Measurement of Indonesian Marine Health Index to Assess The Health of The Coastal Ecosystem of Tuban, East Java

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Abstract. The purpose of this study is to assess marine health on the scale of coastal water and reveal its potential to provide a benchmark for sustainable marine development activities in Tuban Regency. This study uses IKLI (Indeks Kesehatan Laut Indonesia) which is an OHI (Ocean Health Index) framework that has been modified according to the needs and the Indonesian environment. IKLI indicator used is adapted to the Tuban coastal environment. The results showed the overall IKLI value was 58 (out of 100) for the 2016-2020. IKLI value is based on 10 types of marine destinations, namely as a source of food (87), as a support for traditional fisheries (70), as a product of natural materials (65), as a source of livelihood and economy (90), as a provider of tourism and recreation services (80), based on the five objectives shows that the coastal ecosystem of Tuban contributes significantly to community livelihoods and the regional economy. The measurement of low-value IKLI for marine destination types as carbon storage (45), coastal protection (30), protection of species and iconic places (35); clean sea-water (33) and marine biodiversity (41) mean the coastal waters of Tuban with sandy beaches indicate the impact of sea-level rise and excessive activities in coastal areas causing pollution levels to increase.

1. Introduction

The potential of the marine economy and efforts to realize the archipelago as a maritime axis is not enough to rely solely on the territorial waters that are the jurisdiction of the Unitary State of the Republic of Indonesia [1]. Healthy sea conditions are also needed which are reflected in optimal environmental services and sustainable products produced by marine ecosystems for 3 (three) main things, namely meeting the basic needs of human life, fulfilling the nation's needs, and rolling the economy. Currently, almost all over the world, ocean conditions are facing a serious and very fragile threat to climate change. The decline in sea quality is caused by the increasing human needs from the sea, thereby increasing pressure on the utilization of marine resources. As is understood together, 70% of the earth's surface consists of oceans that provide benefits for humans and living things on earth. The World Economic Forum describes the importance of the sea for humans and living creatures on earth so that its existence needs to be protected from damage that results in the decline in the survival of biota that live in the sea. [2]

A healthy marine ecosystem must have a balance between nature and the surrounding community[3]. Human activities such as over fishing, marine resource exploration and marine pollution will have a significant impact on marine and coastal ecosystems in general and can reduce the carrying capacity of coastal and marine ecosystems in meeting the needs of their communities [4]. To realize a healthy marine ecosystem, it is necessary to evaluate all activities that can increase...
pressure on the use of marine resources. Therefore we need an assessment tool that can measure the condition of Indonesia's marine health, especially one that focuses on information related to the current and future conditions of Indonesia's oceans.

Several studies to determine marine health have been carried out with different objectives and from different perspectives, including assessing marine health for current and future interests using ten different objectives [3], assessing marine health with combining human and natural systems [5], modification of the natural environment with socio-economic activities [6]. Several marine health assessments for regional local areas, such as the coast of Antarctica [3], Brazil [7], Canada [8], Fiji [2], Shanghai[9] as well as areas along the Pacific coast of the United States states in Washington and California [10] and finally the city scale, for example in the Chinese coastal cities of Xiamen [11], Tianjin [12]. Based on this research, the OHI framework can guide marine health assessments from local to global scales. While those in Indonesia include DKI Jakarta[13]

The coastal waters of Tuban, which are part of the Indonesian territorial sea, are also expected to meet healthy sea conditions. The coastal waters of Tuban have an average low elevation coastal area and are among the most developed and densely populated areas [14], [15], and in recent years have experienced pressure from various human activities and natural physical influences [16]–[18] which greatly affects marine ecosystems. IKLI (Index Kesehatan Laut Indonesia) is an assessment tool that can measure the condition of Indonesian marine health and is an OHI (Ocean Health Index) framework that has been modified according to the needs and the Indonesian environment [1] The Marine Health Index is a marine area mapping activity to assess marine health and benefits for humans in social and economic aspects. Therefore, the purpose of this study is to assess the health of the sea at the scale of coastal waters and reveal its potential so as to provide a benchmark for sustainable marine development activities in Tuban Regency. Based on this index information, it is expected to build awareness and provide information to the local government of Tuban Regency and East Java Province in formulating and determining policies that promote healthy seas.

2. Materials and Method
2.1 Study Area
Tuban Coastal Waters with a coastline of 65 km with an administrative sea area, namely the territorial sea, which is at a limit of 4 miles from the coastline. Along the coast there are human activities that can put pressure on the utilization of marine resources, such as the activities of fishing ports, industrial ports, coastal tourism, marine cultivation, and several other activities [18].

2.2 IKLI (Indeks Kesehatan Laut Indonesia)
The IKLI indicator is an estimated value calculated based on ten main targets or objectives, namely:

1. The sea as a source of food;
   Healthy seas are expected to produce quality products that are safe for human consumption. Fishery resources as a food source need to be used responsibly with sustainable principles. Therefore, there are 4 (four) variables that become benchmarks in assessing the sea as a food source, including: a) capture fisheries production; b) production of aquaculture and ponds; c) fish consumption per capita;

2. Business and work opportunities for traditional (artisanal) fisheries;
   Artisanal fisheries are fishing and aquaculture activities that are primarily carried out for the purpose of fulfilling household consumption. In many cases in Indonesia, artisanal fishery activities have a marketable surplus for household income. Artisanal fishing is carried out by individuals or families using traditional technology or on a small scale. Usually, artisanal fisheries utilize fish resources that are managed or jointly regulated by the community or traditions that have been passed down from generation to generation by customary law. There are at least 5 (five) variables that are derived from the objectives of Artisanal Fisheries, including: a) opportunities to work and engage in capture fisheries; b) opportunities to work and do aquaculture business; c) opportunity to work and do fish processing business; d) fisherman's exchange rate; and e) fishermen's access to capital

3. The sea as a source of natural products;
In IKLI, this objective will measure the amount of production of 3 (three) natural products whose existence is very important for local economic development and international trade. As for the 3 (three) natural products referred to as variables that can determine the value of this goal, among others: a) the production of salt as raw material; b) seaweed production

4. The sea as a carbon store;
This objective measures the extent and condition of natural coastal ecosystems such as seagrasses, swamps, and mangroves that contribute to carbon storage. As is well known, seagrasses and mangroves store large amounts of carbon in their roots, stems and leaves, which are then absorbed over decades or centuries in sediments. Therefore, this objective consists of 2 variables: a) non-critical mangrove area; and b) the area of seagrass beds.

5. Coastal protection;
This goal is carried out to be able to measure the condition and extent of the four an ecological habitat that can protect the coast against high waves, storms, high tides, and even tsunamis. The habitats that will be focused and assessed are mangrove forests, seagrass beds, salt marshes, tropical reefs and corals. The protection of the coast from extreme weather changes provides protection for coastal communities and their assets. The variables considered to be used as indicators in the IKLI assessment in coastal protection are (1) the width of the coastal border, (2) the area of Marine Conservation Areas/National Marine Parks, and marine nature reserves (KKPD, KKNP, National Parks), (3) reef conditions moderately good, good and very good coral reefs, (4) rehabilitation of mangroves, and (5) rehabilitation of seagrass beds, coral reefs, and coastal vegetation

6. The sea as a source of livelihood and economy;
Coastal communities and surrounding coastal areas rely on the sea as a livelihood and economic source from the sea and coastal areas. Employment and income generated from marine-related industries directly benefit those who work, but also have substantial indirect value for community identity, tax revenues, economic and social aspects of a stable coastal economy. As a source of livelihood for people in coastal areas, of course, the assessment of this goal does not only measure how much labor absorption in coastal areas is in managing marine and fisheries, but this goal also includes the economic value generated from industrial or trade activities in the marine sector. Therefore, the variables that represent this objective include: a) the value of fishery exports; b) Fishery GDP; c) Marine and Fisheries Community Welfare Index (KMKP); and d) Maritime GDP.

7. The sea as a provider of tourism and recreation services;
Maritime tourism as a coastal and marine tourism activity is an important part of the Indonesian economy. This objective is to measure the total proportion of workers engaged in the tourism and coastal tourism sector, taking into account unemployment and its sustainability. In addition, the sea as a tourist destination will also make a significant contribution to tourism GDP and tourism foreign exchange value. This can be realized if there are enough marine tourism destinations that are attractive to foreign tourists and domestic tourists. Variables that describe the health of Indonesian marine conditions in the IKLI assessment are calculated from a) the number of marine tourism destinations; b) the number of domestic tourists; c) number of foreign tourists; d) percentage of tourism GDP contribution; e) tourism foreign exchange value; and f) employment in the tourism sector.

8. Protection of iconic species and places;
The purpose of including the protection of iconic species and places is to appreciate the efforts of coastal communities in maintaining the existence of protected species and iconic places. The existence of protected species and iconic places in coastal areas is one indicator that marine health in the area still has good carrying capacity and a healthy environment. Variables of protection of iconic species and places consist of: a) endemic species; b) utilization of the outermost islands marked by the existence of K/L and Regional Government programs; and c) the toponym of small islands.

9. Clean waters;
This purpose is carried out to determine how clean the waters are indicated by measuring chemical contamination, excess nutrients (eutrophication), human pathogens and waste. In this objective there are 2 (two) variables that represent the assessment of clean waters, including: a) Seawater Quality Index (IKAL); and b) the number of seaports that implement Green Port and plastic waste management.

10. Marine biodiversity.

This goal was chosen to be able to provide an estimate of the level of success in maintaining and protecting the wealth and diversity of marine life globally. As is known, the sea is home to millions of species of fish and other biodiversity. Biodiversity of species in the sea is one indicator of marine health. As one of the goals of IKLI, 4 (four) variables to measure the health of Indonesian seas through biodiversity are (1) fish species, (2) mangrove species, (3) coral species, and (4) seagrass species.

The Variables, Indicators and References of IKLI Targets/Objectives can be seen in Table 1

| No | Purpose/Goal | Variable | Indicator | Reference |
|----|--------------|----------|----------|-----------|
| 1  | The sea as a source of food; (XSP) | Capture Fishery Production | million tons/year | Number of catches allowed (80% MSY) |
|    |              | Marine Cultivation and Pond Production | Million tons/to Total production of Marine Cultivation and aquaculture |
|    |              | Fish consumption per capita | Kg/capita/year | RJPMD targets |
| 2  | The sea as a support for traditional fisheries (XPA) | Opportunities to Work and Try to Capture the Number of RTP | Number of Fisheries RTP | BPS Tuban |
|    |              | Opportunity to work and aquaculture business | Number of RTP Cultivation | RJPMD targets |
|    |              | Opportunity to work and do fish processing business | Number of RTP Processing | RJPMD targets |
|    |              | Fisherman's Exchange Rate | Index | RJPMD targets |
|    |              | Fishermen's Access to Capital | Million /year | RJPMD targets |
| 3  | The sea as a product of Natural Ingredients (XBA) | Production of salt as raw material | Million Tons/year | RJPMD targets |
|    |              | Seaweed Production | Million Tons/year | RJPMD targets |
| 4  | Ocean as a Carbon Store (XRK) | Uncritical Mangrove Area | Million Ha | Mangrove area of Tuban Regency |
|    |              | Area of Seagrass | Ha | Area of Seagrass Fields in Tuban Regency |
| 5  | The Sea as Coastal Protector (XPP) | The width of the beach border | | |
|    |              | Area of Marine Protected Areas/ Marine National Parks and Marine Nature | Million Ha | RJPMD targets |
| Table 1                                                                 | Column 1                                                                 | Column 2                                                                 | Column 3                                                                 |
|------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Reserves                                                               | 5.3 Percentage of Coral Reef Conditions that are quite Good and Very Good | Percentage                                                              | Live Coral Reef Area                                                      |
|                                                                       | 5.4 Mangrove Rehabilitation                                               | Ha                                                                      | RJPMD targets                                                            |
|                                                                       | 5.5 Rehabilitation of seagrass beds, coral reefs and coastal vegetation   | Location                                                                | RJPMD targets                                                            |
| 6 The Sea as a Source of Livelihood (X_{LL})                           | 6.1 Fishery Export Value                                                 | billion/th                                                              | RJPMD targets                                                            |
|                                                                       | 6.2 Fishery GDP                                                          | Contribution to National GDP (%)                                       | RJPMD targets                                                            |
|                                                                       | 6.3 Percentage of Coral Reef Conditions Sufficient, Good and Very Good    | Contribution to National GDP (%)                                       | RJPMD targets                                                            |
|                                                                       | 6.4 Maritime GDP                                                         | Contribution to National GDP (%)                                       | RJPMD targets                                                            |
| 7 The Sea as a Maritime Tourism Destination (X_{WB})                    | 7.1 Marine Tourism Destinations                                           | Number of Destinations                                                  | RJPMD targets                                                            |
|                                                                       | 7.2 Archipelago Tourist                                                  | million trips                                                          | RJPMD targets                                                            |
|                                                                       | 7.3 Foreign Tourist                                                      | Million visits                                                         | RJPMD targets                                                            |
|                                                                       | 7.4 Tourism GDP Contribution % of National GDP                           |                                                                         | RJPMD targets                                                            |
|                                                                       | 7.5 Tourism foreign exchange value                                       | billion/th                                                             | RJPMD targets                                                            |
|                                                                       | 7.6 Employment of Tourism Sector                                         | Number of people                                                       | RJPMD targets                                                            |
| 8 The Sea as Protector of Species and Iconic Places (X_{SI})            | 8.1 Endemic Species Based on CITES                                       | Number of Species that already have a protection management plan        | Peraturan Pemerintah No 8 Tahun 1999 tentang jenis Tumbuhan dan Satwa [19] |
|                                                                       | 8.2 Utilization of outer islands is marked by K/L and local government programs | Total utilization of outer islands                                      | Keppres No 6 Tahun 2017 [20]                                             |
|                                                                       | 8.3 Toponymy of Small Islands                                            | Number of islands                                                      | Nota Diplomatik Pemerintah RI                                            |
| 9 The sea as clean waters (X_{PA})                                     | 9.1 Seawater Quality Index (IKAL)                                        | Index                                                                   | [21]                                                                    |
|                                                                       | 9.2 Number of seaports implementing the Green Port and Plastic Waste Management program | Green Port Program from the Coordinating Ministry for Maritime Affairs | Dirjen Perhubungan laut Kementerian Perhubungan                          |
| 10 The sea as a supporter of biodiversity (X_{KH})                     | 10.1 Fish species (including molluscs and crustaceans)                   | Amount                                                                 | [22]                                                                    |
|                                                                       | 10.2 Mangrove species                                                    | Amount                                                                 | [23]                                                                    |
|                                                                       | 10.3 Coral species                                                       | Amount                                                                 | [24]                                                                    |
2.3 IKLI Calculation Method
Modification in IKLI is very possible because the social and tropical environmental dimensions in the archipelago have their own uniqueness. Sustainability aspects require two conditions at once, namely considering the current status and trends in future changes. There are 10 goals that serve as a methodical reference, as well as those that are used to set baselines, measure changes over time, and can be used as controlling factors that ensure recovery and conservation efforts.

healthy marine ecosystem. The index calculation method for each destination is in accordance with the IKLI formula issued (coordinating minister, 2020). Sections should be numbered with a dot following the number and then separated by a single space:

| No | Purpose/Goal | Formulation IKLI | Parameters used |
|----|--------------|-----------------|-----------------|
| 1  | The sea as a source of food; (XSP) | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | XSP = Destination of the sea as a food source based on 4 variables |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | XSP = sub-destination of food sources from capture fisheries |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | XSPB = sub-destination of aquaculture food sources |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | XSPK = food source sub-destination based on fish consumption figures |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | XSPA = food source sub-destination regarding product safety |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | w = variable weighting |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | SS = total allowable catch allocation |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | Yc = total crop yield |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | k = superior commodity of aquaculture and ponds |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | S_m,k = sustainability score for each commodity |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | Ac = area of coastal area where cultivation & ponds are located (within 3 nautical miles) |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | AKI = Fish Consumption Rate |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | KRT = household consumption |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | KLR = consumption outside the home |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | KTC = unrecorded consumption |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | p = province |
|    |              | XSP = (w (XSP + XSPB + XSPK)) + ((1-w) XSPA) | e = variable score (number of ships with logbooks/ports) |
2. The sea as a support for traditional fisheries (\(X_{PA}\))

\[ X_{PA} = \sum_{i} e_{ir} * b \]

- \(r\) = variable reference data
- \(t\) = year of measurement

\(X_{PA}\) = Traditional (artisanal) fisheries goals based on 5 variables

\(e\) = variable score
\(r\) = reference data for each variable
\(t\) = year of measurement
\(b\) = weighting for each habitat type

3. The sea as a product of Natural Ingredients (\(X_{BA}\))

\[ X_{BA} = \sum_{i} e_{it} * b \]

- \(r\) = variable reference data
- \(t\) = year of measurement

\(X_{BA}\) = Purpose of natural ingredients refers to 2 variables

\(e\) = variable score
\(r\) = reference data for each variable
\(t\) = year of measurement
\(b\) = weighting of each variable

4. Ocean as a Carbon Store (\(X_{RK}\))

\[ X_{RK} = \sum_{i} \left( \frac{A_{ki}}{A_{KR}} \right) * OC \]

- \(r\) = atmospheric carbon sink objective based on 3 ecosystem variables
- \(A_{KR}\) = reference area for each habitat type
- \(A_{ki}\) = area of habitat type in year \(i\)
- \(k\) = habitat type/ecosystem
- \(b\) = weighting for each habitat type

5. The Sea as Coastal Protector (\(X_{PP}\))

\[ X_{PP} = \sum_{i} \left[ \log \left( \frac{A_{SP} A_{KK}}{A_{KR}} \right) + P_{TK} \right] * OC \]

- \(a\) = \(\sqrt{\sum_{i} A_{KR}}\)
- \(t\) = year
- \(A_{SP}\) = area of coastal border
- \(A_{KK}\) = area of conservation area
- \(A_{KR}\) = area of rehabilitation area
- \(P_{TK}\) = mean coral reef cover with minimal condition sufficient
- \(a\) = weighting for rehabilitation area
- \(KK\) = Number of Conservation Areas
- \(KR\) = Number of Rehabilitation Areas

6. The Sea as a Source of Livelihood (\(X_{LL}\))

\[ X_{LL} = \left( \sum_{i} e_{cb} * b \right) + 1 \]

- \(r\) = variable reference data
- \(t\) = current year
- \(S\) = measure/sustainability control factor

\(X_{LL}\) = Goals based on 4 livelihood and livelihood variables

\(e\) = variable value
\(c\) = variable score
\(b\) = variable weight
\(t\) = current year

7. The Sea as a Maritime Tourism Destination

\[ X_{WB} = X_{WB1} + X_{WB2} + X_{WB3} + X_{WB4} \]

- \(X_{WB1}\) = Value of group of variables marine tourism

- \(X_{WB1}\) = \(n\)

\(X_{PB}\) = Goal based on 4 variable group
The Sea as Protector of Species and Iconic Places

(XWB)

\[ X_{WB2} = \sum^{c} e_{c,b} \]
\[ e_{Tou} = \left( \frac{D_{v} + D_{t}}{V_{t}} \right) \cdot S_{t} + 1 \]
\[ X_{WB3} = \left( \sum^{k} e_{t,k} \right) \cdot e_{Rc\%} \]
\[ e_{Rev} = \sum^{k} \left( R_{D,k} \cdot m_{k} \right) \]
\[ X_{WB4} = E_{t} \cdot S_{t} \]
\[ e_{Lab} = \frac{E_{WTC}}{L_{t} - \left( L_{T} + U_{T} \right)} \]

n = tourist destination (7.1)
e = variable value
c = variable score
b = variable weight
t = current year
r = data/reference year
\( e_{Tou} \) = visits and trips to tourist destinations nautical (7.2 & 7.3)
\( D_{v} \) = number of days in the area tourist destination
\( D_{t} \) = number of trips from/in tourist destinations
\( V_{t} \) = total population in the area tourist destination
S = Control factor continuity
\( e_{Rev} \) = state revenue/foreign exchange value of the sector marine tourism (7.5)
\( e_{Rc\%} \) = GDP contribution from sector marine tourism (7.4)
\( e_{Lab} \) = employment (NT 4=7.6)
\( R_{D} \) = direct income from marine tourism sub-sector
\( m_{k} \) = additional income indirectly, as continued impact marine tourism
\( E_{WTC} \) = Number of workers in marine tourism sector and travel agency
L = total workforce
U = percentage/number unemployment

8 The Sea as Protector of Species and Iconic Places (XSI)

\[ X_{SI} = \sum^{t} e_{c,b} \]

\( X_{SI} \) = Goal of protecting iconic species and places based on 3 variables
k = protection variable iconic species and places
e = variable value
c = variable score (number of endemic species, outer islands, and toponyms)
b = variable weight

9 The sea as clean waters (XPB)

\[ X_{PB} = X_{IKAL} + X_{PLGP} \]

\( X_{PB} \) = Destination for clean waters
\( X_{IKAL} \) = Value of seawater quality index variable
\( X_{PLGP} \) = Variable value of Seaports
The basic principle of the IKLI estimation method is to calculate the cumulative index of all objectives, variables or indicators. However, IKLI can also be estimated for each destination or for a cluster of objectives. The usual practice is to calculate the index for the three target clusters. The steps for calculating the IKLI are as follows:

1. Calculating the index for each indicator i.e. the present value divided by the value or reference point. The index of each of these indicators needs to be calculated also in previous years to understand its development. The goal is to predict trends in the years to come.

2. Reference points or values can be in the form of: 1) Values that are normatively determined by the government either through regulations or program and policy targets. These normative values can be in the form of development targets set in the form of certain regulations or legal products. The target in the RPJM or Renstra is a measurable and definite reference for a five-year period. 2) Resulting from a stochastic or deterministic analysis. For example, the calculated fish potency values (MSY and JTB) are obtained through statistical analysis. 3) Taken from the same indicators from other regions or countries, for example the number of Indonesian fish species that can be projected with the number of fish species in the waters of the eastern Indian Ocean. 4) Resulted from trend analysis of the previous period's data.

3. Aggregate IKLI estimation is done by giving weights to 10 goals. The basic scenario of weighting is that each goal has the same value, which is 10%. The weighting scenario may change, depending on the policies and conditions of each country or region. For example, the socioeconomic development scenario gives relatively greater weight to socioeconomic goals. Conservation scenarios give more weight to biological and ecological goals.

4. The weighting of each goal is followed by the weighting of each indicator on each goal. For example, if the goal of the Sea as a Food Source (Goal-1) has four indicators, then each indicator is assigned a relative weight, the total weight of the four indicators must be 10%.

5. Based on the calculation of the index for each destination in Table-1, the IKL is the sum of the indexes of all destinations, namely:

\[ \text{IKL} = X_{SP} + X_{PA} + X_{BA} + X_{RK} + X_{PP} + X_{LL} + X_{WB} + X_{SI} + X_{PB} + X_{KH} \]  \hspace{1cm} (1)

At this initial stage, the estimated IKLI is static IKLI, which means that the dynamics of the relationship between goals and variables have not been considered. However, the dynamic IKLI needs to be estimated to determine the interrelationships and dependencies between variables. Thus, it is possible to know the variables and objectives that need or can be intervened in order to have a greater impact. The dynamic IKLI is estimated by considering the following: Pressure and resilience of each variable. Pressure is a factor that negatively affects or decreases its value. Independence is a factor that positively affects or boosts its value.

a. Analysis to understand the trend of variable values in the future.
b. Analysis of interdependence and causality between variables.

### Results and discussion

The economic potential that can be utilized from the Tuban marine waters includes capture fisheries activities, aquaculture activities as a source of food, employment and business opportunities, and
sources of foreign exchange. Fish resources are the main source of economic driving for coastal villages and providers of animal protein, besides that they have various potentials that can provide economic benefits for the community and government through the provision of jobs, the fishing and marine industries with all their derivatives. The country’s foreign exchange income is through the export of fishery commodities and marine products such as marine tourism, and trade traffic such as coal barge traffic. Several other potentials are obtained from the ocean, namely metabolites and bioactive ingredients from various marine species that support the development of the marine biotechnology industry and research by academics.

However, at this time the potential of the sea still cannot be utilized optimally by the marine and fishery industry business actors in Tuban Regency. This condition is due to the low level of infrastructure and capital support for the development of the marine and fishery industry. On the other hand, the growth of the fishing industry that has utilized fish resources has an impact on decreasing catches, loss of economically important fish stocks, damage to fish habitats, ecosystem pollution, and the phenomenon of overfishing due to illegal, illegal, and unreported fishing practices. The management of sea and land space that does not consider the interconnection of water flows and anthropogenic pressures has also added to the burden on the health of the ocean ecosystem.

The results showed the overall IKLI value was 58 (out of 100) (Figure 1). The IKLI value is based on 10 types of marine destinations, namely as a source of food (87), as a support for traditional fisheries (70), as a product of natural materials (65), as a source of livelihood and economy (90), as a provider of tourism and recreation services (80). Based on the five objectives shows that the coastal ecosystem of Tuban contributes significantly to community livelihoods and the regional economy. Low IKLI measurement value for marine destination types as carbon storage (45), coastal protection (30), protection of species and iconic places (35); Clean waters (33) and marine biodiversity (41).

![Figure 1. IKLI assessment with 10 objectives for the sea waters of the Tuban](image-url)

The purpose of this IKLI-based marine health assessment for Tuban Waters is not only to use local data to obtain a more accurate assessment, but also to explore the application of the OHI framework at
the city level more broadly. Adjustment of destination parameters and reference values for specific purposes is required due to local conditions and limited data availability. The range of IKLI scores for each destination has various values, some of which have a score above the overall goal score (58), namely the sea as a food source (87) and as a livelihood for coastal village communities (90) and as a supporter of traditional fisheries (70). This condition can also be shown that 90 percent of the coastal communities of Tuban Regency are fishermen and in the fisheries and marine sector (fish processing industry, aquaculture, marine tourism), the fishing model is carried out starting from one day fishing or weekly fishing. The fishing gear used is also still traditional, starting from fishing rods, trap traps, gill nets, cantrangs, and the size of the boat is still below 30 GT. High scores on these 3 objectives indicate the fishing and marine industry in Tuban brings high benefits in terms of employment and economic income.

The high value for the sea as marine tourism Tourism and Recreation (80) supports the conclusion that Tuban beach visitors enjoy the beauty of the beach, it is proven that there are 13 marine tourism both managed by coastal villages and the government of Tuban. Tourism has become a policy focus for the Tuban government, where the Village can increase its own income through the Bumdes development fund

The quality of the sea waters of Tuban (33) shows that 75% of the population of Tuban Regency is in the coastal area with various economic activities in the coastal area[18] in addition to increasing marine tourism managed by each coastal village, where in Tuban Regency there are 13 village areas that used as marine tourism adds to the burden of marine pollution. The water area unit (SWP) of Prumpung Klero Tuban (with 17 watersheds) which empties into the sea[26] which greatly affects the entry of pollutants from land. Marine pollution is an important and urgent task for the government which must cooperate with other cities to control upstream problems [11] The sea as a coastal protector (30), this is shown in the sandy and sloping beach conditions so that the impact of sea level rise, namely the decline of the coastline is very visible [18], [27], and not all beaches are protected which results in landslides and erosion [28] and indications of seawater intrusion [29]

Assessment of marine health must be carried out on an ongoing basis. The ten objectives of the IKLI research index can be adapted to the existing water conditions in Indonesia. Local supporting data is needed to find out the trends that will occur. The completeness of the data is very helpful in the accuracy of the assessment results [30], and also provides information and incentives for future data collection[31]

4. Conclusions
Measurement of the Marine Health Index is a strategic step that can be applied by each local government that has marine and coastal areas in photographing, updating data, and analyzing it integrally to become an index of the success of development governance of the area in managing the sea and its coasts so that they are healthy globally, environment, and provide sustainable economic and social welfare benefits for the community. By updating this index regularly, for example every 5 (five) years, the marine and coastal governance of each region/province will be properly monitored, measured and evaluated. The aggregation of regional/provincial IKLI achievements will reflect Indonesia's marine health as a whole. This means that the more regions/provinces that have a good Marine Health Index, the Indonesian Marine Health Index will also increase. So that IKLI with 10 (ten) major goals can reflect the contribution of the development of the marine and fisheries sector or the maritime development sector as a whole, so that in the future it may be proposed as one of the new indicators to measure the success of national development.

5. References
[1] Kemenko marves, Biro Perencanaan Kementerian Koodinasi Bidang Kemaritiman dan Investasi dalam Pedoman Pengukuran Indeks Kesehatan Laut Indonesia. 2020.
[2] Selig E R, Frazier M, O’Leary J K, Jupiter S D, Halpern B S, Longo C, and Ranelletti M 2015 Ecos Serv. 16 403-412.
[3] Halpern B S, Longo C, Hardy D, McLeod K L, Samhouri J F, Katona S K, and Zeller D 2012 Nat 488(7413) 615-620.
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