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GIS-Based Interactive Technology in Demographic Record Management and Mapping Towards Sustainable Community

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Abstract: Management of demographic records plays a vital role in understanding and planning for the needs of community living. However, managing conventional records requires more time, cost, and energy without accurate assurance. As there are raising concerns in assessing community information for charity purposes, safety coordination, and crime prevention, especially during emergencies; integrating demographic data with spatial information is becoming significantly important. This paper aims to establish an accessible and visible digital platform of demographic information for respective sectors, namely, the KRT, Qariah group, NGOs, and representatives of CSR projects. The objective is to digitize interactive demographic record management and mapping through GIS-based technology. This study adopts a Geographical Information System (GIS) to digitize information using web GIS integrating with the Unmanned Aerial Vehicle (UAV) technology for data acquisition in the community sampling areas; Puncak Iskandar. The proposed system which leverages the power of spatial analysis and visualization, utilizes GIS technology to store, analyse, and visualize demographic records in a geographical context. It incorporates various demographic data sources, such as census data, health records, and administrative data in managing more efficient and effective data with lower cost, energy, time, and resources. Furthermore, the GIS-based system enables the identification of spatial disparities, inequalities, and interventions in demographic characteristics. Therefore, the integration of this system into community demographic management has provided a powerful platform for accessing and coordinating population dynamics, problem-solving, and sustainable development. The implementation in Puncak Iskandar enhances the accessibility, and visualization of demographic data, enabling policy-makers, researchers, and planners to make informed decisions based on a geographical perspective. The findings demonstrate the reliability of GIS-based demographic record management in a community living towards supporting evidence-based planning, resource allocation, and policy formulation for a wide range of applications, including urban planning, public health, and social services towards a sustainable future.

Keywords: GIS, interactive technology, demography, management, mapping

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1. Introduction

A Neighbourhood Association, also known as a Community Association or Residents' Association, is a formal or informal organization formed by residents within a specific neighbourhood or community. It serves as a platform for neighbours to collaborate, and address local issues and concerns. The primary goal of a Neighbourhood Association is to promote the well-being and improvement of the neighbourhood through collective action and community involvement. Neighbourhood associations have long been recognized as essential entities in fostering community engagement and addressing local concerns. These associations bring together residents, promote social cohesion, and work towards enhancing the quality of life within neighbourhoods. In recent years, integrating Geographic Information Systems (GIS) applications has provided new opportunities to leverage spatial data and analysis in the context of neighbourhood associations.

GIS applications have revolutionized the way spatial data is collected, managed, analysed, and visualized. This valuable tool efficiently enables comprehensive presentations and enhanced visualization of spatial data analysis, thereby facilitating improved planning, analysis, and monitoring of geographic information (Madelyn et al., 2022). By incorporating GIS technology into neighbourhood associations, it becomes possible to harness the power of spatial information for better decision-making and community development. GIS allows for the integration of various data sources, such as demographic information, land use data, infrastructure data, and environmental data, to gain a comprehensive understanding of neighbourhood dynamics. The use of GIS in neighbourhood associations offer several advantages. First, it enables the visualization of spatial patterns and relationships. By mapping data onto a geographic framework, neighbourhood associations can identify spatial disparities, hotspots, and trends within their communities. This spatial perspective enhances the understanding of neighbourhood issues and supports evidence-based planning and decision-making.

Furthermore, GIS applications offer opportunities for community engagement and participation. Interactive mapping platforms and online tools can be utilized to involve residents in neighbourhood planning processes, solicit feedback, and visualize potential changes or developments. This participatory approach empowers community members to contribute to decision-making and fosters a sense of ownership and inclusivity within the neighbourhood. Integrating GIS applications into neighbourhood associations provides a powerful framework for leveraging spatial data and analysis. It enables associations to gain a comprehensive understanding of neighbourhood dynamics, make informed decisions, and engage residents in community development processes. The use of GIS in neighbourhood associations enhances their capabilities in addressing local concerns, promoting sustainable development, and fostering vibrant and resilient communities.

Due to this circumstance, there is a need to find an alternative technology to undertake the powerful function offered by the conventional method of census. For this purpose, the problem is managed by using a system known as Geographical Information System (GIS) that is able to obtain digital information using web GIS with integrated Unmanned Aerial Vehicle (UAV) technology in data acquisition for residential areas. UAV plays a significant role as invaluable tools for sustainable urban planning and development by facilitating data collection, mapping, and monitoring activities (Muhmad. et. al., 2023). At present, GIS is a modern application method, an existing tool used to highlight community assets and display spatial patterns in ways that were not previously possible. GIS data-generated maps can be used to depict community relationships and significant hotspots. The aims of this study are to examine the prevalence and impact of geographic information system (GIS) mapping on socio demographic indicators. It holds significant importance in shaping the perception of a neighbourhood in society. Furthermore, this study is required to evaluate the effects of geographic information system (GIS) mapping on several socio demographic aspects, such as age, gender, location, education, attitudes and knowledge, and socioeconomic status (income).

2. Interactive Technology in Demographic Mapping: Census Population

The census, widely recognized as a comprehensive enumeration survey, stands as the most prevalent and reliable method of data collection. Its long-standing recognition stems from its ability to effectively gather and record information about the members of a population. Censuses serve the purpose of meticulously enumerating individuals within a population, encompassing the classification of different life stages. In contrast, monitoring endeavours to detect and track population trends over a period of time, providing insights into population dynamics and changes (Kody et al., 2021). By offering a robust database, the census enables demographic data comparisons, projections, and the examination of the social and economic characteristics of a society. Governments worldwide employ this method to gather data on population, housing, agriculture, and other relevant topics. The population census is regarded as highly accurate due to the meticulous collection and analysis of data from each household before drawing any conclusions (United Nations New York, 2017).

Despite its significance, the census method does have limitations. Census data is typically collected once every ten years, which may result in a lack of complete accuracy over time, as significant changes can occur within a few years. In certain countries, the interval between censuses may be even longer, further exacerbating this limitation. Additionally, challenges arise when enumerators are unable to access specific locations, particularly those affected by conflicts or disasters, as well as areas where language barriers impede communication. In such cases, the population of

those areas may be either under counted or not counted at all (Geospatial Worlds, 2020). The global challenge of population growth influences the shifting patterns and densities of human settlement. The sustainable development of an area is profoundly impacted by population growth, encompassing both social and spatial dimensions (Yaakub et al., 2022). Moreover, the concept of community engagement encompasses multiple interpretations. It can encompass the practice of actively involving and seeking input from the public to educate stakeholders, shape policy, and enhance the decision-making process (Smardon, 2018).

Technological advancements have enabled the statistical organization to overcome the challenges associated with processing extensive datasets (Arip et. al, 2019). Interactive Technology in Demographic Mapping refers to the use of interactive tools and technologies to facilitate the visualization, analysis, and exploration of demographic data within a spatial context. This approach leverages advanced software and user-friendly interfaces to create interactive maps that enable users to interact with and manipulate demographic information, allowing for customized data exploration, comparisons, and insights. It emphasizes the integration of technology to enhance the accessibility, usability, and engagement of demographic mapping processes (Oliver & James, 2016).

Geospatial data management acts as a bridge that links various stages of the data lifecycle, including data acquisition, data modelling, data visualization, and data analysis. It facilitates the uninterrupted accessibility of geospatial data and ensures the reproducibility of geospatial data analysis (Martin et al., 2020). GIS applications have evolved to enable user interaction and data analysis requests, resulting in the generation of visually appealing and easily comprehensible mapping distributions for the community. Therefore, the existence of a comprehensive resident database becomes highly important to ensure the completeness of resident information, particularly in residential areas and their adjacent regions.

3. GIS-Based Demographic Management

Managing Managing the population is a challenging and complex task due to its ever-changing and multifaceted nature. When talking about demography, it refers to the study of the human population in a certain geographical area, emphasizing that demography is indeed interrelated with spatial science. The Geographic Information System (GIS) is a contemporary tool employed across various disciplines to effectively handle both attribute data and spatial data, encompassing population management as well (Diana et al., (2021); Le Thi Minh et. al., (2021)).

GIS-based demographic record management refers to the utilization of Geographic Information Systems (GIS) technology to manage and analyse demographic data. It involves integrating spatial data with demographic information to gain insights into population patterns, characteristics, and trends. The use of GIS in demographic record management has become increasingly prevalent due to the advantages it offers (Ershad Ali, 2020). GIS allows for the visualization, storage, and analysis of spatially-referenced data, such as population data, census information, and socioeconomic indicators. By linking demographic data to specific locations on a map, GIS enables a spatial perspective that enhances understanding and decision-making.

GIS-based demographic record management can assist various organizations and institutions in several ways. For example, government agencies can use GIS to visualize population distributions, identify areas with specific demographic characteristics or needs, and plan for resource allocation or service provision accordingly. Urban planners can utilize GIS to analyse population growth patterns, assess the impact of development projects on communities, and make informed decisions regarding land use and infrastructure. Despite limitations in technical knowledge, the significance of GIS mapping in monitoring and displaying performance indicators within the Neighbourhood Pillar Program has been underscored in various studies (Robin et al., 2018).

In academic and research settings, the utilization of GIS-based demographic record management facilitates the spatial analysis of population dynamics, including migration patterns, population density, and demographic disparities. By employing GIS, researchers gain the ability to investigate relationships between demographic factors and spatial variables, thereby generating valuable insights for social, economic, and environmental studies (Sedaghati & Omrani, (2017); Boscoe et al., (2012)).

In the context of demographic information, geocoding and statistical data integration using GIS can provide valuable insights into the spatial distribution and characteristics of population-related variables. In GIS, the relationship between geocoding and statistical data is fundamental for spatial analysis. Geocoding enables the integration of statistical data with geographic coordinates, allowing for the exploration and understanding of spatial patterns, relationships, and trends (Figure 1). Geocoding is commonly referred to as the process of geospatially enabling statistical unit records, allowing them to be utilized in geospatial analysis. It involves linking location information, such as an address, that is associated with a statistical unit, to a geocode, which is a geospatial reference object. Alternatively, the geocode can be directly incorporated into the statistical unit record. Geocoding facilitates the integration of location data into a geospatial framework, enabling the utilization of statistical data in geospatial analysis and visualization (Amor Laaribi, 2020). Geocoded demographic data can be incorporated into spatial models using GIS. For instance, develop spatial regression models to examine the relationships between demographic variables and other spatial factors, such as accessibility to amenities, socioeconomic indicators, or environmental attributes. This integration of geocoded demographic data into spatial models provides a comprehensive understanding of how demographic patterns interact with the surrounding environment (Sameer & Hamid, 2023).

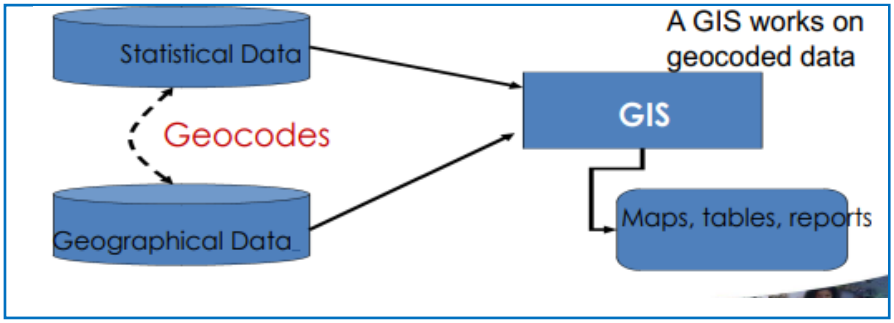

Fig. 1 - GIS-Based process
(Sources: Amor Laaribi, 2020)

4. Material and Method

In this study, population information was collected in the housing area of Puncak Iskandar, Perak (Figure 2). The methodology process is divided into 4 main stages to achieve the study's objectives such as exploratory research, data acquisition, data processing, and results. By following these four main stages (exploratory research, data acquisition, data processing, and results), the study can effectively achieve its objectives of utilizing GIS-based interactive technology in demographic record management and mapping. The methodology for GIS-based interactive technology implementation in demographic record management and mapping may be subject to variations based on the specific tools, software, and data available. The specific approach and techniques utilized in each stage of the methodology process can differ depending on the resources and technologies employed.

Fig. 2 - Basemap of Puncak Iskandar
Sources: Google Map, 2020

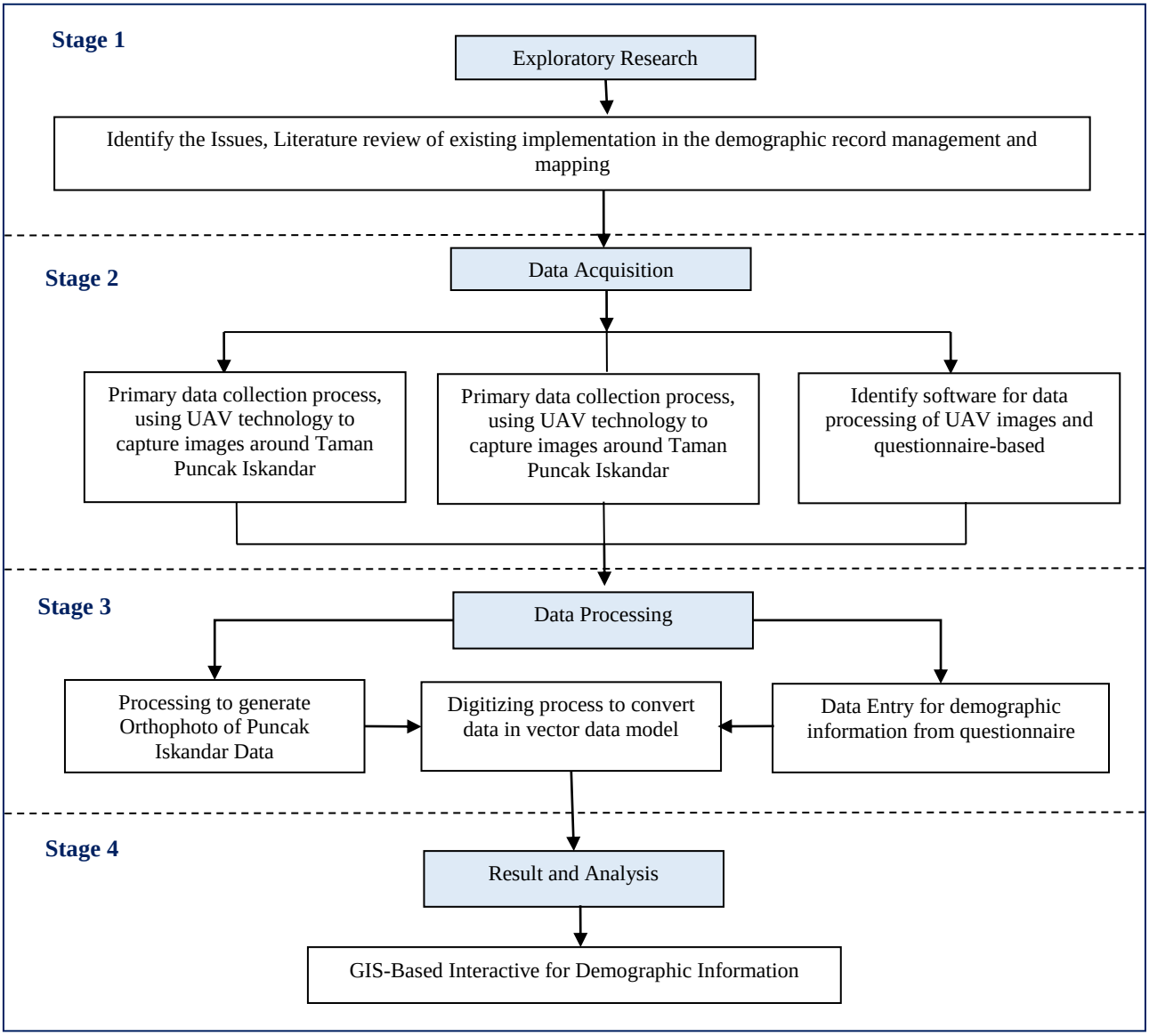

Fig. 3 - The implementation of demographic record management and mapping using GIS

The methodology process for the implementation of demographic record management and mapping using GIS involves a series of systematic steps. Firstly, the study area is clearly defined, specifying the geographic boundaries and extent to be covered. Next, demographic data were collected from reliable sources like census records using questionnaires and aerial images using UAV were collected around the Taman Puncak Iskandar. Figure 3 shows the methodological process for this study and will be explained in detail in stages.

5. Exploratory Research

In this stage, the focus is on conducting exploratory research to gain a comprehensive understanding of the study's objectives. This involves conducting a literature review to identify existing studies, frameworks, and methodologies related to GIS-based interactive technology in demographic record management and mapping. The research also includes identifying the study's specific objectives and determining the key variables and data sources that will be utilized. In this study, the existing literature and studies on GIS-based interactive technologies in demographic record administration and mapping are investigated. At this stage, an analysis was conducted on how GIS technology has been used in managing demographic records and mapping, finding successful examples, best practices, and potential challenges. This helps to identify the appropriate framework and methodology that can be adapted to achieve the study's objectives.

6. Data Acquisition

The second stage involves acquiring the necessary data for this study. The data were collected using a questionnaire to capture relevant demographic information based on the objectives of this study. The questionnaire is related to name, address, gender, contact, occupation, and other demographic variables of interest. It is crucial to ensure the data collected are accurate, reliable, and relevant to the study objectives. Figure 3 depicts the process of creating a questionnaire to gather demographic information using field mapping and form software. The development of this questionnaire involved several steps to collect relevant data from respondents. In the initial stage, field mapping was conducted to identify and define the geographic areas or locations where data would be collected. This may involve physically visiting the areas by using UAV imagery to demarcate the boundaries. Based on the objectives of the survey and the demographic information required, a structured questionnaire was designed. The questions were carefully crafted to capture specific demographic attributes, such as name, address, status, phone number, type of house and etc. The designed questionnaire was then translated into a digital format using form software. This software enables the creation of electronic forms that can be easily filled out by respondents, whether on mobile devices or computers. Once all the data had been collected and entered, the form software was used to analyse the demographic information. The results of the demographic survey can be visualized through interactive maps or reports, allowing stakeholders to understand patterns and trends within the geographic areas surveyed. The use of field mapping and form software streamlines the process of collecting demographic information, reduces data entry errors, and facilitates real-time data access and analysis. It is an efficient and effective approach for acquiring crucial demographic data, which can be utilized for research, planning, and various other decision-making processes.

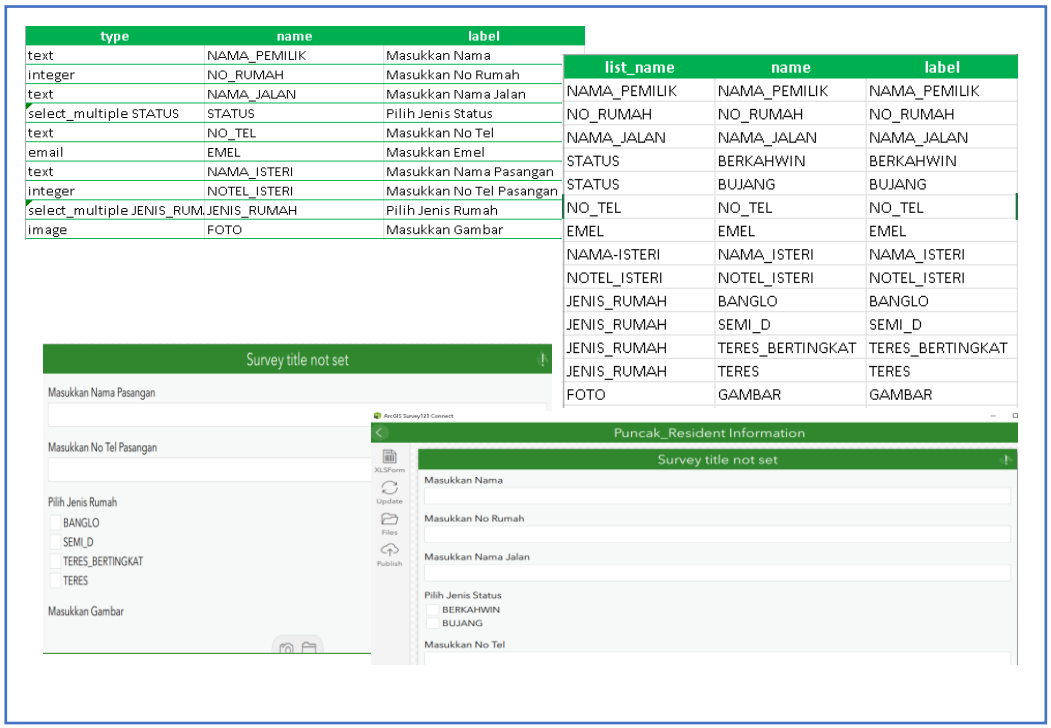

Fig. 3 - Development of Questionnaire for Demographic Information

7. Data Processing

Once the data had been acquired, it underwent a series of processing steps to prepare it for analysis and mapping. This stage includes data input, data cleaning, data integration, and data transformation. In data input, a base map of the demographic data is required to geocode and assign geographic coordinates to the relevant locations. Geocoding allows the data to be spatially referenced and integrated with other spatial datasets in the GIS. The demographic data are entered based on the questionnaire completed by the residents.

Data processing is a crucial step in demographic record management and mapping using GIS technology. It involves data collection, integration, standardization, geocoding, spatial analysis, visualization, and quality assurance. By effectively processing demographic data, stakeholders can gain valuable insights into population dynamics, spatial patterns, and demographic characteristics. These insights inform informed decision-making, planning, and policy development, leading to more effective and targeted interventions to address the needs of specific populations and promote sustainable development.

The digitizing process of demographic information and geocoding the demographic location involves several steps to convert and link the data for spatial representation and analysis (Figure 4). Firstly, demographic data were collected from reliable sources, such as census records or surveys, capturing information about population counts, age groups, income levels, and other relevant attributes. Once the demographic data had been collected, the data underwent a process of digitization, which was then converted from its original format (paper-based or digital records) into a digital format. This process usually involves data entry into a computer system or spreadsheet, enabling easier manipulation and analysis. In the GIS software, spatial data layers were either created or imported, representing geographic boundaries such as administrative areas or census tracts. These spatial layers would serve as a framework for displaying the geocoded demographic data on a map.

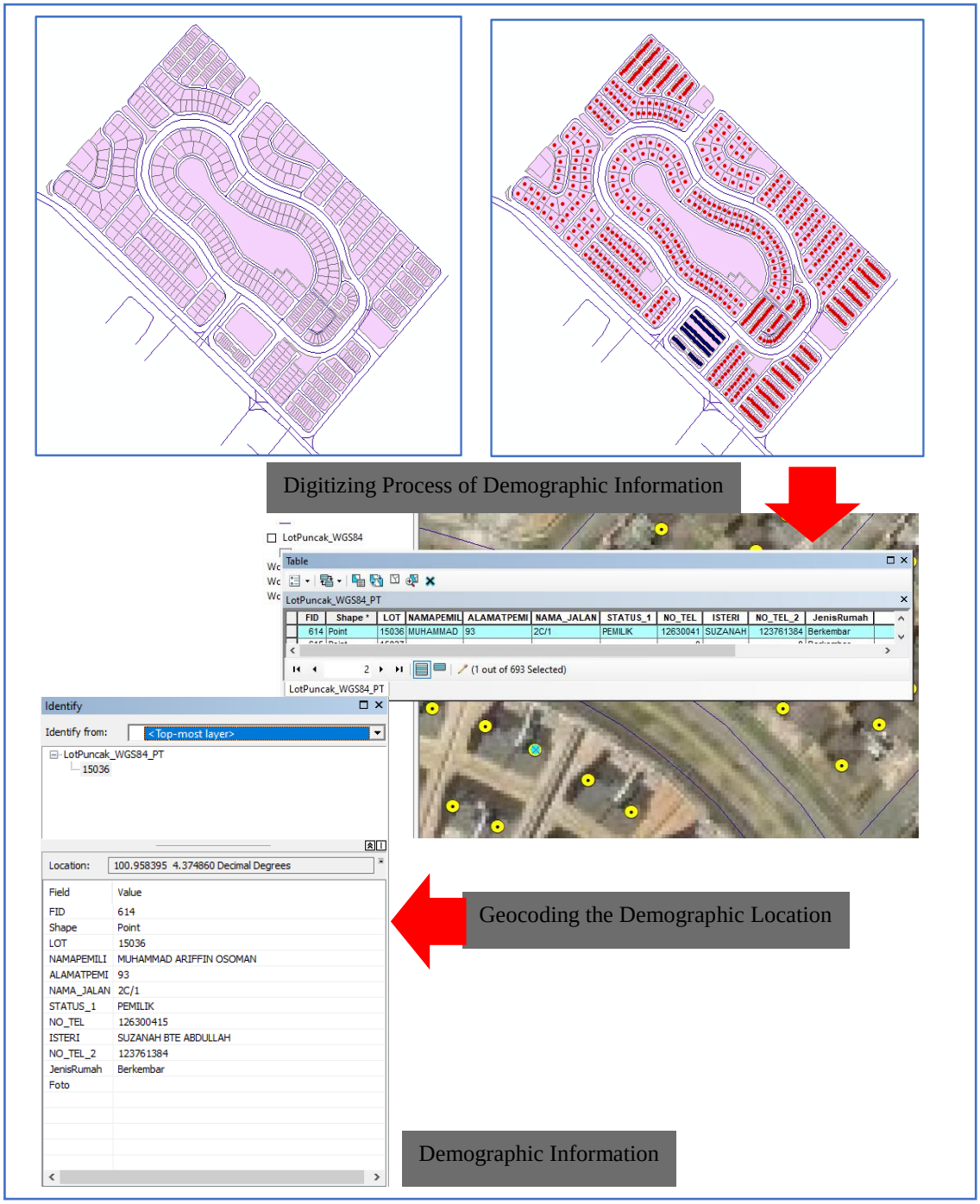

Fig. 4 - Data Processing for Demographic Information using GIS

By linking the demographic data to the geographic locations through geocoding, each entry becomes associated with its corresponding spatial area. This linkage enables visual representation and spatial analysis of the demographic

information. Moreover, the data analysis process involves studying the spatial distribution of demographic information to identify patterns, trends, and disparities across different geographic areas. This analysis can reveal insights into population characteristics and support decision-making processes in various fields, such as urban planning, public health, and business analysis. Overall, the digitizing and geocoding process is essential for making informed decisions based on demographic data within a spatial context.

8. Result and Discussion

The implementation of GIS-based interactive technology in demographic record management and mapping yields significant benefits and transformative outcomes. This section presents a comprehensive and persuasive discussion of the results obtained from utilizing this technology, highlighting its implications for research, planning, and decision-making processes. The adoption of GIS-based interactive technology in demographic record management and mapping offers significant advantages in data analysis, planning, decision-making, and community engagement. This technology enables enhanced data visualization, real-time monitoring, and evidence-based policy development.

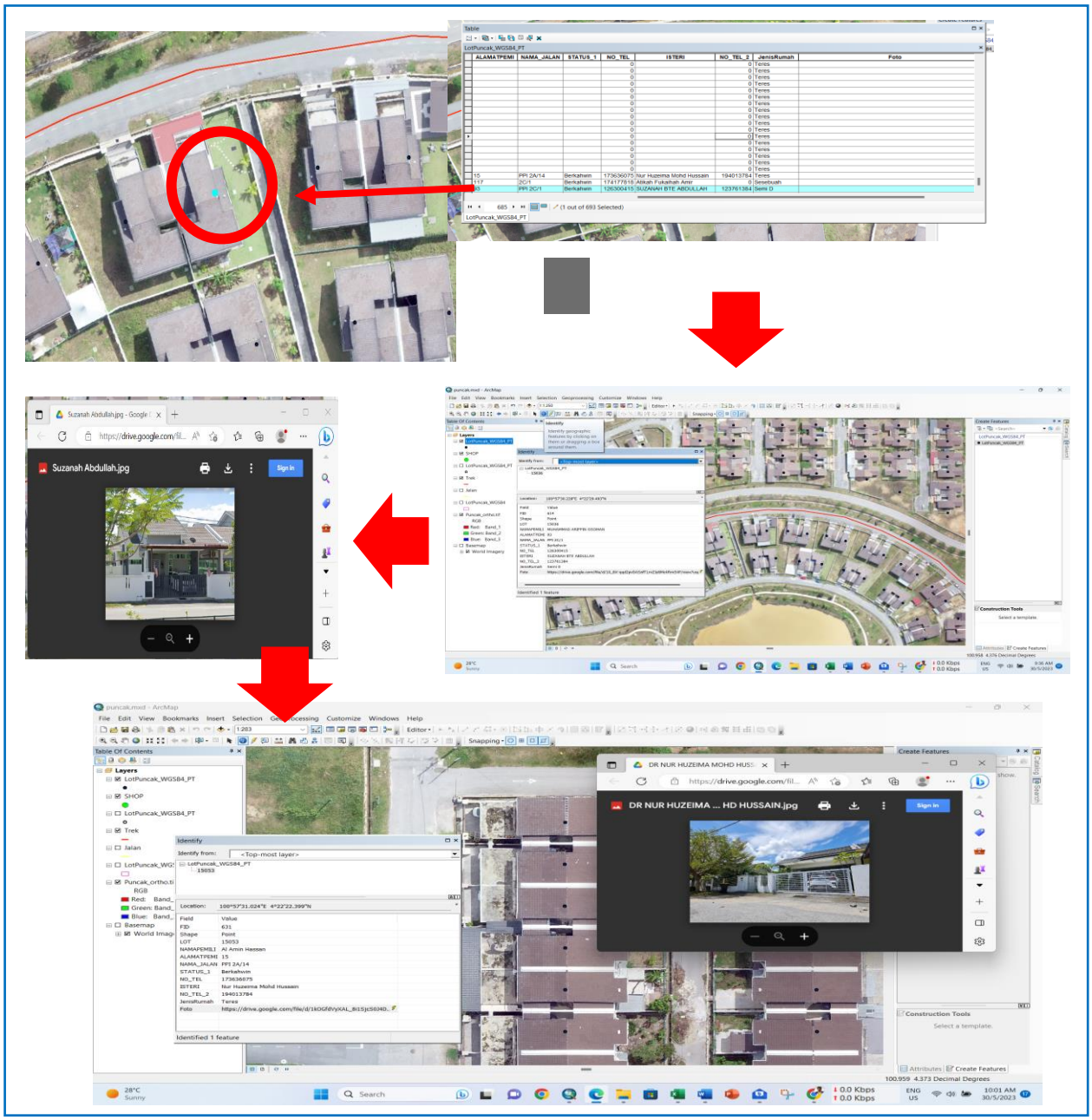

Fig. 5 - Hyperlink Process for Demographic Information

Figure 5 shows the process of data entry and hyperlinks for demographic information using GIS. The data that had been gathered were tabulated into GIS software. Once inside the GIS software, this data were connected or linked to the corresponding spatial data, such as maps, geographic boundaries, or locations. This linking process allows the demographic information to be associated with specific geographic areas, enabling the visualization and analysis of the demographic data within the context of the mapped regions. The GIS software was used to link the demographic data to the corresponding geographic boundaries using the common identifier. With this hyperlink process, users can click on a geographic area of interest on the map and access detailed demographic information related to that specific location. This can be a powerful tool for researchers, planners, and decision-makers to gain insights into the distribution of population characteristics and make informed decisions based on the data. This would enable the demographic information to become associated with specific geographic areas on the map which allows user to visualize and analyse the demographic attributes within the context of the mapped regions, gaining insights into population characteristics, distribution, and patterns across different geographic areas.

9. Conclusion

GIS-based interactive technology revolutionizes the way demographic data is managed, analysed, and visualized, offering unprecedented insights into population dynamics and spatial patterns. This study prototyped a digitized residential data of Puncak Iskandar achieving the study's aims in establishing an accessible and visible digital platform of demographic information. By leveraging the power of geographic information systems (GIS), this innovative approach enhances the accuracy, efficiency, and accessibility of demographic record management and mapping processes. Furthermore, with GIS-based interactive technology, demographic data as presented in Puncak Iskandar can be seamlessly integrated with spatial information, enabling a comprehensive understanding of how populations are distributed and how they interact with their environment. This technology empowers researchers, policy-makers, and urban planners to make data-driven decisions, optimize resource allocation, and design targeted interventions that address the specific needs and challenges of diverse populations. In conclusion, this GIS-based interactive technology enhances the conventional information, accessibility, and typology of demographic management with an advancement platform toward an equitable and sustainable community for the future.

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