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Evaluating the Distribution of Educational Services Using GIS: A Case Study of Kut City, Iraq

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Abstract

Iraq's education system has been facing significant challenges in providing quality educational services, particularly for schools. The most important of these challenges are the number of schools, their distribution, and the difficulty of reaching schools by students. The assessment and analysis of spatial patterns play a crucial role in enhancing the accessibility and quality of education using Geographic Information System (GIS). Spatial and attribute data of schools were collected by Wasit Education Directorate using GPS. Spatial analysis techniques were utilized for primary and secondary schools in Kut city/ Iraq , including kernel density and Moran's I. Kernel density values indicated primary school concentrations up to 91,660 in Kut district and secondary concentrations up to 79,879 in Kut. Moran's I detected no significant spatial autocorrelation for any schools. The results exposed considerable gaps in educational access and highlighted uneven, inequitable distribution of schools across Kut city. The techniques used offer valuable quantitative insights to inform evidence-based planning and policymaking.

Keywords:

Spatial analysis, GIS ,Educational access, Wasit, Iraq

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تقييم توزيع الخدمات التعليمية باستخدام نظم المعلومات الجغرافية : دراسة حالة لمدينة الكوت، العراق

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جامعة بغداد , كلية الهندسة , قسم هندسة المساحة

المستخلص

يواجه نظام التعليم في العراق تحديات كبيرة في تقديم خدمات تعليمية عالية الجودة، لا سيما في المدارس. ومن أهم هذه التحديات عدد المدارس وتوزيعها وصعوبة وصول الطلاب إلى المدارس. يؤدي تقييم وتحليل الأنماط المكانية دورًا حاسمًا في تعزيز إمكانية الوصول إلى التعليم وجودته باستعمال نظام المعلومات الجغرافية (GIS). تم جمع البيانات المكانية والخصائصية للمدارس من مديرية تربية واسط باستعمال نظام تحديد المواقع العالمي (GPS).

تم استخدام تقنيات التحليل المكاني للمدارس الابتدائية والثانوية في مدينة الكوت، العراق، بما في ذلك كثافة النواة ومعامل موران. أشارت قيم كثافة النواة إلى تركيزات المدارس الابتدائية تصل إلى 91,660 في منطقة الكوت وتركيزات ثانوية تصل إلى 79,879 في الكوت. لقد اكتشف معامل موران عدم وجود ارتباط ذاتي مكاني مهم لأي مدرسة. كشفت النتائج عن فجوات كبيرة في الوصول إلى التعليم وسلطت الضوء على التوزيع غير متكافئ وغير عادل للمدارس في جميع أنحاء مدينة الكوت. وبهذا قدمت التقنيات المُستعملة رؤى قيمة لإرشاد التخطيط القائم على الأدلة وصناع السياسات .

الكلمات المفتاحية:

التحليل المكاني، نظام المعلومات الجغرافي , الوصول التعليمي، واسط، العراق

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1. Introduction

The provision of high-quality primary school education in Iraq has been fraught with difficulty (Alkinani and Abdulrasool 2021). There are still a lot of issues that make it hard for pupils to learn and do well in school, even though the government is always trying to fix the problem.

Using geographic information system (GIS) technology,(Lagrab and Aknin ,2015) conduct a useful study of the kindergarten distribution in Yemen's Mukalla districts. The research highlights the usefulness of GIS in determining the local kindergartens' concentration, dispersion, clustering, and distribution direction. Additional research into variables like population density and socioeconomic status might strengthen the study's conclusions, but it does help shed light on why it's important to use standard standards when building schools. In order to guarantee social fairness, (Gh Ibrahim et al. ,2019) use GIS to study the distribution of educational services in Mansoura city, Egypt. Findings from the study show that geographic information system (GIS) technology can be useful for determining which school buildings are available and where new services would be most effectively placed. A more thorough examination of accessibility, transportation, and socioeconomic issues could enhance the study and help refine the selected locations. The location of Saudi Arabian schools in Jeddah City is analyzed by (Al-Enazi et al. ,2016) using geographic information systems (GIS). In order to make informed decisions on educational planning, the study highlights the value of GIS in offering comprehensive data packages and sophisticated analysis. The results show how GIS technology has the ability to improve educational outcomes and how location matters in education.

The distribution of secondary public schools in "Chikun Local Government Area, Kaduna State, Nigeria" is studied by(Doyani et al. ,2020) using GIS. Considering the unequal distribution of schools and the inadequate infrastructure, the inquiry emphasizes the need to expand and upgrade existing schools. Educational planning and decision-making should benefit from GIS, as the study shows how useful it is for spatially viewing and evaluating data. A study on the distribution of public schools in Jeddah City, Saudi Arabia, using GIS techniques was presented by (Murad et al. ,2020). The importance of geographic information systems (GIS) in comprehending school accessibility, student density, and site dispersion is highlighted in the study. Educational planning authorities can use the findings to inform their decision-making and tackle issues related to primary school provision. (Idan and Khudhir ,2019) use GIS to assess how well schools are distributed geographically in Bartala city, Iraq. The study highlights the need of addressing issues related to school dispersion and access. The study showcases the potential of GIS in evaluating efficiency and informing decision-making, and it stresses the significance of standards and controls for efficient allocation of educational institutions.

(Alwan and Jaber ,2022, Yousef and Jaber ,2023, and Dibs et al. ,2023) are only a few of the studies that have shown the effectiveness of GIS in spatial analysis and assessment within the study region. Research in Iraq found that GIS was a lifesaver when it came to solving a number of geospatial problems. Using GIS, (Jasim and AL-Hamadani ,2020) integrated open-source data and remotely sensed images to evaluate the dependability of data and determine the positional correctness of updated geospatial datasets. In order to assist with urban planning and management, (Faraj and Mahmood ,2018) used GIS to remove undeveloped land in Baghdad City by utilizing categorization algorithms and extremely high-resolution satellite imagery. In order to track the decline of wetland areas, (Ali and Jaber ,2020) used GIS and satellite data to look at how things changed over time and figure out how to protect them. (Al-Timimi ,2021) also using GIS to track desertification in some parts of Iraq; by integrating satellite images with environmental data, they were able to create a map and comprehend the extent and distribution of desertification, which helped with conservation and land management. In these researches, GIS was found to be a vital tool for data processing, visualization, and decision-making in a variety of geographic applications.

This study aimed to address the challenges related to the availability and accessibility of educational services in Wasit city, Iraq, by conducting a spatial analysis using GIS technology. The research objectives were to assess the distribution and efficiency of educational services, evaluate the adequacy of schools based on planning criteria, and identify areas where new schools are needed to address the shortage of educational facilities

2-Material and Methodology

2.1 Case Study

Kut is a district located in the Wasit Governorate in eastern Iraq. Roughly one million people call this area home; it covers about 6,000 square kilometers. The district is situated on the eastern bank of the Tigris River, which flows through the heart of the district. Kut is characterized by a diverse landscape, including fertile agricultural lands, arid desert areas, and marshlands (Ali and Jaber 2020). Figure1 illustrates the map of the study area. This central region is characterized by its unique blend of historical significance and geographical prominence

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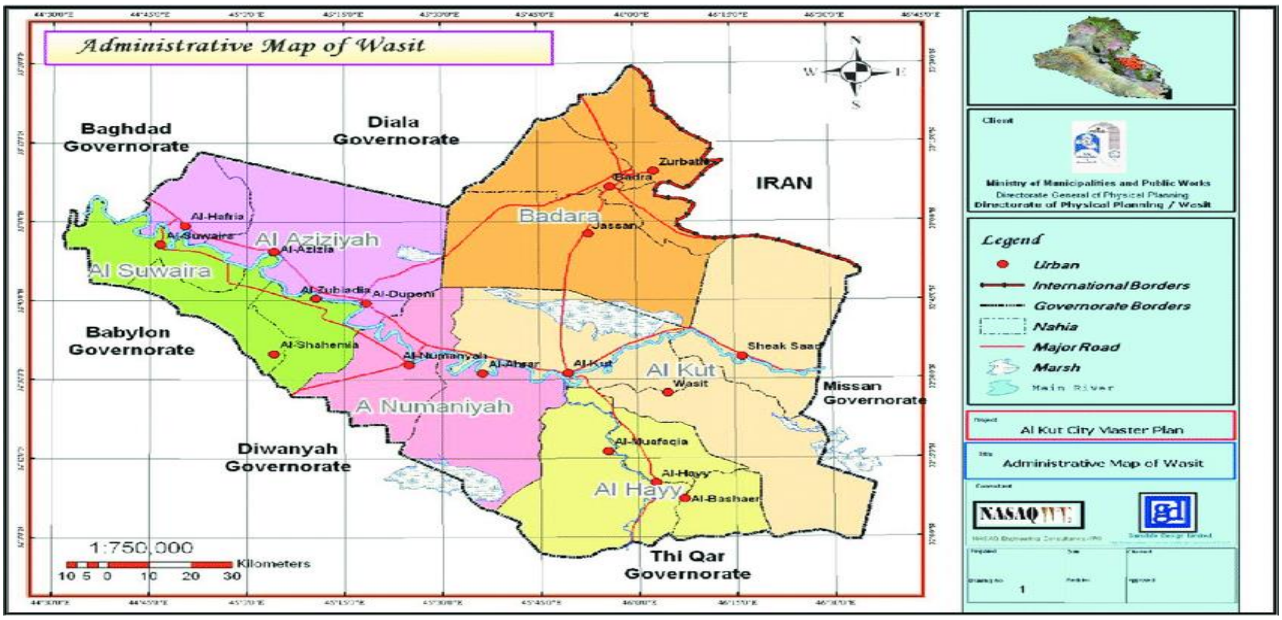

Figure 1: Map of Wasit province, Iraq, and its districts (Al-Maliki et al. 2021).

2.2 Data and Methodology of research

The investigation will be carried out by following the subsequent procedures:

2-2-1-Data collection:

Data Spatial, non-spatial, and vector data were collected, population data, land use data, and environmental data will be collected from relevant sources.

2-2-2-Data processing:

The collected data will be processed and analyzed using ArcGIS 10.8 software.

2-2-3-Spatial analysis:

The Geographical arrangement of educational services within study area will be analyzed using ArcGIS 10.x. Thematic maps and maps that include the scope of educational services will be produced

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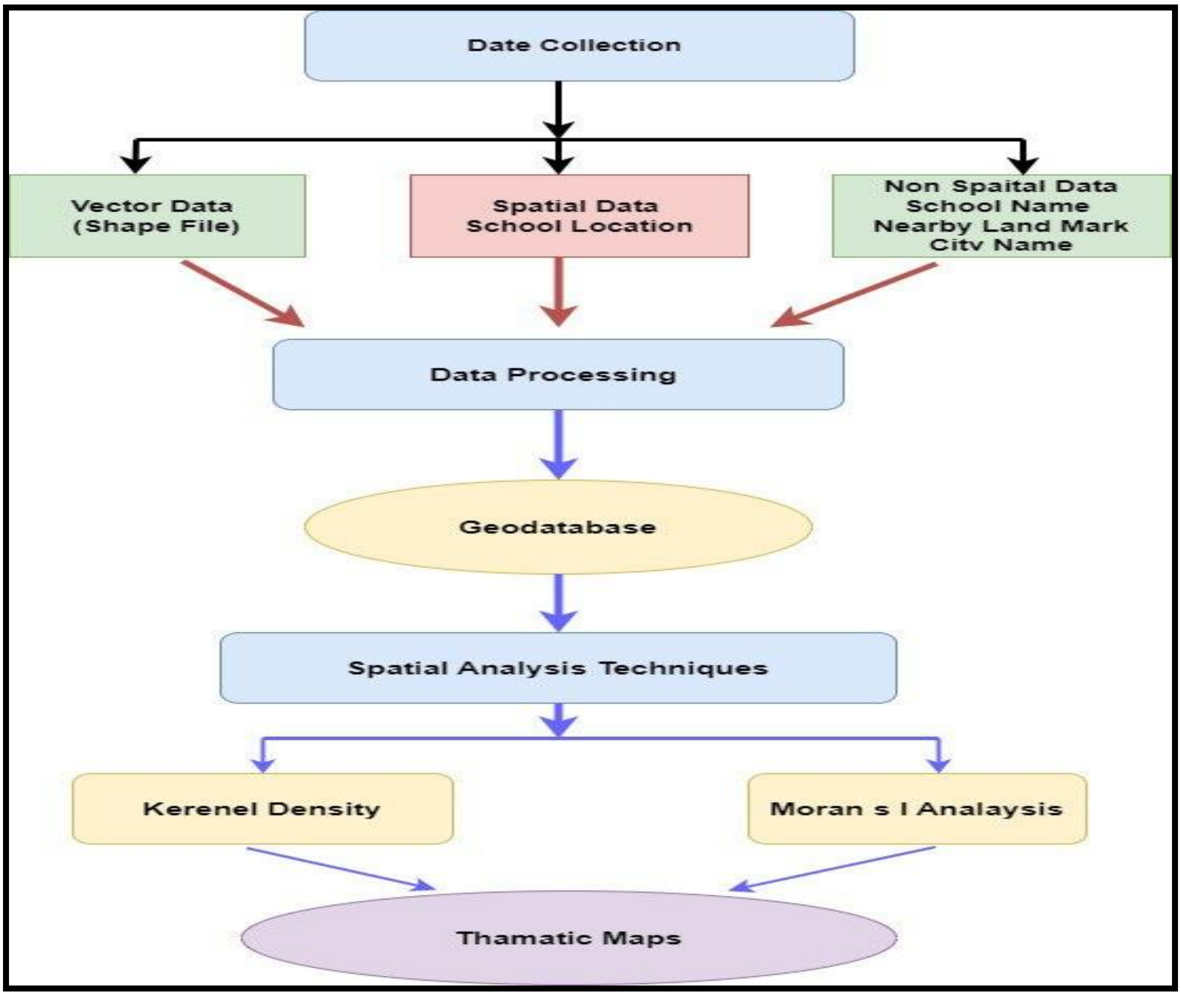

Figure 2: Flowchart of the overview of the proposed methodology.

2.3.1 Spatial Analysis Techniques

Spatial analysis is a general term that encompasses spatial data manipulation via GIS, descriptive and exploratory spatial data analysis, spatial statistics that utilize statistical methods to determine whether inferences are possible, and spatial modeling that entails the build of models to locate relations and predict results in a spatial context (Grekousis, 2020).

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2.3.1.1- Kernel Density Analysis

A feature's density in its immediate vicinity can be determined using the Kernel Density Analysis tool. It is possible to compute for line and point characteristics alike (ESRI 2023). One potential application is in community planning, where it might be used to examine housing density or crime rates. Another could be in investigating the effects of roads or utility lines on wildlife habitats.

The generated kernel density maps were visually inspected and analyzed to identify areas of high and low school density. Hotspots or clusters of schools were identified based on the intensity of the density surface. This information helped in understanding the spatial distribution patterns, identifying areas with a high concentration of schools, and highlighting potential gaps or disparities in the distribution.

The following formula (Esri, 2023) is used to determine the anticipated density at a new (x,y) location:

$$\text{Density} = \frac{1}{(radius)^2} \sum_{i=1}^{n} \left[\frac{3}{\pi} . pop_i \left(1 - \left(\frac{dist_i}{radius} \right) \right)^2 \right] \text{.......2.1}$$

where:

If the input points are i = 1,..., n. Points beyond the (x,y) location's radius should not be included in the total.

An optional argument, popi is the value of the population field at point i.

As a function of x and y, disti is the distance from i to those coordinates.

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2.3.1.2- Moran's I Analysis

The Moran's I Analysis takes both the positions and values of features into account when assessing spatial autocorrelation. It takes a collection of traits and an auxiliary characteristic as the input and produces the pattern's clustering, randomness, or dispersion. The application determines the numerical value of Moran's I Index together with a z-score and a p-value to determine its significance. can You use p-values to numerically estimate the location underneath the curve for a known distribution, with the check statistic appearing as a restriction (ESRI 2023).

With this instrument, you can tell if the pattern you're seeing is random, scattered, or clustered. If the z-score or p-value is statistically significant, then a positive Moran's I index value suggests a clustering tendency and a negative value shows a dispersion tendency.
On the right side of the GIS spatial autocorrelation report you can see the expected values of the Z score (its mean in statistical standard scores), and on the left side you can see the curve and confidence levels ranging from 0.01 to 0.10. In order to confirm the nearest neighbor index, the Z-score was employed. (ESRI 2023).

3.Results and Discussions

The results provides a general assessment of the schools of Kut City, focusing on the distribution and number of schools within the region. The assessment includes primary schools and secondary schools, providing insights into the educational infrastructure in the region.

Table .1 presents the data on the number of schools in Kut City. It is clear by looking at the number of schools in each district that a variety of factors, including population density, size and shape of the population, and educational requirements, affect the distribution. Policymakers and educational authorities must comprehend these dynamics in order to properly allocate resources, pinpoint regions in need of development, and guarantee that educational demands are sufficiently satisfied across Al-Wasit Province.

Table.1: Number of Schools in Kut City

District	of Primary Schools	of Secondary Schools
Kut	235	99

3.1.Rusult of Kernel Density Analysis in Kut City

The kernel density map for primary schools in Kut district displayed a higher density, particularly in the central area. The density values ranged from 0 to 91,660, highlighting the concentration of schools in the central region. Similarly, the kernel density map for secondary schools in Kut district revealed a high density in the central area, with density values ranging from 0 to 79,879. This indicates a considerable concentration of secondary schools in the central part of the district. The results are shown in(Figure 3.a, and -b)

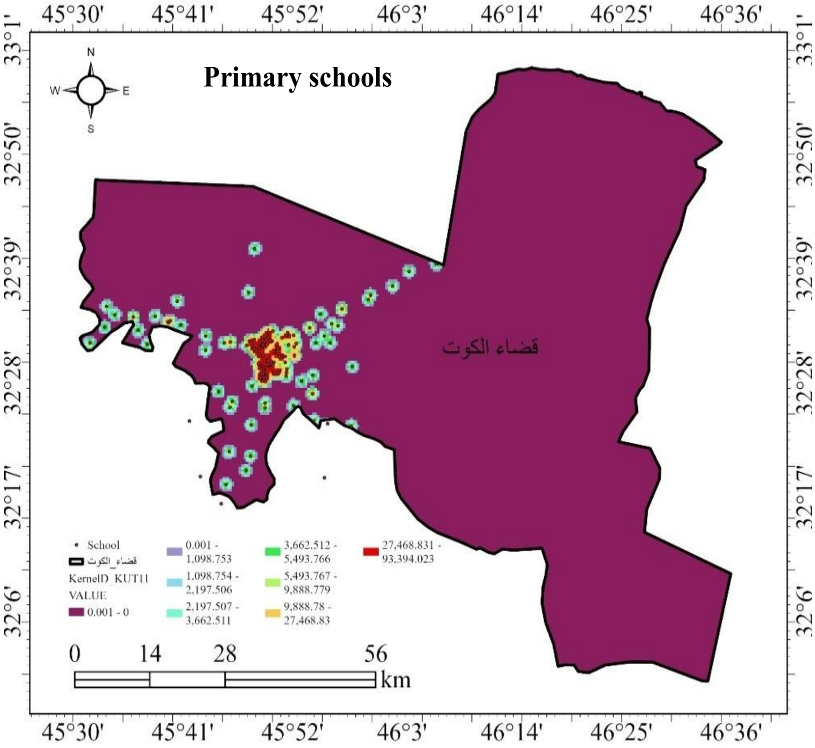

Figure 3.a: Kernel density analysis in Kut district of primary schools

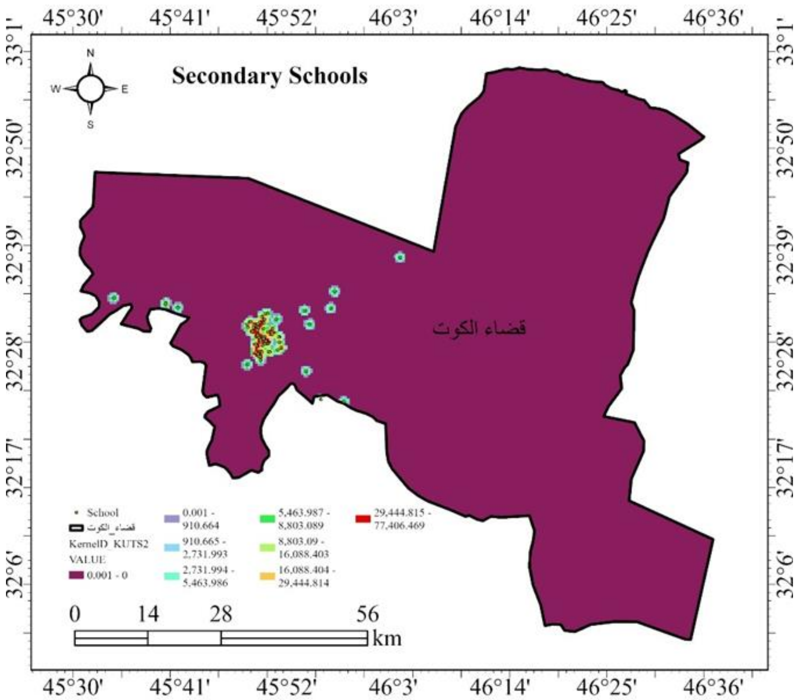

Figure 3.b: Kernel density analysis in Kut district of Secondary schools

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3.2 Results of Moran's I Analysis

In Kut district, the Moran plot showed a random distribution of primary and secondary schools. The absence of clustering or dispersion patterns indicates that the locations of these schools were not influenced by spatial proximity or specific spatial factors. Other factors such as population distribution, transportation networks, or urban development patterns may have played a more significant role in determining school locations in this district. The results are shown in (Figure 4. And a-b)

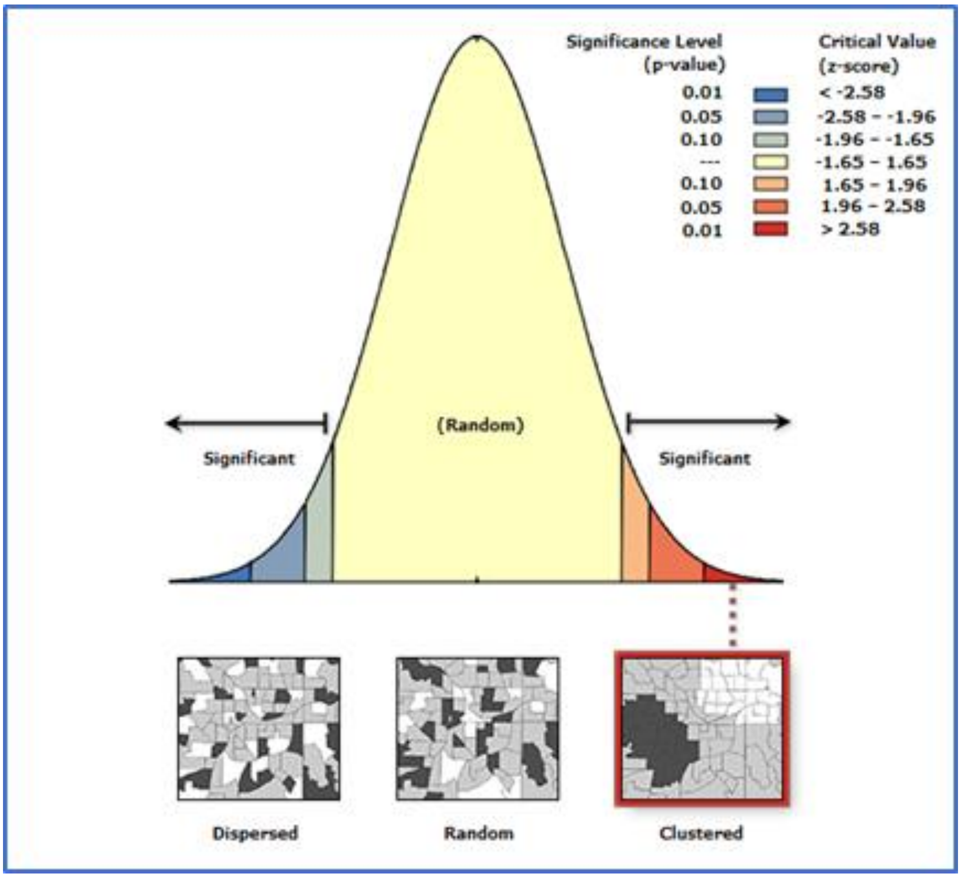

Figure 5.a.: Moran analysis in Kut district of primary schools

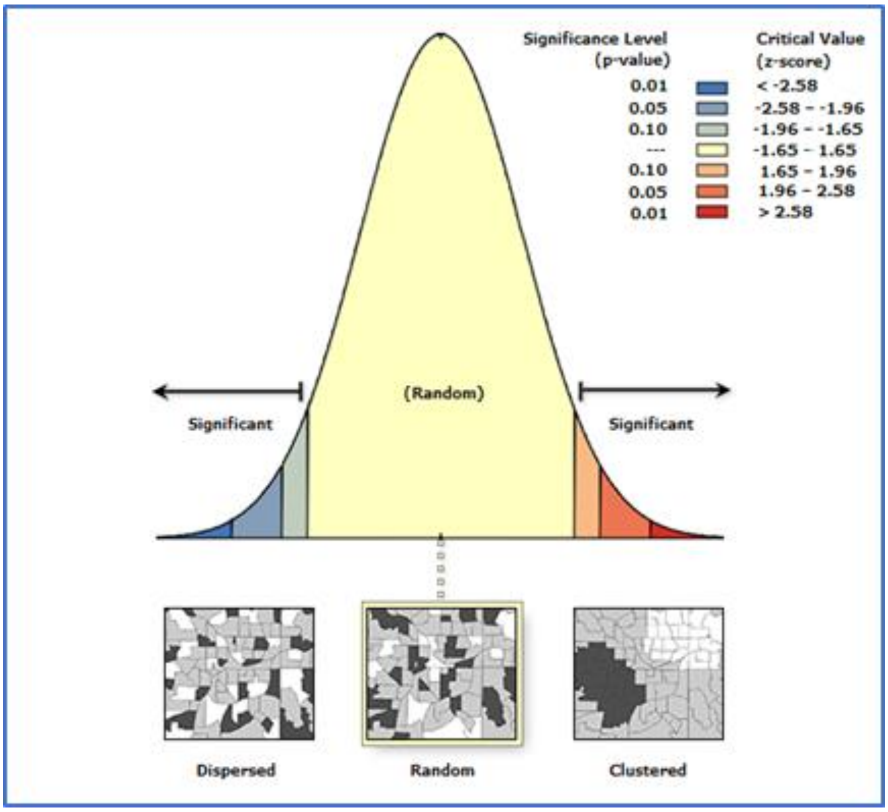

Figure 5.b.: Moran analysis in Kut district of secondary schools

4. Conclusions

The findings of this study will furnish policymakers and educational planners with crucial insights to steer their choices about the establishment and allocation of educational infrastructure in Kut city. Additionally, the study will add to the body of knowledge already available on the application of GIS technology to evaluate the effectiveness and distribution of educational services, serving as a useful resource for further research in this field.

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