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ASSESSING THE EVOLUTION OF PADDY CULTIVATION IN KOTA BELUD, SABAH USING GIS AND REMOTE SENSING TECHNIQUES

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Abstract

This study aims to analyse the development of paddy cultivation in Kota Belud, Sabah using remote sensing and Geographic Information Systems (GIS) from 1990 to 2020. The cultivation of agriculture-based crops began in the early 1990s, and in 2017-2018, the Malaysian and state government identified Kota Belud as a paddy granary, making the cultivation of paddy a priority. This was in line with the National Agro-Food Policy 2021-2030, which aims to improve food security policies and reduce dependence on imports by enhancing rice production through technology reform and various initiatives. This study employed GIS and remote sensing techniques to analyse the changes in land use for paddy cultivation. Landsat TM 5 and Landsat TM 8 images were used to extract data of land use from 1990 to 2020. The results indicate that the area of paddy cultivation increased from 4,329 ha in 1990 to 12,564 ha in 2020, with fluctuations in between. The specific GIS and remote sensing techniques used in the analysis included unsupervised and supervised classification technique with accuracy classification of 94%, 86%, 98.30% and 91.60 % for year 1990, 2000, 2010 and 2010, respectively. Overall, the findings of this study can be used as a guideline by local authorities to improve rice production and food security in Malaysia.

Keywords: GIS, Remote Sensing, Paddy cultivation, National Agro-Food Policy, Food security

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INTRODUCTION

The National Agro-Food Policy 2021-2030 prioritizes rice as a primary commodity for food security in Malaysia, given its importance as a staple food. The production of rice contributes significantly to Malaysia's GDP, with an expected increase in revenue from RM 2.47 billion in 2021 to RM 2.91 billion in 2030. This priority in the production of rice is explained in the results of rice production in Malaysia, which is estimated to experience an increase from 2.98 million MT in 2021 and an increase of 2.62 million MT by 2030 at a rate of 2.16% which causes an increase in rice production from 1.92 million MT to 2.33 million MT at the same time (Ministry of Agriculture and Food Industry, 2021).

Kota Belud in Sabah has the largest paddy field area in the state, making it a focus area for the Malaysian government to increase rice production. The potential for developing paddy cultivation in this district has encouraged the Malaysian government to cooperate with the state government to formulate a strategic step to strengthen the Agrofood policy. The government has allocated funds for the development of Kota Belud as a new rice granary area to strengthen national food security through the 11th Malaysia Plan in presenting the state budget from 2017 to 2019 (Siti Hadawiah Tahir & Talip, 2020). According to Rahim et al., (2019), the paddy granary area in Kota Belud is in the East Malaysian part of IADA Kota Belud, which has 9,083 ha to 9,672 ha.

Despite many efforts to increase production of paddy, however, the paddy and rice sub-sector still falls short of meeting the country's needs, as the gap between production and consumption remains significant. To address this issue, it is necessary to focus on holistic and sustainable solutions that consider factors such as efficient resource utilisation and diversification of products.

Therefore, this study aims to use GIS and Remote Sensing techniques to investigate the development of rice cultivation in Kota Belud between 1990 and 2020. The study will analyse potential land use changes that may have resulted from government policies and funding between 2017 and 2019. Latip et al. (2022) indicates that the GIS study approach to the land use changing pattern will result in government policy towards the current situation. By utilising GIS and Remote Sensing, the study will provide valuable insights for policymakers to make informed decisions and improve rice production in the district, thereby enhancing the country's food security.

LITERATURE REVIEW

Application of GIS and remote sensing in agriculture

Digital agriculture is a modern approach that involves the use of large data sources and environmental analysis tools to assist farmers in adopting proper crop management practices that are both economically viable and environmentally sustainable. Remote Sensing is a digital agricultural technology that allows

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farmers to gather, visualize, and assess crop and soil health at various production stages using low-cost methods. The technology helps to detect possible problems and make early recommendations for timely action (Khanal et al., 2020).

Remote Sensing technology has been used in agriculture since the launch of the Landsat Multispectral Scanner System (MSS) satellite in 1972. It provides high spatial resolution data that can help distinguish crop characteristics at the stand level and assess crop health patterns that are not visible to the naked eye. Different spectral resolutions are required for different agricultural applications depending on management objectives, crop growth stages, and farm size (Khanal et al., 2020).

GIS, in combination with Remote Sensing, is a useful technology for monitoring crops and preventing yield losses due to weather, diseases, and pests. It can analyze yield estimates, crop soil conditions, and agricultural accuracy. The technology can also provide decision support for crop and agricultural strategies by producing land use/land cover (LU/LC) information important for agricultural land planning and development (Vibhute & Gawali, 2013).

Crop identification is critical for determining the crop area and expected yields. Remote sensing techniques use multispectral and multitemporal data for crop identification and classification, with supervised and unsupervised classification approaches available. Supervised classification requires providing an exercise in pixels, while unsupervised classification evaluates many unknown pixels and separates them into different classes based on the image value's groupings (Vibhute & Gawali, 2013).

Study Area

Kota Belud is a coastal district located in the West Coast Division of Sabah, Malaysia, approximately 77 kilometres away from Kota Kinabalu. The district features a lowland or coastal area facing the sea, while the inland area consists of hilly and mountainous terrain, with Mount Kinabalu, the highest peak in the country at 4,095 meters, located at the centre of the valley. Figure 1 showed the geographic features of Kota Belud that dominated by lowland area. The region's unique topography plays a crucial role in shaping its land use and agricultural development, making it an ideal area for paddy cultivation.

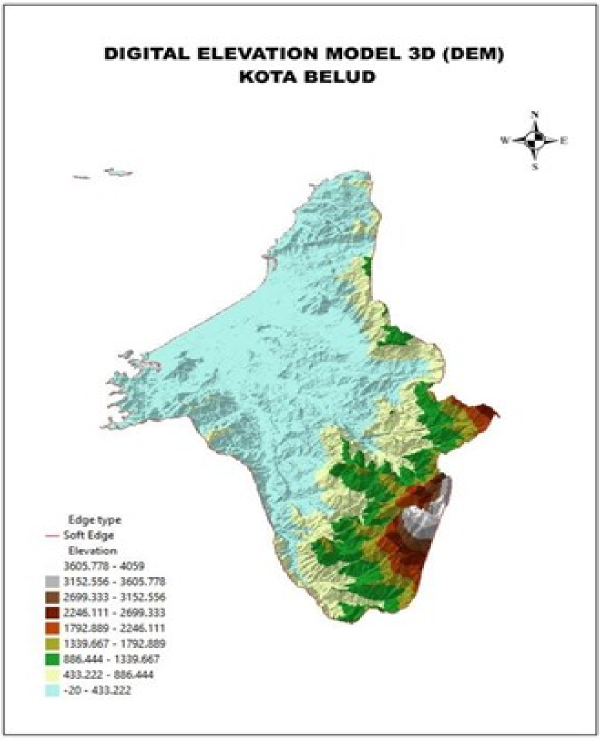

Figure 1: Digital Elevation Model of Kota Belud, Sabah

RESEARCH METHOD

Remote Sensing Data

In this study, land use data obtained from Landsat TM 5 and Landsat TM 8 data products were downloaded from the United States Geological Survey (USGS) website. The data was acquired for the years 1990, 2000, 2010, and 2020, and was used to analyse land cover changes and the rate of change of paddy cultivation in the study area. The data was obtained in GeoTiff format and was processed in raster form using ArcGIS 10.8 software. Table 1 shows the details of remote sensing data used in this study.

Table 1: Details of Remote Sensing data

Data availability	Date	Source	Format (band)
Landsat 5 Satellite Image	1990 2000 2010	USGS	7 band
Landsat 8 Satellite Image	2020	USGS	11 band

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Figure 2 illustrates the process flow for deriving land use data from satellite images. The process involves several steps, starting with the download of product data from the USGS website, followed by radiometric correction to ensure that image values accurately reflect the surface reflectance of the earth. To cover the entire study area, two scenes are required, and Figure 3 demonstrates the mosaic technique used to combine both images to create a single image. Cloud masking was then performed to remove clouds from the satellite imagery, as clouds can obscure features on the ground and affect the accuracy of land cover classification. Figure 4 shows the satellite image after cloud masking.

To classify the images, both supervised and unsupervised classification techniques were used. Unsupervised classification grouped pixels based on spectral properties into clusters, while supervised classification required manual labeling of training samples representing known land cover types, which were then used to train the classification algorithm. Supervised classification is more accurate but time-consuming, while unsupervised classification is faster but less accurate. Both techniques were applied in this study to ensure high accuracy of data (Figure 5). Finally, the raster data was converted to vector format to perform geospatial analysis and determine changes in paddy fields from 1990 to 2020.

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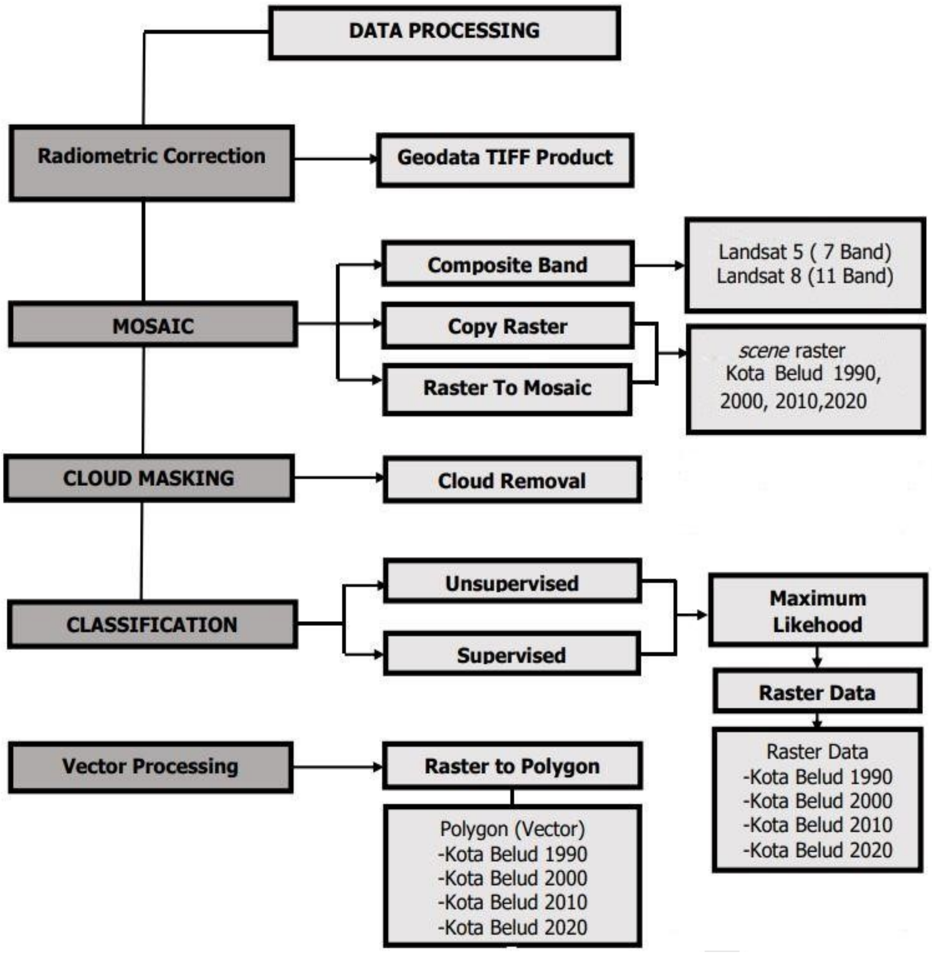

Figure 2: Flowchart of the research

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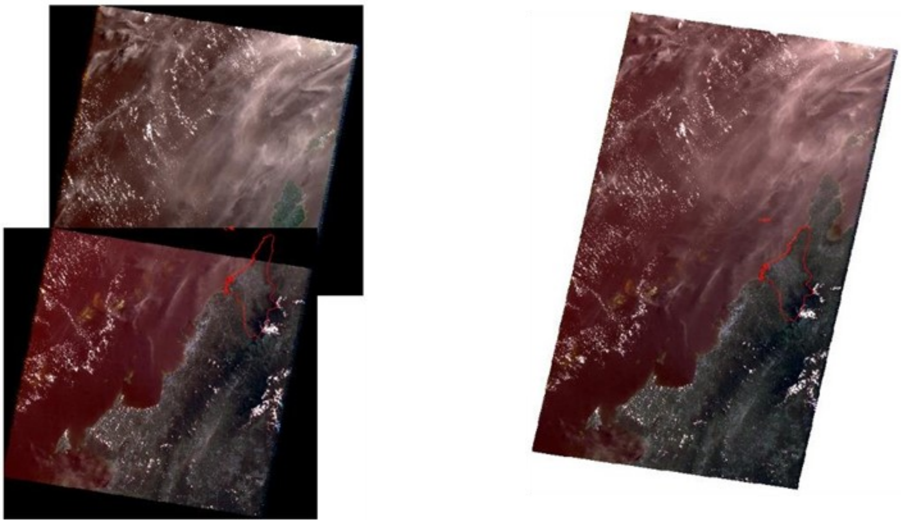
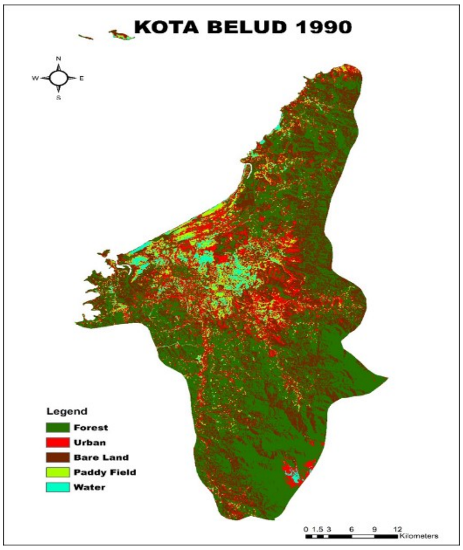
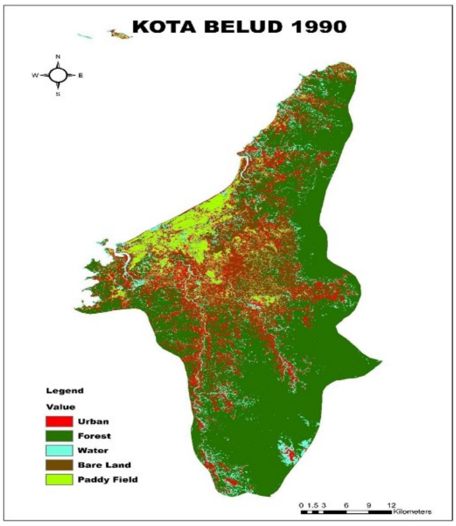


Figure 3: Process of mosaic images

Figure 4: Process of Cloud Masking



(a)



(b)

Figure 5: (a) Unsupervised and (b) Supervised classification.

Accuracy assessment

Accuracy Assessment is an analysis that determines the accuracy of the classification land use in study area. This is to ensure that the results of the classification are accurate and reliable. This study using equation by Congalton,

(1986) to evaluate the accuracy of the classification land use. Table 2 show the results of accuracy assessment for land use classification.

Overall Accuracy = <u>Total Number Of Correctly Classified Pixels (Diagonal)</u> x 100 Total Number Of Refference Pixels

Table 2: Accuracy Assessment of land use classification

Satellite image	Percentage of accuracy
1990	94%
2000	86%
2010	98.30%
2020	91.60%

RESULTS AND DISCUSSIONS

Spatial pattern of change in paddy cultivation area from 1990 to 2020

Table 3 presents the area of land use types in Kota Belud from 1990 to 2020. In 1990, Kota Belud had paddy area of 4,329 ha, bare land (17,887 ha), forests (91,393 ha), urban areas (7,008 ha) and oil palm (1,092 ha). By 2000, the paddy area had increased to 10,917 ha, bare land (13,619 ha), forests (85,426 ha), urban areas (8,208 ha) and oil palm (1660 ha). The area changed further in 2010, with paddy area decreased to 7,935 ha, bare land (15,800 ha), forests (80,788 ha), urban areas (8,636 ha) and oil palm (2,088 ha). In 2020, Kota Belud had paddy area had increased to 12,564 ha, bare land (10,151 ha), forests (77,848 ha), urban areas (9,535 ha) and oil palm (5,589 ha).

Table 3: Land use change in Kota Belud from 1990 to 2020

	Area ha			
Land Use	**1990**	**2000**	**2010**	**2020**
Paddy	4,329	10,917	7,935	12,564
Bare Land	17,887	13,619	15,800	10,151
Forest	91,393	85,426	80,788	77,848
Urban	7,008	8,208	8,636	9,535
Oil palm	1,092	1,660	2,088	5,589

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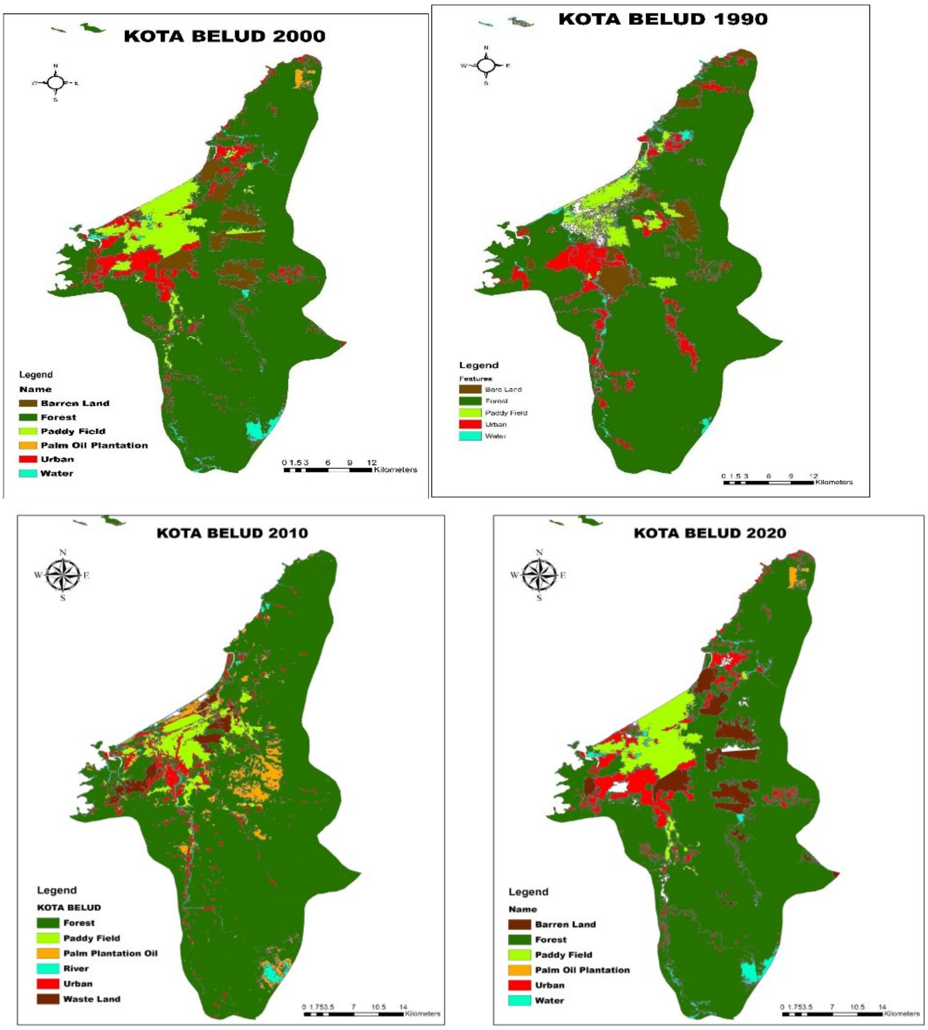

Figure 8: Map of evolution of land use from 1990 to 2020

The Kota Belud district has a significant contribution to the agricultural land area of Sabah, with 22% of the total agricultural land out of 52% in Sabah (Gindanau Sakat, 2005). The earliest villages in development, such as Kampung Piasau, were used as initial areas in the study of agricultural practices and technology development. Kota Belud's agricultural development is closely linked to various government policies and initiatives aimed at achieving food security and production, such as the National Agro-Food Policy.

The map in Figure 8 shows the changes in land use in Kota Belud from 1990 to 2020, which were calculated through pixel-by-pixel digitization and

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supervised classification of paddy areas. The trend in paddy area evolution shows an increasing trend with fluctuations between 1990 to 2020. However, the decline in paddy production in 2016 due to natural disasters had a direct impact on the overall performance of the paddy, while the subsidy reduction in 2016 only affected the interest rate reduction that year.

After the earthquake occurred in 2015 in Ranau, the frequency of floods in the Kota Belud area increased due to rock erosion deposition into the river, which reduced the river's capacity to hold a large amount of rainwater. As a result, the lowland topography of Kota Belud became susceptible to floods. Furthermore, the floodwater carried sand from the river, resulting in rice fields being flooded and no longer cultivable. This situation particularly occurred in Kg Lingkodon, which contributed to rice cultivation areas turning into bare land because they were no longer viable for cultivation. This issue caused a decline in rice production and productivity between 2015 and 2017, as the set target could not be reached due to the negative impact of the earthquake and subsequent flooding.

Among other factors, weaknesses in the management of rice crop development from a financial aspect, the method of granting Plowing Incentives to Farmers (IPKP) and plowing machinery, as well as weaknesses in irrigation and drainage systems, also affect the level of efficiency of rice crop development management. To increase the productivity of rice production, it is recommended that the State Department of Agriculture, Sabah Farmers Organization Board, and the State Department of Irrigation and Drainage study commercial rice cultivation alternatives and invest in suitable rice cultivation technology. The Department and the agency are also recommended to review the method of channeling subsidies or assistance from various Federal agencies to be managed or coordinated by the state government and consider the use of technology such as 'drone' or the Global Positioning System (GPS) to facilitate the monitoring of subsidy claim verification methods more effectively.

The Sabah State Department of Agriculture (2017) reported that Sabah has maintained an agricultural or rice planting area of 33,530 ha, producing 4.20 metric tons per hectare with an allocation of RM 17,200,000. Based on the policy and development initiatives taken by the state and federal governments, Kota Belud is one of the new rice granary areas aimed at improving national security policy. The lowland area in Kota Belud is 13,8560 ha and is one of the Malaysian rice granaries that have been declared in the Malaysian Plan the 9th. The potential for the development of a new agricultural chain in Kota Belud is greatly influenced by the Malaysian Government and Sabah State policy in achieving the National Agro-Food Policy, which focuses on food security and production. The increase in rice cultivation in Kota Belud began in 2017 after the corporation carried out various measures to help farmers cultivate their paddy.

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CONCLUSION

The analysis showed significant changes in land use from 1990 to 2020, largely driven by economic factors and government policies to develop the area as a new rice granary. The development of infrastructure, such as roads and irrigation systems, also played a significant role in shaping and giving potential to Kota Belud as a strategic agricultural area. The study recommends further strengthening of agricultural practices and technological support, such as the use of agricultural drones, to ensure the quality and production of crops. Overall, the study shows that there has been significant progress and development in agriculture in Kota Belud, supported by clear factors and the economic history of the area.

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