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Research Article

Monitoring Infectious Diseases Diffusion through GIS

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ABSTRACT

Awareness of the spread of the disease becomes a part that must monitor carefully. This monitoring requires solutions, one of which is through Geographic Information Systems (GIS). This paper discusses the use of GIS in controlling the spread of infectious diseases. The method used is to study previous research. This study provides an understanding of the application of GIS in various situations of the range of contagious diseases. This study includes GIS technology, which monitored the spread of infectious diseases, the application layer of GIS technology, the technology that supports development, and various types of map information displayed. This research provides an essential reference in the event of GIS, especially in the development of map-based software on the spread of infectious diseases.

Keywords: *GIS, infectious diseases, spatial-temporal, mapping.*

1. INTRODUCTION

GIS, spatial, and temporal were first associated with the field of health written in the Soil Science Society of America Journal in 1959 by Walter H. Wischemeier (Wischmeier, 1959). Lately, several studies on GIS and spatial-temporal related diseases are written by various world researchers each year. However, from existing research, scarce research that discusses how the application of GIS, especially in monitoring the progress of infectious diseases using GIS.

This study discusses the foundation of the development of GIS in monitoring the spread of infectious diseases (Arji et al., 2019; Yi et al., 2019). The discussion covers the application of GIS-based technology in various situations. The situations both promotive (Ganeshan et al., 2019), preventive (Roblin, Luini, Fleurat-Lessard, Larignon, & Berjeaud, 2019; Yu et al., 2019), curative (Roblin et al., 2019), and rehabilitative (Sciriha, Lungaro-Mifsud, Fsadni, Scerri, & Montefort, 2019). Furthermore, various alternative activities that have the potential to be monitored through this mapping system, such as demographic analysis (Kolpan & Warren, 2017), spread and diffusion (Gao, Gao, Song, Ye, & Dong, 2019), site selection (Messaoudi et al., 2019), and zone management (Siddi Raju, Sudarsana Raju, & Rajasekhar, 2019). The discussion also covers the layers of technology application that exist in

the GIS environment. The development of various technological capabilities that are likely to be applied to GIS is also examined in this study and includes multiple types of mapping used by numerous studies (Hardi et al., 2019; Rusdi, Abu, Agustina, Kchouri, & Dewi, 2019).

This research study uses a variety of literature derived from ScienceDirect. This research covers information technology related to GIS development and the spread of infectious diseases viewed from an information technology perspective.

This research is a source for other researchers to develop GIS, especially in the development of information systems monitoring the spread of geographical-based infectious diseases.

2. MATERIAL

Infectious diseases

Various infectious diseases are very easy to spread, endemic (Chen et al., 2019), epidemic (Lee & Nishiura, 2019), and pandemic (Cheng et al., 2019; Germann et al., 2019). Concerns about the spread of disease require a certain concentration, especially when a case occurs and has the possibility of spread in a wider range (Feng & Jin, 2019; Hao et al., 2019).

Infectious diseases of concern include dengue fever (Jácome, Vilela, & Yoo, 2019), HIV (Wijting et al., 2019), respiratory infections (Lasselin et al., 2019), flu (Shinjoh et al., 2019), tuberculosis (Rakhmawati, Nilmanat, & Hatthakit, 2019), Anthrax (Gachohi et al., 2019), SARS (Cao, Fang, & Xiao, 2019), and MERS disease (Alagaili, Briese, Amor, Mohammed, & Lipkin, 2019). The spread of the disease has the potential to be fatal and ultimately impact on death (Cordner, Bouwer, & Tidball-Binz, 2017). Spread can be caused by viruses and bacteria (Hu, Tan, & Huang, 2019).

GIS

Geographic Information System is a unique system that processes information in the form of spatial data relating to the location of space or equipped with time (Febrian, 2002; Lind et al., 2019). This information system usually displays the data it has in various types of mapping (Arabameri, Pradhan, Rezaei, & Conoscenti, 2019; Sun, Chen, Zhong, Liu, & Wang, 2019).

The application of GIS is snowballing since various information interconnected in the internet world (Febrian, 2004, 2007, 2008). Higher education research (Febrian, 2000; Rusdi, Salam, Abu, Baktina, et al., 2019) also helped the growth of GIS implementation applied in many fields (Sunaryo, Hardi, et al., 2019; Sunaryo, Rusydi, Rusdi, Suriani, & Daus, 2019), but based on the results of the search for the use of GIS in mapping the spread of diseases originating in ScienceDirect, it appears that research in this field still gets little study from researchers.

GIS technology is a mapping system that has increased capabilities over time, including in terms of performance (Murray, Xu, Wang, & Church, 2019; Rusdi, 2019). This technology has been applied including in a variety of activities, in addition to the health sector, this technology is also used in decision-makers in urban renewal (Omidipoor, Jelokhani-Niaraki, Moeinmehr, Sadeghi-Niaraki, & Choi, 2019), Management of water needs (Jayarathna et al., 2017), outdoor moving activities, traffic management (Campbell, Both, & Sun, 2019), field reporting (Sunaryo, Rusydi, et al., 2019), as well as human behavior (Rusdi, Salam, Abu, Sahib, et al., 2019; Rusdi, Salam, Abu, Sunaryo, et al., 2019).

In the health sector, specifically related to the monitoring of the spread of infectious diseases, several studies carried out including those associated with the review of dengue distribution in the use of GIS (Yue, Liu, Xu, Ren, & Liu, 2019; Zambrano et al., 2019), analysis and mapping (Mala & Jat, 2019), the use of geospatial data-fusion (Hoffman-Hall, Loboda, Hall, Carroll, & Chen, 2019), epidemiological dengue fever in China, and Markers of hepatitis B virus infection in central Nigeria (Mohammed, Pennap, Oti, & Adoga, 2019).

Several studies of disease transmission using this mapping aid include the Case study of child health in Istanbul (Dogru, Kahraman, Seker, & Sivri, 2019), public health implications in Honduras (Zambrano et al., 2019), disease transmission in China (Yue et al., 2019).

3. METHODOLOGY

This research is related to two main sciences, namely health and information technology. These two sciences integrated through the use of GIS technology, which applied in the health sector, namely the monitoring of the diffusion of infectious diseases. The scientific study explored through a literature review. This illustration, as shown in Figure 1.

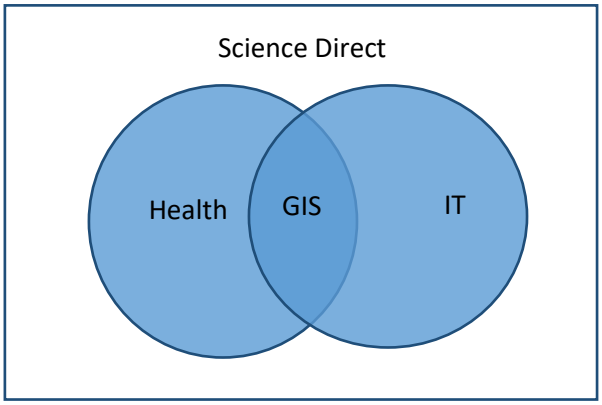

Figure 1: Implementation of GIS between two sciences, scilicet Information Technology and Health Sciences

Literature review comes from various research and journal sources through Science Direct. The keyword used to explore multiple sources is "mapping gis spatial temporal infectious diseases." Research restrictions carried out in the last ten years (2010-2019).

The research articles collected sorted and adjusted to the needs of this research. Not all of the journal-articles are used, except those that have a strong connection to this study.

4. RESULTS AND DISCUSSION

GIS research to monitor the spread of infectious diseases

The results of the study on the use of GIS to control the spread of contagious diseases shown in Figure 2.

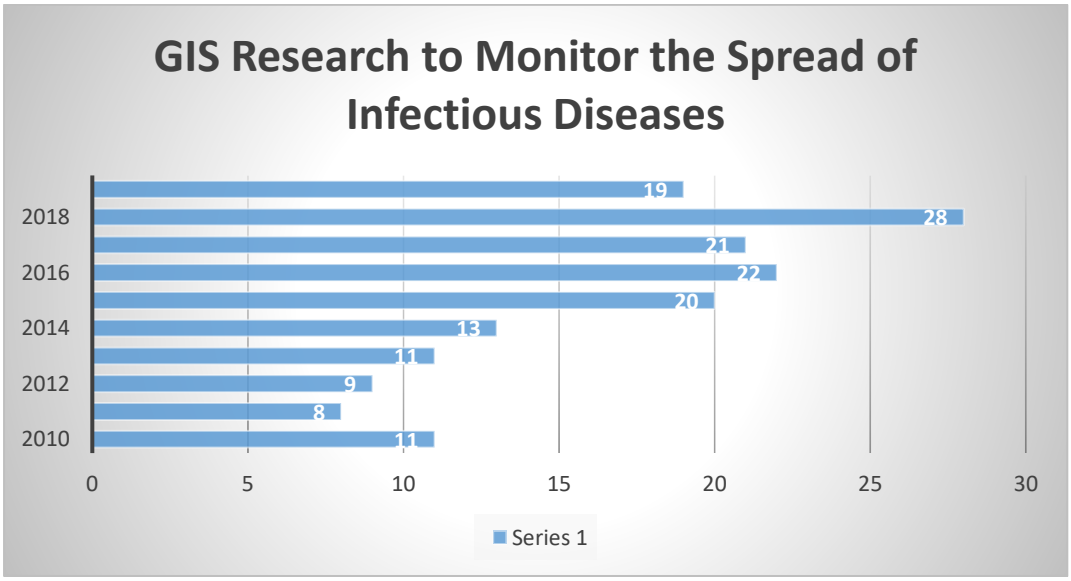

Figure 2: GIS research to monitor the spread of infectious diseases

From the last ten years of the research (2010-2019), it appears that the world research related to monitoring the spread of infectious diseases using GIS studied by various researchers. At least, between 8 and 28 studies published annually. The average research was 16.2 studies per year. Analysis, in general, is relatively increasing, although it still does not get much attention from researchers.

Implementation of GIS in various infectious disease diffusion situations.

GIS, spatial, and temporal implemented in various situations. Both at the time of promotive, preventive, curative, or rehabilitation (see Figure 3). These multiple stages have their uniqueness and characteristics.

For example. The use of GIS at the time of promotion used in the monitoring of the socialization of infectious diseases. Likewise, during preventive measures, GIS is used to map preventive actions from various regions. When Curative, mapping is done in connection with the mapping of recovery from the multiple areas. These different situations developed in one information system that suits your needs

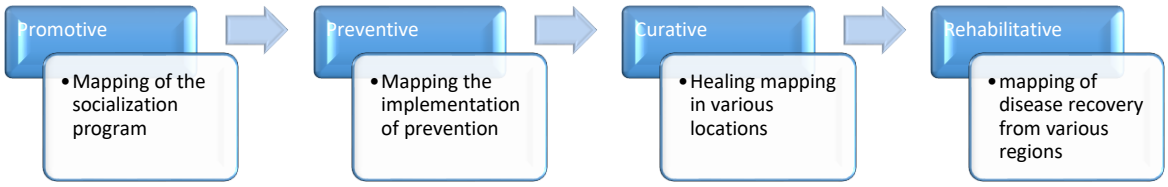

Figure 3: Stages of the mapping application in the monitoring of Infectious Diseases Diffusion through GIS

Monitoring Activities

Services related to the implementation of GIS, spatial, and temporal in the health sector applied to several aspects. Including corridor selection, demographic analysis, engineering design, facility management, geoprocessing modeling, incident mapping, land management, logistics routing, network analysis, source exploration power, resource inventory, site selection, spatial management, distribution, and diffusion, topographic analysis, transportation modeling, water shield analysis as shown in Figure 4.

A wealth of features potentially developed in the monitoring of the spread of infectious diseases. The Features that developed consists of primary and secondary needs. The primary need is Fundamental requirements, which are the direct needs of the system developed, while secondary needs are features that considered as support.

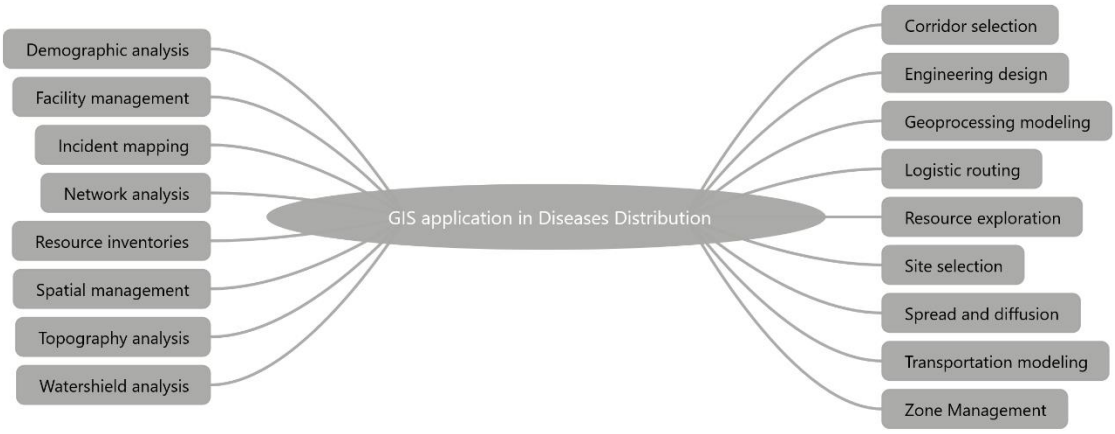

Figure 4: Application of GIS to Disease Distribution

GIS Technological Layer in the Monitoring Infectious Diseases Diffusion

In the application of GIS technology, there are at least four layers that are components of this system that can run well. The four layers include the Server Layer, Platform Layer, Publication Layer, and Application (See Figure 5).

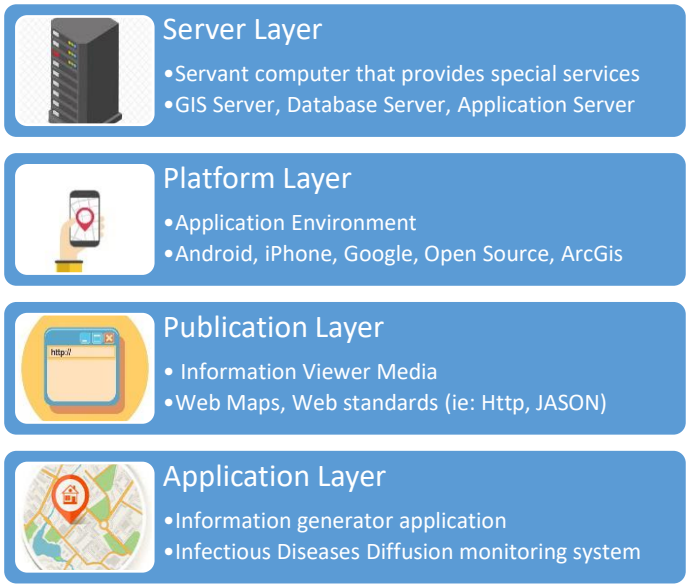

Figure 5: GIS Technological Layer in the Monitoring Infectious Disease diffusion

Each layer has its main tasks related to managing infectious disease information management. In the first layer, the Server Layer is usually responsible for GIS services. This database stores various categories of data related to infectious disease information that is owned by the system, as well as the provision of services at the request of the application. Platform Layer is the application environment run, for example, on Android, iPhone, Google, Open Source, or ArcGIS. Likewise, with the Publication Layer, a channel for flowing information, for example, through Web Maps, or Web standards. While at the lowest layer is an application that used directly to interact between the system and its users, called the Application Layer. At the bottom of this layer is a generator of information based on user interaction with the services provided by the application. The available layers illustrated in Figure 5.

Supporting technology in Monitoring

Potential developments in information technology in the health sector include the potential to be supported through various types of technology. Some of them are 3D Printing, Artificial Intelligence, Augmented Reality, Big Data, Blockchains, Cloud Computing, Drones, Genetics, Internet of Things, Machine Learning, Mobile Applications, Robots, Sensors, and Social Networks. This alternative is shown in Figure 6.

Figure 6: Supporting technology for GIS application in the mapping of disease diffusion

The utilization of this technological support used following the environment of the monitoring system of the spread of infectious diseases developed. For example, the use of sensors to find out which coordinates used in the system, the sensors are taken through the coordinate tracker found on the user's smartphone, likewise with the use of other support Placement of supporting technology-adjusted to the needs of the system built, while also considering the service system used. This placement corresponds to each layer of system development (See Figure 5).

Display information on mapping (Model of Mapping)

Data that processed through a geographic information system displays the results of the study of information in the form of mapping.

This mapping display in various forms in the form of zones (Figure 1), depictions with directional distribution (Figure 8), clusters (Figure 9), density and history (Figure 10), as well as location points such as the placement of a sensor in various locations (Figure 11).

Figure 7: Vulnerability area of infectious diseases based on the zone (Adopted (Daoudi, Boussaa, Echchakery, & Boumezzough, 2019)*)*

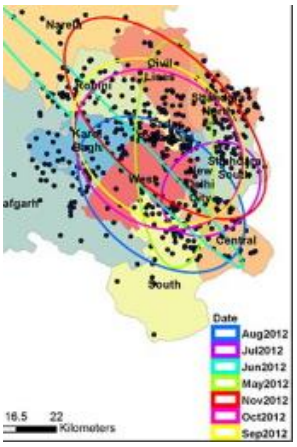

Figure 8: Directional Distribution (Adopted (Mala & Jat, 2019)*)*

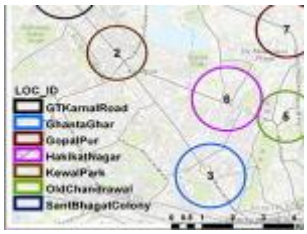

Figure 9: Potential Clusters based on statistical significance (Adopted (Mala & Jat, 2019)*)*

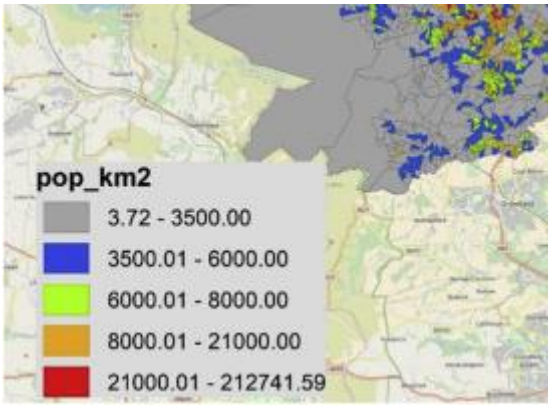

Figure 10: Population density (residents/km2) (Adopted (Munir, Mayfield, Coca, & Jubb, 2019)*)*

Figure 11: Mapping of Sensor location (Adopted (Munir et al., 2019)*)*

5. CONCLUSIONS

This research has reviewed various developments in GIS that are applied to monitor the spread of infectious diseases based on multiple studies that have done before. This article has also provided some notes on the development of GIS to control the spread of contagious diseases, including that research in this area, is still relatively small when viewed based on the results of research publications through Science Direct.

Besides that, this article also raised various supporting technologies that can be synergized through GIS, precisely to monitor the spread of this infectious disease. Meanwhile, layers of the system have discussed and optimized in building GIS-based systems, especially for tracking the spread of contagious diseases.

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