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REMOTE SENSING LANDSCAPE INDICES ON LAND COVER CHANGE DETECTION BAKUN HYDROPOWER BAKUN, SARAWAK.

AUTHORS INFO

Ricky Anak Kemarau
Faculty Social Science and Humanities,
Universiti Malaysia Sabah
ricky.geo2005@gmail.com

Oliver Valentine Eboy
Faculty Social Science and Humanities,
Universiti Malaysia Sabah

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Abstract

Sarawak's location in the equatorial region makes it an area rich in rainfall. Therefore, hydroelectric power generation facilities have been established in several hydrological basins in Sarawak, especially in the Kapit area. In particular, this must be used to improve the economic and social living standards of the people of Sarawak. This article analyzes the stratum changes of the Bakun Dam in Sarawak over the past 30 years (1985 to 2018) and proposes land use and land protection. This study uses Landsat 5 and Landsat 8 satellite data. Both of these data need to be pre-processed, such as radiometric measurement and atmospheric correction. In this study, the selected landscape index was used to classify the water body area, vegetation, and man-made buildings, namely the Modified Normalized Water Difference Index (MNDWI), the Normalized Water Difference Index (NDWI), and the Normalized Difference Vegetation Index (NDVI). Apply overlay analysis to identify areas in the study area that have changed in the past 30 years. The results showed that MNDWI showed better results compared with other selected indicators. The study also found the biggest change from vegetation to water bodies in 30 years. The results showed that the most severely affected land cover was the formation of forests, which was reduced by 740km^2, and was mainly transferred to the water body of 669.9km^2, while the area of human habitation was 68.7 km^2. Land cover mapping is very important when providing information to those responsible for planning for sustainable development. In addition, land cover maps are also important for avoiding land-use conflicts for land use planning and land use regulations.

Keywords: Remote Sensing, Landscape Index, Change Detection, hydroelectric Energy

A. Introduction

Krishna et al. (2019) pointed out that land cover changes in Southeast Asian countries such as Indonesia, Malaysia, Singapore, Thailand, Vietnam, and Cambodia are occurring rapidly. This rapid change is caused by population growth, urban expansion, and large development such as dams. The demand for energy and the rich in rainfall make hydropower plants the best

choice to provide electricity to the people of Sarawak to improve the economy and society. Monitoring, recording, and recording of land cover changes are very important in Malaysia because the product can advise policymakers and improve land management (Ricky and Oliver, 2021). Generally speaking, traditional methods are still used when drawing land cover maps in developing countries. Compared with remote sensing technology, the previous method is time-consuming and expensive. Technology can provide data in multiple time, summary, and repetitive ways. Therefore, remote sensing provides a practical and best tool for mapping and calculating surface changes in different proportions, times, and locations. [Lorbede et al., 2017; Shimabukuro et al., 2014; Cowie et al., 2018). Besides, it is a very useful tool detection and mapping of analytical changes in forest land cover. It also has an important contribution to records Regional land use/land cover changes And the global scale since the mid-1970s (Hoa et al. 2016). A survey of the writing has focused on the recognition of land cover changes utilizing different models, techniques, and satellite pictures, in particular (Ricky and Oliver, 2019), NDVI, Principal Component Analysis (PCA). Nutini et al., (2018) performed the multi-temporal investigation and Landsat imaging. Kim et al. (2015) utilizing Landsat data; Mayes et al. (2016) continued from Landsat 5–8 information and linear mixture examination and Choudhary and Pathak (2017) researched the identification of land-use changes utilizing Landsat TM, ETM, and OLI imaging. Leite et al. (2018) utilized Landsat 5/TM photos and geological items. Sidhu et al. (2019) utilized Google Earth for planning ground cover changes and Zoungrana et al. (2018) utilized MODIS satellites to study the ground cover change recognition applications. NDWI to plan glacial mass lakes dependent on a nearby versatile thresholding technique (Li and Sheng, 2012). This strategy was additionally utilized by Allen and Pavelsky (2015) to create a land/water cover for North America utilizing the Modified Normalized Difference Water Index (MNDWI). Rokni et al. (2014) demonstrated the spatial-fleeting varieties of Urmia Lake over the period 2000–2013. They researched diverse satellite-determined unearthly records (NDWI, MNDWI, NDMI (Normalized Difference Moisture Index), AWEI (Automated Water Extraction Index), NDVI, and WRI (Water Ratio Index)) for water extraction. NDWI showed the best outcomes thought about with the other files (Rokni et al. 2014) The Weighted Normalized Difference Water Index (WNDWI) is proposed by Guo et al. (2017) to diminish mistakes due to misclassified turbid water, little water bodies, and some land highlights in a shadow region. This study to determine the effectiveness of the selected landscape index in extract freshwater bodies. There is no past work in the writing investigating land cover in Bakun, Sarawak. To address this difficulty, the specialists utilized distant detecting information with a spatial goal of 30 meters for a time of 30 years (1990-2020) to identity land chance between the year where there start of construction of the hydroelectric power plant and the current period.

B. Methodology

1. Location of Study

The Bakun hydropower dam is positioned at the Batang Balui, the higher direction of the Rajang River, Kapit division. The Bakun hydropower dam around 37 km upstream of Belaga town (Tipol, 2019). Bakun hydroelectric electricity plant generation ability of 2,400 MW (Tipol, 2019).

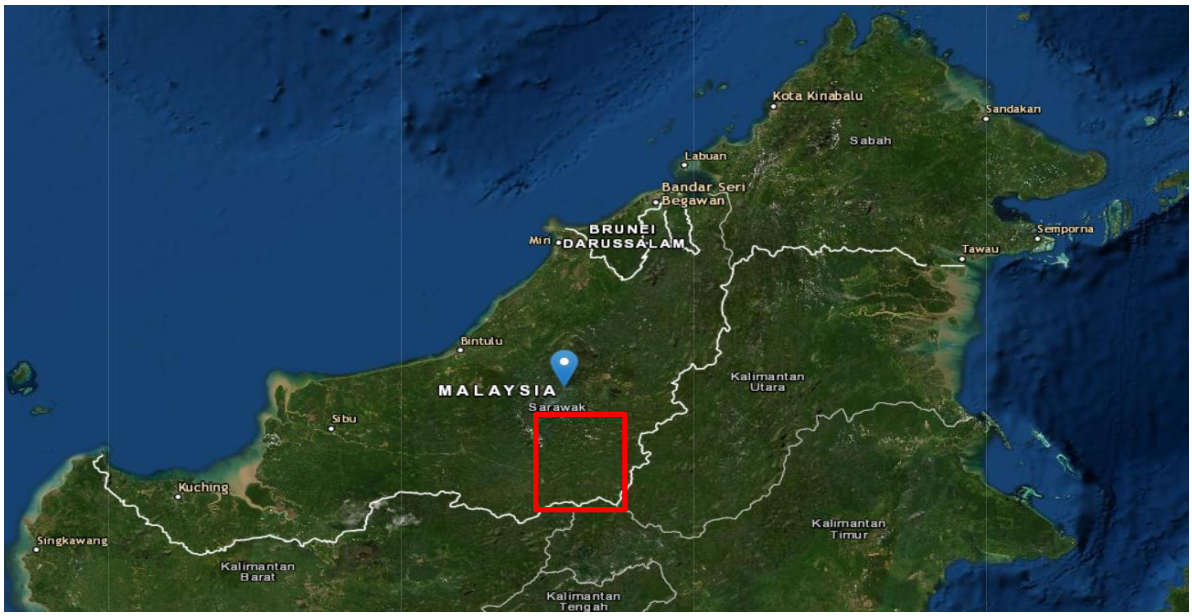


Figure 1: *Location of Study (Bakun Dam)*

Table 1: Information of dataset

Sensor	Data Level	Data Acquisition	Cloud Cover
Landsat 5 Thematic Mapper (TM)	Level 1	25 May 1990	Less from 10%
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	Level 1	21 August 2020	Less from 10%

This study uses data from Landsat 5 TM and 8 OLI TIRS satellites as shown in table 1. The provider has been done the geometric correction for both data. The detailed flow of the method will discuss the next sentence.

Table 2: Information of Landsat 5 TM

Landsat 4-5 TM	Wavelength detailed	Wavelength (Micrometers)	Resolution (meters)
Band 1	Visible – Blue	0.43 – 0.45	30
Band 2	Visible – Green	0.45 -0.61	30
Band 3	Visible – Red	0.53 – 0.59	30
Band 4	Near Infrared	0.64 – 0.67	30
Band 5	Short wave Infrared 1	0.85 – 0.88	30
Band 6	Thermal Band	1.57 – 1.65	60
Band 7	Short Wave Infrared 2	2.11 – 2.29	30
Band 8	Panchromatic	-0.68	15

Table 2 shows the bands available in Landsat 5 TM which was applied in this study.

Table 3: Information for Landsat 8 OLI and TIRS.

Landsat 8 OLI and TIRS	Wavelength detailed	Wavelength (micrometers)	Resolution (meters)
Band 1	Coastal Aerosol	0.45 – 0.52	30
Band 2	Blue	0.52 -0.60	30
Band 3	Green	0.63 – 0.69	30
Band 4	Red	0.76 – 0.90	30
Band 5	Near Infrared	1.55 – 1.75	30

Band 6	Shortwave infrared	10.40 – 12.50	60
Band 7	Shortwave infrared	2.08 – 2.35	30
Band 8	Panchromatic	0.50 -0.68	15
Band 9	Cirrus	1.36 – 1.38	30
Band 10	Thermal Infrared 1	10.6 – 11.19	100
Band 11 Thermal	Thermal Infrared 2	11.50 – 12.51	100

Table 3 shows the detailed information for Landsat 8 which applied to this study. NDWI, MNDWI, and NDVI at Landsat 5 TM and Landsat 8 OLI and TIRS can be generated using the following formula:

NDWI = ((Near Infrared – Short Wave Infrared) / (Near Infrared + Shortwave Infrared)).

MNDWI makes use of green and shortwave infrared bands for the enhancement of open water features. It additionally diminishes built-up region features which are frequently correlated with open water in different indices (Xu, 2006).

MNDWI = ((Green – Short Wave Infrared) / (Green – Short Wave Infrared).

NDVI is a standardized index allowing you to generate an image displaying greenness, additionally known as relative biomass. This index takes gain of the contrast of traits among two bands from a multispectral raster dataset—the chlorophyll pigment absorption in the red band and the excessive reflectivity of plant cloth within the near-infrared (NIR) band (Ricky and Oliver, 2019).

NDVI = ((Near Infrared – Red)/ (Near Infrared + Red)).

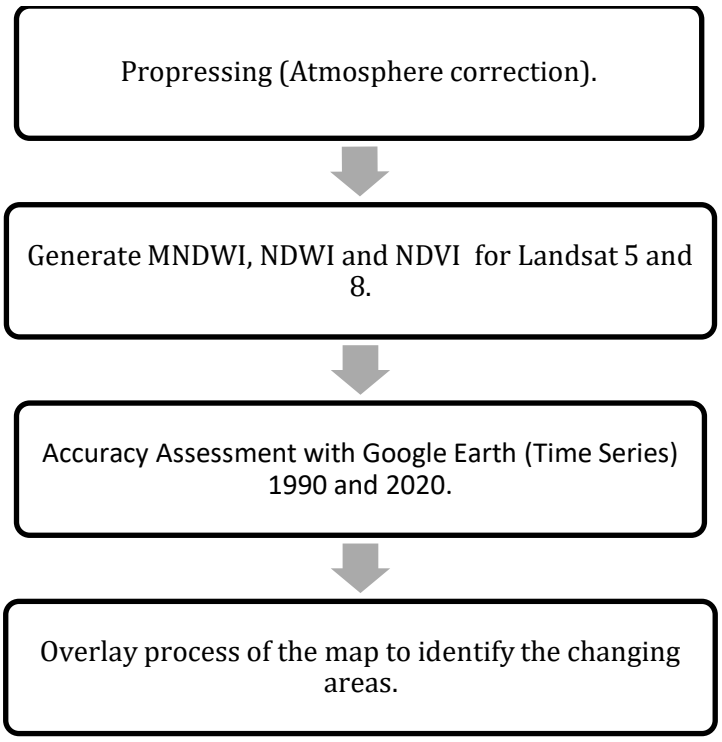


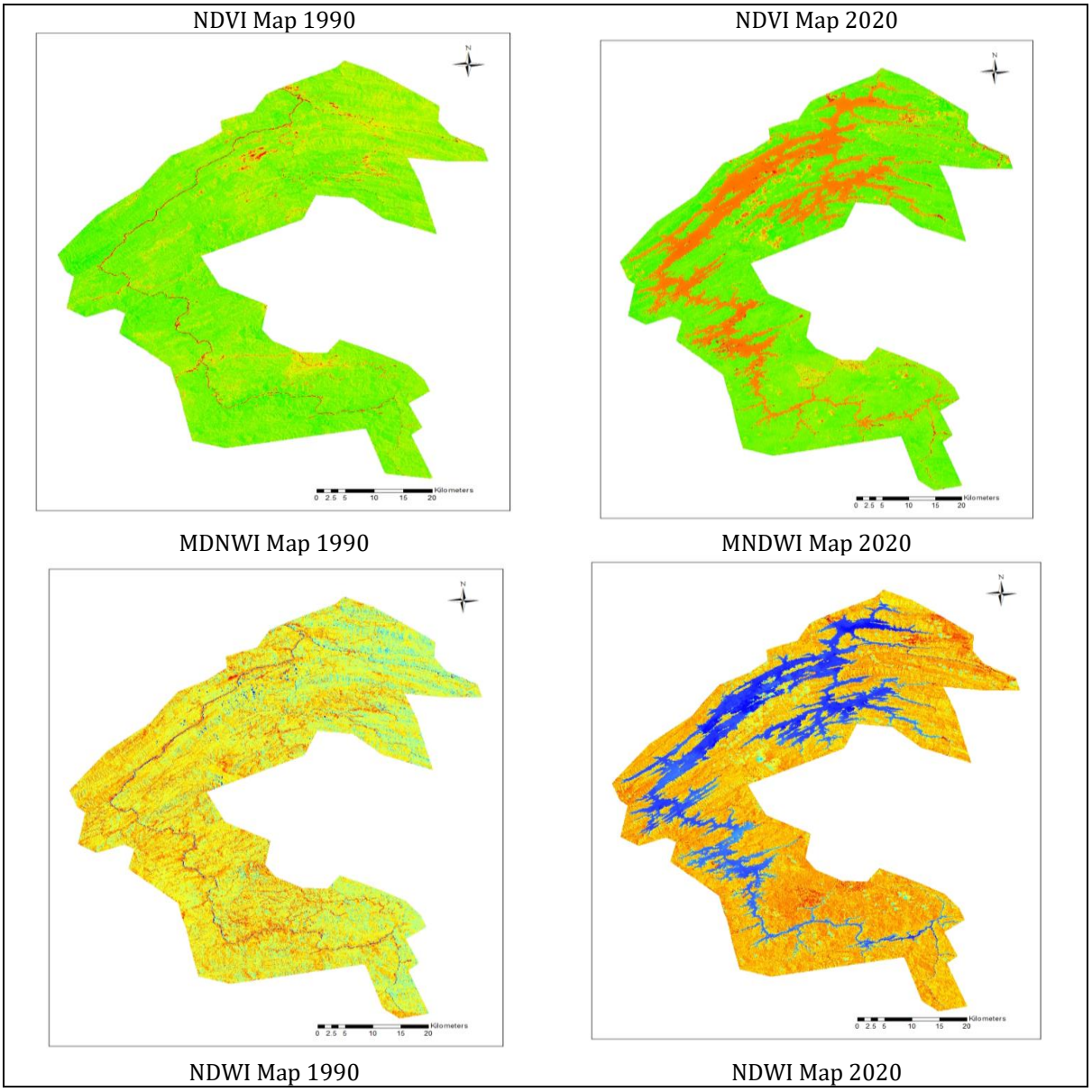
Figure 2: *Flow Methodology.*

Figure 2 indicates the steps that were taken in reaching the goals of the study. Step one is to carry out pre-approaches which includes atmospheric, and radiometric. The second step is

producing a land cover map using landscape indices namely MNDWI, NDWI, and NDVI using a formula that is extensively used. The next step is needed for the calculated areas of every land cover in ArcGIS. Change detection in ArcGIS will be applied to examine the areas of land cover change between the years 1990 and 2020 at study areas. The remaining step is to assess the accuracy of the 1990 and 2020 land cover maps finished with time series analysis on Google Earth as practiced by way of Ricky and Oliver (2021).

C. Findings and Discussion

Referring to figure 3, it is found that all the selected indices successfully classify the area of vegetation, water bodies, and human-built up. For example on the left side of figure 3 is the landscape index map during 1990 and on the right during 2020. For example, for the NDVI map, the green-colored area represents plants and the orange-colored one is a body of water and built-up human. For the MNDWI and NDWI maps, the blue area represents the water body area and the yellow and orange areas are non -water body areas ie built up humans and vegetation. In this context, researchers need to perform classification in ArcGIS for each NDVI, NDWI, and MNDWI image. The discussion of each area based on each landscape index will be discussed in the next paragraph. This study found that there is a difference in the value of the area of each land cover for each selected landscape index. An in-depth discussion of the differences will be discussed in the next paragraph.



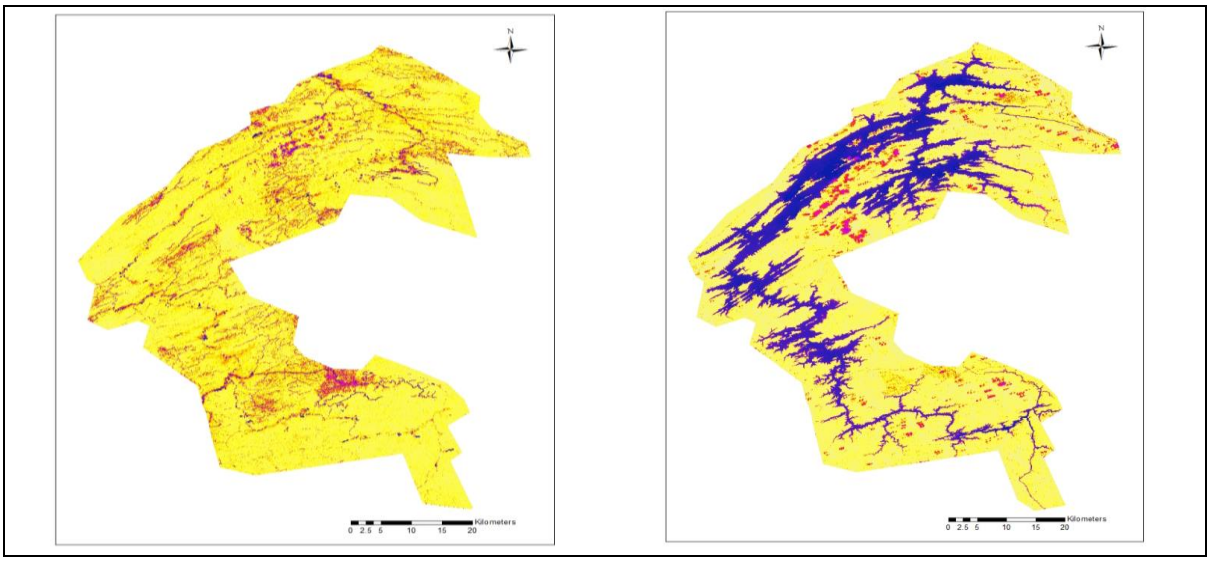
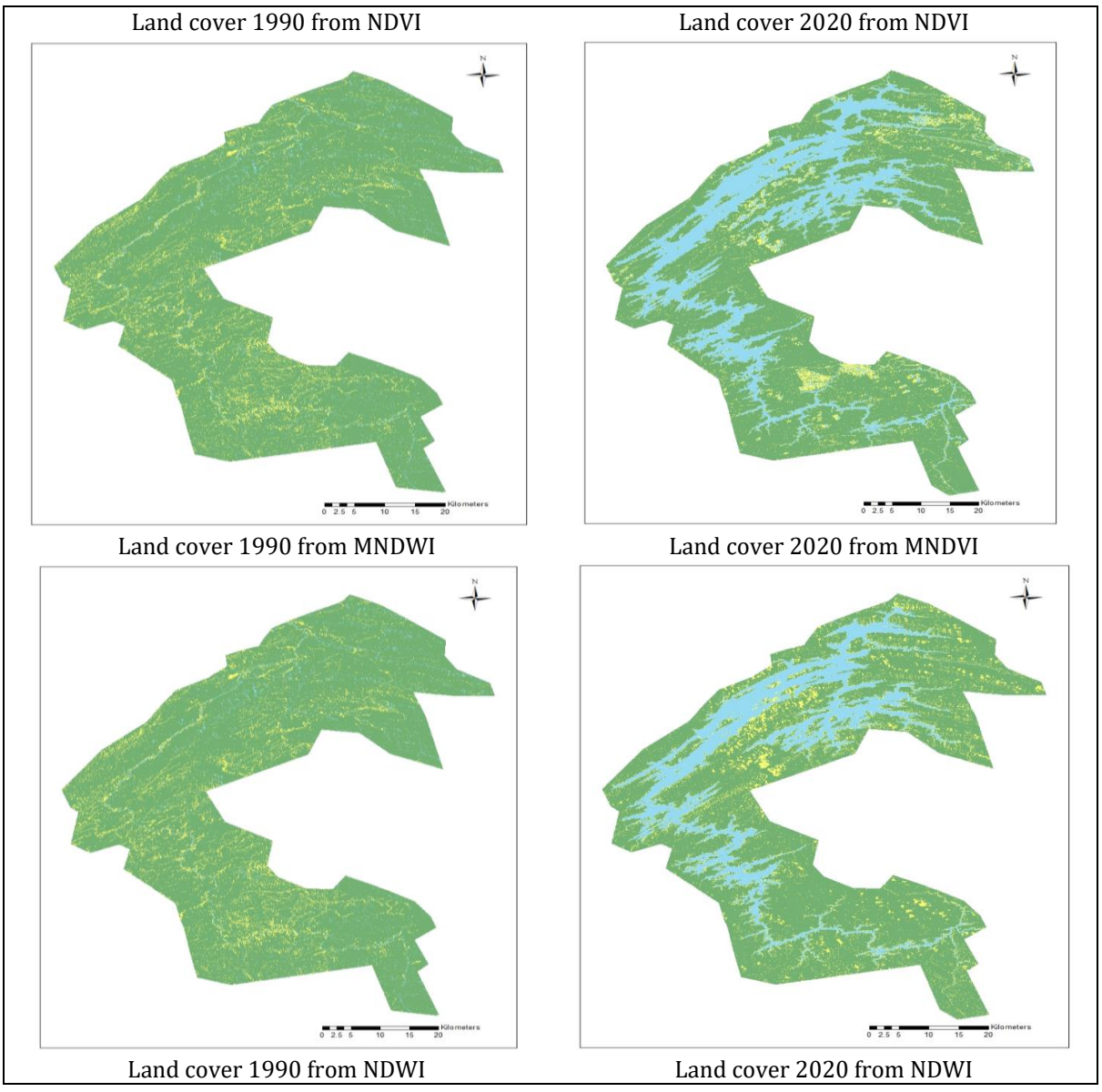


Figure 3: *Map of NDWI, MNDWI, and NDWI for the years 1990 and 2020.*

Refer figure 4 shows the observed big change of vegetation between the years 1990 and 2020. In the year 1990, the figure shows the vegetation area was the largest area at area study compare to the water body and built up.



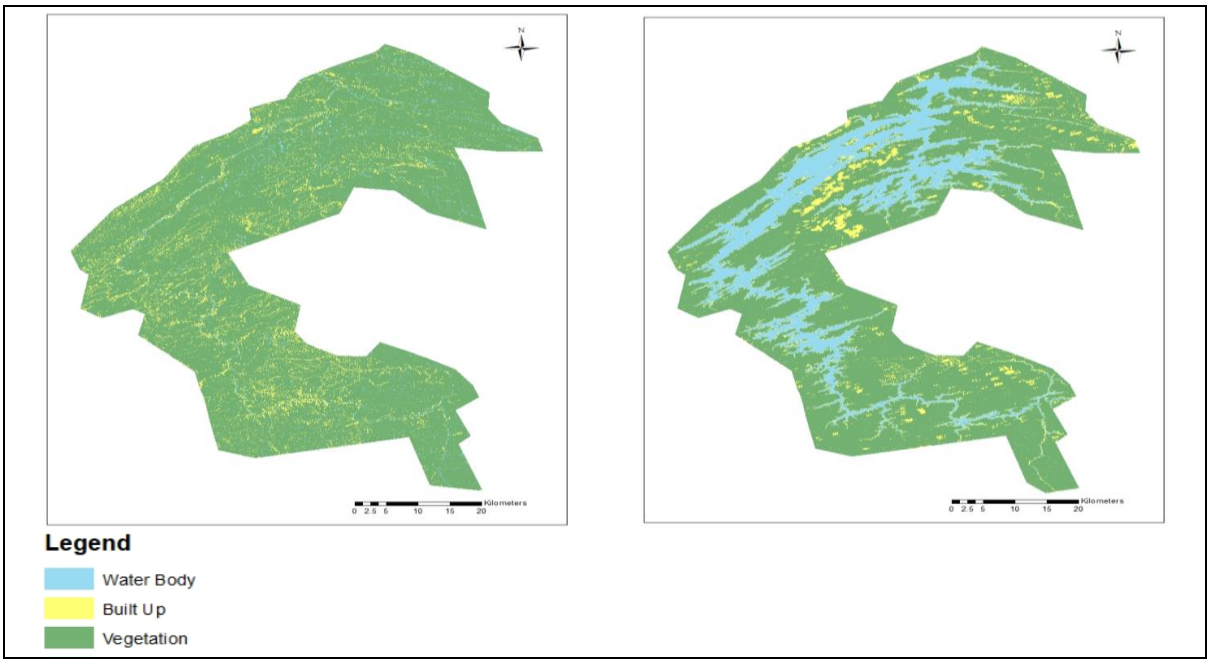
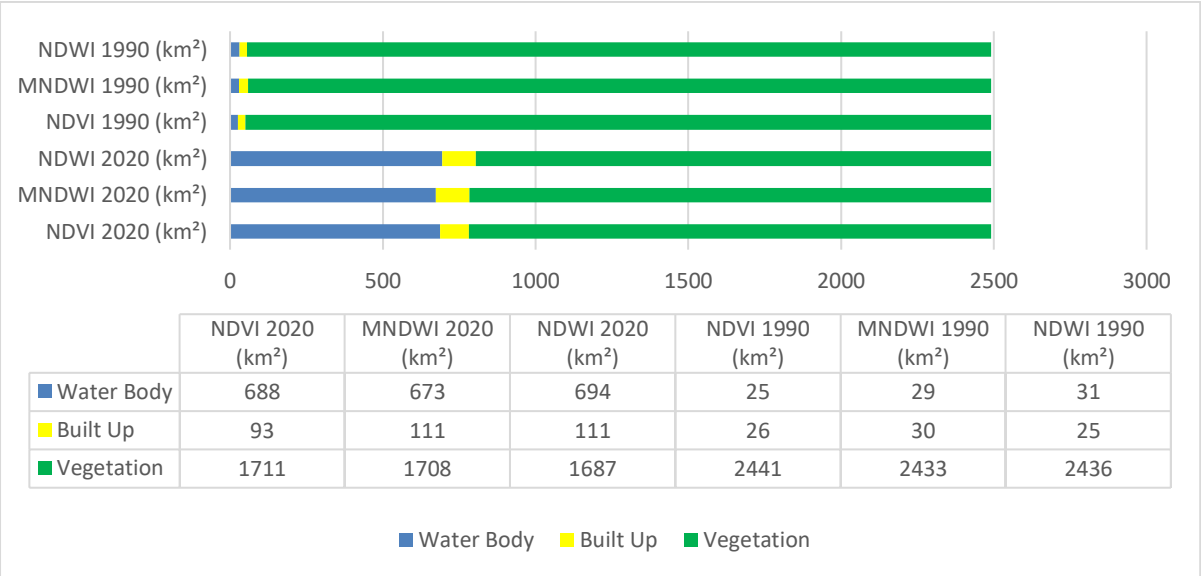


Figure 4: *The land cover map in the Bakun area in 1990 and 2020 from NDVI, MNDWI, and NDWI.*

The year 2020 also shows the vegetation areas still the largest areas compare to build-up areas and water bodies. This major change is due to the construction of the Bakun dam which was fully completed and fully operational in 2011 (Sarawak Energy, 2019; Tipol, 2019). This causes changes in the conversion of land cover from plant areas and water bodies (Tipol, 2019). The detailed explanations of land cover change require to refer to figure 5 for every 3 landscape index.



	NDVI 2020 (km²)	MNDWI 2020 (km²)	NDWI 2020 (km²)	NDVI 1990 (km²)	MNDWI 1990 (km²)	NDWI 1990 (km²)
Water Body	688	673	694	25	29	31
Built Up	93	111	111	26	30	25
Vegetation	1711	1708	1687	2441	2433	2436

Figure 5: *The land cover area for 1990 and 2020.*

Figure 5 shows the area for each land cover area, namely vegetation area, water body, and built-up human. Based on the figure above, it is found that the plant area is the largest in the study area for 2020, namely 1711 km^2 for NDVI and 1708 km^2 for MNDWI, and 1687 km^2 for NDWI. While for 1990 it was found that the total vegetation area was 2441 km^2 for NDVI, 2433 km^{2}for MNDWI, and 2436 km^2. The three selected indexes found that the vegetation area was the largest. The change from vegetation area to water body due to the Bakun reservoir dam which is an area of 688 km^2 for NDVI, 673 km for MNDWI, and NDVI is 694 km^2. The study also found an increase in a human built-up area of 93 km^2 for NDVI and 111 km^2 for both NDWI and MNDWI indices. To confirm the accuracy of the total area of water bodies, this study compares the area of water bodies produced by Sarawak Energy (2019) which is the owner of the dam which is 695 km^2 (Tipol, 2019). The table below shows the differences in water body area from the three indices with the official report.

Table 4: *Difference area water body from Official Report (km^2)*

Landscape Index	NDVI	MNDWI	NDWI
Difference area water body from Official Report (km^2)	7 km^2	22 km^2	1 km^2

Determine table 4 various classifications using NDWI index having a difference of 1 km^2 compared to MNDWI and NDVI. This author is clear the accuracy of NDWI in explaining body areas is best with NDVI da MNDWI. These results differ similar to the findings of Ozlken (2016). The next student is to make changes to the area between 1990 and 2020 by using the NDWI classification.

Table 5: *Changes in different land-use classes in Bakun area from 1990 to 2020*

Land cover type	1990 – 2020 (km^2)	Trend %
Water body	663	Increase 26.6%
Vegetation	749	Decrease 30.05%
Built-up	335	Increase 3.45%

Table 5 shows the change in land area between 1990 and 2020. This study shows that the air body area increased by 26.6 % equivalent to 663 km^2. Area, while developed area, is an increase of 86 km^2 each increase increased by 3.45%. However, the output of the vegetation area decreases by 749 km^2 equivalents to 30.05%. Decreased area output as a result of the conversion of the land cover of the area around the body to the air body due to the construction of the Bakun dam. The construction of dams is very important in providing electricity to the people of Sarawak to improve their social and economic status. Researchers predict activities such as those developed through logging and settlement activities will result in a decrease in the area of growing area in the future.

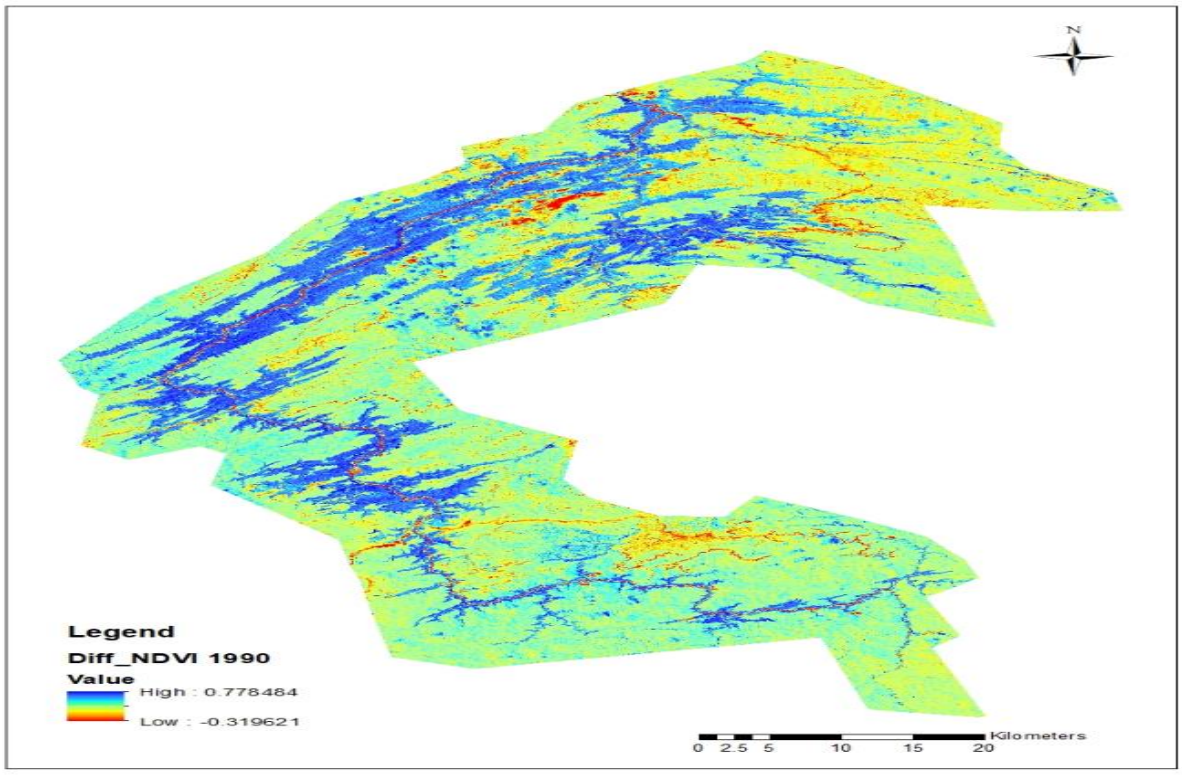


Figure 6: The Bakun area that changed for the years 1990 and 2020 through the GIS Overlay analysis process.

Figure 6 shows the color-changed areas represented in blue and green, yellow and red areas that changed slightly between 1990 and 2020. This study is about the color-changed areas

in the Rajang river bank area in the south and Long Murum River in the north of the study area. In 1990 the study area was a dense forest not occupied by logging activities. In 2020 the study area changes to part 27% of the study area are the water body, 67% is vegetation area, and 4.45% is developed / human-built up. In contrast year, in 1990 for 97% of the study area is vegetation area and 1.003% is developed / human-built up and 1.24% is area air body.

D. Conclusion.

This study successfully achieved the objective of mapping land cover changes in 1990 and 2020 by using the selection of landscape indices on NDWI, MNDWI, and NDVI. This study finds that the NDWI index can map the air body area well and has only 2 km^2 different from the official report from Sarawak Energy. The second-best index is NDVI and MNDWI next. The study is located vegetation areas is the largest area for 1990 and 2020. However, experienced a decrease in area in 2020 of 30% which is different for water bodies 26%. The study expects the area of vegetation will change in the future due to logging activities and placement. The mapping of the study area at all times is very important because the activities related to Bakun will affect the hydrological process of the users of logging activities. Sarawak, a state in Malaysia is less populated and the anthropogenic impact is lower, but deforestation is witnessed in the upper river valleys. This activity may regulate the hydrological behavior of the catchment in destiny and there is a need to examine future changes in catchment characteristics/changes in land use and its impact on river water yields. For this, we use the reservoir garage to not move in the future; which is unlikely to occur under destiny reservoir operations unless the catchment area is designated as a forest reserve and well protected to reduce sedimentation problems in the river. There is also a need to conduct in-depth sedimentation studies to assess the severity of the problem and to address it. Land cover mapped in 1990 and 2020 were compared with google Earth through time series analysis. Information on the ground covering the results is acknowledged and corrected. Monitoring, supervision, and documentation of land cover are critical for policymakers and regional planners to understand the impact of land opportunities on the environment and society. In addition, land cover maps are important as baseline maps for future land management and area planning.

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