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Modelling Spatio-Temporal of Mangrove Ecosystem and Community Local Wisdom in Taman Hutan Raya (Tahura), Ngurah Rai, Bali

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***Abstract*— Taman Hutan Raya (Tahura) Ngurah Rai Bali has a vital role in providing environmental services in supporting the tourism in Bali. This research aims to find out the condition of area and density of mangrove and local wisdom conditions of the surrounding community in support of mangrove conservation in Tahura Ngurah Rai Bali. Identification of mangrove using band composites of NIR+SWIR+RED. The method of separating mangroves and non-mangroves using a supervised classification, while the mangrove density calculation using the Normalized Difference Vegetation Index. Literature review and descriptive analysis were also conducted to determine the conditions of local wisdom. The results of the accuracy test of mangrove mapping obtained the accuracy Kappa by 79%. The condition of the mangrove from 1995-2015 has an increase in the area of 27.87 Ha or about 0.22%, while in 2015-2019, it suffered a decrease in the area of 7.2 Ha or 0.06%. Mangrove density in the north and southwest of the research location changed from medium to high density. In 2015, new mangrove cover was found in the two regions, indicating mangrove rehabilitation efforts. This effort is supported by the community's local wisdom, who appreciate mangroves' existence in their area. The community's local wisdom is an essential part of community social capital in mangrove conservation, which can be seen from several aspects, including trust and solidarity, collective aspects and cooperation, and empowerment and political aspects.**

***Keywords*— Mangrove; local wisdom; Tahura Ngurah Rai; landsat; supervised classification.**

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I. INTRODUCTION

Mangrove ecosystem habitats are often found in coastal areas, especially in Indonesia. Mangrove ecosystems are almost found in all areas of the Indonesian archipelago. This has led to Indonesia being the largest country with a mangrove ecosystem cover, around 26 to 29% of the total 100% of the total mangrove cover in the world [1]. The breakdown of the total mangrove area in Asia is 42%, Africa 20%, North America and Central America 15%, so that the total mangrove area worldwide is 16,530,000 Ha [2] so that Indonesia contributes to the increase or decrease of mangrove ecosystems in the world. In 1990, about 99,000 kilometers of Indonesia's coastline was overgrown by a 3.5-million-hectare mangrove ecosystem. Mangrove ecosystems are wetland resources located in coastal areas with significant losses in recent decades under economic and population pressure [3]. After 26 years, in 2016, the extent of mangrove ecosystem cover in Indonesia had decreased to only 2.9 million hectares [4]. The decline in mangroves in Indonesia shows these mangroves' existence has received serious threats from various developments, incredibly rapid development the coastal zone [5].

One of Indonesia's mangrove conservation areas affected by reclamation activities is in Tahura Ngurah Rai around Benoa Bay, Bali. Many of the reclamation activities were opposed, especially from the community around the mangrove ecosystem. Community rejection occurs because Peraturan Presiden No. 51 Tahun 2014 related to changes in the status of coastal zones and small islands in the Benoa Bay region and the general direction of spatial use of the area. The regulation is contrary to several laws, namely Undang-Undang No. 16 Tahun 2009, Undang-Undang No. 1 Tahun 2014 about Rencana Tata Ruang Wilayah Provinsi Bali Tahun 2009-2029, and Peraturan Daerah Kabupaten Badung No. 26 Tahun 2013, that the area around Tahura Ngurah Rai and Benoa Bay in Bali has a function as a Conservation Area. In addition to conflicting with several laws, this area is a sacred area for the surrounding community used to hold Hindu traditional ceremonies in Bali and certainly could not be reclaimed for business purposes [6]. According to tradition and also in Hinduism in Bali, changing nature is an act that is not commendable if it disturbs the natural balance, for example doing environmental damage such as reclaiming [7]. The reclamation will damage the waters' function and the value of conservation and threaten biodiversity in Tahura Ngurah Rai, Benoa Bay, and surrounding areas. Mangrove trees also have an essential role in natural disaster mitigation in coastal areas and small islands [8].

Monitoring the condition of mangrove ecosystems can be done using remote sensing technology. This technology can provide convenience in the process of identifying mangrove objects. Some research on mangrove ecosystems that have been carried out using remote sensing includes monitoring, community structure, and detection of mangroves and their extent [9], [10], and [11]. The basic concept in identifying mangroves using remote sensing technology is based on two essential properties: mangroves have leaf green (chlorophyll), and mangroves grow on the coast. Chlorophyll can focus sunlight so that it can be interpreted using remote sensing technology [12]. Another advantage of this technology is analyzing the factors that cause mangrove damage, including reclamation activities and others, especially mangrove ecosystems Tahura Ngurah Rai Bali [13] and [14].

One type of satellite imagery that is often used for mangrove ecosystem monitoring is Landsat imagery. Landsat satellite imagery has a spatial resolution of 30 meters x 30 meters and a temporal resolution of 16 days. Landsat imagery is included as the image most often used to classify land-use features in an area of a research study [15] and [16]. This is because this image can be easily downloaded for free to use. This image is suitable to be used in this study, which examines issues regarding mangrove ecosystem damage in Tahura Ngurah Rai Bali. Landsat imagery can also be used to analyze and identify land use in the mangrove areas [17]. Identification of mangroves using radar satellite imagery (ALOS Palsar) has also been carried out by using Machine Learning techniques [18].

The results of the monitoring of mangrove ecosystems using satellite remote sensing data will be more comprehensive if linked to the analysis of local wisdom conditions of local communities, especially those living around mangrove areas. Local wisdom is one embodiment of social capital in society [19] and [20]. Sustainable management of mangrove forests requires social capital [21]. Social capital consists of several aspects, including groups and networks, trust and solidarity, collective and cooperation aspects, aspects of information and communication, aspects of social cohesion and inclusion, and aspects of empowerment and political aspects [21]. Based on the problems that have been explained before, this research aims to know the condition of mangrove's area and density and to know the local wisdom conditions of the surrounding community in support of mangrove conservation in Tahura Ngurah Rai, Bali.

II. MATERIALS AND METHODS

The location of the study was conducted in Tahura Ngurah Rai This area connects Denpasar City and Badung Regency through the waters of Benoa Bay with coordinates of 08° 35' 31"- 08° 44' 49"S and 115° 10' 23' - 115° 16' 27" E. The research uses Landsat multi-temporal Path 116/Row 066 satellite imagery data, Landsat 5 TM imagery acquisition on May 26, 1995, Landsat 8 OLI / TIRS imagery acquisition on April 15, 2015, and September 17, 2019 (see Figure 1).

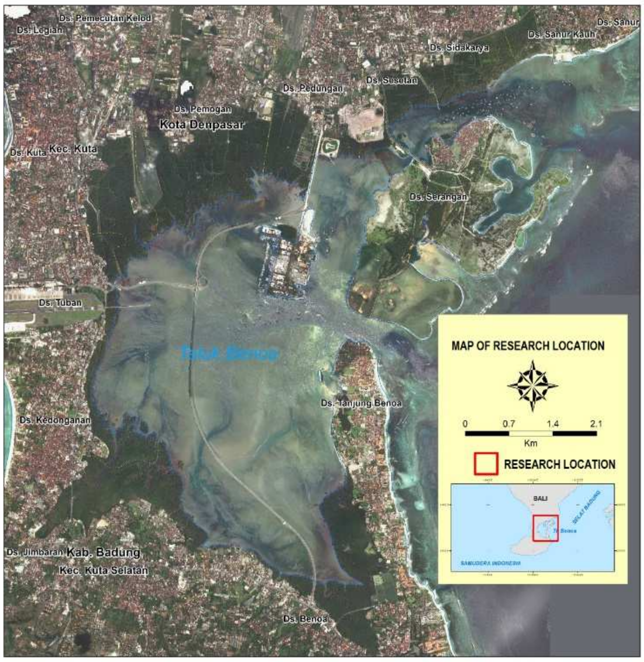


Fig. 1 Research Location

Selection of image data in 2015 was subject to see the condition of the mangrove ecosystem before reclamation. While the image data in 2015 was subject to see the condition of mangroves approaching the time of reclamation at the end of 2012, image data in 2019 was subject to see the ecosystem's condition after the reclamation. The One Map Mangrove data released by the Ministry of Forestry and the Environment was also used to see patterns of changes in the mangrove ecosystem. Mosaics are used to determine the accuracy of mapping mangroves and non-mangroves in Tahura Ngurah Rai, Bali, SPOT 6/7 2018 and 2019 imagery data. Table 1 is a comparison of the band specifications of Landsat 5 TM and Landsat 8 OLI. The software used includes image processing and tabulation data applications. The research location can be seen in Figure 1.

The pre-processing method used is a geometric correction, radiometric correction, and atmospheric correction using Fast Line of sight Atmospheric Analysis of Spectral Hypercubes (FLAASH). The atmospheric correction process aims to produce a new image that has been almost free from atmospheric disturbances [24]. After the image is corrected, image cropping is performed in the area of the research study. After cropping the image focused on the research study area, then making a composite of false color (NIR, SWIR, RED) then does the land class classification using the supervised method. NIR + SWIR + RED band composites are the best combinations of bands in identifying mangroves using Landsat satellite imagery [25].

TABLE I
BAND SPECIFICATIONS OF LANDSAT TM/ETM+ AND LANDSAT 8 OLI/TIRS [22], [23]

Landsat TM/ETM+		Landsat 8	
Band no	**Central Wavelength**	**Band no**	**Central Wavelength**
		Band 1	Coastal/Aerosol, (0.443 µm), 30 m
Band 1	Blue, (0.485 µm), 30 m	Band 2	Blue, (0.482 µm), 30 m
Band 2	Green, (0.57 µm), 30 m	Band 3	Green, (0.561 µm), 30 m
Band 3	Red, (0.66 µm), 30 m	Band 4	Red, (0.655 µm), 30 m
Band 4	Near-Infrared, (0.84 µm), 30 m	Band 5	Near-Infrared, (0.865 µm), 30 m
Band 5	SWIR 1, (1.65 µm), 30 m	Band 6	SWIR 1, (1.609 µm), 30 m
Band 7	SWIR 2, (2.22 µm), 30 m	Band 7	SWIR 2, (2.201 µm), 30 m
Band 8	Pan, (0.71 µm), 15 m	Band 8	Pan, (0.590 µm), 15 m
		Band 9	Cirrus, (1.373 µm), 30 m
Band 6	LWIR, (11.45 µm), 15 m	Band 10	LWIR 1, (10.895 µm), 100 m
		Band 11	LWIR 2, (12.005 µm), 100 m

The supervised classification method is divided into three classification classes: water bodies, mangroves, and non-mangroves to determine mangrove areas in 1995, 2015, and 2019. Meanwhile, to know the development of mangrove density due to reclamation in this region using the Normalized Difference Vegetation Index (NDVI) method by utilizing the response of objects in the red band radiation spectrum (RED) with near-infrared bands (NIR - Near Infra-Red) on Landsat satellite imagery. The use of band in analyzing this density is using band 3 and band 4 on Landsat 5 TM satellite imagery, while on Landsat 8 OLI / TIRS satellite images using band 4 and band 5.

Mangrove density calculation uses NDVI method, which is divided into three density classifications. These are high, medium, and low-density classifications. The NDVI algorithm utilizes the NIR band and Red band on Landsat satellite imagery (Equation 1) [26], [27], and [28]. Determination of mangrove density class using Equation 2 based on the interval class formula [29].

The following is the equation algorithm used in determining the condition of mangrove density in Tahura Ngurah Rai Bali:

$$\text{NDVI} = (\text{NIR-Red})/(\text{NIR+Red}) \quad (1)$$

In Which
NDVI = Normalized Difference Vegetation Index
NIR = Near-Infrared Band
Red = Red Band

$$\text{Interval}= \frac{Highest\ Class\ Value - Lowest\ Class\ Value}{Number\ of\ Interval\ Classes} \quad (2)$$

The accuracy calculation method is carried out on the map of mangrove and non-mangrove classification in 2019, using the confusion matrix method. The accuracy value is a percentage of the number of samples that match/correct the total number of samples. The kappa accuracy value is recommended to determine the accuracy value because it uses all the elements in the matrix [30]. The equation for calculating kappa accuracy is described in Equation 3 [31]. Samples were randomly determined, as many as 100 points spread throughout the study area, including mangrove and non-mangrove areas (classification results). In general, the classification results are said to be good if they have an overall accuracy value of more than 60% [31] and [32].

TABLE II
KAPPA ACCURACY CALCULATION

Field Data \ Images	Mangrove	Non-Mangrove	Total
Mangrove	A	B	A+B
Non-Mangrove	C	D	C+D
Total	A+C	B+D	A+B+C+D

$$Kappa\ (k) = \frac{N\sum Xkk - \sum Xk{+}X{+}k}{N^2 - \sum Xk{+}X{+}k}\ x\ 100\% \quad (3)$$

In Which
$\sum Xkk$ = Total of diagonal samples performed
$Xk+$ = Total of column
$X+k$ = Total of row
N = Total of sample

The literature review method and descriptive analysis use secondary data that has already existed to determine the local community's local wisdom, especially around the mangrove area of Tahura Ngurah Rai Bali. This is related to the community's local wisdom that supports the condition of mangrove ecosystems in this area. The research flow diagram was conducted for the data processing stage from the initial stage (data collection) to the analysis phase results in Figure 2.

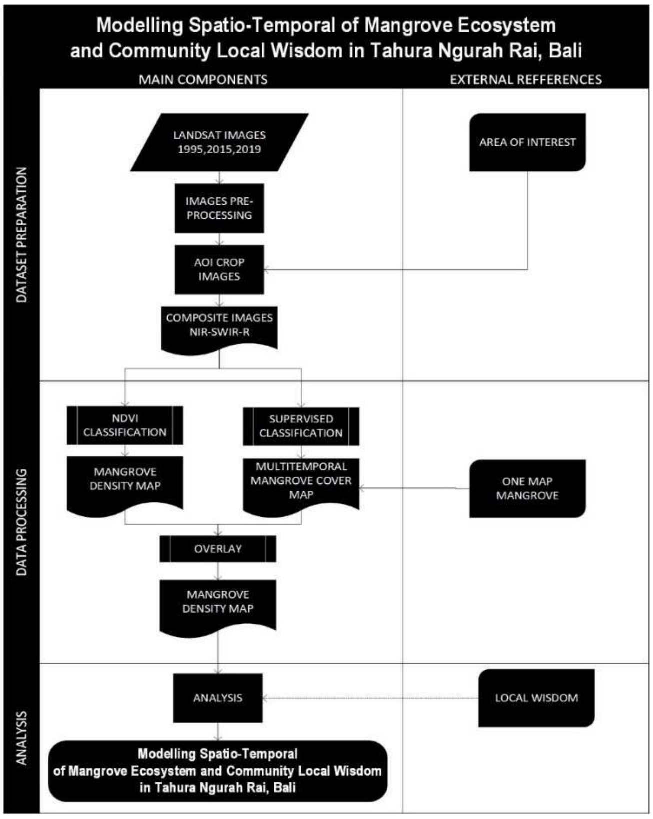


Fig. 2 Diagram of Research Flow

III. Results and Discussion

A. *Spectral Value Patterns of Mangrove and Non-Mangrove Objects*

Mangrove cover conditions can be identified using remote sensing satellite imagery. The condition of the image quality of the three images used has relatively good quality. This can be seen from the lack of cloud cover, especially at research sites in the mangrove area Tahura Ngurah Rai, Bali. However, there are differences in image sharpness where the objects in the Landsat 8 are more clearly visible than the Landsat TM. This is because the number of bits used in Landsat 8 OLI is greater than Landsat TM. The number of bits of Landsat 8 image is 16 bits with a range of bit values of 0 - 65535, resulting in the many variations in color produced. Whereas Landsat 7 imagery only has 8 bits with a bit range between 0-255, the resulting color variations are relatively less. The higher the sensor's ability to record object spectral responses, the higher the ability to distinguish objects on the earth's surface [33].

Early identification of mangrove ecosystems in Tahura Ngurah Rai Area was done by visual analysis of the different colors of Landsat imagery with a combination of NIR, SWIR and Red bands as shown in Figure 3. Based on the band specifications in Table 1, the NIR + SWIR + Red composite in Landsat TM imagery is in band 4, band 5 and band 3, whereas in Landsat 8 image, there is band 6, band 5 and band 4. The band combination results showed that the appearance of the mangrove looked reddish tended to be dark, while the other colors are the appearance of non-mangrove objects. The dark red color of mangrove forest objects also has an intensity that is not the same. This is due to the variation in stands, the dominance of the type and age of vegetation so that it causes differences in reflected objects' proportion. The spectral characteristics of mangroves are influenced not only by the chlorophyll content but also by environmental conditions, namely water and soil [34], [35]. The existence of mangrove forests located on the coast makes it easy to recognize and differentiate between mangrove and non-mangrove objects.

Figure 3 also shown 4 tests transect (Ts) locations used to see the spectral values of the three bands used (Red, NIR and SWIR bands) of the detected objects from both Landsat TM imagery and Landsat 8 imagery. The selection of transect sites is based on changes in mangrove and non-mangrove conditions and their distribution represents the entire area of research location. Intake of spectral transects also represents all classes of objects used, namely mangroves, non-mangroves, and water bodies. The transect 1 location is in the southwest of the study site, around the Jimbaran Village and Kedonganan Village. Transect 2 location is in the vicinity of Benoa Village and Tanjung Benoa Village. Transect 2 locations are in the vicinity of Kuta Village, Pemogan Village, and Pedungan Village. Transect 4 locations are around Sesetan Village, Sidakarya Village, and Sanur Kauh Village.

Based on Landsat TM and Landsat 8 OLI (Figure 3) shows in the process of identifying mangrove objects, the NIR and SWIR bands in Tahura Ngurah Rai Bali have opposite spectral values curves. Mangrove objects are detected when the NIR band's spectral values curve shows an increase and at the same time, the spectral values curve of the SWIR band shows a decrease. By the specifications, the NIR band is very sensitive to detect vegetation, which is the object of mangrove forests. While the SWIR band is very sensitive in detecting the condition of wetlands from mangrove objects. NIR band responds to the highest spectral value in identifying mangrove forest objects using Landsat 8 imagery. Based on existing references and visual observations in the field, it can be seen the environmental conditions of mangrove habitats in Tahura Ngurah Rai Bali shows a relatively stable level of tranquility. But that must be checked again by tidal analysis in a more comprehensive. The condition of the spectral value pattern might change if implemented in other locations, especially in mangrove areas with a substrate environment that is relatively slightly inundated by water.

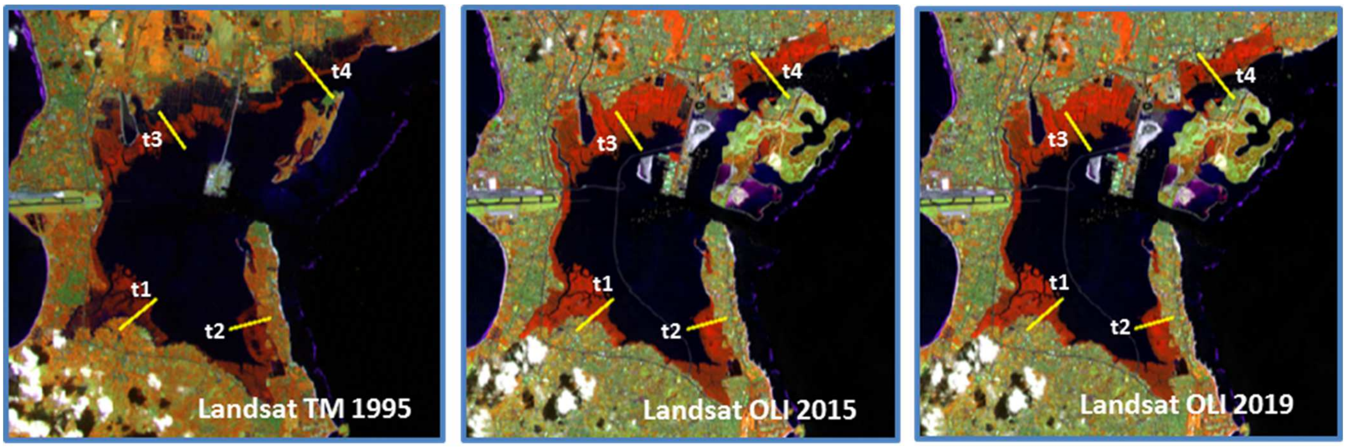
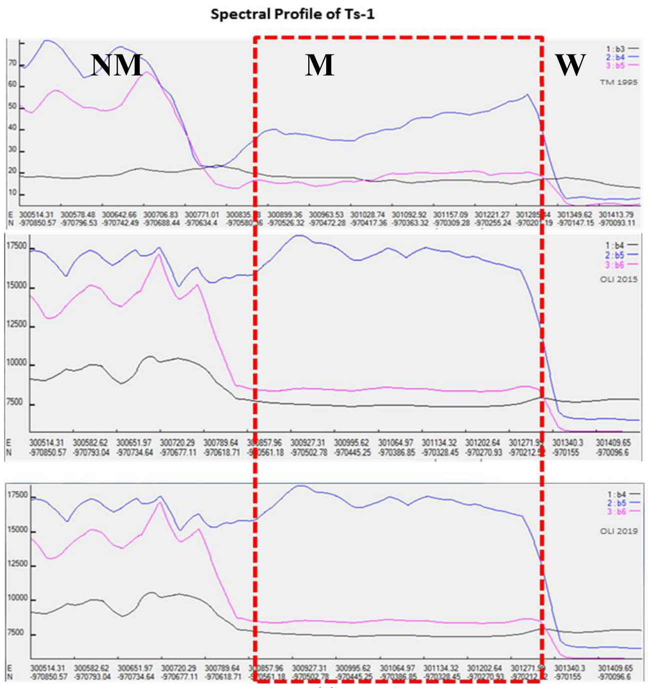
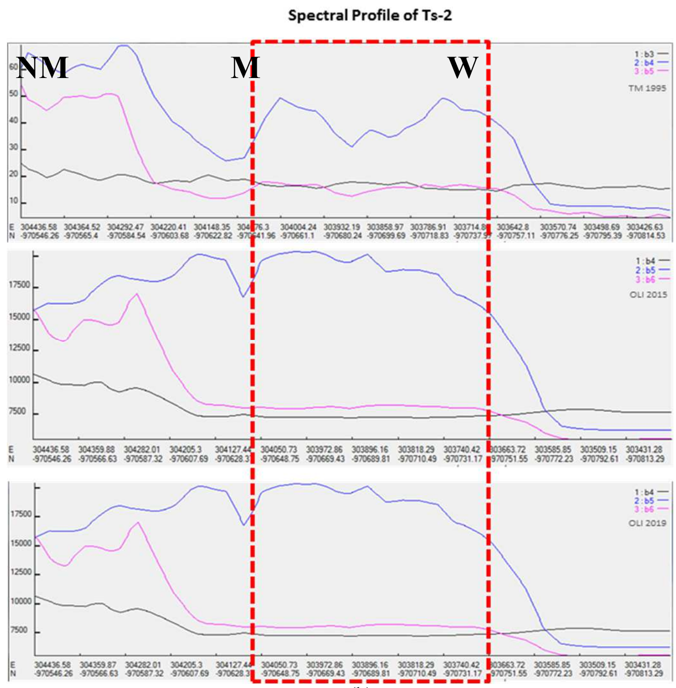


Fig. 3 The appearance of Mangroves using NIR + SWIR + Red composite bands and Spectral Transect Locations



(a)



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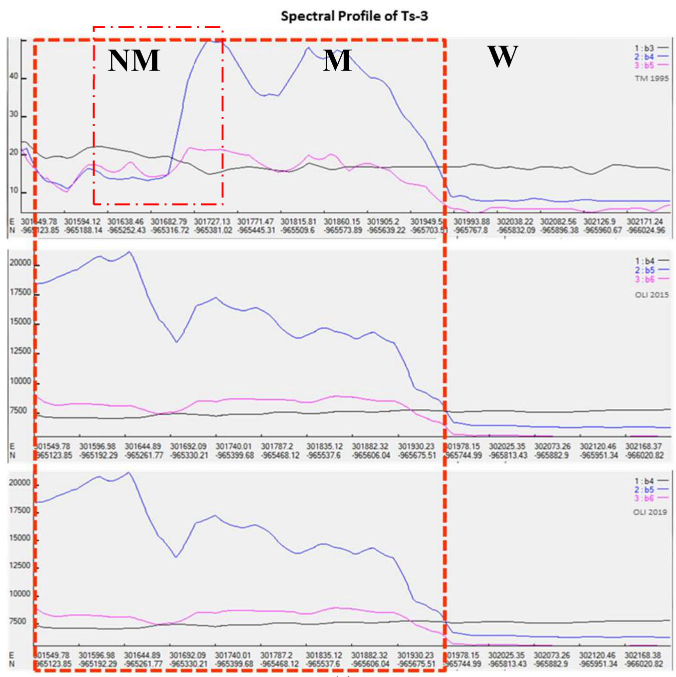

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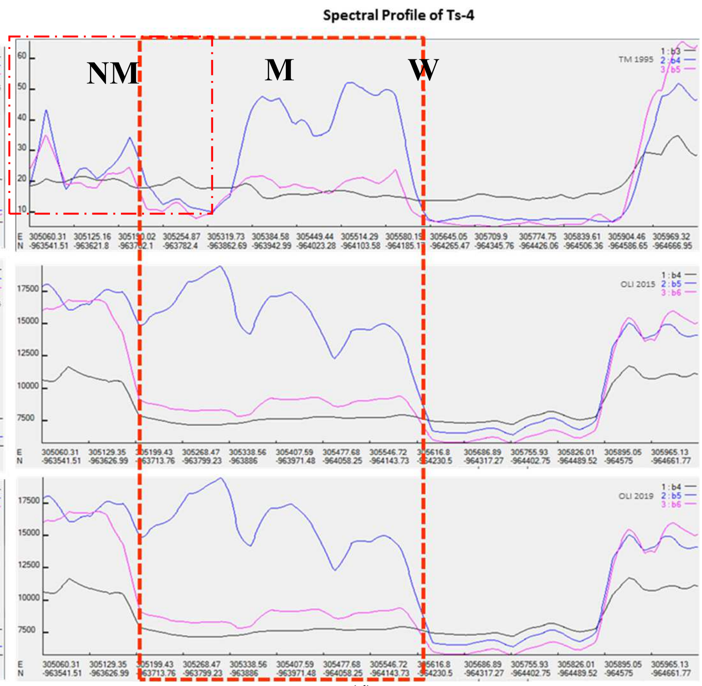

(d)

Fig. 4 Patterns of Spectral Values of Mangrove (M), Non-Mangrove (NM) and Water Bodies (W) of (a) Transect 1, (b) Transect 2, (c) Transect 3, (d) Transect 4

The spectral values pattern at transects 1 and transect 2 locations shows that mangrove conditions were relatively stable from 1995-2019. This can be seen from the relatively equal spectral value patterns of the three-image data used. However, there is a slight difference related to the magnitude of the spectral value produced between Landsat TM and Landsat 8 images, where the sensitivity level of Landsat 8 images is higher than Landsat TM. Another interesting condition is the spectral value pattern at the location of transect 3 and transect 4. The spectral value patterns are not the same at these two transect locations, especially Landsat TM imagery data with OLI Landsat in 2015 and 2019. Landsat TM imagery's initial spectral value pattern looks low for Red, NIR and SWIR bands and then experiences an increase in spectral values, especially for NIR bands. The condition of Landsat OLI imagery's spectral value pattern in 2015 and 2019 shows that the NIR band has the highest initial spectral value pattern compared to the Red and SWIR bands. This shows the addition of mangrove areas in 2015 and 2019. Changes in land cover come from objects of water bodies into mangrove objects. The addition of mangrove areas can occur due to natural and non-natural factors (the presence of mangrove tree planting, etc.).

B. Analysis of Mangrove Distribution and Density Conditions

Mangrove ecosystem habitat in Tahura Ngurah Rai Bali supports the growth of mangroves because it is in semi-enclosed waters which causes the area to be quite protected and relatively safe from sea waves. The characteristics of Tahura Ngurah Rai area are around the Benoa Bay which is a muddy and protected area so that the mangrove ecosystem can develop well in the area [36]. The introduction of mangrove and non-mangrove objects in this study can be divided into 3 (three) classes, including mangrove, non-mangrove, and water classes. The results of satellite image processing show that the distribution of mangroves is dominated in the northern and southern parts of the study sites that are included in the South Denpasar District, Kuta District, and South Kuta District.

The condition of the addition of mangrove area in 1995-2015 is caused by one of them being the Mangrove Tree Plantation or Adoption Program since 1992 [37]. Besides, the condition of the mangrove area in this area also increased due to the many activities of conservation and conservation of mangrove ecosystems and increasing human resources (including surrounding communities) in the field of mangrove forest conservation, including the Development of Sustainable Mangrove Management Project (1991-1999), Mangrove Information Center (2001-2006), sustainable mangrove development (2007-2010). In the effort to conserve mangrove forests, the Government has continued to collaborate with JICA until 2014 [37]. On November 23, 2012, Bali's Provincial Government conducted a 1,000-mangrove tree-planting movement in the area of Tahura Ngurah Rai Area, Bali, which was carried out by all groups of society, institutions, and institutions. Mangrove planting is included in efforts to conserve mangroves in the Benoa Bay Bali mangrove ecosystem. The results of mapping the distribution of mangroves in Tahura Ngurah Rai Bali in 1995, 2015, and 2019 are shown in Figure 5.

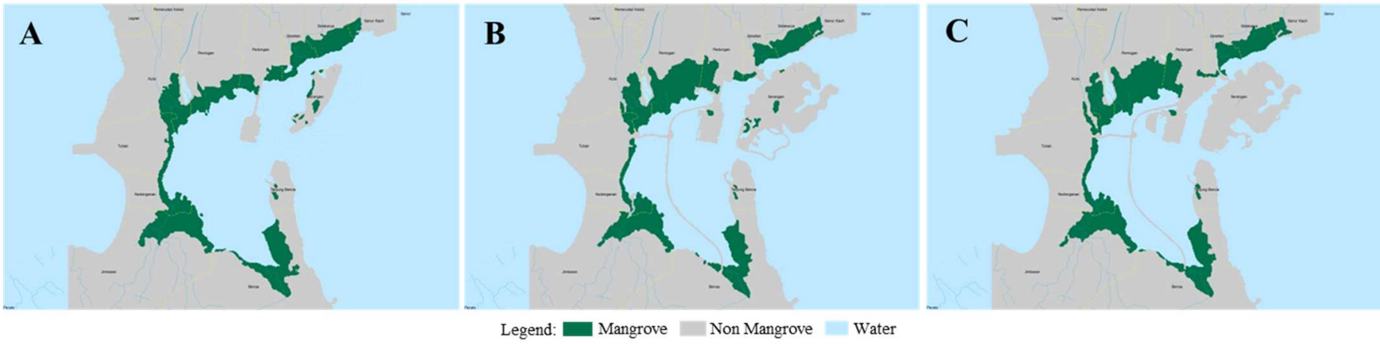

Fig. 5 Map of the distribution of mangroves in Tahura Ngurah Rai Bali. (a) 1995, (b) 2015, (c) 2019

When a significant development of mangroves occurred in 1991 to 2012, then the construction of a toll road that crosses Bali's Benoa Bay was inaugurated on 23 September 2012 and permitted a reclamation project by the Governor of Bali on 26 December 2012 on the Northeast side of the Benoa Bay, Bali, affected the distribution of the condition of mangroves in Tahura Ngurah Rai, Bali. Table 3 is the result of calculating changes in the extent of mangrove cover in Tahura Ngurah Rai, Bali.

TABLE III

THE RESULTS OF THE CALCULATION OF MANGROVE AREAS IN TAHURA NGURAH RAI BALI IN 1995, 2015 AND 2019

Classification	Area						Area Change (Ha)	
	1995		2015		2019		(1995 – 2015)	(2015 – 2019)
	Ha	%	Ha	%	Ha	%		
Water	6340.14	49.19	5753.33	44.64	5725.58	44.42	-586.81	-27.75
Non-Mangrove	5517.91	42.81	6076.85	47.15	6111.80	47.42	+558.94	+34.95
Mangrove	1030.35	7.99	1058.22	8.21	1051.02	8.15	27.87	-7.2
Total	12888.4	100	12888.4	100	12888.4	100	-	-

Source: Data Processing Results, 2019

The analysis of changes in the extent of water bodies, mangroves, and non-mangroves in the study location showed a significant change in each study year. In 1995-2015, changes in the body of water were reduced quite significantly in an area of 586.81 hectares because, in this area, reclamation had occurred, which caused the area of the water to decrease. The condition of non-mangrove land also increased by 558.94 hectares due to reclamation activities on the Benoa Bay coast. Meanwhile, the area of mangrove increased by 27.87 hectares due to the planting and conservation of mangroves carried out by the Regional Government in collaboration with JICA, which also involved the community and other parties in planting mangroves on the coast of Benoa Bay. Over the next four years, from 2015 to 2019, there has also been a change in the existing land area, including the extent of water bodies and mangroves, respectively, by 27.75 hectares and 7.2 hectares. Also, the non-mangrove area has increased by 34.95 hectares due to the reclamation process continues to the present (the end of 2019).

TABLE IV
COMPARISON OF MANGROVE AREAS OF TAHURA NGURAH RAI BALI BETWEEN THIS STUDY AND PREVIOUS RESEARCH

S*	Area of Mangrove (Ha)					Data Source
	1995	2006	2012	2015	2019	
[38]	-	1095,89	1005,91	1066,53	-	SPOT 6
This study (2020)	1030.35	-	-	1058.22	1051.02	Landsat 5 TM and Landsat 8 OLI

*Studies

Table 4 compares the results of mangrove calculations based on remote sensing satellite image data in Tahura Ngurah Rai Bali between the results of this study and previous studies [38]. Table 3 shows the mangrove area calculation results, which is relatively the same, especially in 2015, where there were only differences in the calculation results of 8.31 Ha. Based on Table 3, it can also be explained that there was an increase in the area of mangrove ecosystems from 1995-2006, then in 2006-2012, there was a significant reduction in mangroves, which was estimated due to reclamation activities in the form of toll road construction around Tahura Ngurah Rai Bali. Bali Mandara toll road construction activities along the waters of the Benoa Bay area were carried out in 2012 and are feared to impact the mangrove ecosystem in Tahura Ngurah Rai [39]. Spatial reduction in mangrove vegetation is due to the felling of mangrove trees for the construction of toll roads above the waters of Benoa Bay [38].

The predominance of decreasing mangrove areas mainly occurs in the southern part of the bay and close to Ngurah Rai Airport. Then from 2012-2015, there was an increase in the area of mangroves, and in 2015-2019 the condition of the mangrove area decreased in line with the decline in environmental quality conditions and land conversion activities around Tahura Ngurah Rai Bali mangrove ecosystem. The graph of mangrove change in Tahura Ngurah Rai Bali is shown in Figure 5. An interesting thing to know about changes in the condition of Tahura Ngurah Rai Bali ecosystem (Figure 6) was the condition when mangrove areas were added. The information search results and literature results explained that one of the causes of the increase in mangrove area is a natural factor. Besides, community support around the mangrove area to preserve mangrove ecosystems also significantly affects mangroves' existence.

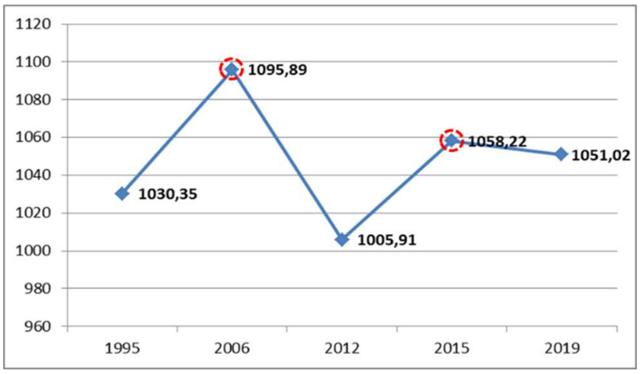

Fig. 6 Graph of Mangroves Changes in Tahura Ngurah Rai Bali 1995-2019

The calculation of mangrove density using the NDVI method has a range of different maximum and minimum values within the three study periods. Visualization results from the analysis of NDVI value calculations show different color gradations from the three mangrove density classification classes. In displaying the optimal level of proportion of mangroves, the classification of 3 (three) classes of mangrove density is to be low density, medium density and high density [40]. Determination of NDVI class intervals using class interval classification calculations. Visualization of mangrove density calculation results can be seen in Figure 7, while the range of NDVI values is shown in Table 5.

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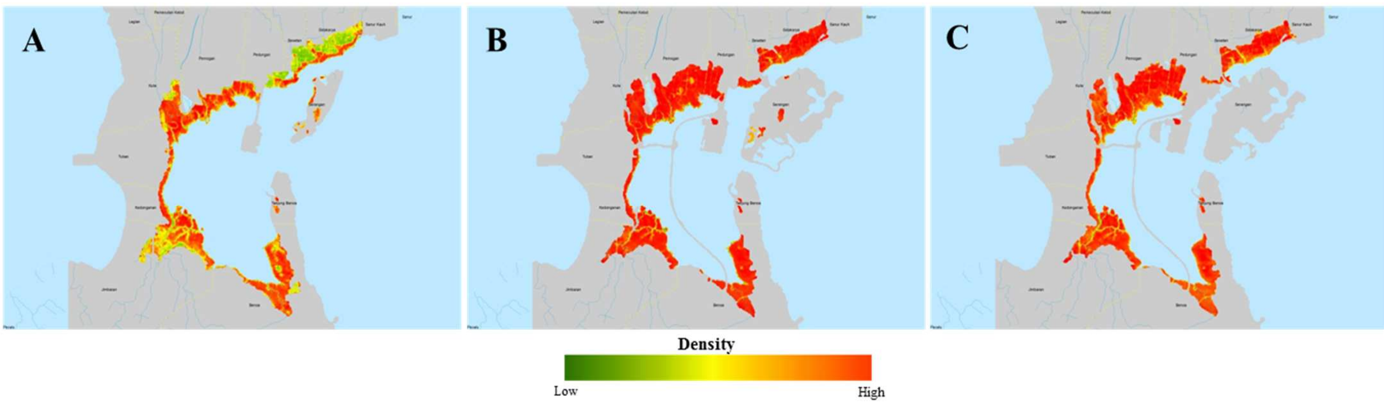


Fig. 7 Map of distribution of mangrove density in Tahura Ngurah Rai, Bali. (a) 1995, (b) 2015, (c) 2019

TABLE V
NDVI VALUE RANGE

Year	NDVI	
	Min	Max
1995	-0.6030	0.6993
2015	-0.9818	0.7701
2019	-0.6180	0.6993

Source: Data Processing Results, 2019

The results of the calculation of mangrove density in the Benoa Bay of Bali showed that in the period 1995-2019, the mangrove density did not change significantly with an average of 0.7, indicating a high-grade density value. Mangrove density is grouped into 3 (three) density classes, namely low density, medium density, and high density, where the higher the NDVI value, the higher the mangrove density in Tahura Ngurah Rai Area (Figure 7), Based on the results from image analysis and through NDVI calculations, the density of mangrove ecosystems in Tahura Ngurah Rai Bali has a high-density level. The distribution of high-density mangroves is dominated in the northern part of the study location, around the Pemogan and Pedungan Villages of South Denpasar District. It also further supports that the surrounding community has high awareness and awareness in maintaining the mangrove ecosystem in this area.

C. Mangrove and Non-Mangrove Mapping Accuracy Test

Accuracy test was done by using the map of mangrove classification results in 2019 of the mangrove area identified through Image Mosaics SPOT6 / 7 in 2018 and 2019. The accuracy test uses a random method with a total sample of 100 points (80 mangrove samples, 20 non-mangrove samples) as shown in Figure 8.

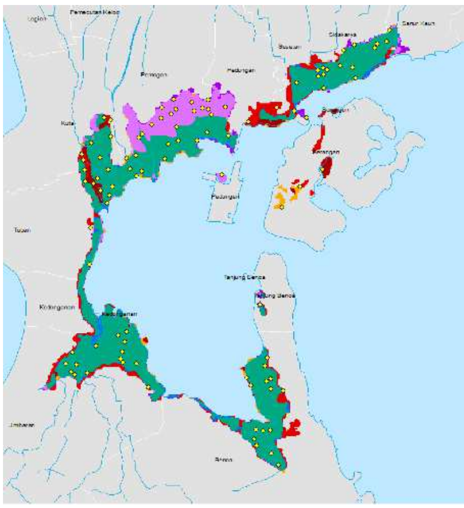


Fig. 8 Distribution of Accuracy Test Sample Points

TABLE VI
KAPPA ACCURACY CALCULATION RESULTS

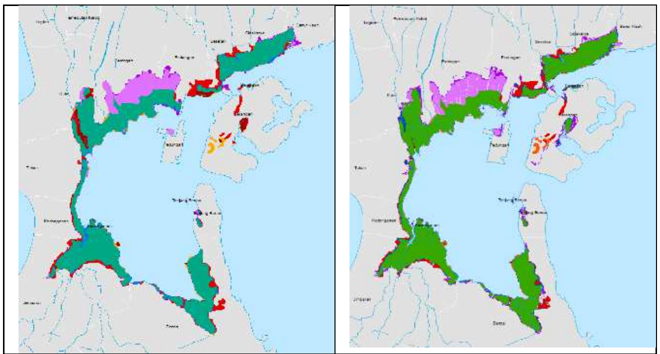
SPOT 6/7 \ 2019	Mangrove	Non-Mangrove	Total
Mangrove	71	12	83
Non-Mangrove	9	8	17
Total	**80**	**20**	**100**

The calculation results show an accuracy of 79% (Table 6). The difference influences the accuracy value in resolution between the data tested (Landsat 30 m) and the comparison (SPOT 15 m). Error-values (21%) are mostly in areas that have an area of <30% of Landsat resolution, so they are not mapped in the classification results but are identified/mapped on SPOT images with higher resolution. However, omission accuracy (80 mangrove samples) gives a value of close to 89%.

D. The Dynamics of Mangrove Cover Tahura Ngurah Rai, Bali 1995, 2015 and 2019

Overlay analysis of the results of identification of mangrove cover in 1995, 2015, and 2019 (Figure 9a) in addition to showing the existence of mangrove cover that survived from 1995 to 2019, it also shows the dynamics of changes in mangrove cover in the study area, in the form of additions, reductions and other changes (addition of mangrove cover identified in 2015, but decreased in 2019).

The total mangrove cover area identified, there are 68% mangrove forests until 2019. Changes in mangrove cover by 32%, with an increase of about 16% and a reduction of 14%, the remainder (2%) are areas of additional mangrove cover identified in 2015 but decreased in 2019. These results are then overlaid with the One Map Mangrove Map as a control/correction of changes in 2019 (Figure 9b). One Map Mangrove Map is a map of mangrove cover resulting from multi-sectoral integration between BIG, KLHK, KKP, and LIPI. This stage is done to improve the accuracy of the analysis of changes (additions and subtractions) of the mangrove cover area, especially those identified from 2019.



(a) (b)

Legend:

1995	2015	2019	CHANGED	INFORMATION	INDICATION
√	√	√		UNCHANGED	-
x	x	√		INCREASE	Continuously increase
x	√	√		INCREASE	
√	√	x		REDUCE	Continuously reduce
√	x	x		REDUCE	
√	x	√		INCREASE	Successful Replanting
x	√	x		-	Unsuccessful Replanting

Fig. 9 (a) The Dynamics of Mangrove Changing in Tahura Ngurah Rai Bali Mangrove Ecosystem, (b) Overlay with One Map Mangrove data

The visualization results of the map of changes in mangrove cover in the study area that have been overlaid with the One Map Mangrove Map. (Figure 9b) provides information on the phenomenon of mangrove cover changes that are interesting to observe.

1) Addition of Mangrove Coverage Area in 1995-2019: The addition of mangrove cover area interesting to observe is the relatively massive and progressive addition, namely the addition of a relatively large and consecutive mangrove area to occur in 2015 and 2019. At least 3 locations in the study area are indicated to have progressively added mangrove cover areas, the first being in Tahura Ngurah Rai area (Pemogan and Pedungan Village). The second is on the west coast of the Pelindo III gebang, which is the mainland reclamation. A very significant addition occurred in the first location, which covers an area of almost 143 Ha, which took place in the period 1995-2015 (±7 ha/year) and increased by (±10 hectares in 2019. Conditions for increasing mangrove cover areas in 1995-2019 are shown in Figure 10.

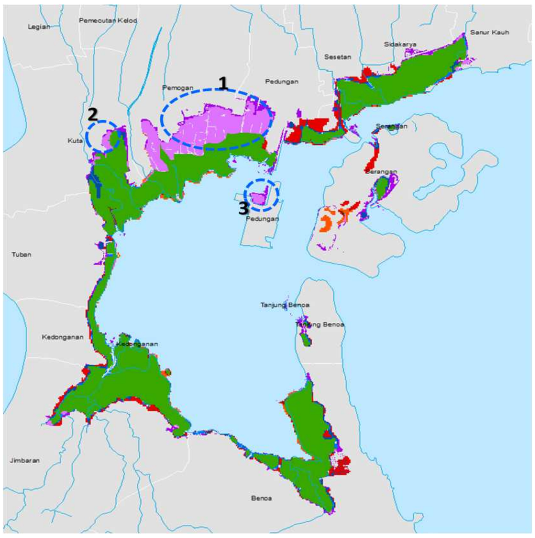


Fig. 10 Addition of Mangrove Cover

2) Reduction of Mangrove Coverage Areas 1995-2019: The decreasing area of mangrove cover occurs almost evenly in the coastal area of Benoa Bay, both in the north and south, especially those bordering the land or built area. However, several locations where the mangrove cover area has been massively reduced / significant compared to the cover of the 1995 image identification results. The first location is in the northern part of Benoa Bay, namely in Pedungan Village, Sesetan Village, and Serangan Island, South Denpasar District, Denpasar City. The second location is in ITDC Lagoon Nusa Dua Bali, which is in an area that is currently a wastewater treatment pond. Image analysis in 1995 showed that the location was still in mangrove cover, similar to the surrounding area. However, further verification is needed related to the accuracy of mangrove identification results from 1995 images, because based on available information, the lagoon has been around since the early 1990s. The condition of the reduced mangrove cover area in 1995-2019 is shown in Figure 11.

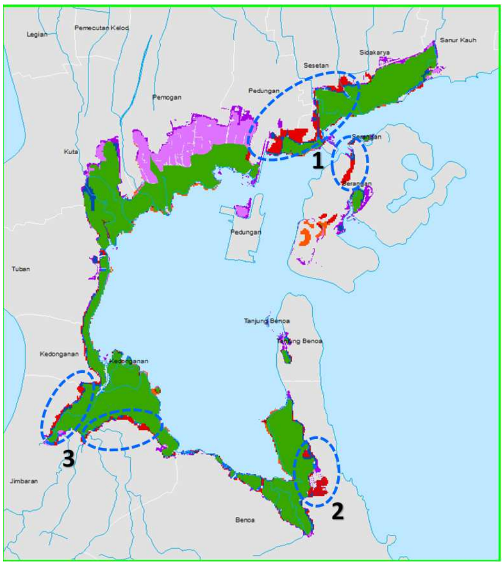


Fig. 11 Reduction of Mangrove Cover 1995-2019

3) Reduction of Mangrove Coverage Areas 2015-2019

Analysis of mangrove cover changes also shows the condition of mangrove cover which only appears in the 2015 image as shown in Figure 12. This indicates an effort to rehabilitate/replant mangroves that were done before 2015 but did not last (failed), so it is not identified in the 2019 image. The location is in the Tanjung Tunggaktiying area. However, this also needs further verification to get better accuracy.

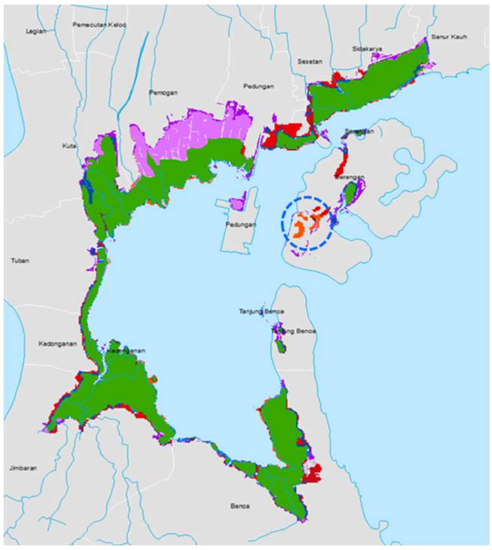


Fig. 12 Reduction of Mangrove Cover 2015-2019

E. Importance of Local Wisdom in Maintaining Mangrove Sustainability

In the life of the Balinese, there are social values that shape local wisdom, which has finally been integrated into their lives. Bali's local wisdom's unique characteristics and uniqueness make it strong to attract tourists both at home and abroad [41]. This local wisdom cannot be separated from the religious values adopted by the community [19]. So, it can be said that Bali's people appreciate the life of living creatures around them, including mangrove plants in their area. The level of community awareness in preserving mangroves in the area of mangrove ecosystems in Tahura Ngurah Rai and surrounding areas is also high as shown in Figure 13 and

Figure 14 [42], [43]. Communities are dependent on mangrove ecosystems so that the demand for the management of Tahura Ngurah Rai area involves the role of the community in maintaining mangrove conservation by the concept of sustainable development.

Fig. 13 Mangrove Planting Activities

Fig. 14 Condition of mangrove forests and ecotourism facilities in Tahura Ngurah Rai, Bali

Previous studies describe Tahura utilization activities which are always used by several community groups, especially fishing groups [43]. One such group is Segara Guna Batu Lumbang Batu Lumbang Fishermen Group. For fisherman of Batu Lumbang, the existence of mangroves is very important and their role is the source of income of fishermen because most of the fishermen groups are diverse Hindus and adhere to the *Tri Hita Karana* concept (three causes of harmony), consist of *Parahyangan* (the harmonious relationship between humans with *Ida Sang Hyang Widi Wasa* : The One Almighty God); *Pawongan* (the harmonious relationship between humans and others, including family, friends, and society); and Palemahan (the harmonious relationship between mankind and its environment). These three concepts are used as benchmarks in the success of a development. Fishermen consider the impact of development activities for the short and long term. The reclamation plan (development) will restrict fishermen from fishing, worship activities will be disrupted and threaten the balance of the mangrove ecosystem. This group of fishermen took the initiative to plant deforested mangrove areas using canoes. Not only that, Batu Lumbang Fishermen Group replaces dead mangrove plants with new seeds, and in this planting also involves elementary school students and Scouts to maintain its sustainability.

Based on the results of mapping the distribution of mangroves in Tahura Ngurah Rai, Bali, it shows that in 2015-2019 the area decreased by 0.06% or 7.2 Ha. This becomes interesting because in the year the overall mangrove area condition has decreased but two regions have experienced an increase in the area of mangrove cover progressively including in Pemogan Village and Pedungan Village. In these two regions, mangrove conditions are well preserved while other locations are experiencing a decline in mangrove area.

Pemogan and Pedugan villages have quite good social capital that supports mangrove conservation. Social capital is in the community which enables community members to improve their quality of life through healthy and beneficial social interactions so that the values of local wisdom become more and more inherent in themselves [19]. The social capital owned by Pemogan Village includes multicultural life in the village that can live in peace and harmony. Religious differences are everyday things that the Pemogan Village community has faced. Hindus and Muslims in Pemogan Village are accustomed to engaging in various activities. Menyama braya is the social capital of the Balinese people. This proves that equalizing the community in the village of Pemogan has given birth to a spirit of cooperation between religious communities. This kind of tradition is an implementation of *menyama braya* that strengthens social ties to a plural society and builds harmonious community relations [20], [44]. Therefore, the aspects of trust and solidarity look pretty good in this village where there is a person's will to rely on others because they have confidence in others.

Other social capital is in the collective aspect and cooperation. The Pemogan Village community is active and enthusiastic in participating in activities related to mangroves, among others, activities carried out by Denpasar City government agencies such as conducting mangrove laying and collecting garbage in the mangrove area. This shows that social capital owned coastal communities, which can be built by the government to support the implementation of the development program [45]. Pemogan Village people do not dare to cut down mangrove trees because mangroves' existence is precious for them. The community understands the importance of the existence of mangroves in their area, the benefits of which include the direct use value (fish catches, silvofishery results: crabs, shrimp and fish, and tourism), while the indirect benefits (mangroves as breakwater) and optional benefits (biodiversity values) [46]. This shows the awareness and concern of the community towards the importance of mangrove forest conservation. Groups and networks contained in mangrove conservation are also actively involved in mangrove activities. At the same time, the aspects of empowerment and political aspects that are development processes that involve the community to start the process of social activities include training and adding knowledge to the community about the conservation of mangroves that are continually being intensified by the government the city and village governments [21].

One of the progressive growths of mangroves in Pedungan Village is due to the planting of mangrove seedlings by PT. Pelindo III, because Pedungan Village is an area affected by reclamation so rehabilitation is done. Social capital in the village of Pedungan supports the preservation of mangroves, including in this village it is indeed the last area so that the community is very appreciative of this area and is trying to improve back to its original function. Like Pamogan Village, Pendungan Village community is also actively doing river alignment for clean-up actions in the mangrove area. Aspects of trust and solidarity in this village, indigenous people support the preservation of mangroves. The mutual attitude of life and cooperation and cooperation for activities involving common interests is a form of local wisdom that needs to be continually fostered. Efforts to build social capital mirror increasing equity, social cohesion, and community participation [21]. This is important because strong cooperation and coordination between communities can support the sustainability of the mangrove's ecosystem in their place.

IV. Conclusions

Landsat satellite imagery effectively identified distribution and density of mangrove ecosystems in Tahura Ngurah Rai Bali. The condition of mangrove forests from 1995-2015 was increase in the area of 27.87 Ha or around 0.22%, whereas in 2015-2019 there was a decrease in the area of 7.2 hectares or 0.06%. The calculation result of mangrove and non-mangrove mapping accuracy shows kappa accuracy of 79%, which means that the mapping information produced has a sufficient level of accuracy and can be trusted. Mangrove density in the north and southwest of the study site showed a change in density from moderate to high density. In 2015, new mangrove cover was found in the two regions, indicating mangrove rehabilitation efforts. This effort is supported by the local wisdom of the people who appreciate mangroves' existence in their area. Community local wisdom is an important part of community social capital in mangrove conservation, which can be seen from several aspects including trust and solidarity aspects, the collective and collaborative aspects, as well as the empowerment and political aspects.

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