Use of GIS Technology as a Tool for Locating Public Libraries

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ABSTRACT

Due to its versatile nature, GIS provides a vast platform for the managers in decision making. GIS can be used in the management of public libraries too. Public libraries play a major role in the development process by upgrading educational levels in general and the literacy level in particular. Sri Lanka has 1199 public libraries. However, the public libraries must be correctly located in order to cater to the society at large with the notion that no any segment of the society could be marginalized in terms of access to information, and each citizen has the right to access information without being discriminated. It is believed that public libraries are publicly utilized when they are located in the correct places wherever deserved. This paper is aimed at analysing some key literature findings which forms only a part of a bigger research area, addressing the question whether public libraries are accessible to the population in local authority domain areas of the Uva province. The study fulfilled this knowledge vacuum by using GIS technology in locating public libraries. The Uva province was selected for the study considering its socio-economic status with the minimum provincial population in education attainment, low literacy rate and poverty incidence. Through this study, the service areas of public libraries in the Uva Province were identified and this will help most of the users to use this service qualitatively.

Keywords: *GIS, Library Management, Location-Allocation, Public Libraries.*

1. INTRODUCTION

One of the smartest ways of assigning locations for libraries is by using the merits of GIS technology. Geographic Information System (GIS) is a computer-based information system based which enable digitally represent and analyse geospatial and geographic data (Bhatta, 2011). There are many definitions produced by many authors and all of them are correct in an appropriate context. However, there are two definitions which are matching to the present study. As per the Rhind (1989) GIS is a system consisting of hardware, software, and procedure which are designed to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data for solving complex planning and management problems" as cited as (Lo & Yeung, 2007) while Burrough (1986) defines GIS in a similar manner but to address a particular set of purpose as cited by (Bhatta, 2011).

A dictum is that an estimate of 80% of all governmental data having a geographic component and public libraries too share this same character (Koontz, 2005). Therefore, GIS can be effectively used in research regarding assigning locations for libraries as appropriate. As per the Burnett, Jaeger & Thompson, 2008 as cited by (Adkins, et al., 2014) information access can be divided into three categories as physical, intellectual, and social. Accordingly, public library outlets provide the physical access and this in fact determines whether a user gains access. IFLA (2010) too highlights the physical accessibility as a major concern over the successful delivery of public library services. Even if library services are of high quality there is no use if not accessible without locational difficulties. Therefore, location is an important factor which largely determines the effective utilization of public libraries that are funded by public money.

However, in Sri Lanka, service areas of public libraries is the geographical area inside the respective local authority and there are several public libraries lies within the same local authority. This leads to an underutilization of public libraries as well as over utilisation due to the overlapping of service areas. Further, in Sri Lanka the technology of GIS has not been used previously in demarcating library service areas. Hence, the purpose of this paper is to offer key literature findings with regard to use of GIS

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technology as a tool of public library location decision. Hence, the basic research question considered in this paper is 'what is the suitable method in GIS to demarcate the service areas of public libraries to serve public at an optimum level?

2. RESEARCH AIM AND OBJECTIVES

The aim of this research is to introduce a model that effectively allocates locations for public libraries using GIS technology so that the majority of the communities can be better served in terms of information access. This essentially requires determining the physical accessibility to the public libraries in local authority domain areas and identify the literature with regard to spatial distribution of public libraries. The main objective of this study was to identify a most suitable method that can be used to locate public libraries and associated neighborhood.

3. RESEARCH METHODOLOGY

A literature review is systematic way of collecting and synthesizing previous research (Baumeister & Leary, 1997; Tranfield, Denyer, & Smart, 2003). Therefore, an effective literature review will create a rigid foundation in progression of knowledge and enable development of theories (Webster & Watson, 2002). A research question can be addressed with much power by the integration of findings of many other empirical studies. (Hannah Snyder, 2019). This study conducted a comprehensive and systematic literature survey based on a review protocol which is consisting of three main stages namely planning, conducting and reporting the review as described by Xiao & Watson, 2019.

The review was planned by developing a review protocol and formulating a research question. This literature survey was consisting of searching the literature at the outset, screening for inclusions /exclusions criterion, assessing the quality and extracting, analysing and synthesizing data at the end. The latest literature findings have been accessed using electronic databases available in UGC consortia such as EMERALD, WILEY ONLINE and SAGE and Google Scholar. Keywords were used for the search which were derived from the research question with
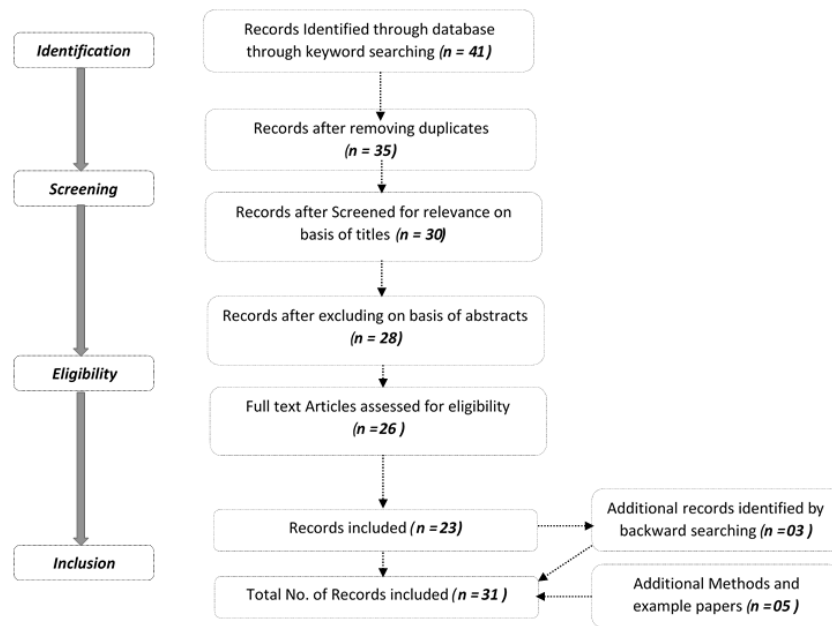

Figure 01: Summary of the Process of Literature Survey

BOOLEAN operators. Apart from electronic databases, The Library Review being the official journal of Sri Lanka Library Association was searched. In addition, text books on library science and GIS were read. Further, institutional repositories such as in the Department of Census and statistics, Central Bank were also investigated.

After preparation of the master list of references, inclusions and exclusion were identified by reading the abstracts. Quality was emphasized by referring to the methodologies of the studies. Since most of

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the research articles were obtained from recognised journals dedicated for library science, a need to assess the quality did not arise. As the final stage synthesized information was reported. Summary of the process of literature survey is shown in Figure 1.

4. FINDINGS AND DISCUSSION

In 2010 Bishop and Mandel identified two categories of library research types that used GIS as use of GIS in managing library facilities and collections and analysis of library service area using GIS based on two main library databases namely, Library Literature and Information Full Text and Library, Information Science and Technology Abstracts (LISTA). Therefore, findings of this literature survey were summarized based on above two categories and visualized in a tabular form to enable the researchers to go through very conveniently and to provide background information in prior approach to the core of the study.

Use of location-allocation model in service area analysis; the core literature of this study was described in details next to the summary table of findings & discussion in two categories of research types that used GIS in LIS

4.1 Use of Gis in Managing Library Facilities and Collections

Table 01: Summary of findings & discussion in two categories of research types that used GIS in LIS

Ref. No.	Author	Findings	Further Research
1)	Alan D. Jones (1993)	Identified active and inactive users by evaluation of library services and mapping circulation patterns.	Linking the circulation patterns with census data at an aggregated level to identify the needs of the local population.
2)	David Deckelbaum (1999)	Described what a GIS is and its implications for incorporation into a library environment	Standards for geospatial metadata
3)	Elizabeth M LaRue (2004)	Identified the population served by the library and collection type based on the mapped demographics of populations associated with the public libraries.	Incorporating results of GIS analyses in collection purchasing decisions
4)	Jingfeng Xia (2004)	Incorporation of GIS to analyze data relating to daily operations of libraries.	To integrate RFID with GIS.
5)	Jingfeng Xia (2005)	Analysed and presented spatial data of collection locations dynamically in maps and introduced a GIS item-locating system.	Integrating GIS item-locating system into current online catalogue system enabling users to have search results in both textual display and visual demonstration.
6)	Sedighi (2008)	Demonstrated the use of GIS in cataloguing library documents.	Use of customization features of GIS other than the editing and updating to provide access to the available data as per the requirements and to fill the research gaps in different geographic regions

7)	Lauren H. Mandel (2010)	Introduced an open source GIS called "Mapwindow" to analyze and display library usage patterns.	Use of GIS as tools in evaluation of library facility, research in in-library use and valuation and justification of library.
8)	Bradly Bishop (2011)	Revealed the ability of GIS to convey information other than the other means and the ability in spatial analysis of library services	Promotion of experimenting using open source GIS products and applications as additional research tools among LIS researchers, practitioners and stakeholder groups
9)	Ann L. Holstein (2015)	Capture information regarding geographic needs of their respective campuses	Standards for geospatial metadata

4.2 Analysis Of Library Service Area Using Gis

Ref. No.	Author	Findings	Further Research
1)	C.M Koontz (2005)	Developed a web based Public Library Geographic Database which contains all public library data in USA including user data.	Library planning in future.
2)	Japson & Gong, 2005	Investigated the relationship between public library use and associated demographics using theissen polygons.	Improving the use of library branches with the assistance of GIS.
3)	Preiser & Wang (2006)	Analyzed the branch library performance by delineation of service area by geocoding the location of active users based on their home addresses.	Incorporating GIS in master plans for library facility management as a rational decision-making tool
4)	Hertel & Sprague (2007)	Used GIS to analyze the population or demographic characters for establishing two branches for Boise Public library in Boise, the capital of Idaho called west and east branch respectively using buffer zones.	Analysis of demographics of will allow to critical analysis of collection of the new libraries and quantitatively and visually provides methods for prioritize resource allocations future.
5)	Abazari, Babalhaveaji, & Jahangirifard (2012)	Examined the locations of existing public libraries in four regions of Tehran in order to find more suitable locations for new libraries to be constructed by considering the terrain, distance etc. to find appropriate locations other than the population demographics.	Recommended to maintain a minimum distance of 1600m between two libraries in order to avoid overlapping of service areas.
6)	Adkins, Haggerty, & Haggerty, (2014)	Identified the patron base of two branch libraries using buffer zones.	Incorporating census tract-level data to determine the accessibility of poor.

4.3 Service Area Analysis Using Location Allocation Model

There are key customer markets such as Consumer markets, Business markets, Global markets and Nonprofit and Governmental markets which are physical places where buyers and sellers interact and transact over a particular product or product class (Kotler, Keller, Koshy, & Jha, 2013). Libraries fall in to the category of nonprofit and governmental markets simultaneously. Further a market is a system in which manages profitable customer relationships with the aim to create value for customers and capture value from customers and the marketing process includes understanding the marketplace and expectations of customer, designing of a marketing strategy based on the customers' expectations, constructing a marketing program delivering higher values, build profitable relationship and make the customer delightful and finally capture value from customers to create profits and customer equity. (Kotler, Armstrong, Agnihotri, & UL Haque, 2010). When considering the all above marketing processes, operations inside a library each resembles the same. In this case marketers are the library staff and customers are the patrons.

The geographic area that most of users can be captured is the market place of a library. (Koontz & Jue, 2000). In turn this is the service area owned by the public library. The public library services should be adapted accordingly to the different needs of communities in both urban and rural areas since needs and expectations will change with time and this adaptation will have to carry on continuously (IFLA, 2010). Since public libraries are places for serving public there is a possible challenge facing by libraries to know the public base and types of services and collections will best fit the expectations of associated public (Hertel & Sprague, 2007).

Authors have adopted several methods to demarcate public library service areas in order to analyze the service areas of public libraries and Koontz & Jue, (2000) described five ways to determine the library market/service area as listed below.

1. Assigning each library, a definite number of census tract or block group.

2. Demarcating the service area of a library through overlay of zip code boundaries based on customer/user addresses.

3. Determine the service area of a library by assign a certain mile radius to be served.

4. Determining actual service area by geocoding user address data.

5. Determining service area by assigning equal quotas of the population to the nearest existing library by the modeling technique "location-allocation".

Location-Allocation model can be used to form structural form of services of facilities to demand optimally and this model help spatial planners to choose optimal locations of public facilities and to plan for new facilities and as well as to evaluate and improve the efficiency of prevailing location decisions (Tali, Malik, Divya, Nusrath, & Mahalingam, 2017). Public facilities such as schools, hospitals, libraries, fire stations, and emergency response services (ERS) centers will be able to provide services of high quality to the community at a low cost if they are established in appropriate locations. Location-Allocation model simultaneously locate facilities and allocate demand point to the located facilities (ESRI, 2019).

To work with Location-Allocation model there are some data layers needed as Network Analyst extension in Arc GIS, a network dataset, a demand point feature class and a facility feature class (Schietzelt & Densham, 2003). When solving a location-allocation problem there are two parameters to be predetermined. They are location-allocation problem type and impedance cut-off. There are seven location-allocation problem type namely; minimize impedance, maximize coverage, minimize facilities, maximize capacitated coverage, maximize attendance, maximize market share and target market share (ESRI, 2019). For studies related public facilities mostly used problem type is maximizing coverage (Buzai, 2013) & (Tali, Malik, Divya, Nusrath, & Mahalingam, 2017). Maximize coverage chooses the maximum number of demand points as far as possible within the given impedance cutoff (ESRI, 2019). Largest amount of demand points will remain assigned within these surfaces (Buzai, 2013).

$$\text{Maximize } \{F = \sum_{i \in I} a_i x_i\} \qquad\qquad\qquad\qquad (\text{Eq:01})$$

 I is the group of demand points (indexed by i) and a_i is the population in the demand node i and x_i are 1 if the center of demand i is located inside the area of coverage ($xi \leq R$) and 0 in a contrary case. R is the coverage ratio prefixed for the supply points (Buzai, 2013). As per the Shia, (2003) as cited by (Abazari, Babalhaveaji, & Jahangirifard, 2012), the public library is a democratic place responsible to serve all the people in the society with a book and to fulfill this responsibility, location of the library in terms of distance and time is a main condition that should be satisfied in order serve maximum people in charge of books. Therefore, maximum coverage model of the location allocation best suited for the current study.

The other important factor is the impedance cut-off which specifies the network cost attribute used to define the traversal cost along the elements of the network in terms of time (minutes) or distance (meters) (ESRI, 2019). Considering the decision-making requirement type of impedance cut off can be selected. Determining library market areas is done by assigning equal proportions of populations to the nearest facility (Koontz & Jue, 2000). According to Hertel & Sprague, (2007) many libraries assign a one-mile radius (1600m) for libraries in urban areas and two mile radius (3200m) for libraries outside the urban area.

In the primary research service areas of public libraries in UVA province were demarcated using the location-allocation model.

5. CONCLUSION

Most of the studies have been carried out in various countries to analyze public library service areas and associated Population demographics using several approaches to demarcate the service areas. Location –Allocation model is one of the best methods to demarcate the service areas. However, for the 1199 public libraries in Sri Lanka the service areas are the domain area inside the local authority from which the public library is governed. Therefore, this literature survey has provided a solid framework for the successful use of location-allocation model in GIS for demarcating service areas by the public libraries in Sri Lanka.

6. SIGNIFICANCE OF THE STUDY

 The primary research investigated the present status of public library system in the Uva province and provided a strong basement upon which the development of the Uva province could be built upon. Further, this study has been carried inside a GIS framework which is novel to studies in Library and Information Science in Sri Lanka and at the same time this study reveals the versatile nature of GIS in the discipline of Library and Information Science. Therefore, this study will be a turning point in the discipline of Sri Lankan LIS being the first attempt to using GIS in LIS.

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