Benchmarking UI BlueMetric to ocean monitoring indicator and marine environmental indicator

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Abstract. This paper reviews some seawater quality evaluation methods such as Ocean Health Index (OHI) and Puget Sound Partnership (PSP). In this paper, we discuss our UI BlueMetric assessment tools which is a new tool proposed as performance indicators of coastal areas in terms of its biodiversity, water quality, waste, and human activity. This paper presents a benchmarking of BlueMetric with two existing marine assessment tools. We compare UI BlueMetric to the OHI and PSP in terms of the assessment of the seawater quality in the coastal area. The coastal area environmental quality has produced a growing body of literature with meta-analyses on methods. The considerations and evaluation systems that influenced its original design are presented. We also discussed the comparison framework. This paper presents the methodology used in different seawater quality evaluation, the intended users, as well as discussing the difference in the goals and missions of the assessment tools. This paper concludes that all of the three evaluation systems have some similarities in their indicators related to seawater evaluation. UI BlueMetric has the least number of parameters so that it is suitable to be applied in early assessment.

1. Introduction

The oceans, which are fluid, make it unusually difficult to assess. The evaluation of ocean health ecosystems is not straightforward due to the movement of biodiversity, waste, and other objects as the impact of human activities. The evaluation of the quality of the ecosystem in seawater is not in line with political boundaries and the exclusive economic zone (EEZ), where policies are determined at the national level [1]. The importance of concerted effort to improve the environmental quality of the coastal area and ocean will be discussed in this paper.

Sustainable Development Goals (SDGs), a result of the United Nations Conference on Sustainable Development in Rio de Janeiro, has some goals related to marine environment, particularly the goal number 14 on ‘conserve and sustainably use the oceans, seas and marine resources for sustainable development’ [2]. In consequence, properly designed indicators are needed to monitor and evaluate the underlying complex economic and sociological condition. These scientific data are expensive to measure directly and difficult to explain to the general audience [3]. In addition, it should also consider multi-stakeholder perspectives [1].

There are four key issues which are affecting ocean sustainability: (i) unsustainable fishing; (ii) climate change and ocean acidification; (iii) pollution and waste; (iv) loss of habitats and biodiversity and invasive species [4]. Based on those parameters, seawater monitoring and evaluation indicators can be grouped under three areas: fisheries; biodiversity; and water quality and pollution [5].
In this paper we evaluated the Puget sound Partnership (PSP) indicators which is introduced in Washington, United State. PSP is a tool to measure ecosystem’s health. We also look into the Ocean Health Index (OHI), a global ocean evaluation tool. We compared these tools to our UI BlueMetric which was introduced in 2019 to evaluate coastal area. These indicators were launched in 2019 by the University of Indonesia (UI).

The rest of the paper is presented as follows. In section 2 we present the methods for the assessment tool with a case study. Section 3 presents a literature study about the tools to evaluate sustainability in marine and the results. The final section is dedicated to present the conclusions.

2. Method
This section provides a simple method to compare the categories and indicators in UI BlueMetric with other assessments tools of seawater quality. The challenge is to show a huge amount of information in a concise form and allow a basic comparison of categories and indicators in different methods. We compare the UI BlueMetric indicators, categories, and weightings with two existing assessment tools: Puget Sound Partnership (https://www.psp.wa.gov/evaluating-vital-signs.php) [6], and Ocean Health Index (http://www.oceanhealthindex.org/) [7]. The degree of detail provided allows the comparison of the similarity and differences of category and indicators in one system to the other also we compare how the scoring have been made.

In doing the evaluation of the coastal area using UI BlueMetric we conducted a case study which can be describe as follow:

2.1. Case study location
The study was conducted in the coastal area of Pantai Bahagia Village, West Java. Pantai Bahagia Village is a maritime village located on the coast of the Citarum River in West Java, Indonesia. It is geographically located at positions 5°57'04.3"S 107°02'03.8"E. The area of Pantai Bahagia Village is 4,900 ha, consisting of 70% ponds; 15% housing area, 15% rice fields [8]. Pantai Bahagia Village is being inundated due to the rise of sea level caused by climate change and exaggerated used of the extraction of groundwater by human activity [9].

The village, which has the green areas for mangroves and various fauna, is also inhabited by fishermen and farmers. Pantai Bahagia Village has the potential for community economic development and the development of a center for monitoring the quality of the northern coastal waters of Java Island. This area needs attention regarding the community’s ability to manage green areas that are almost lost due to abrasion and contamination of sea water. Pantai Bahagia Village should be assessed and evaluated regularly to design programs for prevention and overcoming problems caused by natural footprint, human footprint, industrial footprint, transportation footprint, and marine tourism footprint.

2.2. Data collection and analysis
The data is collected through literature studies. In 2018, the condition of mangrove area in Pantai Bahagia covering 20 hectares of rehabilitation of damaged mangrove areas has 3-4 Species Diversity; Vegetation Density of 11-15 per 100 m2; and with low Mangrove Coverage [10]. The extensive abrasion and accretion in the year 1976 to 2018 in each village in Pantai Bahagia Village results in 482.94 ha and 330.46 ha of affected areas [11]. A survey reported that 14 out of 15 fisherman households agreed that they were dependent on mangroves and about 3% of respondents took the initiative to carry out rehabilitation by self-financing [10].

3. Results and discussion

3.1. Environmental aspect
Table 1 provides the benchmarking list of seawater quality evaluation tools which is based on the following features such as (i) indicator; (ii) comparability; (iii) data source; (iv) assessed area; and (v) accessibility of the tool on the internet.
Table 1. Seawater Assessment Tools and brief description.

| Tool                          | Description                                                                                                                                                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UI BlueMetric                 | Consist of 4 domains (Biodiversity-Natural Ecosystem, Water Quality, Waste and Human Activity); 33 indicators; ranking point method enabling comparison and benchmarking; each province will be evaluated through questionnaire and collected water quality data. |
|                               | Tool available online, https://aip.scitation.org/doi/10.1063/5.0002330 Province, Indonesia                                                                                                                                 |
| Puget Sound Partnership       | Based on 6 recovery goals (Healthy human population, thriving species and food web, Protected and restored habitat, Vibrant quality of life, Abundant water quantity and Healthy water quality); 52 indicators; Technical and scientific expert provide the data and supervise the analysis of the results. |
|                               | Tool available online, https://vitalsigns.pugetsoundinfo.wa.gov/ Washington, U. S                                                                                                                                 |
| Ocean Health Index            | Based on 10 goals and 8 sub-goal (Food Provision, Artisanal Fishing Opportunities, Natural Products, Carbon Storage, Coastal Protection, Tourism & Recreation, Coastal Livelihoods & Economies, Sense of Place, Clean Waters and Biodiversity); 62 indicators for status, 148 indicators for Pressure and 64 indicators for resilience; used global database |
|                               | Tool available online, http://www.oceanhealthindex.org/methodology/ 221 regions, including all coastal countries, territories and the Antarctic                                                                 |

UI BlueMetric is a series of indicators that describe the seawater condition which is monitored from a series of evaluation processes involving the community and government as policymakers. This tool pointed out the importance of knowledge related to environmental sustainability issues in coastal areas and ocean. A summary of the categories and indicators that are used in the UI BlueMetric is provided in this paper. The Indicators of UI BlueMetric consists of Biodiversity, Water Quality, Waste, and Human Activity [12].

UI BlueMetric assessment is based on an online survey. Each parameter in the questionnaire has five options which indicates the condition i.e. very bad, bad, neutral, good and very good. These numerical representations will be calculated to get an overall score, except for the human activity category. The water quality category parameters are based on the State Minister of Environment Decree No. 51/2004: Seawater Quality Standard [13].

Puget sound Partnership which has six recovery goals are expressed with 52 Puget Sound Vital Sign indicators. The evaluation is represented as differently labelled circles for “progress” which tell how the changes relative to a point back in time and “status” which shows the vital signs as whether or not they meet their 2020 targets [6].

Ocean Health Index has 10 goals and 62 components. The score of OHI is unique and only could be compared to the same region area and the area itself over time [14]. The OHI score calculated the average of the Present Status and Likely Future Status (Pressures and Resilience factors and the Trend of the Status) [15]. Overall, OHI has the most comprehensive indicator of all the factors affecting the sustainability of the marine. However, how weight should be given to the various OHI objectives to
reflect priorities is unclear [16]. Some country or area adopted the OHI assessment and add some rule or the calculation such as penalty point [17], and change some goal, sub goal and the definition [16]. Two out of the three tools of seawater evaluation we evaluated, are based on methods that convert information into a simple score and published them as a rank, i.e. Ocean Health Index and UI BlueMetric. On the other hand, Puget Sound Partnership presented the state as a labelled circle for showing their progress and status. The comparison of the indicator from the UI BlueMetric, Puget Sound Partnership, and Ocean Health Index will be presented in this section. The comparison of these 3 tools is depicted in Table 2. Thus, a systematic review of the seawater evaluation tool was conducted in this study which is based on the following requirements:

a) evolved particularly for evaluating the result of sustainability enforcement in coastal area and ocean;

b) including no less than two of the various aspect of sustainability implementation in coastal area and ocean (i) biodiversity; (ii) seawater quality; (iii) waste; (iv) tourism; (v) fisheries; (vi) community;

c) including no less than two of the sustainability pillars (environmental, social, and economic).

| BlueMetric                  | Puget Sound Partnership                              | Ocean Health Index                  |
|-----------------------------|------------------------------------------------------|-------------------------------------|
| **Biodiversity-Natural Ecosystem** | **Healthy Human Population**                         | **Food Provision**                  |
| Fish                        | Air Quality                                          | Wild Caught Fisheries               |
| Total area of coral reefs   | Drinking Water                                       | Mariculture                         |
| Coral reef condition        | Local Foods                                          | Artisanal Fishing Opportunities     |
| Mangrove density            | Onsite Sewage Systems                                 | Natural Products                    |
| Seagrass                    | Outdoor Activity                                     | Carbon Storage                      |
| Makrozoobentos              | Shellfish Beds                                       | Coastal Protection                  |
| **Water Quality**           | **Vibrant Human Quality of Life**                    | Tourism & Recreation                |
| Turbidity                   | Cultural Wellbeing                                   | Coastal livelihoods & Economies     |
| Total Suspended Solids (TSS)|                                               | Economies                           |
| pH                          | Economic Vitality                                    | Livelihoods                         |
| Salinity                    | Good Governance                                      | Sense of Place                      |
| Dissolved Oxygen (DO)       | Sense of Place                                       | Sound Stewardship                   |
| Biochemical Oxygen Demand   | **Thriving Species and Food Web**                   | **Thriving Species and Food Web**   |
| (BODs)                      | Birds                                                | **Thriving Species and Food Web**   |
| Free ammonia (NH3-N)        | Chinook Salmon                                       | **Thriving Species and Food Web**   |
| Total phosphate (T-P04)     | Orcas                                               | **Thriving Species and Food Web**   |
| Nitrate (NO3-N)             | Pacific Herring                                      | **Thriving Species and Food Web**   |
| Mercury (Hg)                | **Protected and Restored Habitat**                  | **Thriving Species and Food Web**   |
| Sulphide (H2S)              | Eelgrass                                             | **Thriving Species and Food Web**   |
| Surfactants (MBAS)          | Estuaries                                            | **Thriving Species and Food Web**   |
| Oil and grease              | Floodplains                                          | **Thriving Species and Food Web**   |
| Cadmium (Cd)                | Land Cover and Development                           | **Thriving Species and Food Web**   |
| Copper (Cu)                 | Shoreline Armoring                                   | **Thriving Species and Food Web**   |
| Lead (Pb)                   | **Abundant Water**                                   | **Thriving Species and Food Web**   |
| E-coliiform (fecal)         | Summer Stream Flows                                  | **Thriving Species and Food Web**   |
| Coliform (total)            | **Healthy Water Quality**                            | **Thriving Species and Food Web**   |
| **Waste**                   | Freshwater Quality                                   | **Thriving Species and Food Web**   |
| Total number of waste types | Marine Sediment Quality                              | **Thriving Species and Food Web**   |
| Type of waste               |                                                     | **Thriving Species and Food Web**   |
Total amount of waste
Spreading of waste
Trash can provision program
Existence of garbage patch

**Human Activity**
Industry
Transportation
Fisherman
Marine tourism

| Marine Water Quality | Toxics in Fish |
|----------------------|---------------|

3.2 *Biodiversity aspect*

Table 3 provides indicators which is related to Biodiversity – Natural Ecosystem in each seawater assessment tools. UI BlueMetric biodiversity category has six outcomes: the evaluation of fish, coral reefs, mangrove, seagrass and macrozoobenthos condition. In the PSP there are two indicators that are thriving species and food web which contain five outcomes. The outcomes are condition of birds, chinook salmon, orcas, pacific herring. The second indicator is protected and restored habitat with five outcomes that are eelgrass, estuaries, floodplains, land cover and development, and shoreline armoring. The third model, The Ocean Health Index (OHI) has four goals i.e. natural product; carbon storage; coastal protection; biodiversity. The outcomes are condition of ornamental fish, shells, fish oil, seaweed and plants, sponges, coral, mangroves, seagrass, salt marsh, sea ice, and coral reefs and condition of species: range maps and threat categories. The similarities are found in the outcomes being evaluated. Each model evaluates the fish, seagrass, coral reefs and mangrove condition. The differences are that OHI also has outcomes to evaluate ice areas such as sea ice, shells, sponges, seaweeds, and salt marsh. On the other side, PSP has some outcomes for monitoring birds, specific species of salmon, and land and feeder bluffs area.

**Table 3. Category and Indicator Comparison – Biodiversity Related.**

| BlueMetric | Puget Sound Partnership | Ocean Health Index |
|------------|-------------------------|--------------------|
| Biodiversity-Natural Ecosystem | Thriving Species and Food Web Protected and Restored Habitat | Natural Products Carbon Storage Coastal Protection Biodiversity |

3.2. *Water aspect*

The category of different seawater quality indicators can be seen in Table 4. The water category of UI BlueMetric evaluation tool contains eighteen parameters which covers physical, chemical, dissolved metal and biology. It refers to the standard of the Indonesian Ministry of Environment Decree No 51 of 2004. PSP has three goals (Healthy Human Population, Healthy Water Quality, and Abundant Water) which covers 6 parameters i.e. drinking water; summer stream flows; quality of freshwater; quality of marine sediment; quality of seawater; and toxicant in fish. On OHI, seawater quality related goal is the clean water which contain nutrients (nitrogen and phosphorus), pathogen (caused by sanitation, runoff of animal waste, and discharge from ships and boats), and chemical (oil, toxic metals and persistent organic pollutants) pollution components. In some conditions, heavy metals in the waters are still below the quality standard value but exceeded the standard value for the fish as a food product [18].

**Table 4. Comparison of category and indicator related to Water aspect.**

| BlueMetric | Puget Sound | Ocean Health Index |
|------------|-------------|--------------------|
| Water Quality | Healthy Human Population Healthy Water Quality | Clean Water |
3.3. Waste aspect

Waste related category in each assessment tools is presented in Table 5. Waste category on UI BlueMetric evaluates the type, amount, and the spreading of waste, as well as the existences of trash can and landfill. The second tools, Puget Sound Partnership has a so called ‘Healthy Human Population goal’. This goal also belongs to seawater quality related component, but there is one component that evaluate waste related aspect, which is the onsite sewage systems. This is similar to Puget Sound Partnership which have the same goal as as the seawater quality aspect. OHI has a goal on clean water that evaluate the trash pollution. Overall, all the three models evaluate all trash, whether they are dumped intentionally or unintentionally to the marine. The impact of the dumping can produce another pollutant which cannot be seen nor evaluated such as Hexabromodiphenyl, Pentabromodiphenyl ether, Gammexane and Chlordecone. This will be an addition of toxic that will be taken into account in the evaluation index system [19].

Seawater quality depends on the ocean ecosystem and can be assessed by the natural science components. However social components are also important in ocean sustainability [1]. Therefore, human activity related to this category should be included to the seawater assessment. The increase levels of pollution, pathogenic pollution, and disturbance to wildlife as a result of the increased human activities furthermore is exacerbated by climate change in the future [20]. An example of the human activity in the marine is the cage aquaculture in which the impact can be seen on the three most relevant parameters such as chlorophyll, salinity, and dissolved oxygen [21].

Table 5. Comparison of category and indicator related to Waste.

| BlueMetric       | Puget Sound                | Ocean Health Index |
|------------------|----------------------------|--------------------|
| Waste            | Healthy Human Population   | Clean Water        |

3.4. Human activity aspect

The comparison of the indicators related human activity category is depicted in Table 6. UI BlueMetric provides the evaluation result of the impact of industry, transportation, fisherman, and marine tourism activities into marine ecosystem. PSP assesses two human activity related goals i.e. Healthy Human Population (local foods, activity in outdoor, and shellfish beds) and Vibrant Human Quality of Life (cultural, economic, governance, sense of place, and sound stewardship). Some goals related to human activity in OHI are Food Provision (wild caught and mariculture), Artisanal Fishing Opportunities, Tourism & Recreation (status, size of population, competitiveness index, and direct contribution to employment), Coastal livelihoods & Economies (distribution of least concern and the list of iconic species; protected areas: coastline, coastal; and marine and sense of place)

Table 6. Comparison of category and indicator related to Human Activity.

| BlueMetric      | Puget Sound                          | Ocean Health Index                           |
|-----------------|--------------------------------------|----------------------------------------------|
| Human Activity  | Healthy Human Population              | Food Provision                                |
|                 | Vibrant Human Quality of Life         | Artisanal Fishing Opportunities               |
|                 |                                       | Tourism & Recreation                          |
|                 |                                       | Coastal livelihoods & Economies               |
|                 |                                       | Sense of Place                                |

UI BlueMetric have the least number of parameters or indicators to assess. Therefore, it is suitable for early assessment that needs a minimum budget. It is also the easiest method to be deployed by government or used by marine environment experts based on their understanding on the scoring mechanism. The Puget Sound Partnership has an indicator that are missing on other assessment tools,
which is Air Quality. Also, indicators in PSP is relatively specific to some species or condition. It is possible to consider that the assessment tool was created for the recovery of the Puget Sound area. OHI has the broadest scope of the evaluation aspect in order to be used globally, in which it could cover all types of areas including Antarctic. the use of the OHI assessment will adjust the area to be evaluated which means that it only uses the indicators found in that area and ignores the rest. Over all among the three tools assessed, the most important parameters or component to evaluate and monitor the seawater quality or marine ecosystem is the general condition of the coast. It cannot be denied that there are many differences in their indicators. Even though the parameters are available, some challenges in data collection process should be faced. The problems could be found in the finance, technology and knowledge requirements.

4. Conclusion
This paper compares UI BlueMetric to other seawater evaluation systems, i.e. Puget Sound, and Ocean Health Index. This paper concludes that all three evaluation systems have some similarities in their indicators related to measuring the seawater. These indicators include biodiversity inside the water (BlueMetric: Biodiversity-Natural Ecosystem; PSP: Thriving Species and Food Web and Protected and Restored Habitat; OHI: Biodiversity), quality of the water (BlueMetric: Water Quality; PSP: Healthy Water Quality; OHI: Clean Water), and human-related activity around the sea (BlueMetric: Human Activity; Puget Sound: Vibrant Human Quality of Life; OHI: Coastal livelihoods & Economies, Tourism & Recreation).

It can be concluded that the comparison result of some methodologies used for seawater quality evaluation shows that there exist some similarities. The intended users, the goals and missions, lead to the identified differences. This paper concludes that all of the three evaluation systems have some similarities in their indicators. UI BlueMetric have the least number of parameters so that it is suitable to be applied in early assessment.

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