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THE APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM IN ANALYSING THE VOTING PATTERNS AMONG DAYAK VOTERS IN THE SARAWAK STATE ELECTIONS OF 2016 AND 2021

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ABSTRACT

Geographic information system (GIS) and election-related research focuses on the geographical characteristics of election boundaries, the election information management system and the application of GIS analysis to election boundaries. This article aims to acquire a deeper understanding of the issues affecting Dayak voters during the state elections of 2016 and 2021, geographically. This study employs three spatial analyses: Thematic Map-Density, Spatial Autocorrelation Moran's I Index and Hot Spot Analysis (Getis-Ord Gi). In select constituencies with a Dayak-majority, interviews and observations supplemented the spatial data. This article examines Dayak-majority constituencies' geographical distribution and spatial concentration in the 2016 and 2021 elections. It demonstrates that there are significant differences in the density of voter participation, majorities obtained by candidates, and total votes cast by the electorate across the state in both state elections, confirming the assertion made by researchers of electoral politics in Sarawak that election issues are primarily location-specific and that understanding the problems faced by communities at the local level is essential. It is anticipated that the outcome of this study will aid in providing a spatial overview and projection of state election results and in strategising the future management of state elections.*

Keywords: 2021 Sarawak State Election, voting pattern, Dayak constituencies, geographic information system (GIS), electoral studies

INTRODUCTION

All different kinds of data can be created, managed, analysed and mapped using a geographical information system (GIS). GIS links data to maps by combining information about locations (i.e., where objects are) with other descriptive details (what things are like there). The combination of GIS analysis and electoral research helps connect geographical aspects of elections. According to Udoh (2014), one of the most critical roles that GIS performs is to deliver information to stakeholders through mapping and spatial analysis. He also stated that the application of GIS is now extensively used in various fields, including social sciences and politics. GIS performs essential roles in delivering information to stakeholders through mapping and spatial analysis, particularly in general elections.

According to Nabila et al. (2018), incorporating GIS application into elections emphasises geospatial aspects such as election boundaries, election information databases and GIS analysis in electoral studies. This is something that can be accomplished by integrating GIS applications into elections. The management of voters' data, the localisation of polling stations and the delivery of election outcomes are all functions performed by election information databases (Udoh 2014).

Several nations, including the United States of America (USA) and Ghana, have incorporated GIS into their political procedures. In the USA, the map was shown on television and was updated whenever there were new findings. It exhibited different map symbols, including roads and urban areas (Brace 2019). This is the new paradigm for using GIS in covering and reporting electoral outcomes. It is effective in enriching data and generating visually compelling maps for election. In Ghana, the GIS platform was utilised to display the election results in real time. This was done to prevent disseminating inaccurate information or results prone to error (Asare, Antwi and Adu-afare 2017).

The primary objective of this study is to map the voting pattern among Dayak voters and to investigate how critical issues in the Dayak-majority constituencies are reflected in the results of the Sarawak State Elections of 2016 and 2021 (henceforth, SSE16 and SSE21). The study aims to determine whether there is a spatial relationship between voting patterns, majority votes and popular votes in the Dayak-majority constituencies.

LITERATURE REVIEW

The Role of GIS in Election Study

Malaysia is a constitutional democracy that operates under a parliamentary form of government. At the core of this form of government is a dedication to holding consistent, accessible and fair elections. These elections are run following the stipulations outlined in the constitution and any additional laws passed by parliament. According to the constitution, the Election Commission (EC) possesses the residuary powers necessary to operate elections appropriately. GIS has the potential to play an essential part in the orderly, trouble-free and open process of electoral administration. By utilising both spatial and non-spatial data, GIS could be used to help facilitate election administration through the use of thematic map representation as well as map-based web applications (Biswas 2022). The role of GIS in electoral studies is multifaceted. For instance, it can serve as a database for election-related data, redefine the election boundary and generate maps for spatial relationships related to elections.

GIS and Information Management Systems

It has been established that using GIS is one of the most helpful methods for depicting spatial data related to the location of polling stations and the development of electoral databases. In addition to facilitating more effective election coordination, administration and surveillance, GIS' primary objective is to improve electoral demographics, which can be visualised on a map (Thomas 2020).

By utilising GIS, which is capable of producing dynamic and interactive maps, one can evaluate data based on specific locations and display information pertaining to elections. During the election process in the county, the streamlined process of managing and disseminating election statistics proved beneficial. It has helped election workers save time and made the election process simpler to navigate in an otherwise chaotic environment that typically surrounds election seasons.

A GIS strategy is used for data collection and analysis of elections. This methodology allows voters and election officials to demonstrate relationships, structures, and trends to achieve an all-encompassing knowledge of their constituent base and effectively manage the entire electoral process (Salifu, Sule and Idoko 2021). This knowledge can then be used to make better decisions about who should be elected. The application of software for data representation is how this can be accomplished.

GIS and Election Boundaries

The application of GIS and elections is a study that focuses on geospatial elements and supports election boundaries, information management systems and GIS analysis in election boundaries (Nabila et al. 2018).

In order to achieve this goal, the data from the census department and other available resources can be integrated. For instance, in the USA, data are obtained from the county editor or other organisations that maintain a record of the location and dimensions of individual land parcels (Brace 2019). This supplies the officials in charge of elections with a complete data collection that can be used as a data source. The data source includes geographical data and data on infrastructures such as roads shown on top of aerial photos, allowing poll officials to see these data alongside GIS (Gupta, Kumar and Kumar 2014).

The use of GIS in elections can encompass the entirety of the election cycle, beginning with the demarcation of boundaries (polling units and area mapping) and continuing all the way through the transmission of election results, including results management and citizen participation. According to Ojiako, Fashina and Igbokwe (2016), the use of GIS can improve the accessibility of information, from the boundaries to the position of polling stations, which in turn contributes to an increased level of confidence in the electoral process.

GIS and Mapping

An additional function of GIS in electoral research is to map the election patterns using a spatial perspective. When this is done, fascinating geographical patterns become apparent. For instance, there is often a significant gap between the voting shares for certain parties in urban and rural areas. This is especially true when comparing urban and rural regions. It is a pattern observed in Europe and other parts of the world that conservative parties are more successful in rural areas. In contrast, green parties are more prevalent in metropolitan areas (Spörl, Wilkening and Kirschenbauer 2021). Figure 1 shows the comparative map for Sarawak State Elections in 2006, 2011 and 2016.

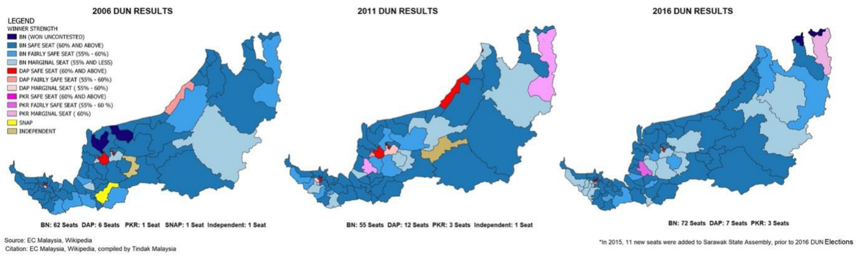

Figure 1: Comparative map of Sarawak State Elections from 2006 until 2016.
Source: Tindak Malaysia (2021)

METHODOLOGY

Case Study Area

In Sarawak's 82 state legislative assembly seats, there are 35 Dayak-majority constituencies. The number of seats according to ethnic groups is as follows: eight seats are Bidayuh-majority, 22 are Iban-majority and five are Orang Ulu-majority. Figure 2 shows the map of Dayak-majority constituencies. This research analysed the voting pattern for all 35 Dayak-majority constituencies in the SSE16 and SSE21.

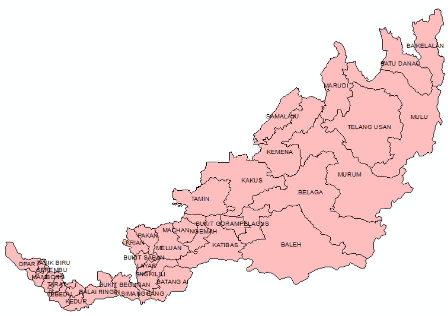

Figure 2: Dayak-majority state constituencies (Dewan Undangan Negeri) in Sarawak.

Data Collection

Figure 3 shows the process of data collection and analysis for this study. It made use of both primary and secondary sources of information. The primary material consists of site visits and interviews with *tuai rumah* in several Sri Aman, Engkilili and Bintulu areas. The primary data were obtained through observation of surrounding development, issues and challenges encountered by residents in the targeted areas. The original data were utilised to support the spatial analysis pattern that would be used for the SSE16 and SSE21. Tindak Malaysia provided the master document of state election results for 2016 and 2021, as well as the boundaries of the voting districts. This information was used to compile the secondary data.

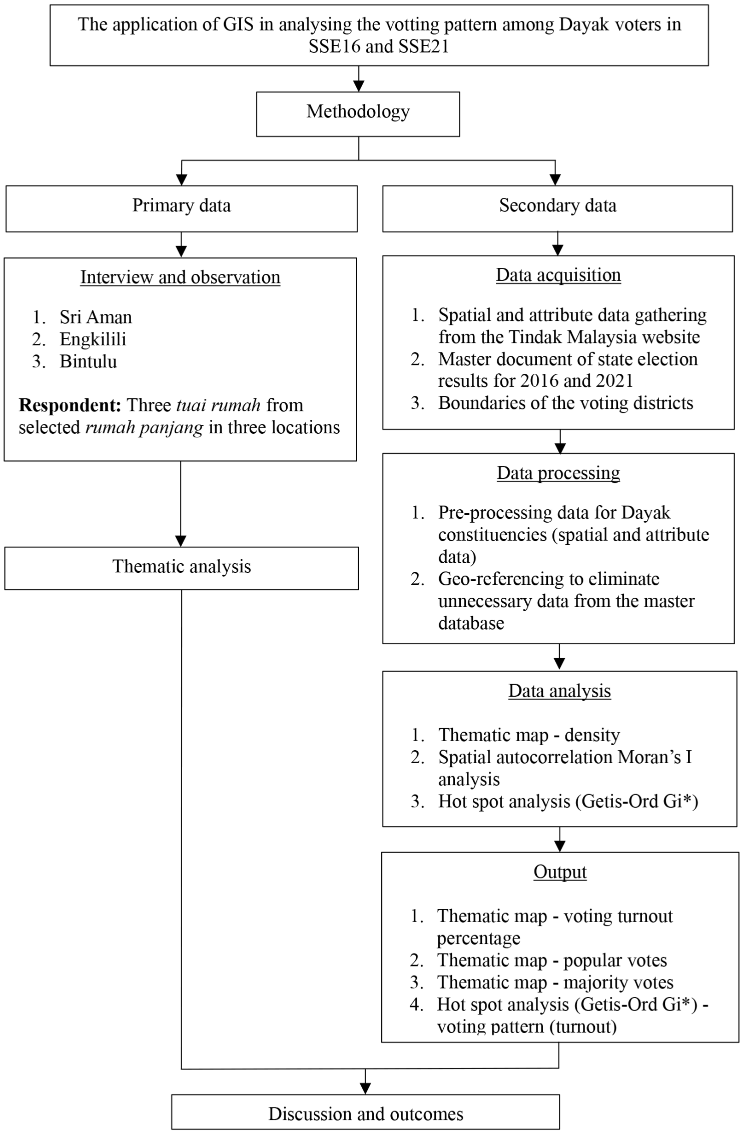

Figure 3: The process of data collection and analysis for this study.

Data Processing

As can be seen in Table 1, attribute and spatial data are the two types of data used in the system. The data for the Dayak-majority constituencies needed to be pre-processed because secondary data were acquired from the master sheet of state election results. After applying geo-referencing, all the data in the database were filtered to eliminate information unrelated to the subject under study. In the SSE16 and SSE21, the WGS 1984 Coordinate System was used for the spatial data to define the boundaries of electoral districts.

Table 1: Datasets for GIS-database system

Attribute data		Spatial data	
Data	Year	Data	Year
DUN's name (Dewan Undangan Negeri or State Legislative Assembly)	2016 and 2021	Vector image of election boundary for 35 Dayak-majority constituencies in Sarawak	2016 and 2021
ADUN's name (Ahli Dewan Undangan Negeri or Member of State Legislative Assembly)	2016 and 2021		
Winning political party	2016 and 2021		
Voting turnout (%)	2016 and 2021		
Majority votes	2016 and 2021		
Popular votes (%)	2016 and 2021		
GPS point	2016 and 2021		

Data Analysis

In order to provide a better comprehension and performance, a sequence of spatial analysis needs to be performed in this research before any implementation of GIS analysis can take place. The following is the order in which spatial analysis will be performed for this study:

1. Thematic map – density
2. Spatial autocorrelation Moran's I Index
3. Hot Spot Analysis (Getis-Ord Gi*)

Within the scope of this research, three different spatial analyses were carried out to accomplish this study's goals. The order in which the spatial analyses for this research were carried out is depicted in Figure 4.

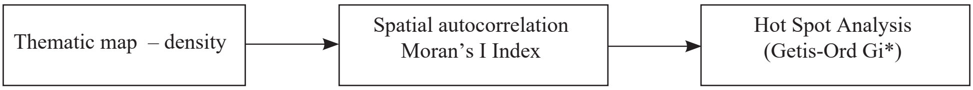

Figure 4: Sequence of spatial analysis.

A density thematic map is the conceptualisation of a spatial analysis for three components: the percentage of people who voted, the percentage of people who voted for popular candidates and the percentage of people who voted for candidates with majority wins. For this research, an equal interval was used with 10 breaks. While spatial autocorrelation Moran's I Index was being done, it was used on the model residuals and to locate spatial patterns to produce a correctly specified model. The most recent results of the spatial research are Getis-Ord Gi*, also known as "hot spot analysis," a collection of spatial statistical tools that are used to map the clusters of data to reveal the higher value and lower value of datasets.

ANALYSIS AND FINDINGS

Thematic Map: Voting Turnout

The thematic map (density) for voter participation proportion can be found in Figure 5. Red represents a lower percentage of eligible voters who cast their ballots, whereas green represents a more significant percentage of eligible voters who cast their ballots. Bukit Goram (58.7%), Baleh (60.5%), Pelagus (64.9%), Telang Usan (63.9%) and Marudi (66%), were the five seats in 2016 with the lowest proportion, while Serembu (77.2%), Kedup (77.1%), Balai Ringin (78.4%), Krian (77.4%) and Pakan (77.4%) had a more significant percentage.

Despite this, the findings for 2021 demonstrate a declining trend for these 10 seats. Regarding voter participation, Bukit Goram had the lowest proportion, while Balai Ringin had the highest.

Thematic Map: Popular Votes

As can be seen in Figure 6, the area with the highest concentration of popular votes in 2016 was located in the state's geographic centre. However, in 2021, this had shifted to the northern portion of the state. In 2016, there were five districts with less than 50 percentage. These seats were Opar (49.4%), Serembu (49.3%), Simanggang (49.9%), Meluan (36.8%) and Ngemah (45.2%). Tebedu (84.8%), Bukit Begunan (84.8%), Bukit Saban (83.9%), Baleh (91%) and Belaga (88.8%) were the other five districts that received more than 80% of the popular votes.

Most of the candidates who obtained fewer votes in 2016 experienced a gain in popularity in 2021, whereas those who won the most in 2016 saw a decline in popularity in 2021. The popular votes for each of the five seats with the highest percentage of popular votes significantly decreased in 2021. For instance, Belaga's percentage of popular votes decreased from 88.8% in 2016 to 45.5% in 2021 — a decrease of 48.7%. The highest percentage of votes cast by the electorate was 91% in 2016, while it was just 76.74% in 2021.

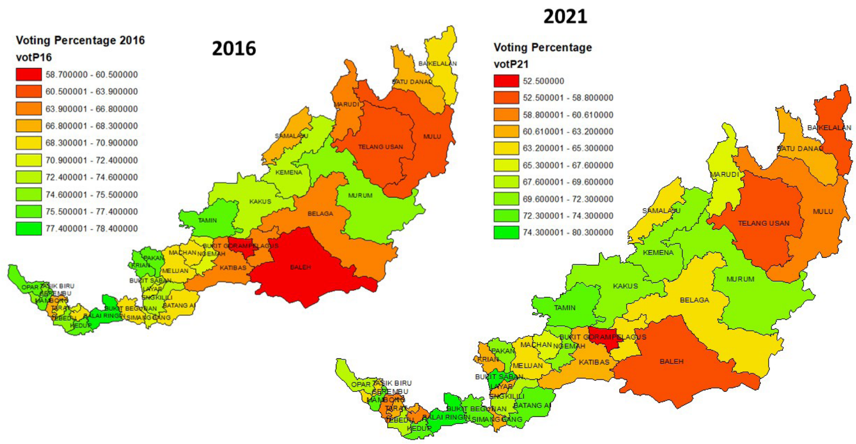

Figure 5: Thematic map for voting turnout for 2016 and 2021.

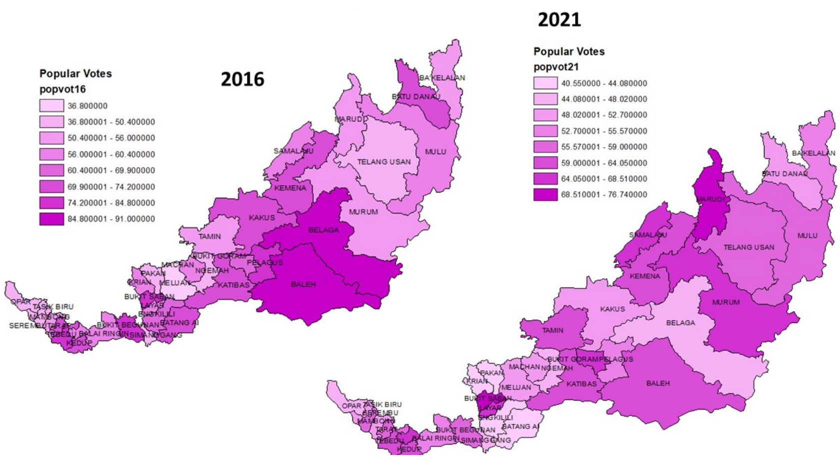

Figure 6: Thematic map for percentage of popular votes for 2016 and 2021.

Thematic Map: Majority Votes

Figure 7 depicts the distribution of seats with majority victories. The darker the colour, the larger the majority obtained by the candidates. In 2016, Pakan (426 votes), Meluan (677 votes), Ngemah (154 votes), Telang Usan (167 votes) and Ba' Kelalan (167 votes) were the five seats with minor majorities (538 votes). In 2021, however, the majorities for Pakan (714), Meluan (822), Ngemah (261), Telang Usan (2,422) and Ba' Kelalan (680) had significantly increased.

Tarat (5,421 votes), Tebedu (6,193 votes), Kakus (5,211 votes), Baleh (4,843 votes) and Kemena (4,868 votes) received resounding majorities in 2016. In 2021, the majorities obtained in the respective districts, including most Dayak areas in the state's central region, had decreased. For instance, Tarat (5,008 votes), Tebedu (3,273 votes), Kakus (1,897 votes), Baleh (1,909 votes) and Kemena (3,611 votes). Figure 7 depicts the change in the distribution of state election majorities between 2016 and 2021.

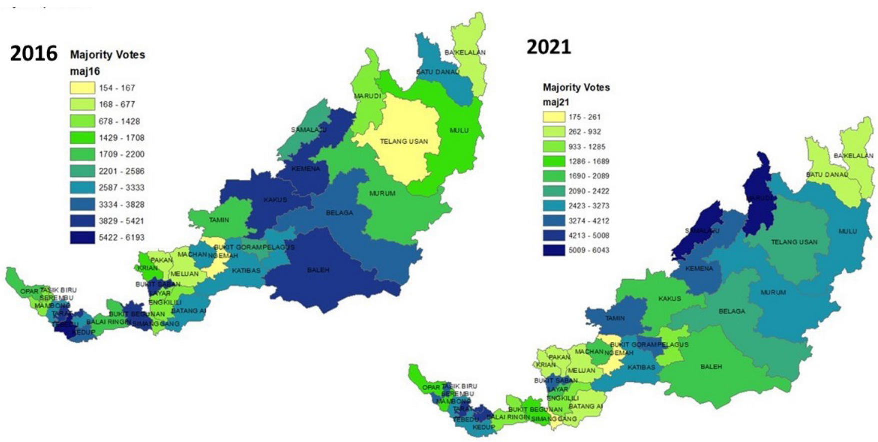

Figure 7: Thematic map for majority votes for 2016 and 2021.

Spatial Autocorrelation Moran's I Index

Understanding the degree to which one object is similar to other adjacent objects can be facilitated through spatial autocorrelation in GIS. The degree to which observations (values) at spatial locations (whether they are points, areas or raster cells) are comparable to each other can be described using measures of spatial autocorrelation. The number of the Moran's I Index will be between −1 and 1, inclusive. When there is a positive spatial autocorrelation, the numbers appear clustered. The negative autocorrelation is spread out across the data. Roughly equal to zero is random. The algorithm is displayed in Figure 8. The utility calculates a *z*-score and a *p*-value, which help determine the significance of the Moran's I Index.

The Moran's I statistic for spatial autocorrelation is given as:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \quad (1)$$

where z_i is the deviation of an attribute for feature i from its mean $(x_i - \bar{X})$, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features, and S_0 is the aggregate of all the spatial weights:

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \quad (2)$$

The z_I-score for the statistic is computed as:

$$z_I = \frac{I - \mathrm{E}[I]}{\sqrt{\mathrm{V}[I]}} \quad (3)$$

where:

$$\mathrm{E}[I] = -1/(n-1) \quad (4)$$

$$\mathrm{V}[I] = \mathrm{E}[I^2] - \mathrm{E}[I]^2 \quad (5)$$

Figure 8: Formula for the Moran's I statistic autocorrelation.

Source: Chen (2021).

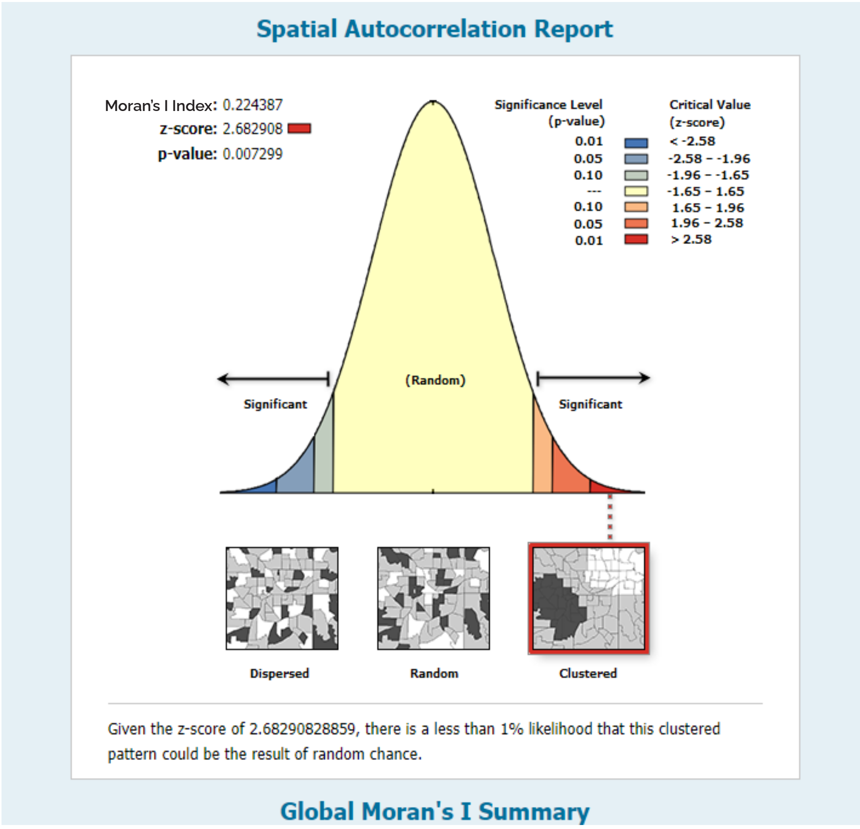

Figure 9: Spatial autocorrelation report for 2016.

According to the findings of the spatial autocorrelation tool in Figure 9, the distribution of the majority of votes cast in the state election of 2016 at each feature position appears to be clustered. The Moran's I Index was calculated to be 0.224387, the *z*-score was calculated to be 2.682908, and the *p*-value was calculated to be 0.007299. The fact that the critical value, also known as the *z*-score, was higher than 2.58 indicates a significantly lower than 1% chance that the clustered pattern is the product of random chance.

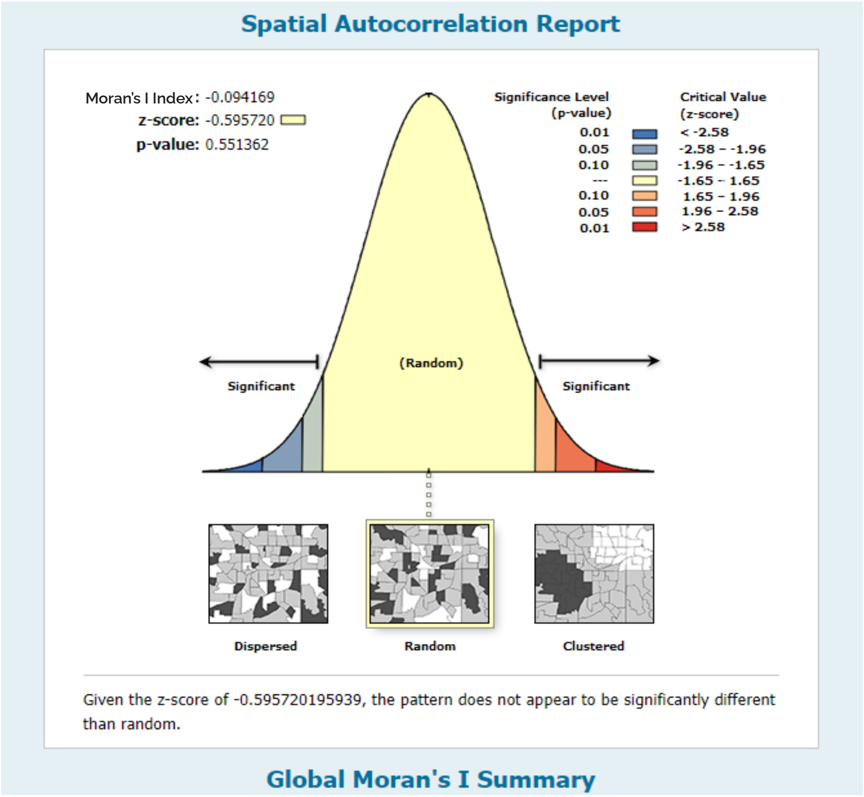

Figure 10: Spatial autocorrelation report for 2021.

The findings of the spatial autocorrelation tool in Figure 10 indicate that there is likely to be a clustering of the pattern of majority ballots cast in the state election 2021 at each feature location. The value of Moran's I Index was –0.094169, the value of the *z*-score was –0.595720, and the *p*-value was 0.551362. Since the critical value (*z*-score) was within the range of –1.65 to 1.65, the pattern does not appear to be statistically different from chance occurrences. Fixed distance was the technique for conceptualising spatial relationships and Euclidean distance measure was used for the distance method, with a distance of 76,476 metres, as shown in Figure 11.

Global Moran's I Summary

Moran's Index:	0.224387
Expected Index:	-0.029412
Variance:	0.008949
z-score:	2.682908
p-value:	0.007299

Dataset Information

Input Feature Class:	Majority Votes
Input Field:	SARAWAK LIST DAYAK VOTING 2.CSV.VOTP16
Conceptualization:	FIXED_DISTANCE
Distance Method:	EUCLIDEAN
Row Standardization:	False
Distance Threshold:	76476.6523 Meters
Weights Matrix File:	None
Selection Set:	False

Figure 11: Global Moran's I summary.

Hot Spot Analysis (Getis-Ord Gi*): Voting Pattern (Turnout)

Referring to Figure 12, the southern portion of Sarawak, specifically Tarat and Tebedu, had the highest voter participation rates in 2016. In 2021, areas with the highest voter participation were located in the central part of the state, namely Balai Ringin and Bukit Saban.

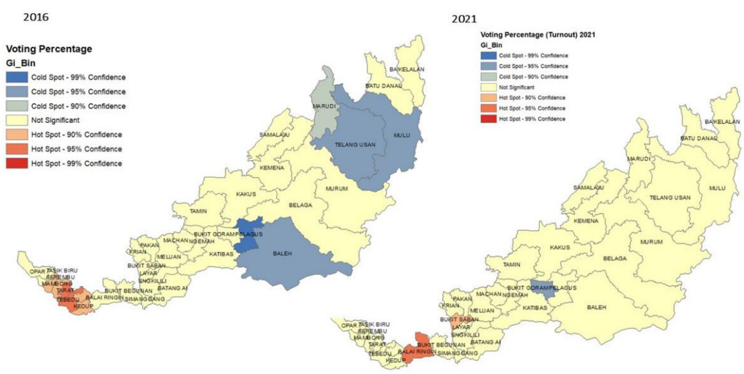

Figure 12: Hot spot analysis for voting turnout percentage.

DISCUSSION

By using GIS in analysing the data for the SSE16 and SSE21, we can identify stark differences in voting trends in 2016 and 2021. In 2016, the highest voter participation was in the southern part of Sarawak, particularly in Tarat and Tebedu. In 2021, it made its way towards Sarawak's centre, especially in Balai Ringin and Bukit Saban, amongst other destinations. This subtopic discussed three significant findings in voting pattern and turnout, popular votes and majority votes.

Voting Pattern and Turnout

According to Table 2, the proportion of voters who cast their ballots and those who participated in the election dropped in all three seats of Simanggang, Engkilili and Kemena. This is evident from the data presented in Figure 11, demonstrating a decline in the number of hotspot areas between 2016 and 2021.

Table 2: The change of percentage for voting pattern and turnout between SSE16 and SSE21

Seat	Voting pattern and turnout (%)		Percentage change
	SSE16	SSE21	
Simanggang	71.5	62.3	12.9% (–)
Engkilili	73.8	68.5	7.2% (–)
Kemena	74.6	72.0	2.7% (–)

Note: (–) refer to decreasing number of percentage between SSE16 and SSE21

Popular Votes

The same pattern can be seen in terms of popular votes in Table 3, whereby all three seats of Simanggang, Engkilili and Kemena experienced a drop in popular votes. Among these three areas, Engkilili has seen the most significant drop in popular votes, greater than 30% since 2016.

Table 3: The change in percentage of popular votes between SSE16 and SSE21

Seat	Popular votes (%)		Percentage change
	SSE16	SSE21	
Simanggang	50.70	48.94	3.47% (–)
Engkilili	70.75	43.48	38.54% (–)
Kemena	75.58	62.82	16.88% (–)

Note: (–) refer to decreasing number of percentage between SSE16 and SSE21

Majority Votes

Even though the number of popular votes cast for Simanggang only decreased by 3.47% (Table 4), the number of majority votes cast for this seat decreased significantly, falling from 1,288 to 175 votes—a difference of 87.4%. It appears that Simanggang is not the only seat with a reduced majority win; most of the candidates in the Dayak areas also received lower majorities in 2021.

Table 4: The change of percentage for majority votes between SSE16 and SSE21

Seat	Majority votes		Percentage change
	SSE16	SSE21	
Simanggang	1,388	175	87.4 (–)
Engkilili	1,388	1191	14.2 (–)
Kemena	4,868	3611	25.8 (–)

Note: (–) refer to decreasing number of percentage between SSE16 and SSE21

This percentage has decreased as a consequence of the combination of several different variables. Following interviews and site visits to various long houses in three distinct DUN seats, a number of issues have become apparent. The issues include the development of infrastructure, the generation of income and the cost of living, unemployment rates, the availability of water and electricity, and internet and telecommunications access.

Undoubtedly, the accelerated progress of the Pan Borneo Highway construction is a cause for concern, as it is being constructed mainly in areas inhabited by the Dayak communities. Lack of road access to remote locations such as Engkilili is one of the persistent issues. Many remote areas are still not yet accessible by paved roads in that location. Therefore, this persistent problem can cause voter turnout and electoral support to fluctuate over time.

In addition to the exorbitant cost of living in Engkilili and Kemena, the people often raise the issue of generating income. People are struck by how limited and non-existent the opportunities are to generate economic activity and revenue in the areas. Unemployment rates are an additional issue that has been brought up, particularly in Simanggang and Kemena. Kemena is also affected by the accelerated development occurring in Bintulu, which has some of the most expensive housing prices and rental rates in Sarawak. The increased cost of living in the adjacent areas, including Kemena, is a direct consequence of Bintulu's development.

In addition to the availability of pure water and electricity, access to the internet and various forms of communication were also significant topics of discussion in the affected areas. Given the level of development progress made in Sarawak, most people believe this issue should no longer be a concern today. Despite this, a substantial portion of Sarawak's more remote rural areas need access to reliable sources of treated water and electricity. During the pandemic season, when more children study from home, the issue of inadequate internet connectivity becomes more apparent. Many cannot partake in online classes because they need internet access or have an unreliable internet connection.

CONCLUSION

The role of GIS has shifted from being simply a data storage/facts repository tool to a robust analytical tool for any field, including political studies. GIS was created as a means of disseminating and analysing information in order to not only assess vote outcomes but also to display the correlations between voting patterns and local demographic and socioeconomic data. A wide range of stakeholders can gain from using GIS to enhance electoral research and the election process in Malaysia. It is crucial to look into the feasibility of employing GIS in the state election and do so before the next election in response to the state government's call for digitalisation. Our understanding of voters' voting behaviour depends heavily on the voting pattern, popular votes received by the candidates, votes cast by the people, and their relationship to location. Using a GIS as a tool can be quite helpful when studying Malaysia's political scene, especially when it comes to understanding the important issues at the local levels.

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