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Implementation of Marine Cadastre for Sustainable Marine Management and Spatial Planning: A Case Study of the Bajau Tribe in Indonesia

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ABSTRACT

Marine management and spatial planning based on zoning allocation needs to be implemented considering that the sea is a place where humans live. This is supported by the presence of the Bajau Tribe in Indonesia as an indigenous community that has lived in the sea all their lives by building houses above the sea. This condition raises potential problems related to the recognition of sea property rights and legal guarantees as a form of justice and equality. For this reason, the implementation of a marine cadastre as a marine spatial planning and management system is carried out to realize the 3R principle (right, restriction, and responsibility). This concept uses the approach that the sea is a continuation of land where there is land on the seabed.

This research aims to produce a map of marine cadastre objects for Bajau Tribe Houses based on the analysis of technical and legal aspects. Identification of technical aspects succeeded in determining Mean Sea Level (MSL) as a vertical datum at a height of 60.229 meters against the ellipsoid with an accuracy of ± 0.034 meters. Supported by legal aspects, the opportunity to grant sea property rights to the Bajau Tribe's land can be carried out as a manifestation of sustainable marine management and spatial planning.

1. Introduction.

Nowadays, half of the world's population lives within 60 kilometers of the coast with an increasing trend to three-quarters of the world's population by 2020 (Economou et al., 2020). In fact, coastal and marine areas have become the place where humans live because they have resources that support their survival (Ng'ang'a et al., 2004).

This condition occurs in Indonesia as a maritime country that has a sea area of two-thirds of the land (Elliott et al., 2001), with 60% of the population living and scattered in coastal and marine areas (Jaya et al., 2022; Mushynsky, 2020).

Life at sea is evident in the existence of the Bajau Tribe as one of Indonesia's native populations or ethnic groups who have lived by the sea all their lives (Maulidyna et al., 2021; Rahman et al., 2023). They are an indigenous sea community recognized by the government and recorded in history since the 13th century through a nomadic way of life (Abdullah, 2013; Nasir, 2022). This is supported by their strong maritime cultural specialty, which is building and living in floating settlements above the sea as a place for daily activities (Fahlman & Schagatay, 2014).

The settlement known as Bajau Village consists of buildings that stand above the sea (Lapian, 2009). This existence is an issue and potential problem related to the legitimacy of the fulfillment of rights and legal guarantees in the form of recognition of land ownership rights that refer to the sea as the place

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where they live (Irwansyah, 2023; Jumriani, 2023). Indonesian legislation, namely the Basic Agrarian Law of 1960, states that every Indonesian citizen has the same opportunity to obtain land rights (Hanna & Vanclay, 2013; McWilliam, 2006). In addition, recognition of the rights of citizens, especially indigenous communities, is supported internationally in the United Nations (UN) Declaration 2007 (Vierros et al., 2020). Unfortunately, these rights have not been fully realized for the Bajau Tribe so that criminalization and legal problems threaten even their survival (Clifton & Majors, 2012). Like people who live on land, the Bajau Tribe should get property rights to the land where they live in the form of legal and permanent certificate ownership as a form of justice (Clifton, 2013). However, the government only provides certificates in the form of building use rights periodically that needs to be renewed for a certain period of time (Pebrianto & Wibowo, 2022). This unclear and inconsistent status has led to ownership problems and losses for both the Bajau and the state, especially regarding tax payments (Pentassuglia, 2011).

The problem is also influenced by spatial factors related to the suboptimal marine management and spatial planning (Astor et al., 2014; Krishna et al., 2017). In this case, it is caused by conflicts of interest in the utilization of overlapping marine space, management of marine areas by many institutions (Abdulharis et al., 2008), and marine arrangements with various maritime zones that have different legal status (Hernandi et al., 2012). If not followed by integrated regulations and policies, the management and planning of marine space cannot be ideally realized (Astor et al., 2017; Rudolph et al., 2020).

Therefore, marine management and spatial planning in accordance with its allocation zone needs to be carried out (Frazão Santos et al., 2018; Maes, 2008). This can be realized through the implementation of a marine cadastre as a system that aims to spatially record and regulate the 3R (right, restriction, and responsibility) so as to minimize conflicts and provide space guarantees for indigenous communities (Smith et al., 2011). This will provide information on parcel boundaries in a geographical coordinate for water objects that have legal force and attach rights and obligations to the subjects who control them (Astor et al., 2015). In addition, marine management and spatial planning will be a way to effectively manage the use of a water area and achieve equality so that a community is not marginalized (Rajabifard et al., 2005). This is in line with Sustainable Development Goals (SDGs) 14, which is to conserve and sustainably utilize marine and ocean resources for sustainable development (Caruso et al., 2022).

In the case of Bajau Tribe Settlement in Samabahari Village, Wakatobi Regency (Adimu et al., 2018), buildings above the sea are analogous to buildings on land (Athanasiou et al., 2016). So, this research aims to produce a map of marine cadastre objects for Bajau Tribe House based on the analysis of technical and legal aspects in Indonesia. The remote sensing method is used to identify the existence of object locations with satellite imagery. The technical aspect specifically focuses on determining the vertical datum of the marine cadastre as a reference to the height of the object against a certain sea level based on tidal data (Djunarsjah, 2008). Meanwhile, legal aspects were analyzed to see the suitability of technical aspects and opportunities for granting sea property rights to the Bajau Tribe by reviewing applicable laws and regulations. This research is important to strive for the recognition of rights (Ponce et al., 2015) and legal guarantees for indigenous communities and to support the implementation of the marine cadastre (Kurniawan et al., 2023) as the basis for sustainable marine management and spatial planning.

2. Research Methodology.

2.1. Methods.

Table 1: Research Data.

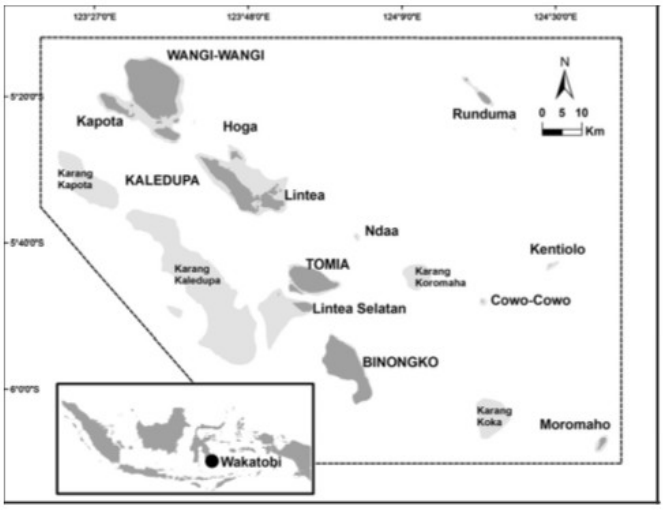
No.	Data	Source
1.	Google Earth Satellite Imagery	Google
2.	Indonesia's Coastline	Indonesia Geospatial Information Agency (BIG)
3.	Tides	Indonesia Geospatial Information Agency (BIG)
4.	Law	Constitution (code: UUD), Laws (code: UU), Government Regulations (code: PP), Ministerial Regulations (code: Permen)
5.	Secondary data related to Bajau Tribe	Interview, FGD (*Forum Group Discussion*), Expertise, Researcher, Indigenous Community

Source: Authors.

Table 1 is the data used in this research. The object of marine cadastre study is focused on the Bajau Tribe House in Wakatobi National Park, Southeast Sulawesi, precisely in Kaledupa Island as shown in Figure 1.

The research used remote sensing method with Google Earth Satellite Imagery to identify the location of buildings above the sea. Furthermore, the visualization of objects was carried out through a digitization process on the image in accordance with the appearance in the study area in the form of a two-dimensional (2D) parcel field to produce a map of marine cadastre objects. The map is based on the analysis of technical and legal aspects related to the marine cadastre to see the potential for granting sea property rights. In particular, the technical aspects identify the determination of the vertical datum of the marine cadastre based on tidal data. So far, the determination of vertical datum as a reference for height, especially at sea, is still unclear because it is not supported by policies that regulate it. Therefore, the legal aspects used in this research become the basis for the application of technical aspects in the implementation of marine cadastre.

Figure 1: Location map for the Wakatobi National Park.



Source: Clifton, 2013.

2.2. Marine Cadastre.

According to The International Federation of Surveyors (FIG), a cadastre is a spatial system of land information, where the smallest unit of data is a parcel, and each parcel is linked to attribute data about the interests attached to the parcel (Astor et al., 2014, 2017).

A parcel is a land area owned by an individual, legal entity, or customary tribe, and can be in the form of land with certain management rights, land with certain uses, or government administrative areas, with geometrically clear and accurate boundaries to other parcels in the vicinity (Budiyono & Aditya, 2022). Meanwhile, attribute data attached to a parcel includes (Djunarsjah, 2008):

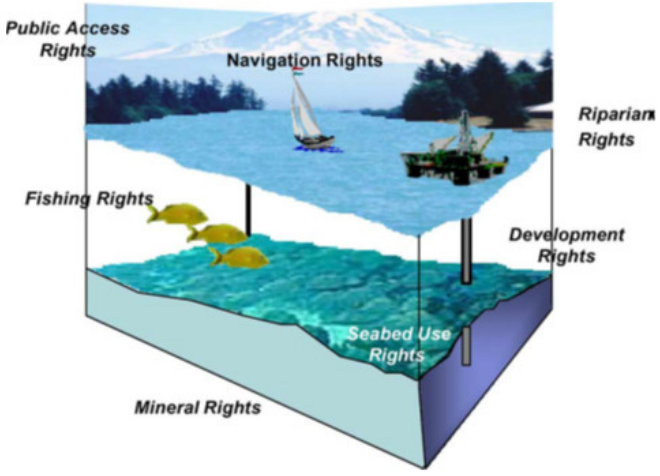
1. Ownership rights or utilization rights over a parcel.
2. Data of the person, legal entity, or community group that has rights to the parcel.
3. Type of land use on the parcel.
4. Tax and price value of the parcel.

Cadastre serves to support public land administration in particular to formulate, implement, and monitor land policies, such as land distribution, land consolidation, acquisition, and allocation of land resources.

Sea is a continuation of the land (Athanasiou et al., 2016), so the concept of marine cadastre for marine area management and planning is known. The concept actually applies the land cadastre system but at sea. Marine cadastre is related to the management of coastal and marine resources, especially to create order in the implementation of administrative processes, marine spatial planning, and legal practices on the utilization of marine space (Rajabifard et al., 2005). According to Rais (2002), marine cadastre is a system that applies the principles of land cadastre in marine areas through registration or administration of objects and subjects including:

1. Use of marine areas by public and government activities.
2. Marine spatial planning for protection and conservation, such as national parks, wildlife sanctuary parks.
3. Use of marine areas by indigenous communities.

Figure 2: Three-dimensional (3D) perspective of marine cadastre rights.



Source: Ng'ang'a et al., 2004.

Figure 2 shows the marine space in a 3D perspective including the rights regulated by the marine cadastre. According to the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), the marine cadastre as a system enables the recording of boundaries and interests in the sea, which are spatially organized and physically defined, in relation to the boundaries of overlapping or adjacent rights and interests. In addition, a marine cadastre manages how a country administers its marine resources in the context of the United Nations Convention of the Law of the Sea (UNCLOS) III 1973-1982. The objectives of a marine cadastre include:

1. Providing legal certainty and protection to holders of rights and permits over a parcel at sea.
2. Establish a comprehensive spatial data infrastructure where parcel boundaries, vested rights, utilization limits, obligations and responsibilities in the marine environment can be properly organized, administered and managed.
3. Implementation of an orderly marine administration.

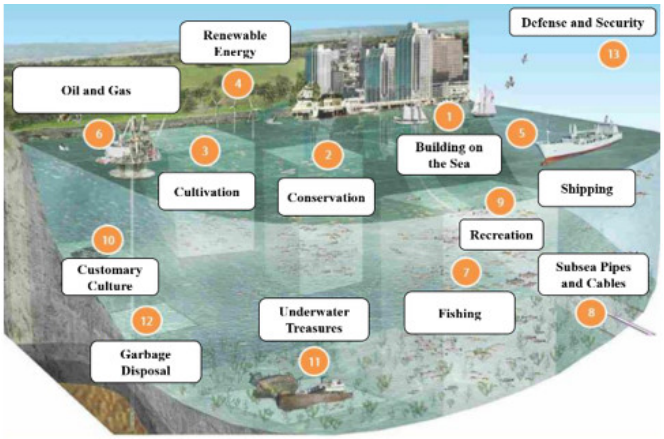
Marine cadastre regulates the management of 13 water objects based on the suitability of zoning space as shown in Figure 3.

In particular, water objects in the form of buildings on the water are spatially managed and planned, including settlements, fishermen's housing, places of worship, and so on (Sutherland, 2005).

Figure 4 shows the distribution of the Bajau Tribe in various parts of Southeast Asia including Indonesia, Malaysia, Brunei Darussalam, Philippines, Vietnam, and Thailand whose existence is recognized by the United Nations (Lapian, 2009). The name Bajau is more well-known in eastern Indonesia and inhabits locations such as the Sulawesi Sea, Makassar Strait, Bone

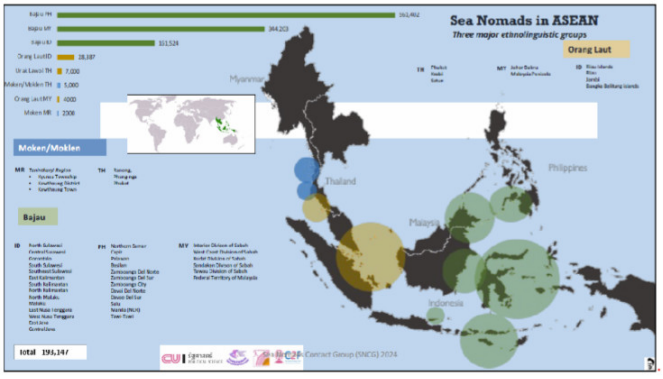
Bay, Tomini Bay, East Nusa Tenggara, North Maluku, and East Kalimantan. The Bajau Tribe is regionally known as the Sama Tribe, which means similar or countrymen where they assume that their ancestors came from heaven, descended to earth, and left descendants of the same nation whose orientation is to live in the sea. On the other hand, they call themselves descendants of the sea gods of South Sulawesi. In fact, they are one of the ethnic groups in Indonesia who know the sea and life in it through a sea nomadic way (Obie, 2018).

Figure 3: Water objects in marine cadastre.



Source: Authors.

Figure 4: Distribution of the Bajau tribe in various parts of Indonesia and Southeast Asia.

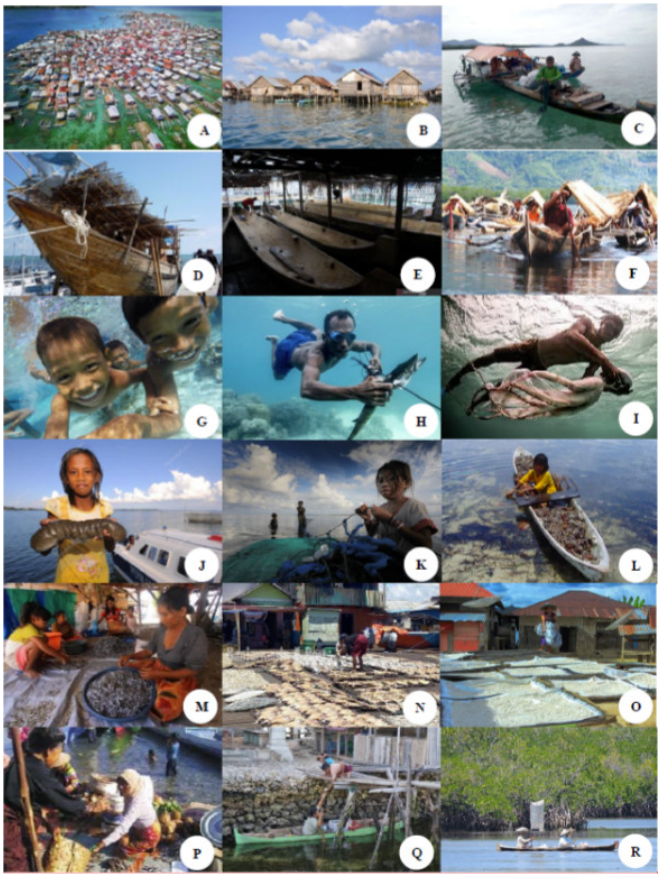


Source: Adhuri, 2024.

The Bajau Tribe, as an ethnic group, chooses to live on the coast and build their homes on the water, so that socio-culturally they live according to maritime culture. To them is attached an indigenous customary right (Hanna & Vanclay, 2013) because they inhabit the territorial sea area for a long time and their lives are inseparable from the sea (Pentassuglia, 2011; Vierros et al., 2020).

Figure 5 shows the daily life of the Bajau Tribe who are closely associated with the sea. Based on the demographic data of the Bajau Tribe, in 1960 there were 81,000 people and reached 200,000 people in 1968. It is estimated that if the increase is about 17.5% each year, then by 1990 there will be 400,000 people. 90% of the Bajau live in houses built on and towards the sea. It is a rule of thumb to not turn back from the sea as it is the source of life (Abdullah, 2013).

Figure 5: Life of the Bajau Tribe.



Source: Maulidyna et al., 2021.

The Bajau Tribe's house is characterized (Syam, 2021) by being shaped like a house on stilts whose poles consist of three to four rows to the side and to the front with a shape of a square crossing from east to west. In connecting one house to another, planks or wooden beams are used as pedestrian traffic and there are canals between settlements as boat shipping lanes. The permanent settlements of the Bajau Tribe, known as Bajau Villages, are the result of acculturation that began in the 19th century. They began to accept a more settled life from the initial life on boats and moving around. When the Bajau Tribe settles down, they will look for a place to live with fresh water criteria, protected from strong winds, shallow water depth so that in certain seasons the sea will be dry, coral areas, and there are many sources of seafood (fish, shellfish, etc). The Bajau Tribe's house is built far to the center of the beach, so that it looks more protruding into the sea with a sign in the form of sticking wooden beams supporting the house which indicates a village for them. Each house is inhabited by one or more families. The Bajau are scattered along the coast, in river estuaries, on islands, and in swamps along the coast. The place is used as a settlement both temporarily and permanently with the

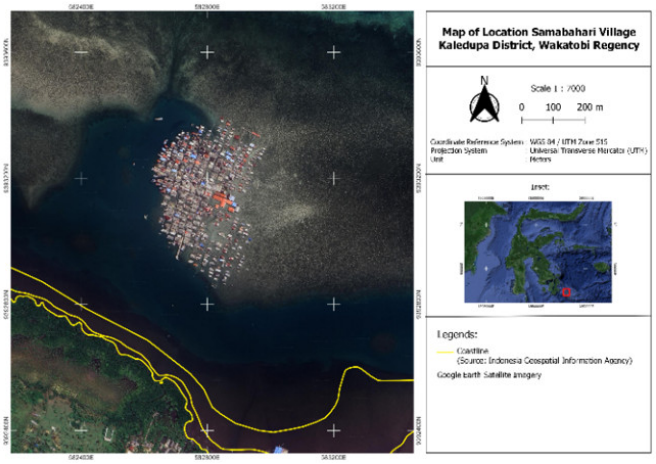
characteristic that the place is inundated with water at high tide, because of consideration:

1. As a guidance to determine the right time to go to sea, namely when the sound of waves at high tide is heard.
2. Being a reassurance, comfort and lullaby at rest time due to the influence of the tidal waves that make the boat sway as if it were a tune and rhythm.
3. Above the sea will make it faster and easier for the Bajau Tribe to go to the sea during high tide.

3. Results and Discussion.

3.1. Mapping of Bajau Tribe Settlements as Marine Cadastral Objects.

Figure 6: Map of location Bajau Tribe Settlement in Samabahari Village, Kaledupa District, Wakatobi Regency.

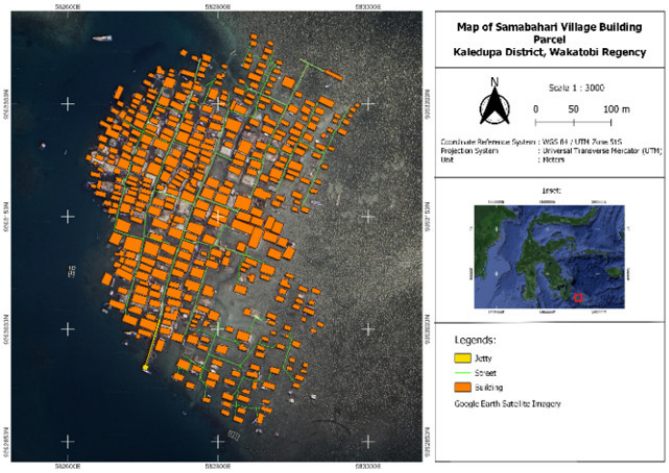


Source: Authors.

Figure 6 is a visualization of Google Earth Satellite Imagery that shows the location of the Bajau Tribe Settlement in the Wakatobi National Park Area, precisely in Samabahari Village, Kaledupa District, Wakatobi Regency, Southeast Sulawesi or within UTM Zone 51S. Geographically, the village is located in waters flanked by Kaledupa Island to the south and Hoga Island to the northeast. In addition, the village is directly adjacent to the open sea in the north. Based on its topography, Samabahari Village is jutting towards and above the sea with most of its area being coral reefs. When measured by drawing a perpendicular line from the coast to the nearest building, the Bajau Tribal Settlement has a distance of ± 350 meters from the highest tide coastline. The coastline is sourced from Indonesia Geospatial Information Agency, including the position of the Highest Astronomical Tide (HAT), the Mean Sea Level (MSL), and the Lowest Astronomical Tide (LAT).

Figure 7 is a map of building parcels in Samabahari Village obtained by digitizing satellite imagery. The digitization process is carried out by creating polygons that refer to each end of the building as an approach so that rectangular building parcels are produced which are two-dimensional (2D) representations

Figure 7: Map of building parcels in Samabahari Village, Kaledupa District, Wakatobi Regency.



Source: Authors.

of buildings. From the results of the digitization of the Bajau Tribe Settlement, there are three marine cadastre objects built on the sea, including buildings, roads, and jetty. When reviewing the map visualization, it appears that buildings in Samabahari Village have a dense pattern and are densely distributed between buildings so that they fill the sea area. There are 410 building parcels (orange), a jetty (yellow), and roads (green) that have been identified. The appearance of existing buildings indicates that Samabahari Village is a permanent Bajau Tribe Settlement. This can be seen from infrastructure of jetty that are permanent.

Table 2: Area of each building parcel in Samabahari Village, Kaledupa District, Wakatobi Regency that was identified using the digitization method.

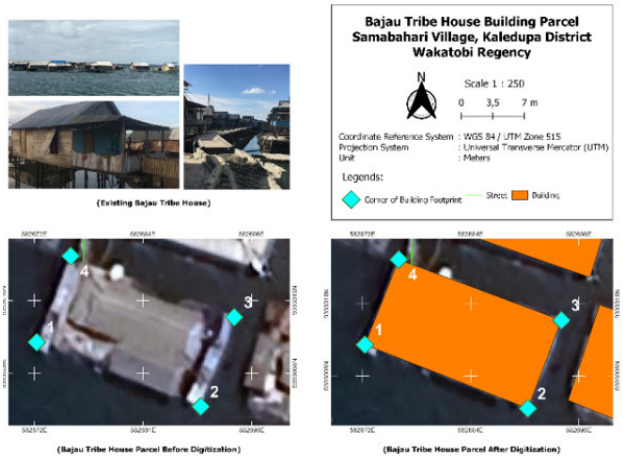
Building parcel	Area (m^2)
1	18.007
10	26.892
50	43.400
100	56.872
150	128.045
…	…
410	404.199

Source: Authors.

Table 2 shows the area of each building parcel that has been identified during the digitization process, then the area of each parcel area is calculated. Based on the data obtained, the Bajau Tribe Settlement in Samabahari Village has buildings with varying parcel areas, which are between 18.007 - 404.199 m^2 consisting of houses, places of worship, and schools.

Figure 8 is a detailed representation of a sample Bajau Tribe House before and after the digitization process with an enlarged scale of 1 : 250. The purpose of the digitization is to obtain

Figure 8: Representation of the existing Bajau Tribe House before and after the digitization process.



Source: Authors.

building parcels (orange). This process starts from the existing condition of the Bajau Tribal House visualized by satellite imagery in the form of the roof of the house, then pinpointing or determining the position of the corner of building footprint. The points are then connected to form a polygon and produce a two-dimensional (2D) building parcel. Because the building object is defined in a coordinate reference system and projection system, namely WGS 1984 / Universal Transverse Mercator (UTM) Zone 51S, the coordinate points and building parcel area can be determined as obtained in Table 3.

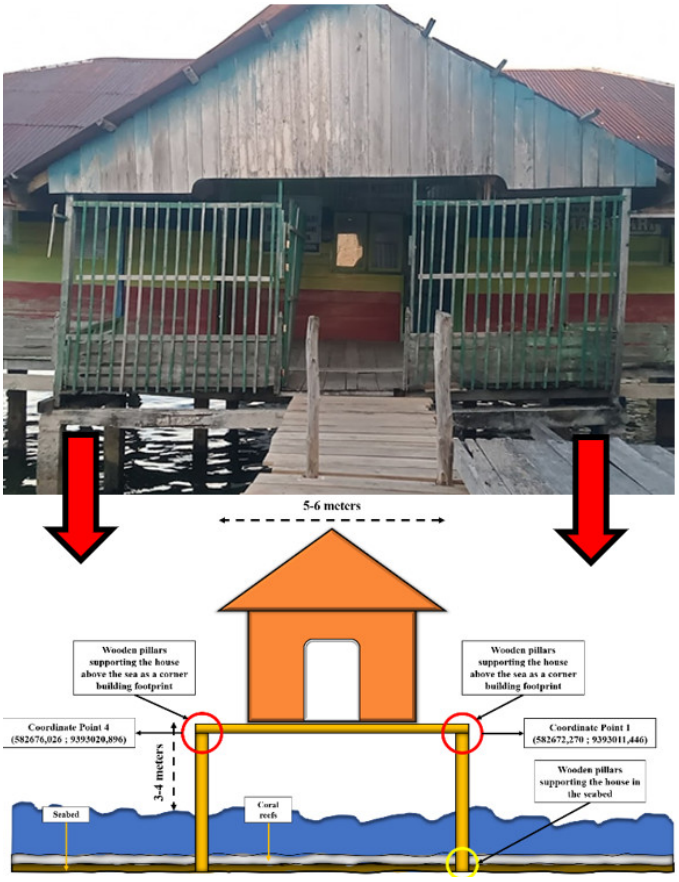
Table 3: Coordinates UTM (X, Y) for each corner of building footprints.

Corner of Building Footprint	Coordinates (UTM)	
	X (*Latitude*)	Y (*Longitude*)
1	582672.270	9393011.446
2	582690.360	9393004.371
3	582694.086	9393014.162
4	582676.026	9393020.896

Source: Authors.

Figure 9 is the result of 2D modeling of the Bajau Tribe House. Modeling is conducted to produce illustrations to help the interpretation process in defining the position of the Bajau Tribe House above the sea. The illustration also shows the coordinate values for the corner of building footprint that have been obtained previously. The Bajau Tribe's house is known as a house on stilts built above the sea and at a depth of between 1 – 8 meters. The house ideally has a building area of 50 m^2 with a building frontage width of 5 – 6 meters. However, when reviewed based on the plot area, Bajau houses vary in size. The house is supported by wooden beams with supporting poles in each segment or corner of the building site at 3 – 4 meters above

Figure 9: Two-dimensional (2D) modeling of Bajau Tribe House based on existing view.



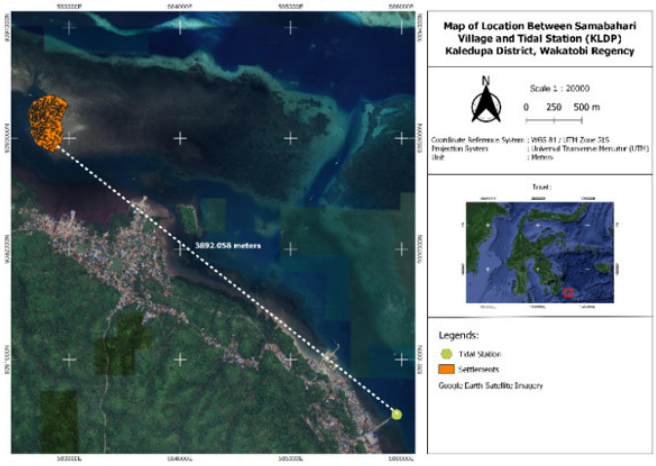
Source: Authors.

sea level. The supporting poles are embedded in the soil and coral reefs at the bottom of the sea which have a function as a foundation and provide strength against physical disturbances or threats from seawater such as waves, currents, and tides. This is an indicator that wooden poles/beams as house supports can represent the land on the seabed. This analogy is similar to the representation of a building parcel on land, where the house is built on land and the cadaster concept applies as a legal administrative system.

3.2. *Determination of Marine Cadastre Vertical Datum.*

Figure 10 is the location between Samabahari Village and the nearest tidal station, namely Kaledupa Tidal Station (KLDP). The station is located at the Wanci Port Office precisely at coordinates (585956.227; 9390504.540). If a straight line is drawn, the Kaledupa Tidal Station has a distance of 3892.058 meters to the Bajau Tribe Settlement in the Samabahari Village. Kaledupa Tidal Station as one of the tidal stations owned by the Indonesia Geospatial Information Agency used to produce a tidal model. Tidal modeling is obtained from periodic tidal observation data which is then analyzed and predicted so as to provide a certain sea level approach value for determining the tidal datum model.

Figure 10: Map of location between Samabahari Village and Kaledupa Tidal Station (KLDP) in Kaledupa District, Wakatobi Regency.



Source: Authors.

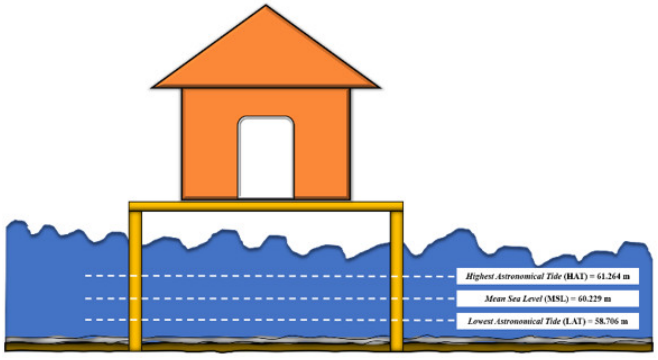
Table 4: Tidal datum values from tidal modeling at Kaledupa Tidal Station.

Tidal Datum	Values (m)*	RMSE (m)
HAT	61.264	± 0.034
MSL	60.229	
LAT	58.706	
*) Height with respect to the ellipsoid		

Source: BIG, 2023a.

Table 4 is the value of the tidal datum resulting from the Indonesia Geospatial Information Agency modeled at the Kaledupa Tidal Station with the height referring to the ellipsoid. The value of the tidal datum is a reference for the height or vertical datum of the marine cadastre. The validation of the tidal datum model is based on the RMSE (Root Mean Square Error) value, which is ± 0.034 meters.

Figure 11: Representation of vertical datum position on marine cadastre object of Bajau Tribe House in Samabahari Village, Kaledupa District, Wakatobi Regency.

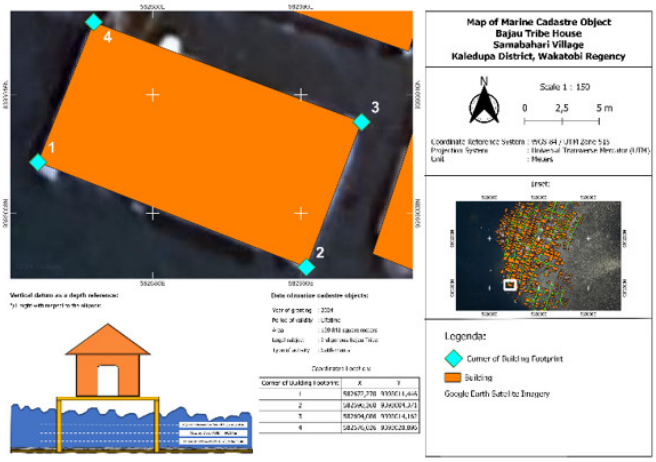


Source: Authors.

Figure 11 is an illustration of the vertical datum position of the Bajau Tribe House. From the three values, one of the sea levels at Mean Sea Level (MSL) was chosen to be the vertical datum of the marine cadastre with a value of 60.229 meters.

3.3. Compilation and Visualization of Data Information Bajau Tribe Settlement in Marine Cadastre Object Map.

Figure 12: Map of marine cadastre object for Bajau Tribe House in Samabahari Village, Kaledupa District, Wakatobi Regency.



Source: Authors.

Figure 12 is a map containing information on the recording of marine cadastre objects for the Bajau Tribe House at a detailed scale of 1:150. The information includes the year of granting, validity period, building parcel area, legal subject, type of activity, location coordinates, and vertical datum. All attributes are used for the process of land registration or location licensing as well as efforts to maintain and update marine cadastre data in both spatial and non-spatial forms.

3.4. Discussion.

3.4.1. Law Aspects.

Table 5 is the result of the identification of laws and regulations in the marine cadastre framework that support the granting of sea property rights for the Bajau Tribe. Indonesia's Basic Agrarian Law (UU 5/1960) is the basis for regulating land in the sea by looking at the scope of certain sea areas that can be controlled. The analogy that the sea is a continuation of the land is an approach that can be used to implement the concept of marine cadastre. This regulation underlies the granting of property rights to the Bajau Tribe as an indigenous community. They have customary rights over the sea area as a place to live. The granting of sea property rights for the Bajau Tribe is considered by taking into account the technical aspects of land registration in the sea.

Indonesian law (UU 32/2014) regulates marine spatial planning based on technical aspects such as not disturbing shipping lanes and must consider the preservation of coastal resources and surrounding small islands. This regulation provides space

Table 5: Sources of law in Indonesia that regulate and relate to the marine cadastre and indigenous community.

No.	Source of Law	Regulate
1.	Constitution of the Republic of Indonesia (UUD 1945)	The highest source of law governing equality and justice
2.	Indonesia's Basic Agrarian Law (UU 5/1960)	Basic regulation of agrarian principles
3.	Indonesia law (UU 32/2014)	Marine
4.	Indonesia law (UU 1/2014)	Management of coastal areas and small islands
5.	Indonesia law (UU 6/2023)	Omnibus law
6.	Government Regulations (PP 18/2021)	Management rights, land rights, residential units, and land registration
7.	Government Regulations (PP 21/2021)	Implementation of spatial planning
8.	Regulation of the Minister of Agrarian Spatial Planning/Indonesia Land Agency (Permen 17/2016)	Land management in coastal areas and small islands
9.	Regulation of the Minister of Agrarian Spatial Planning/Indonesia Land Agency (Permen 18/2019)	Procedures for administration of customary land of the indigenous law communities.
10.	Regulation of the Minister of Marine Affairs and Fisheries (Permen 28/2021)	Implementation of marine spatial planning

Source: Authors.

for a community group to not be marginalized in the implementation of marine development. Indonesian law (UU 1/2014) regulates zoning plans in the utilization of marine areas. With the existence of zones, community activities and the space representing buildings above the sea can be managed.

Indonesian law (UU 6/2023) regulates marine spatial planning as a place where humans carry out activities and maintain their survival. In this regulation, adjustments are made to the zoning plan for coastal areas and small islands. In addition, the Bajau Tribe is not required to have a permit for the suitability of marine space utilization activities on the basis that they are customary law communities who occupy the sea as a place to meet their daily needs.

Government Regulations (PP 18/2021) provide an understanding that the existence of land is not only limited to land but also at sea, which refers to land on the seabed as a continuation of land. This condition requires that the process of land registration at sea be carried out. Through land registration at sea, marine cadastre objects referring to the Bajau Tribe House can be mapped so that they have identities or attributes in both spatial and non-spatial forms for the administration, maintenance, and legal updating of marine cadastral data. Government Regulations (PP 21/2021) is a consideration of technical aspects in determining the vertical datum of the marine cadastre as it relates to the timeframe for issuing administrative requirements.

The Regulation of the Minister of Agrarian Spatial Planning or Indonesia Land Agency (Permen 17/2016 and Permen 18/2019) regulates land management which aims to provide direction and limitations on the control, ownership, use and utilization of land in the context of granting rights. This regulation is the basis for indigenous communities that they are a group of people who have the same cultural identity, live for generations in a certain geographical area based on ties of ancestral origin or similarity of residence, have common property or customary objects and a value system that determines customary institutions and customary law norms as long as they are still alive in accordance with the development of society and the principles of Indonesia. Regulation of the Minister of Marine Affairs and Fisheries (Permen 28/2021) regulates buildings and installations at sea.

3.4.2. Technical Aspects.

Measurement and mapping were carried out to determine and define the location of the Bajau Tribe Settlement in Samabahari Village, Kaledupa District, Wakatobi Regency. The method used is by utilizing remote sensing technology in the form of Google Earth Satellite Imagery. The image has a spatial resolution of 30 meters (Malarvizhi et al., 2016; Utami et al., 2018) and a temporal resolution of 2024. The Bajau Tribe settlement in Samabahari Village is located in Coastal Waters. This can be seen from the location of the object against the coastline. Based on geographical conditions, the Bajau Tribe's settlements tend to be safe from physical threats to seawater (hydro-oseanographic conditions) such as currents and waves because there are two islands that protect them. This condition is in accordance with the culture of the Bajau Tribe when settling, namely they will look for a place to live with the criteria of avoiding strong winds, shallow water depth so that in certain seasons the sea water will be dry, areas with coral reefs, and built far to the center of the beach, so that it looks more protruding into the sea.

The determination of the vertical datum is based on tidal data from the Indonesia Geospatial Information Agency at the Kaledupa Tidal Station. A vertical datum is a reference surface used to determine height. Errors in binding geodetic coordinates to a particular datum result in position errors of up to hundreds of meters (Poerbandono & Djunarsjah, 2005). Meanwhile, the vertical datum has an accuracy that depends on the length of the tidal recording data, the distance of the observation location to the secondary station, and the distance of the secondary station to the primary station (Djunarsjah & Handayani,

2020). According to Ingham (1975), tidal station location criteria are influenced by several parameters, namely:

1. Location of tidal observations.
2. The distance between the tide station and the object under study is at least 5 miles or ± 15 kilometers.
3. Not located in river estuaries and bays.
4. The beach has homogeneous conditions.

These four things are attempts to minimize the influence of hydro-oseanographic conditions such as strong currents that cause the tidal model to be suboptimal. Based on research (Hadi & Basith, 2016), tidal conditions will change every 15 kilometers along the coast. The statement is proven that at a distance of 15 – 150 kilometers from the tide station shows the results of tidal parameters that are not significantly different. This is the basis for using the Kaledupa Tidal Station which has a distance of less than 15 kilometers to the object of research so that the variation of sea level is relatively the homogeneous. Based on the position of sea level, Mean Sea Level (MSL) was chosen as the vertical datum of the marine cadastre. The selection of MSL is much easier and time effective compared to HAT (Highest Astronomical Tides) and LAT (Lowest Astronomical Tides). LAT is the lowest tidal level predicted to occur under average meteorological conditions and based on a combination of astronomical conditions (Djunarsjah et al., 2023), while HAT is the state of sea level at the highest tide. According to the IHO, determining LAT requires 18.6 years of tidal predictions with at least 12 months of observational data (Abdallah et al., 2016). Other underlying issues, include: First, sea level observations for practical purposes can be obtained with observations for 15 or 30 days. This is in accordance with the recommendations of the International Hydrographic Organization (IHO, 2022). In certain situations, MSL can be obtained with 25 or 39 hours of sea level observations. Second, data integration based on the availability of nationally used data refers to the position of MSL. This is supported by research (Djunarsjah, 2011) which stipulates that the boundary of the marine cadastral area starts from the mean sea level line with the consideration that the marine cadastre is a continuation of the land cadastre. It is hoped that a Seamless Cadastre will be implemented that integrates land and sea areas. This concept is based on the fact that marine space is three-dimensional, meaning that it has a horizontal plane and a vertical plane consisting of the seabed, water column, and the sea surface. This condition allows for multipurpose use in one vertical plane of a marine parcel. Third, MSL as an optimal approximation model for the shape of the Earth. This is because 72% of the Earth is ocean (BIG, 2023b). Global mean sea level can be derived from tidal phenomena for 18.61 years, following one nutation period. Analysis and prediction of tides can provide an approximate value of mean sea level, in order to realize the unification of vertical datum. Based on research (Djunarsjah, 2011), MSL variations in Indonesia have an accuracy of ± 10 centimeters depending on the length of observation time (daily, monthly, quarterly, six monthly). The longer the observation time, the closer the data will be obtained, resulting in optimal accuracy.

Compilation is the process of integrating a collection of spatial and non-spatial information data into a visualization of a marine cadastre object map. The compilation and visualization of the results of this research is a novel idea that produces a map of marine cadastre objects, especially for marine settlements and supports the implementation of marine cadastre. The information data includes:

1. Year of granting;
2. Validity period;
3. Coordinates of the location;
4. Depth or vertical datum;
5. Area;
6. Legal subject;
7. Type of activity; and
8. Other conditions accompanying the granting.

Conclusions.

This research has successfully produced a map of marine cadastre objects for the Bajau Tribe House. The map is an effort to carry out sustainable marine management and spatial planning as well as the basis for recording legal spatial and non-spatial information data. This supports the implementation of a marine cadastre based on technical and legal aspects.

Based on the analysis of technical aspects, it has succssfully determined MSL at 60.229 meters with respect to the ellipsoid with an accuracy ± 0.034 meters as the optimal marine cadastre vertical datum. The selection is based on the factors of practical needs, data integration, and model approach. Meanwhile, the legal aspect analysis has successfully identified the applicable laws and regulations related to the implementation of marine cadastre. Legal aspects provide a strong basis to support technical implementation. Based on the results of the study, sea property rights to the land of the Bajau Tribe can be granted to building objects or houses that stand on the sea with the obligation to maintain and preserve the sustainable marine ecosystem. This is because the Bajau Tribe is a customary law community unit so that it has communal customary land rights to control, manage, and utilize, and preserve its customary territory in accordance with the prevailing values and customary law. The land is located in the territory of the customary law community which in reality still exists.

The findings in this study are very important because through the implementation of the principles and objectives of the marine cadastre, it can realize equitable and structured marine spatial governance based on the 3R principles, namely rights, restrictions, and responsibility.

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