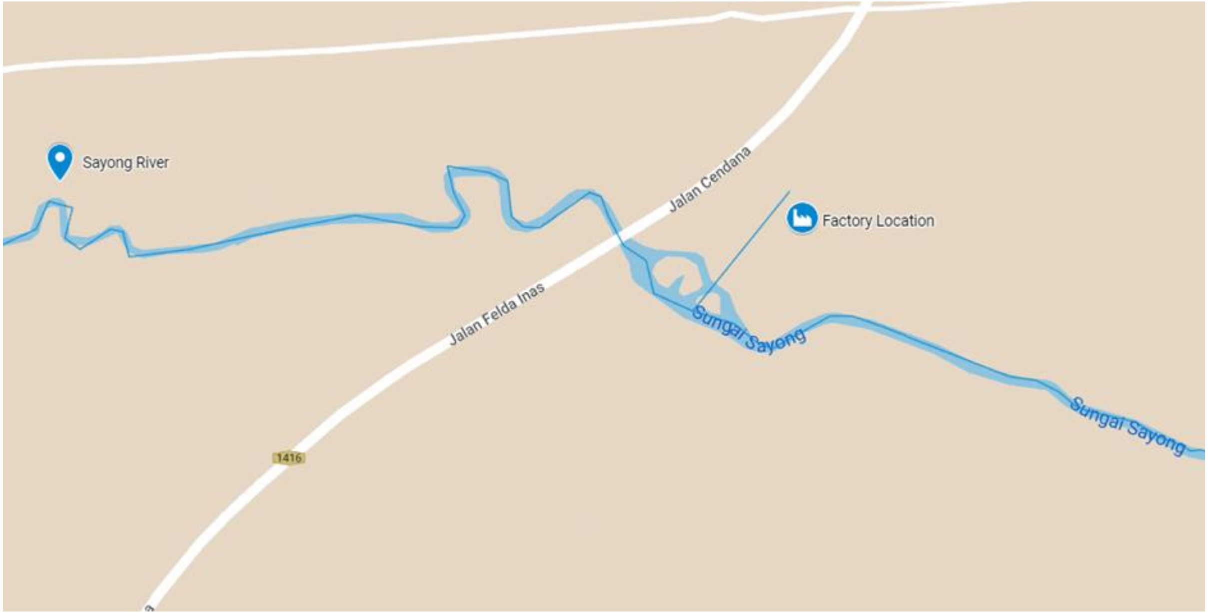


Fig. 3. Location 2: location within sayong river area

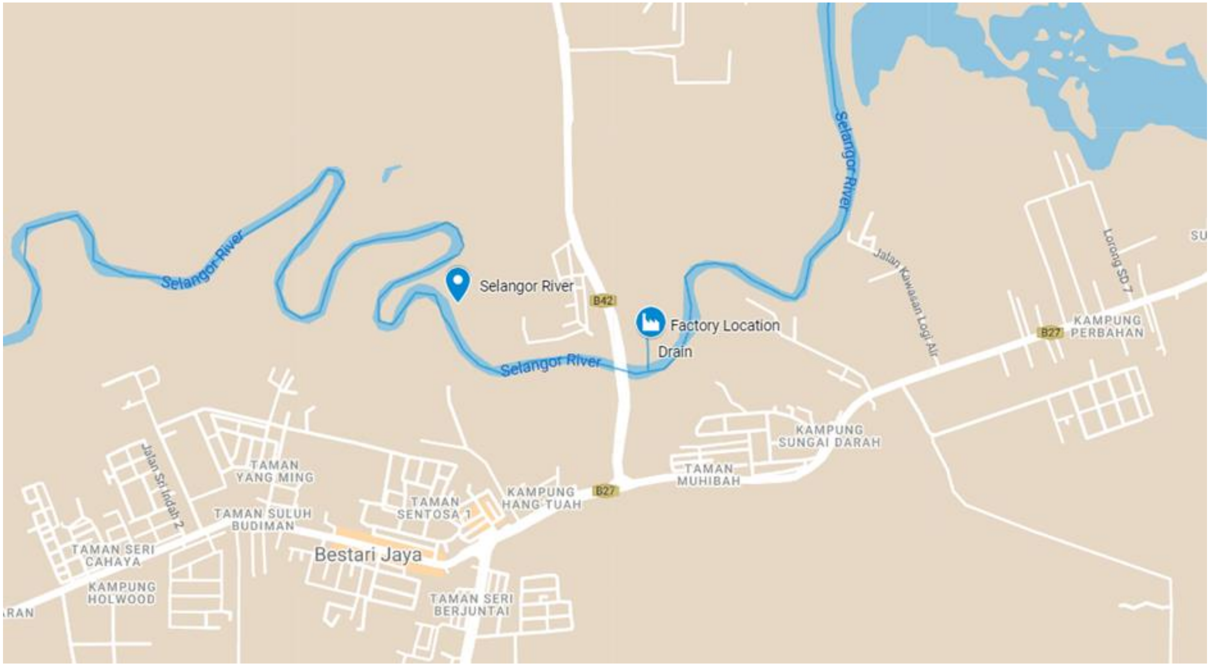


Fig. 4. Location 3: Location within selangor river area

Tab. 2. Water quality parameter for three propose locations

Location	River Class	Water Quality Parameter AN (mg/l)	BOD (mg/l)	COD (mg/l)	DO (mg/l)	pH	TSS (mg/l)	WQI
Location 1: Sebol River[1]	III	1.87	5.56	21.9	4.41	6.03	36.2	68
Location 2: Sayong River[1]	I	0.14	0.40	5.2	5.94	6.2	8.0	90
Location 3: Selangor River[2]	II	0.50	3.69	21.7	5.43	6.58	117.5	79

2.1.2 System boundaries

The creation of graphic paper falls under the LCA system's cradle-to-gate boundary. 2. All upstream inputs, such as electricity, other energy inputs, machinery, and infrastructure, were included based on the ELCD database [28]. OpenLCA 1.11.0 was used to conduct the evaluation. The main characterization method, ReCiPe 2008 Midpoint (Hierarchist) [29], was used with an emphasis on the effects of global warming, climate change, and water depletion. The Water Quality Index and the Water Exploitation Index were both employed in the study to assess the process's location-based feasibility.

2.1.3 Functional unit

The functional unit "manufacturing of 1 tonne of graphic paper" served as the basis for the cradle-to-gate LCA analysis. The "gate" in this illustration was the door leading out of the paper manufacturing facility.

2.1.4 Life cycle inventory data

The LCA was conducted using information from the ELCD database [28]. Paper from forests, both virgin and recycled, makes up the main components. The LCA software (OpenLCA version 1.11.0) received the collected data and processed them. Based on the anticipated location within the Johor River Basin, the Standard A and Standard B of the Malaysian Industrial Effluent Regulation [30] are utilised to estimate effluent flows. The study's application of Standards A and B is shown in Table 3. The Class II standard in the National Water Quality Standards for Malaysia [31] is used to set the dissolved oxygen value.

Tab. 3. Industrial effluent regulation 2009 limits [30]

Parameter	Unit	Standard A	Standard B
Ammoniacal Nitrogen	mg/l	10	20

Biochemical Oxygen Demand	mg/l	20	50
Chemical Oxygen Demand	mg/l	80*	300*
pH	-	6.0-9.0	5.5-9.0

* COD concentration is based on pulp and paper mill industry

2.2 Adaptation of LCA methodology

2.2.1 Integration of LCA with water quality index

Characterization parameters taken from the Malaysia WQI [31] are multiplied by the indicators for the environmental impact categories and the inventory data in this study. Equation 1 [31] can be used to compute the conversion between effluent concentration and sub-index.

$$WQI = 0.22(siDO) + 0.19(siBOD) + 0.16(siCOD) + 0.15(siAN) + 0.16(siTSS) + 0.12(sipH)$$
Equation 1

Where:

siDO:subindex for dissolved oxygen,
siBOD:subindex for biochemical oxygen demand,
siCOD:subindex for chemical oxygen demand,
siAN:subindex for ammoniacal-nitrogen,
sits:subindex for total suspended solid.

The three locations' water characteristics from the inventory research are displayed in Table 3 and are based on concentration using a sub-index value. The process for transforming water quality data to subindex values is shown in Table 4. The OpenLCA software's sub index is shown in Figure 5. The water quality parameter is converted into Malaysian WQI using the LCIA technique. The geographical consideration of the mixing point between the process location and the target river is taken into account to assess the project's viability (Figure 6). The predicted pollutant dispersion analysis can be used to generate the concentration at the mixing point. The relevance of the project or system in the river basin system is determined by Equation 2, and the dWQI value must be greater than 0. A low dWQI score indicates that the process's current effluent is degrading the river's class, making it undesirable and calling for a concentration reduction. The goal of this study is to ensure that the suggested system maintains the present river class.

Tab. 4. Subindex calculation for dWQI [31]

Sublndex for DO (In % saturatlon)	
$SIDO = 0$	for $x \leq 8$
$SIDO = 100$	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$
Sublndex for BOD	
$SIDOD = 100.4 - 4.23x$	for $x \leq 5$
$SIDOD = 108^* \exp(-0.055x) - 0.1x$	for $x > 5$
Sublndex for COD	
$SICOD = -1.33x + 99.1$	for $x \leq 20$
$SICOD = 103^* \exp(-0.0157x) - 0.04x$	for $x > 20$
Sublndex for NH3-N	
$SIAN = 100.5 - 105x$	for $x \leq 0.3$
$SIAN = 94^* \exp(-0.573x) - 5^* I x - 2 I$	for $0.3 < x < 4$
$SIAN = 0$	for $x \geq 4$
Sublndex for SS	
$SISS = 97.5^* \exp(-0.00676x) + 0.05x$	for $x \leq 100$
$SISS = 71^* \exp(-0.0061x) + 0.015x$	for $100 < x < 1000$
$SISS = 0$	for $x \geq 1000$
Sublndex for pH	
$SlpH = 17.02 - 17.2x + 5.02x^2$	for $x < 5.5$
$SlpH = -242 + 95.5x - 6.67x^2$	for $5.5 \leq x < 7$
$SlpH = -181 + 82.4x - 6.05x^2$	for $7 \leq x < 8.75$
$SlpH = 536 - 77.0x + 2.76x^2$	for $x \geq 8.75$

$$dWQI = WQIi - WQIr \qquad \text{Equation 2}$$

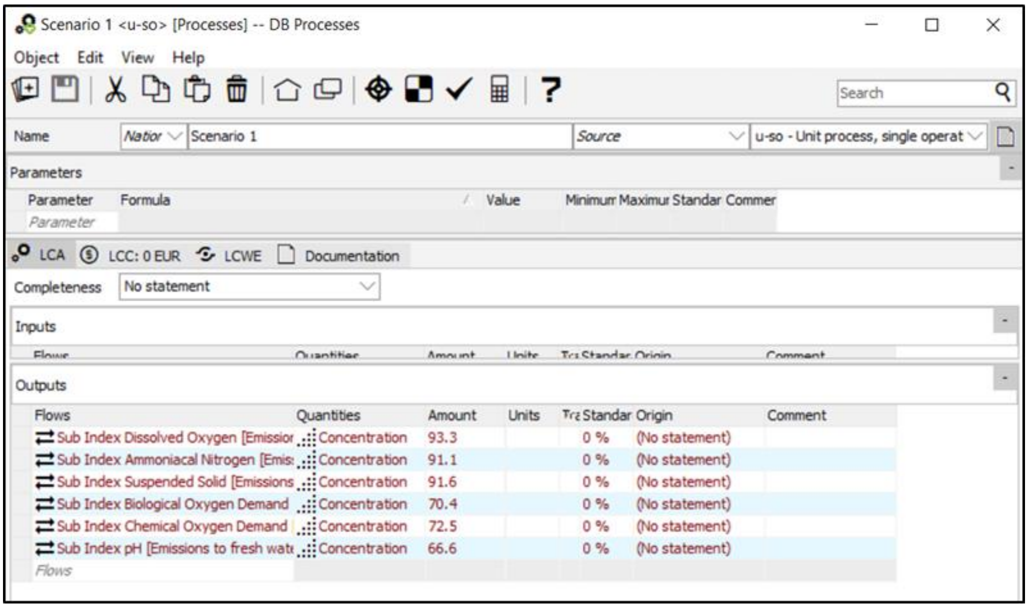
where;

WQIi = Water quality index for mixing point when effluent mix at target river

WQIr = Water quality index for target river based on current class (Class I=92.7, Class II=76.5, Class III=51.9, Class IV=31.0)

dWQI > 0; System does not degrade river class

dWQI < 0; System will degrade river class



Name: Scenario 1

Source: u-so - Unit process, single operat

Completeness: No statement

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Sub Index Dissolved Oxygen [Emissior	Concentration	93.3			0 %	(No statement)	
Sub Index Ammoniacal Nitrogen [Emis	Concentration	91.1			0 %	(No statement)	
Sub Index Suspended Solid [Emissions	Concentration	91.6			0 %	(No statement)	
Sub Index Biological Oxygen Demand	Concentration	70.4			0 %	(No statement)	
Sub Index Chemical Oxygen Demand	Concentration	72.5			0 %	(No statement)	
Sub Index pH [Emissions to fresh wat	Concentration	66.6			0 %	(No statement)	

Fig. 5. Inventory data in open LCA software

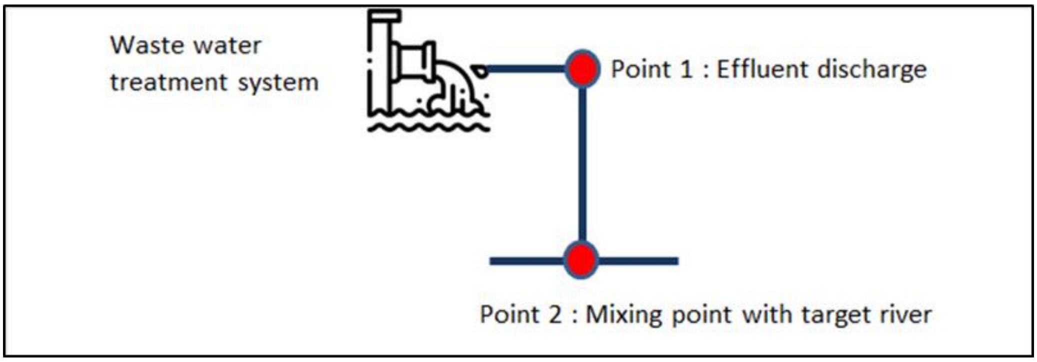


Fig. 6. Scenario builds up in the river basin area

2.2.2. Integration of LCA with water exploitation index

In order to estimate potential environmental or public health harm from excessive water withdrawal, Pfister et al. [32] used WEI or WSI as a screening indicator or characterisation factor (CF) for water withdrawal. It safeguards three key areas: natural resources, ecological quality, and human health [33]. Pfister et al. [32] study, in which blue virtual water withdrawal was utilised to create the WSI, concentrated on the measurement of consumptive water consumption. The actual ratio of water extraction to hydrological availability (WTA) is used to calculate the WSI. According to Gheewala et al. [34], the WTA ratio can be used to calculate a watershed's water scarcity. Table 5 shows the WEI for the main river basin in Malaysia. These values are used as characterization factors for Water Exploitation Index integration.

Tab. 5. Water Exploitation Index in the main river basin in Malaysia [35]

River	Annual Water Volume (MCM)	Annual Water Abstraction	WEI	Level of Water Stress
River	2606.8	1962.31	75.3	Severe stress
Kelantan	16451	1411.02	8.6	Not stress

Pahang	18939.5	893.89	4.7	Not stress
Johor	2049.5	847.86	41.4	Severe stress
Linggi	1234.2	227.65	18.4	Low stress
Selangor	2474	1134.79	45.9	Severe stress
Padas	7593.4	249.4	3.3	Not stress
Sadong	5067.7	128.81	2.3	Not stress

3. Results and Discussion

3.1 Climate change and water depletion impact

In this framework, the Life Cycle Assessment (LCA) approach was used to evaluate the environmental effects of the manufacture of graphic paper. A variety of impact categories that underline the process's environmental impact were taken into consideration in the current analysis. In this way, the current study was developed to help project proponents make the best choice possible about the viability of producing graphic paper. The effects of climatic change, water depletion, and water exploitation index are shown for the three locations in Table 6. In the absence of the transportation factor, the value for climate change and water depletion is the same. 829.93 kg of CO2 equivalent are produced by one tonne of graphic paper. This is the result of processes like the extraction of raw materials and manufacturing, both of which generate sizable amounts of CO2.

Tab. 6. Result for production of graphic paper for three impact categories

Location	Climate Change (kg CO_2 eq)	Water Depletion (m^3)	Water Exploitation Index (m^3)
Location 1: Sebol River	829.93	57.78	23.92
Location 2: Sayong River			23.92
Location 3: Selangor River			26.52

Land use alteration and the paper industry can be challenging. By acting as a natural filter, mature trees may absorb around 22 kg of CO2 annually. As a result, trees preserved as a result of the valueization of manufacturing waste can be predicted to absorb about 70,5 t of CO2 annually [36]. However, the production of paper uses a sizable amount of wood (trees) and generates sizable amounts of production waste with potential for recycling [37]. The study's utilisation of 21% recycled fibre resulted in a reduced impact. In turn, less dependency on essential raw materials is created by lengthening the product's life cycle.

A total of 57.78 m3 of water is used during the entire process. This is less than what a typical paper mill needs to produce one tonne of paper, which is roughly 10–20 m3 of fresh water and 100–150 m3 of process water [38]. In the process of manufacturing paper, water is an extremely important component. It is essential for the movement of fibres, equipment cleaning, lubrication, cooling, and the improvement of product quality. It makes sense economically and environmentally to want to use less fresh water when making paper, but it should be highlighted that severe water system closure in paper mills has a significant negative impact on many technological activities [38]. For instance, reduced water use could lead to mechanical issues, paper flaws, and decreased product quality. Water use is also impacted by the raw materials used, such as recycled paper. In order to get the best paper quality, a sufficient amount of water loop closure is essential [38].

Focusing on each step in the creation of graphic paper, different paper grades demand various quantities of water. The following processes in paper technology generally use water [38]:

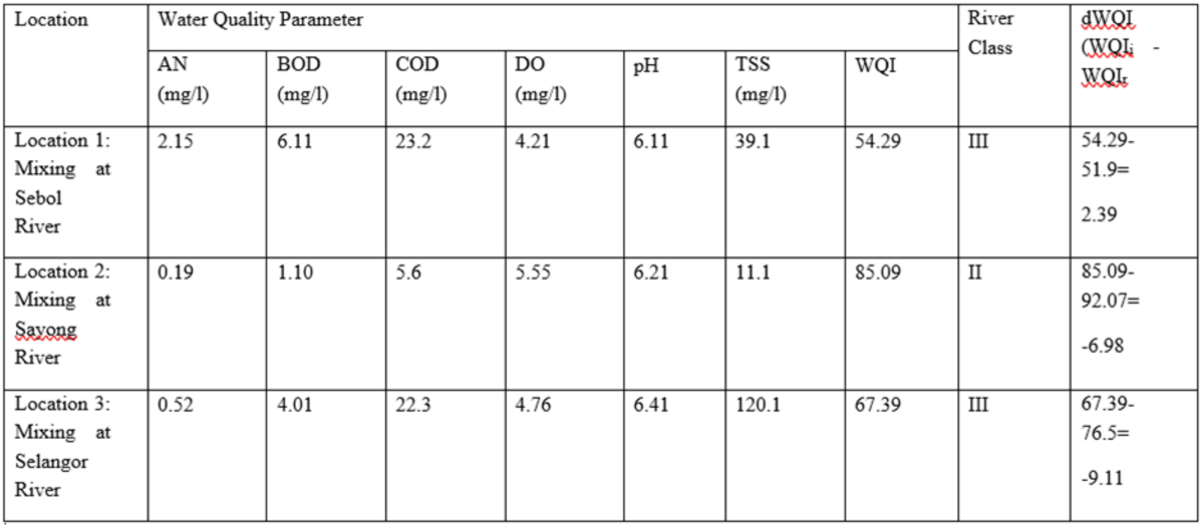
- Preparation of raw materials and chemicals,
- Development of fibres papermaking properties,
- Transportation and dilution of pulp,
- Formation and consolidation of paper web,
- Cleaning of parts of paper machines and accompanying equipment.
- Cooling,
- Sealing,
- Lubrication,
- Heating (in the form of steam).

Olejnik (2011) [38] asserts that pulp manufacturing and paper machines, which account for 40% and 35% of total production, respectively, demand the most water. Thus, these processes should be the main emphasis of any water reduction approach. In comparison to two places in the Johor River Basin, the Selangor River exhibits the highest value from the perspective of location (Table 6). This is mostly because both river basins use the same characterisation factor, with Selangor River Basin and Johor River Basin adopting values of 0.459 and 0.414, respectively. According to the requirements for the water stress score, both rivers are under severe stress; nevertheless, the position within the Johor River Basin has demonstrated a better option. As a result, it is possible to implement the use of alternate water resources, such as groundwater and rainfall harvesting, to lessen the dependence on river water supply.

3.2 Water quality index

The effects of using the LCA-WQI technique are discussed in this section. The baseline WQI values for the investigation are shown in Table 7 for each scenario and river class. Only position 1 at Sebol River has a positive score (2.39) in Table 7 that indicates the project is feasible at the desired site. The Placement 1 number is greater than zero, suggesting that the industrial location is feasible and that the increased maximum concentration of effluent entering the target river will not result in a decrease in the river's class. The negative readings at locations 2 and 3 were -6.98 and -9.11, respectively. This indicates that the target river class will decline as a result of the factory's presence in the area. This indicates how straightforward the procedure for figuring up the effluent concentration requirements for new systems is, which enhances the methodology for life cycle assessments' applicability.

Tab. 7. Water quality parameter for the mixing point and dWQI



Location	Water Quality Parameter							River Class	dWQI (WQI_i - WQI_r)
	AN (mg/l)	BOD (mg/l)	COD (mg/l)	DO (mg/l)	pH	TSS (mg/l)	WQI		
Location 1: Mixing at Sebol River	2.15	6.11	23.2	4.21	6.11	39.1	54.29	III	54.29-51.9= 2.39
Location 2: Mixing at Sayong River	0.19	1.10	5.6	5.55	6.21	11.1	85.09	II	85.09-92.07= -6.98
Location 3: Mixing at Selangor River	0.52	4.01	22.3	4.76	6.41	120.1	67.39	III	67.39-76.5= -9.11

4. Future Research

A thorough method of assessing project feasibility with an emphasis on water sensitivity is represented by the integration of life cycle assessment, water quality index, and water exploitation index. Subsequent studies may focus on improving the techniques, broadening the scope to include various project kinds, and examining the possible effects of climate change on water resources. In order to improve data accuracy and prediction capacities, future research may also focus on the integration of cutting-edge technology like artificial intelligence and remote sensing. In the end, this research may provide insightful information to decision-makers, professionals in the sector, and legislators looking for practical ways to guarantee water-sensitive project planning and execution in the face of changing environmental issues.

5. Conclusion

By locating the optimum process design solutions with the lowest possible environmental impact, LCA is used in decision-making. Since LCA evaluates reality using a simplified model, a more thorough investigation is necessary to highlight the variations and accentuate the advantages and disadvantages of the products, making it challenging for decision-makers to choose the best solutions. In this work, the LCA analysis has been improved by the use of the Water Quality Index (WQI) and the Water Scarcity Index (WSI), particularly when they relate to geographical conditions. Paper manufacturing has a huge impact on climate change since it uses a lot of wood (trees) and produces a lot of waste that can be recycled. Due to the study's usage of 21% recycled fibre, the impact was lessened. Water usage is lower than what a typical paper mill would need to produce one tonne of paper, which would require between 10 and 20 m3 of fresh water and 100 and 150 m3 of process water. In order to prevent paper defects, product quality loss, and mechanical issues, it is necessary to take the process limitation into consideration. The use of raw materials, such as recycled paper, also affects how much water is used.

The Selangor River Basin has the greatest influence on water extraction when compared to other river basin sites, suggesting that situating the facility within the Johor River Basin is the best choice. Only position 1 at Sebol River has a positive value according to the LCA-WQI technique, indicating that the project is feasible in the intended area. Locations 2 and 3 likewise received poor results, proving that the factory's proximity will be detrimental to the target river class. The results show that the method for determining a water treatment system's effluent requirements is straightforward and repeatable. The approach could be used, for instance, in an analysis of the environmental impact of a project to confirm its viability.

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7. Conflict of Interest

The authors declare no conflict of interest.

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