A feasibility study of seabed cover classification standard in generating related geospatial data

Dewayany Sutrisno, Rizka Windiastuti, Nadya Octaviani and Aninda W. Rudiastuti

Badan Informasi Geospasial - Division of Research, Center for research, promotion and cooperation, West Java, Indonesia

ABSTRACT
This article assesses the feasibility of generating the geospatial data from a national classification standard. In this case, the National Standardization Agency (Badan Standardisasi Nasional) of Indonesia created and published a national seabed cover classification standard called SNI 7987–2014 but has not developed corresponding geospatial data. Geospatial data on seabed cover can be generated by integrating related thematic data, such as those on seafloor surficial sediments, coastal ecosystems, and coastal infrastructure. With consideration for these issues, this research evaluated the feasibility of using SNI 7987–2014 as a means of generating seabed cover geospatial data at scales of 1:250,000 and 1:50,000. To this end, the documentation accompanying the standard was evaluated via descriptive quantitative analysis through weighted scoring, and logical testing, after which overlay, feature selection based on the scored method and remote sensing analysis were carried out to develop the geospatial data prototypes. Results showed that the feasibility levels of using the prototypes for generating data at scales of 1:250,000 and 1:50,000 were 87.5% and 86.5%, respectively, indicating that SNI 7987–2014 can be fully used as the basis for generating geospatial data on seabed cover.

1. Introduction
As an archipelagic state, Indonesia accords priority to marine development, thereby prompting the country’s president to unveil the maritime axis concept as a means of reinvigorating Indonesia’s identity as a maritime nation and boosting its maritime sector (Sambhi 2015; Hidayat and Ridwan 2017). The prioritization of marine development is also served by the launch of the sea toll road program, which is designed to integrate Indonesia’s marine logistics system for the purpose of advancing the national economy (Wicaksana 2017). The implementation of these initiatives requires accurate marine data, such as Geospatial Data (GD) on seabed cover.

In the Indonesian context, the availability of GD is guaranteed by the government through the establishment of a one-map policy designed to advance the interoperability, exchange, and ease of multi-layer analyses. The one-map policy program is underlain by four main pillars, namely, a reference system, a standard, a database, and a geoportal (http://tanahair.indonesia.go.id). The development of the national geoportal offers public easy access, share, and download of GD. Online data sharing, however, is efficient only when data are sufficiently described in related standards systems (Fredericks and Botts 2018).

Concerning the importance of standard for generating geospatial information (Genderen 2017), the government of Indonesia, through the National Standardization Agency [Badan Standardisasi Nasional (BSN)], regularly issues various national standards (known as SNI) as a reference and as a requirement for producing certain GD. One of the standards that have been published by BSN is SNI 7987–2014, which is a guideline on the classification of seabed cover (BSN 2014). Seabed cover classification is an essential part of current coastal studies because it enables the characterization of the seabed and the habitats found on them (Lee, Acharya, and Lee 2017). Despite the value of classification standards, however, these guidelines remain meaningless without their conversion into GD. In this regard, the challenges that have yet to be addressed in Indonesia are how to use SNI 7987–2014 as a means of generating seabed cover GD on the basis of integrated marine data and the incorporation of the GD overseen by custodians into the national geoportal.

Seabed mapping has been conducted for years to ensure the effectiveness with which information is provided regarding the geologic characteristics of the seabed, the benthic habitats, and the sediment dynamics at different spatial scales. Many researchers generated seabed cover maps only on the basis of seabed objects. Todd and Kostylev (2011), Shaw, Todd, and Li (2013) and Henrique et al. (2014), for example, mapped seabed by referring to benthic habitats as a basis and using a geological approach. These studies did not map sea cover as a whole at the surface, column, and seabed levels, as mandated by SNI 7989–2014. In this standard, the term “seabed” also
encompasses objects on the sea surface, sea column, and sea bottom. Thus, classifications based on SNI 7989–2014 include natural features (abiotic and biotic) and unnatural features (cultural or man-made).

In view of the above-mentioned issues, the present research evaluated the feasibility of using SNI 7989–2014 as a means of generating seabed cover GD at scales of 1:250,000 and 1:50,000 on the basis of integrated marine data that are overseen by member custodians of Indonesia’s national geoportal. The challenges that confront this initiative are that the target database geometry has not been determined and that the issue of who should serve as data custodians of seabed cover maps is still disputed and therefore requires further evaluation. Indeed, this evaluation also assists the GD custodians to improve the lack of seabed cover elements on the current-related GD.

2. Methods

The item for assessment was SNI 7987–2014, in which classifications are divided into groups (natural and unnatural elements), sub-groups (abiotic and biotic features, marine cultures, and man-made areas), and classes (Tables 1 and 2).

And the study area respecting the scales was illustrated in Figure 1, which is located in the 5°10′00″ S, 106°31′00″ E to 6°10′00″ S, 107°44′30″ E.

Through this standard, the process of generating the seabed cover GD was as follows:

2.1. Evaluation of SNI feasibility

As the first step in the research, the feasibility of SNI 7987–2014 as basis for generating seabed cover GD was determined using weighted scoring and logical testing, which were carried out through focus group discussions with marine spatial data custodians and researchers concentrating on three classification areas of the standard (biotic, abiotic, and man-made). The focus group discussions were meant to evaluate data acquisition from the custodians and research on marine spatial data against SNI elements on the seabed, sea column, and sea surface. In this case, researchers and practitioners of marine data custodians, such as Marine Geological Institute, Naval center for Hydrography and Oceanography (Pushidrosal), the technical center of Geospatial information agency, such as The Center for Topographic mapping and geographical names, The Center for marine and coastal areas mapping and The center for thematic integration mapping, The center for oceanographic research – Indonesian Institute of science and ministry of marine and fisheries Republic of Indonesia – participated in the group discussions. The total group discussion participants were 20 persons each discussing the geospatial data and the associated availability of scale, the marine elements available on these data sets and the form of the spatial database of these elements, and the definition of each element against the SNI elements. Weighted scoring was used to overcome the integration of semantic heterogeneity among GD custodians and the availability of the nature of seabed. The problems of integrated semantic heterogeneity always occur in online data sharing processes as stated by Genderen (2017) and Bermudez (2017).

The formula used for the SNI feasibility evaluation is

\[ n_{i,y} = \frac{\sum (w_1 s_1 + \ldots + w_s s_s)}{x} \]

where \( n \) denotes the feasibility of SNI 7987–2014, \( i, y \) stands for map scales \( i \) to \( y \), \( w \) represents the weight, \( s \) indicates the score, and \( 1 - x \) represents seabed elements.

The logical test was intended to evaluate the correctness of the spatial database geometry (i.e., polygonal, line-based, and point-based) for every class in the seabed cover classification. The logical test followed the condition “if (something is true, then do something; otherwise, do something else)” and can be formulated as

| Type | Name | Description |
|------|------|-------------|
| Natural elements – Abiotic | Rocks | Consolidate rock/reefs, uninterrupted, not fragmented at a certain distance, formed as outcrop, boulder, or canal |
| | Coarse-grained sediments | An unconsolidated substrate, derived from the rock of geomorphological process with uninterrupted pattern, coarse grain, size > 2 mm |
| | Fine-grained sediments | An unconsolidated substrate, derived from the geomorphological process with uninterrupted pattern, very fine to fine grain, size < 2 mm |
| | Mix-grained sediments | A consolidated and unconsolidated substrate, fine to coarse grain, forming the surface characteristic of flat, rippling, bumpy, or hilly |
| Natural elements – Biotic | Coastal wetland vegetation | Vegetation covers the wetland or tidal land area |
| | Underwater vegetation | Vegetation that adaptable to the marine environment |
| | Coral reefs | Clusters of various type of coral which may include a patch of seagrass or other substrates |
| Unnatural elements – Man-made | Transportation | Related to transportation activities or moving good or other facility and infrastructure depend on technology development |
| | Industry | Related to the infrastructure of exploration, process or management services and goods with certain facilities and gears |
| Unnatural elements – culture | Settlements | Object on the sea for residency |
| | Marine culture | Cultural activities within the sea waters to produce goods by utilizing marine resources |
Table 2. Elements of SNI 7987–2014 at the scale of 1: 50,000.

| Type                        | Name                        | Description                                                                 |
|-----------------------------|-----------------------------|-----------------------------------------------------------------------------|
| Natural elements – Abiotic  | Outcrops                    | Parent material emerges from the bottom of the sea                          |
| Pavements                   |                             | Flat reefs profile, lower, fine, associated with sandstone and limestone     |
| Channels                    |                             | The bottom of the canal that has been eroded as sedimented reefs             |
| Solid                       |                             | Reefs, not yet fragmented                                                   |
| Boulders                    |                             | Rock fragment with diameter > 256 mm. Characteristic of abrasion while transported |
| Cobble                      |                             | A clast rock with particle size 64–256 mm, typical of transported abrasion   |
| Fragmented reefs            |                             | The reefs that have been fragmented                                          |
| Gravel                      |                             | A loose aggregation of rock fragment with particle size 2–64 mm             |
| Sandy coral                 |                             | A loose aggregation of reefs with particle size 0.063–2 mm                  |
| Sand                        |                             | A loose aggregation of rock fragment, size 0.063–2 mm                       |
| Silt                        |                             | A loose aggregation of rocks, dominant from rubble, particle size 0.004–0.062 mm |
| Clay                        |                             | A finely-grained natural rock or soil material, sticky, particle size < 0.003 mm |
| Mud                         |                             | A liquid or semi-liquid mixture of water and any combination of loam, silt and clay, fine substrate |
| Others                      |                             | Not an organism of the surficial sea floor                                  |
| Natural elements – Biotic   | High density mangrove       | Mangrove with canopy density > 70%                                          |
| Moderately density mangrove |                             | Mangrove with canopy density 50% – 69%                                      |
| Low density mangrove        |                             | Mangrove with canopy density < 50%                                          |
| Seagrass                    |                             | Flowering plants (angiosperm), rooted, flowering and fruiting that grow in marine, fully saline environment and consist of one or more species. |
| Macroalgae                  |                             | Multi cellular plants, do not have metabolic ducts, various shape and colors, usually grow along the coastal area, attached to rocks, coral reefs, sand or stick to other plants or animal |
| Coral                       |                             | Seabed habitat structure formed from a deposit of calcium carbonate (CaCO₃) |
| Others                      |                             | An organism of the surficial sea floor                                       |
| Unnatural elements– Culture | Marine culture area         | The utilization area of marine resources, seaweed culture, pearl oyster culture, artificial reefs, wrecks etc. |
| Unnatural elements– Man-Made | Liftnet                    | A not permanent fish trap, which submerged, often attracted by light         |
| Waste                       |                             | Industrial or radioactive disposal areas, such as waste/disposal, mine waste and radioactive waste |
| Bridge                      |                             | Structure made to across rivers, straits, bay, railroad or roads            |
| Cables                      |                             | Equipment in the form of wire, wrapped in rubber or plastic and placed on the seabed |
| Floating fishnet            |                             | Equipment made of circular or rectangular net and placed in the sea for fish culture at certain times |
| Rigs                        |                             | Building’s structure above the sea surface that serve industrial/mining operation |
| Pipe                        |                             | Equipment made from iron, Parallon or other materials placed in the seabed surface for dispensing liquid or gaseous materials from production to the collector or from collector to distributor |
| FADs                        |                             | Tools that made from second-hand good, either floating or drowned into the seabed, functioned to attract economic fish |
| Tunnel                      |                             | A building structure under the sea surface or on the seafloor used to connect the two separate places, so the goods and humans can move from and to one place to others |
| Others                      |                             | Other man-made objects                                                      |

\[
if(x_{1,y})_{a,b,c} = 1 \text{ then } (x_{1,y}) = \text{True} \quad (2)
\]

and

\[
if(x_{1,y})_{a,b,c} = 0 \text{ then } (x_{1,y}) = \text{False}. \quad (3)
\]

As reflected in the equations above, if \( x \) is a seabed cover class 1 or (up to) \( y \) with a value of 1 in spatial databases \( a, b, \) and \( c \) (polygon, line, and point, respectively), then the implementation of SNI 7987–2014 as a mapping reference is doable (true). If \( x \) is a seabed cover class 1 or (up to) \( y \) having a value 0 in spatial databases \( a, b, \) and \( c, \) then the implementation is not doable (false).

2.2. Evaluation of prototype feasibility

Prototype maps for seabed cover classification were developed using the union overlay method using ArcGIS software for the scale of 1:250,000 and 1: 50,000, in which classes of the custodians’ GD were then selected and unified based on the score. The function scores were set to zero for classes that do not exist in the study site (i.e., Jakarta Bay), one for classes that can be determined via remote sensing analysis, two for classes that can be determined only from field measurement and laboratory analysis, three for classes that custodians are required to obtain, and four for classes existing in current custodian databases. Higher values were assigned to the data overseen by custodians because a seabed cover map should be an integration of various thematic maps from different custodians.

The formula used to assess the feasibility of the prototypes as seabed mapping references is

\[
n_i = 100x \frac{\sum y S_i}{S_{tot}}, \quad (4)
\]
3. Results

3.1. Results on SNI feasibility

The results of the weighted scoring showed that SNI 7987–2014 could be used to produce GD with a scale of 1:250,000 and 1:50,000 at a feasibility of each at 90 and 78, because the standard was first developed in a respective scale based on each custodian’s guidance. Therefore, the integration of all can be further developed as the GD model for seabed cover. The findings showed that as the evaluation was based on the appropriateness of grain size definition, only mixed sediments under the abiotic sub-group could not be mapped for 1:250,000 scale due to the semantic problems (Figure 2(b)). Abiotic surficial seafloor objects are usually determined on the basis of grain size (Lark et al. 2012; Bockelmann et al. 2017). Revisions to the definition of mixed sediments in accordance with criteria for custodian classification standards are indispensable.

Meanwhile, for the scale of 1:50,000, some classes under the abiotic subgroup could not be mapped either (Figure 2(a)). This reduced feasibility is attributed to the coverage of seabed classes in the abiotic group; that is, not all existing classes in the SNI classification scheme could be adjusted to match the classifications determined on the basis of custodian GD criteria. An advisable measure, therefore, is to

where \( n \) is the feasibility at scale \( i \), \( 1, y \) represents the seabed cover classes based on SNI, \( s \) denotes the score of seabed cover classes at scale \( i \) determined on the basis of the prototype maps, and \( s_{tot} \) is the total score.

\[
\begin{align*}
\text{Feasibility} &= \frac{s}{s_{tot}} \\
&= \frac{\text{score of seabed cover classes at scale } i}{\text{total score}} \\
&= \frac{\text{score of seabed cover classes at scale } i}{\text{total score}}
\end{align*}
\]
adjust and redefine the problem classes in SNI 7987–2014 in accordance with the data and criteria of custodians. Adjustments would include the regrouping of pavement, canals, and solids under the classification of reefs because of similarities in the specification, and the regrouping of fragmented reefs, fractured reefs, and shell sand/rubble into the rubble/biogenic sand group.

### 3.2. Results on prototype feasibility

A Business-as-Usual (BAU) assessment indicated that the existing GD from custodians could be used to generate GD of 1:250,000 scale at the feasibility of only 50.00%. This finding is ascribed to the fact that not all seabed cover classes exist in the existing GD on Jakarta Bay. The prototype of 1:250,000 scale map was generated from the integration of a seafloor surficial sediment map of scale 1:200,000 (custodian = P3GL), Indonesian coastal environmental maps of scale 1:250,000 (custodian = BIG), and a coral reef distribution map of scale 1:250,000 (research from BIG). In Jakarta Bay, the composition of the seafloor is dominated by fine to coarse sediments and contains no rock. Sub-surface vegetation (biotic), marine transportation and marine industries (man-made), and classes of marine cultures are also unavailable from the aforementioned data sources. The small spatial distribution of sub-surface vegetation, such as seagrass, and its relationship with scale prevented the inclusion of this class in existing GD. These data should be available in the GD on Indonesia’s coastal environment (custodian = BIG) because they appear in the national standard SNI 8346.1.2016 (BSN 2016).

The logical testing of the spatial data geometry showed that the feature data is referred to vector data, whereas almost all the sub-classes under the abiotic group fall within a polygonal geometry, all the classes under the biotic group are organized in polygons, and all classes under the unnatural group are stored in lines, except for settlements and marine cultures, which are organized under points (Table 3).

Some research supports the logical test of spatial data geometry about the nature of seabed cover that abiotic surficial seafloor objects are usually organized in a polygon on maps of seafloor surficial sediments (P3GL 2010, 1986; Surachman et al. 1986); biotic surficial seafloor objects are usually arranged in a polygon on maps (Xu and Zhao 2013; Zhang et al. 2017; Sutrisno 2013) and man-made elements and marine cultures can be arranged on maps in a line, polygonal, or point-based (Surachman et al. 1986; BSN-b 2016).

Classifications of sub-surface vegetation, man-made elements, and marine cultures were not performed in the study area. The unavailability of these classes can be overcome through Added Data Suggestion (ADS), such as the generalization of detailed scale maps or the addition of information from visual remote sensing analysis.

### Table 3. Feasibility of prototypes as a reference for generating GD at scale 1:250,000.

| Custodians | Prototype SD | Added Data Suggestions (ADS) | Source | Method | BAU | ADS |
|------------|--------------|-----------------------------|--------|--------|-----|-----|
| SNI elements | Prototype elements | | | | | |
| A1. Natural elements – Abiotic | | | | | | |
| Rock | - | √ | P3GL | P3GL | (1) Integration | 0 | 3 |
| Coarse sediment | Coarse sediment | √ | | | (2) Adjusted to SNI | 4 | 4 |
| Fine sediment | Fine sediment | √ | | | | 0 | 3 |
| Mix sediment | - | | | | | | |
| A2. Natural elements – Biotic | | | | | | |
| Wetland vegetation | Wetland vegetation | | | | | |
| (research result) | BIG | Thematic's custodians, surveying/RS analysis | Adjusted to SNI | (1) Integration | 4 | 4 |
| | | | | (2) Generalization, | | 0 | 3 |
| | | | | (3) Adjusted to SNI, | | | |
| | | | | (4) RS analysis: Visual interpretation | | | |
| | | | | | | | |
| B1. Unnatural elements – Man-made | | | | | | |
| Transportation | - | √ | BIG | BIG, RS data, Surveying | (1) Integration, | 0 | 3 |
| Industry | - | √ | | BIG | (2) Generalization, | 0 | 3 |
| | | | | | (3) Adjusted to SNI, | | | |
| | | | | | (4) Survey: marking position | 4 | 4 |
| Settlement | Settlement | √ | | | Adjusted to SNI | 4 | 4 |
| B2. Unnatural elements – Culture | | | | | | |
| Marine culture | - | √ | BIG | Custodians, surveying | (1) Integration, | 0 | 3 |
| | | | | | (2) Adjusted to SNI | | 4 | 4 |
| Others | Lighthouse | √ | BIG | | | | |

SD = spatial database, P = point, L = line, A = area/polygon, BAU (business as usual/existing conditions) and ADS (added data suggestions) scores:

0 = not exist in the study area, 1 = can be obtained from remote sensing analysis, 2 = can be obtained from field measurement and lab analysis, 3 = supposed to be available from custodians, 4 = existing custodians.
or surveys into the GD prototypes (Table 2). Multi-resolution remote sensing data are available from the Indonesian National Institute of Aeronautics and Space, which is one of the nodes of the national GD infrastructure network in Indonesia and a member of the country’s national geoportal. The works of Petit et al. (2017), Traganoz and Reinartz (2017), Roelfsema et al. (2010), Chauvaud, Bouchan, and Maniere (2010) who mapped coral reefs, seaweed, seagrass, and mangroves by using multi-sensor remote sensing; and Li et al. (2017), who assessed sea area usage types, such as reclamation and aquaculture, by using image fusion obtained from multi-sensor and multi-resolution remote sensing data could assist the availabilities of these informations on seabed cover GD. Incorporating data into the prototypes is expected to increase the feasibility of its use as a reference for GD generation to 87.50%. The prototype of the seabed GD at scale 1:250,000 can be seen in Figure 3.

Furthermore, the BAU analysis results revealed that the existing GD from custodians could be used to generate GD of scale 1:50,000 at the feasibility of 45.14%. This low percentage is due to the limited number of seabed classes covered in existing GD, the limited coverage of the elements in Jakarta Bay, and the unavailability of thematic GD that contain all the classes mentioned in SNI 7987–2014 and characterized by a scale of 1:50,000 (Table 4). The 1:50,000-scale prototype map was

Figure 3. Prototype at scale 1:250,000.
generated from the integration of a map of seafloor surficial sediments of scale 1:100,000 (custodian = P3GL), the map of Indonesian coastal environments of scale 1:50,000 (custodian = BIG), and a map of coral reef and mangrove distribution of scale 1:50,000 (research from BIG). No 1:50,000-scale maps of seafloor surficial sediments in Jakarta Bay are available. Therefore, spatial information on outcrops, reefs, boulders, cobbles, rubble (abiotic), or even fish-aggregating devices (FADs, marine culture) cannot be obtained. Custodians do not classify mangroves into density classes (biotic) but note them only as mangroves; thus, such data do not exist in GD on seabed cover. Additionally, marine cultures, waste, rigs, FADs, and tunnels (man-made) do not exist in Jakarta Bay and also on custodians’ GD. Some of the detailed spatial information of biotic data may not be available in any custodians’ GD except from research.

The ADS was adopted in this work to improve the feasibility of the GD prototypes as a reference for the generation of seabed cover data; specifically, data from surveys and remote sensing analysis were integrated into the prototypes. This recommendation was supported by Diesing et al. (2014) and Puhr et al. (2014), who used remote sensing analysis and field surveys for mapping the seabed to improve data accuracy. The studies explored the mapping of variations in the compositions of coral, fishes, sponges, echinoderms, ascidians, mollusks, and other marine organisms.

Table 4. Feasibility of prototypes as a reference for generating GD at scale 1:50,000.

| Prototype | Added Data Suggestions (ADS) | Score |
|-----------|-----------------------------|-------|
| SNI Elements | Prototype Elements | Source | Method | BAU | ADS |
| Natural elements – Abiotic | | | |
| Outcrop | √ | P3GL | P3GL, Pushidrosal | 1. Integration, 2. Adjusted to SNI | 0 | 3 |
| Pavement | Reefs | | | 2. Adjusted to SNI | 0 | 3 |
| Canal | | | | 2. Adjusted to SNI | 0 | 3 |
| Solid | | | | 2. Adjusted to SNI | 0 | 3 |
| Boulder | Boulder | | | 2. Adjusted to SNI | 0 | 3 |
| Cobble | | | | 2. Adjusted to SNI | 0 | 3 |
| Fractured reefs | | | | 2. Adjusted to SNI | 0 | 3 |
| Rubble/shell sand | | | | 2. Adjusted to SNI | 0 | 3 |
| Gravel | Gravel | | | 2. Adjusted to SNI | 0 | 3 |
| Sand | Sand | | | 2. Adjusted to SNI | 0 | 3 |
| Silt | Silt | | | 2. Adjusted to SNI | 0 | 3 |
| Clay | Clay | | | 2. Adjusted to SNI | 0 | 3 |
| Mud | Mud | | | 2. Adjusted to SNI | 0 | 3 |
| Others | | | | 2. Adjusted to SNI | 0 | 3 |
| Natural element – Biotic | | | |
| High-dense mangrove | Mangrove | | | 1. Integration, 2. Adjusted to SNI | 1 | 4 |
| Med-dense mangrove | | | | 3. Visual or Digital interpretation: NDVI, Hybrid, Survey: Position and Measurement | 1 | 4 |
| Low-dense mangrove | | | | 4. Survey: Position and Measurement | 1 | 4 |
| Seagrass | | | | 1. Integration, 2. Generalization, 3. Adjusted to SNI | 1 | 4 |
| Macro-algae | | | | 4. Visual or Digital interpretation: Survey: Transect, Stop & Go, Photoquad RRA, PIT | 1 | 4 |
| Coral | | | | 1. Integration, 2. Generalization, 3. Adjusted to SNI, 4. Survey: Position and Measurement | 1 | 4 |
| Others | | | | 4. Visual or Digital interpretation: Survey: Transect, Stop & Go, Photoquad RRA, PIT | 1 | 4 |
| Unnatural – Culture | | | |
| marine culture/ floating fishnet | | | | 1. RS analysis, 2. Survey: Marking | 0 | 2 |
| Others | Ponds | | | 2. Survey: Marking | 0 | 2 |
| Unnatural – Man-Made | | | |
| Liftnets | Liftnets | | | Updating Moveable | 4 | 4 |
| Bridge | Bridge | | | 1. Integration, 2. Adjusted to SNI, 3. Survey | 4 | 4 |
| Cable | Cable | | | 3. Survey | 0 | 3 |
| Waste | | | | 3. Survey | 0 | 3 |
| Pipe | | | | 3. Survey | 0 | 3 |
| Rig | | | | 3. Survey | 0 | 3 |
| Fads | | | | 3. Survey | 0 | 3 |
| Tunnels | | | | 3. Survey | 0 | 3 |
| Others | Levee | | | 1. Integration, 2. Adjusted to SNI | 4 | 4 |
| Wharf | | | | 2. Survey: Marking Position | 4 | 4 |
| Lighthouse | | | | 2. Survey: Marking Position | 4 | 4 |
| BAU = 48.5 | ADS = 85.6 |

SD = spatial database, P = point, L = line, A = area/polygon, BAU (business as usual/existing conditions) and ADS (added data suggestions) scores: 0 = not exist in the study area, 1 = can be obtained from remote sensing analysis, 2 = can be obtained from field measurement and lab analysis, 3 = supposed to be available from custodians, 4 = existing custodians.
foraminifera, and macroalgae for entry into a point or polygon database could become the ADS component (Cleary et al. 2016; Setyawan et al. 2014; Farhan and Lim 2012). Meanwhile, surveys may be underlain by the stop-and-go method, the photo-quadrat technique, position marking, Rapid Reef Resource Assessment (RRA), the Point Intercept Transect (PIT) method, and the grab sampling technique followed by grain size analysis. The stop-and-go positioning method based on precise point positioning in the field can reach accuracy due to the existing scale (Zhang, Guo, and Li 2013). Photo-quadrat sampling is commonly used in studies of benthic habitats; when combined with differential GPS, it enables collected images to be georeferenced to within 0.5 m (Trygonis and Sini 2012; Kris et al. 2010). RRA can be an effective method of detecting long-term changes in coral reef or benthic parameters over a large area (Coles, Looker, and Burt 2014), and PIT is very useful in the survey and mapping of seabed habitats, such as coral reefs, with an intermediate level of identification or covering large area of interest (Facon et al. 2015). Moderate or high-resolution visual remote sensing may also help improve data availability. For example, the position of a lift net as a point can be visually interpreted in remote sensing and randomly validated in the field by using marking positions. If the ADS suggestion is applied, the feasibility of obtaining seabed GD at a scale of 1:50,000 can increase to 85.6%. The prototype on seabed GD at the scale of 1:50,000 can be seen in Figure 4.

4. Conclusion and recommendations

The evaluation of SNI 7987–2014 showed the importance of standardizing open GD practices for the generation of GD. The findings indicated that SNI 7987-2014 can be fully implemented as a reference for generating GD on seabed cover. The feasibility levels achieved for GD of scales 1:250,000 and 1:50,000 were 87.5% and 85.6%, respectively. Semantic heterogeneity should be adjustable among the custodians and SNI revision document, and so did the agreement with the spatial data geometry. Some input was also addressed with respect to custodian data to refine the data to a more detailed scale, such as 1:50,000.

Indonesia’s national geoportal (tanahair.indonesia.go.id) should advance the nodes of GD custodianship to improve the quality of seabed cover GD. Agreement among network nodes regarding data sharing within the network is also needed since the status of public data remains unclear and may become the obstacle in

![Maps of Seabed Coverage (SNI 7987:2014)](image)

**Figure 4.** Prototype at scale 1:50,000.
creating GD. But the most important requirement is to establish custodianship of seabed cover GD in a national decree (Sutrisno, Gill, and Suseno 2017). Article 24, paragraph 1 of the Law no.4/2011 supports this suggestion, indicating that BIG can integrate one or more thematic GD produced by government institutions into a single thematic geospatial database (Republik Indonesia 2011) and may become the custodians of the seabed cover GD.

Notes on contributors

Dewayany Sutrisno is a professor in spatial information system, PhD in coastal and marine management, with strong background in remote sensing, spatial environmental modelling and geospatial data infrastructure. Graduated from Bogor Agricultural University for soil sciences for Bachelor degree, marine management for PhD and University of New South Wales for Master degree in remote sensing. She has experiences in the development of many spatial modeling for environment and policy management, development of technical and human resources standard and online analytical process software. She is currently a lecturer for spatial planning in Bogor Agricultural University.

Rizka Windiastuti has been working as a Government Officer at Geospatial Information Agency of Indonesia since 1992. She received a Science and Technology for Industrial Development Scholarship to pursue her undergraduate study and completed her Bachelor of Science in Computer Science from North Carolina State University, USA in 1996. She received an Australia Development Scholarship and attained her Master of Information Technology from University of Newcastle, Australia in 2002. She is currently a senior researcher at Geospatial Information Agency of Indonesia.

Nadya Octaviani is a scientist in geospatial information with the strong background on geodesy engineering. She is obtained the Bachelor degree from Gadjah Mada University for geodetic engineering. She has experiences in marine geospatial information research and marine remote sensing application. Currently, she works in Geospatial Information Agency as a junior scientist.

Aninda W. Rudiausti is graduated from Marine Science and Technology, Bogor Agricultural University in 2008 and Marine Technology, Bogor Agricultural university in 2011 for master degree. Currently she is a junior scientist at Geospatial Information Agency, involved in research related to marine and coastal topics. Her research interests are including but not limited to ocean color, mangroves, mangrove, coastal management.

References

Bermudez, L. 2017. "New Frontiers on Open Standards for Geo-Spatial Sciences." Geo-Spatial Information Sciences Journal 20 (2): 126–133. doi:10.1080/10095020.2017.1325613.

Bockelmann, F. D., W. Puls, U. Kleeberg, D. Muller, and K. C. Emeis. 2017. "Mapping Mud Content and Median Grain-Size of North Sea Sediment – A Geostatistical Approach." Marine Geology 397 (1): 60–71. doi:10.1016/j.margeo.2017.11.003.

BSN (Badan Standardisasi Nasional). 2014. SNI 7987-2014. Classification of Seabed Cover. Jakarta: BSN.

BSN (Badan Standardisasi Nasional). 2016. SNI 8346.1.2016. Specification of Indonesian Coastal Environmental Map Presentation- Part 1 Scale 1: 250.000. Jakarta: BSN.

Chauvaud, S., C. Bouchan, and R. Maniere. 2010. "Remote Sensing Technique Adapted to High Resolution Mapping of Tropical Coastal Marine Ecosystem (Coral Reefs, Seagrass Beds and Mangrove)." International Journal of Remote Sensing 19 (1): 3625–3639. doi:10.1080/014311698213858.

Cleary, D. F., A. R. Polonia, W. Renema, B. W. Hoeksema, P. G. Rachello-Dolmen, R. G. Moonlenbeek, A. Budiyanter, et al. 2016. "Variation in the Composition of Corals, Fishes, Sponges, Echinoderms, Ascidians, Mollusk, Foraminifera and Macro Algae across a Pronounced In-To-Offshore Environmental Gradients in the Jakarta Bay-Thousand Island Coral Reefs Complex." Marine Pollution Bulletin 110: 701–717. doi:10.1016/j.marpbul.2016.04.042.

Coles, S. L., E. Looker, and J. A. Burt. 2014. "Twenty Years Changes in Coral near Muscat, Oman Estimated from Manta Board Tow Observation." Marine Environmental Research 103: 66–73. doi:10.1016/j.marenvres.2014.11.006.

Dings, M., S. L. Green, D. Stephens, R. M. Lark, H. A. Stewart, and D. Dove. 2014. "Mapping Seabed Sediments: Comparison of Manual, Geostatistical, Object-Based Image Analysis and Machine Learning Approaches." Continental Shelf Research 84: 107–119. doi:10.1016/j.csr.2014.05.004.

Facon, M., M. Pinault, D. Obura, S. Pioch, K. Pothin, L. Bigot, R. Garnier, and J. A. Quod. 2015. "A Comparative Study of the Accuracy and Effectiveness of Line and Point Intercept Transect Method for Coral Reefs Monitoring in Southwestern Indian Ocean Island." Ecological Indicators 60: 1045–1055. doi:10.1016/j.ecolind.2015.09.005.

Farhan, A. R., and S. Lim. 2012. "Vulnerability Assessment of Ecological Conditions in Seribu Islands, Indonesia." Ocean and Coastal Management 65: 1–14. doi:10.1016/j.ocecoaman.2012.04.015.

Fredericks, J., and M. Botts. 2018. "Promoting the Capture of Sensor Data Provenance: A Role-Based Approach to Enable Data Quality Assessment, Sensor Management and Interoperability." Open Geospatial Data, Software and Standards 2018 (3): 1–8. doi:10.1186/s40965-018-0048-5.

Genderen, V. J. 2017. "Perspective on the Nature of Geospatial Information." Geo-Spatial Information Science 20 (2): 57–58. doi:10.1080/10095020.2017.1337320.

Henrique, V., M. T. Guerra, B. Mendes, M. J. Gaudêncio, and P. Fonseca. 2014. "Benthic Habitat Mapping in a Portuguese Marine Protected Area Using EUNIS: An Integrated Approach." Journal of Sea Research 100: 77–90. doi:10.1016/j.seares.2014.10.007.
Hidayat, S., and Ridwan. 2017. “Maritime Axis and Indonesia’s National Security: Challenge and Hope.” 
*Journal of Defence and State Defence* 7 (3): 83–98.

Kris, W., B. W. Pick, A. D. Payne, S. L. Grove, E. S. Harvey, G. A. Kendrick, H. F. Taylor, and J. J. Meeuwis. 2010. 
“Description of a Remote Still Photography System for Collection of Benthic Photo-Quadrats.” 
*Marine Technology Society Journal* 44 (2): 56–63. doi:10.4031/MTSJ.44.2.1.

Lark, R. M., D. Dove, S. L. Green, A. E. Richardson, H. Stewart, and A. Stevenson. 2012. “Spatial Prediction of Seabed Sediment Texture Classes by Cokriging from a Legacy Database of Point Observation.” 
*Sedimentary Geology* 281: 35–49. doi:10.1016/j.sedgeo.2012.07.009.

Lee, D. H., T. D. Acharya, and H. S. Lee. 2017. “Evaluation of Seabed Classification Using Hyperspectral around the Coastal Area of Goje Island, Korea.” *Journal of Coastal Research* 79 (Special Issue): 24–328. doi:10.2112/ST79-066.1.

Li, W., S. Liu, J. Zhao, J. Duan, Z. Chen, R. Guo, J. Chu, J. Zhang, X. Li, and J. Liu. 2017. “A Remote Sensing Data Management System for Sea Area Usage Management in China.” *Ocean and Coastal Management* 152: 163–174. doi:10.1016/j.ocecoaman.2017.11.028.

P3GL (Pusat Penelitian dan Pengembangan Geologi Laut). 1986. *Map of Seafloor Surficial Sediments for Jakarta Bay and Surrounding Area*, Scale 1:100.000. Bandung - Indonesia: Pusat Penelitian dan Pengembangan Geologi Laut (Marine Geological Institute).

P3GL (Pusat Penelitian dan Pengembangan Geologi Laut). 2010. *Map of Seafloor Surficial Sediments, Scale 1: 250.000*. Bandung: Pusat Penelitian Pengembangan Geologi Laut (Marine Geological Institute).

Petit, T., T. Bajjouk, P. Mouquet, S. Rochette, B. Vozel, and C. Delacourt. 2017. “Hyperspectral Remote Sensing of Coral Reefs by Semi-Analytical Model Inversion – Comparison of Different Inversion Setups.” *Remote Sensing of Environment* 190: 348–365. doi:10.1016/j.rse.2017.01.004.

Puhr, K., S. Schultz, K. Pikelj, D. Petricioli, and T. Bakran-Petricioli. 2014. “The Performance, Application and Integration of Various Seabed Classification Systems Suitable for Mapping Posidonia Oceanica (L.) Delile Meadows.” *Science of the Total Environment* 470: 364–378. doi:10.1016/j.scitotenv.2013.09.103.

Republik Indonesia. 2011. “Law about Geospatial Information, No 4/2011.” *State Gazette, Statute Book, Republic of Indonesia Number 49*, 2011.

Roelfsema, C. M., S. R. Phinn, N. Udy, and P. Maxwell. 2010. “An Integrated Field and Remote Sensing Approach for Mapping Seagrass Cover, Moreton Bay, Australia.” *Journal of Spatial Science* 54 (1): 45–62. doi:10.1080/14498596.2009.9635166.

Sambhi, N. 2015. “Jokowi’s ‘Global Maritime Axis’: Smooth Sailing or Rocky Seas Ahead?” *Security Challenges* 11 (2): 39–55.

Setyawan, I. E., V. P. Siregar., G. H. Pramono., and D. M. Yuwono. 2014. “Shallow Water Benthic Habitat Mapping Based on Sea Surface Topography: A Case Study of Panggang Island Seribu Archipelago, Jakarta.” *Majalah Ilmiah Globë* 16 (2): 125–132. doi:10.24895/MIG.2014.16-2.58.

Shaw, J., B. I. Todd, and M. Z. Li. 2013. “Geologic Insights from Multibeam Bathymetry and Seascape Maps of the Bay of Fundy, Canada.” *Continental Shelf Research* 83: 53–63. doi:10.1016/j.csr.2013.12.015.

Surachman, M., I. R. Sialahi, D. Setiady, and Kusnida. 1986. *Surficial Sediment Texture Distribution Map of Sheet 1110 (Tanjungkarang) Waters, Scale 1: 250.000*. Jakarta: Ministry of Energy and Mineral Resources Republic of Indonesia.

Sutrisno, D. 2013. “Sustainable Fisheries Management: A Spatial Policy Assessment for Archipelagic State.” *Journal of Emerging Trends in Economics and Management Sciences* 4 (2): 175–180.

Sutrisno, D., S. N. Gill, and Suseno. 2017. “The Development of Spatial Decision Support System Tool for Marine Spatial Planning.” *International Journal of Digital Earth* 11 (9): 863–879. doi:10.1080/17538947.2017.1363825.

Todd, B. J., and V. E. Kostylev. 2011. “Surficial Geology and Benthic Habitat of the German Bank Seabed, Scotian Shelf, Canada.” *Continental Shelf Research* 31 (2): S54–S68. doi:10.1016/j.csr.2010.07.008.

Traganos, D., and P. Reinartz. 2017. “Mapping Mediterranean Seagrasses with Sentinel-2 Imagery.” *Marine Pollution Bulletin* 134: 197–209. doi:10.1016/j.marpolbul.2017.06.075.

Trygonis, V., and M. Sini. 2012. “Photoquad: A Dedicated Seabed Image Processing Software and A Comparative Error Analysis of Four Quadrat Method.” *Journal of Experimental Marine Biology and Ecology* 424–425: 99–108. doi:10.1016/j.jembe.2012.04.018.

Wicaksana, I. G. W. 2017. “Indonesia’s Maritime Connectivity Development: Domestic and International Challenges.” *Asian Journal of Political Science* 25 (2): 212–233. doi:10.1080/02185377.2017.1339618.

Xu, J., and D. Zhao. 2013. “Review of Coral Reef Ecosystem Remote Sensing.” *Acta Ecologica Sinica* 34 (1): 19–25. doi:10.1647/j.cnahcs.2013.11.03.

Zhang, X., P. M. Treiz, D. Chen, C. Quan, L. Shi, and X. Li. 2012. “Mapping Mangrove Forest Using Multi-Tidal Remotely-Sensed Data and a Decision-Tree-Based Procedure.” *International Journal of Applied Earth Observation and Geoinformation* 62: 201–214. doi:10.1016/j.jag.2017.06.010.

Zhang, X. H., F. Guo, and X. X. Li. 2013. “A Novel Stop and Go GPS Precise Point Positioning (PPP) Method and Its Application in Geophysical Exploration and Prospecting.” *Journal Survey Review* 44 (327): 251–255. doi:10.1179/1752270611Y.0000000016.