A GIS Analysis on Service Oriented Accessibility and Road Development Potentials of Northern Sri Lanka

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Abstract
Since the urban-rural linkages mainly depend on the availability of the transportation facilities, any project on infrastructure development should concern the level of accessibility through the existing roads which should be developed. Most of the regional development programmes in post conflict Sri Lanka, particularly in the Northern Province have not reached the expected deliverables due to several reasons. No any particular system has been used yet to prioritize the regions with less access to the services because of insufficient road networks. Even after a decade of war ended, most of the roads in rural areas in the Jaffna District are still in sad condition. Therefore, this paper has aimed to formulae a systematic approach based on the Geographic Information Systems (GIS) to identify the level of development of sub regions and to classify the regions based on level of accessibility and finally to prioritize the road networks which should be developed by any road development project. In order to achieve these aims, the present research selected the Jaffna District using the judgment sampling method for data collection. Most of the data were from secondary sources such as government bodies and open sources and four methods of spatial analysis; distance, density, reclass and weighted overlay were used in data analysis. One of the findings of this paper is the possibility of divide the region into five key development clusters based on the accessibility to 15 services. It was revealed that, the development level of each divisional secretariat division (DSD) of Jaffna District totally depends on the quality of road network and the accessibility to the services. Out of five development based regions in Jaffna District, there are two marginal divisions; Delft and Vadamarchi East which consist less than 30% of accessibility and no any A or B class roads connected to the urban centres. Furthermore, lack of connectivity to the main roads and poor condition of rural roads have adversely affected to the regional development of Jaffna District. It is recommended that the method introduced by this paper can be applied to the regional physical planning.

Keywords – *Accessibility, GIS, Potentials, Road network, Regional Development*

INTRODUCTION

Road network is the most important infrastructure for regional development of Sri Lanka. Roads are one of the key factors when it comes to infrastructure, which develops the livelihoods of the rural population. Development of rural roads which connects with the urban will bring lots of social and economic benefits for the rural population. Rural roads are important to connecting areas of production with markets and connecting these with each other. The rural transport infrastructure consists of roads, paths, and their associated bridges and other forms of water crossings. Better road access would contribute to economic growth by reducing transport cost, travel time and vehicle operating costs (Terefe, 2012). Roads can increase rural households' access to agricultural inputs and product markets. It also facilitates utilization of existing socio-economic services such as education and health which enhances the human capital accumulation of the poor. Moreover, roads play a vital role to enhance productivity by fostering technology and information flows. In addition, roads create employment opportunities for the local people through facilitation of small businesses and industries in the long run while providing temporary employment opportunities through road construction works. The major constraints on access to rural areas are poor condition in rural infrastructures and road database. Rural transport plays an indispensable role in achieving more than half of the Sustainable Development Goals (SDGs) and fulfilling the promise of the 2030 Agenda for Sustainable Development (Cook, 2016). Rural communities in developing countries are often completely disconnected from the major roads, rail lines, and public transport services that enable access to the economic and social activities and opportunities in cities. Good rural road infrastructure and services promote connectivity and social cohesion, drive commercial activities as well as accessibility to social and economic facilities necessary to counteract poverty, isolation and social exclusion. The provision of safe, reliable, and

affordable rural transport infrastructure and services is essential to facilitate rural access to markets and services such as education and health facilities, enterprise and employment opportunities, increase agricultural production, develop modern supply chains for crop delivery, prevent food loss, and hence achieving zero hunger and alleviating poverty. Improving rural access can lead to lower costs for farm inputs and lower transport costs for marketed outputs, thus increasing agricultural production to enhance food security. The understanding of GIS based Road Transport Surface Information management, effective use of geographical information and the knowledge of their advantages is critical to the planning and decision-making process for asset management and transport departments (Musa, 2015). In order to avoid the problems associated with rural road development, it is advisable to prepare a rural road plan by building strong database, which consists of village level information and road inventory details.

Since the main income of the rural population in Jaffna district is agriculture, the rural roads play an important role in developing the livelihood of rural population. Most of the rural roads in Jaffna are not in good condition and sometimes they are too complicated. Soon after the 30-year civil war, many local and foreign agencies have started road construction projects to enhance the livelihood of rural areas. Right now, there's no proper selection criteria to construct or improve the existing roads. Lacking of a scientific method and political interference have fuelled the transportation issues particularly in rural areas in Jaffna District. In order to fill this vacuum the present research has aimed to formulate an appropriate method for selection of roads which should be developed by using Geographic Information Systems.

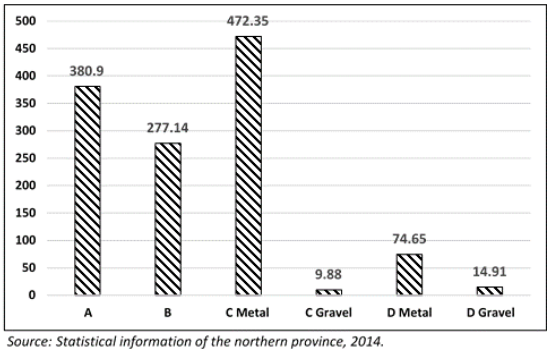
RESEARCH PROBLEM

The Northern Province covers just over 13% (8,847 sq.km) of the total land area of Sri Lanka and contains five Districts: Jaffna, Kilinochchi, Mannar, Mullaittivu and Vavuniya. Jaffna District is the northern-most district and covers an area of 1,025 sq. km. The District includes the Jaffna peninsula and seven inhabited islands. The islands closest to Jaffna are connected to the mainland by a causeway whilst those more distant (notably Delft and Nayinativu) are accessible only by boat. Jaffna City is the commercial and cultural centre of the Province and Jaffna District is the most densely populated in the Northern Province. Topographically, Jaffna District is flat (< 5 degree slope). Elevation is generally less than 10m above mean sea level except along the south-eastern border where the land surface gradually rises.

Northern province had been affecting a prolonged armed conflict since 1983. Fighting between the government military and LTTE was primarily concentrated in the Northern and Eastern provinces of the country, causing widespread destruction, displacement and subsequent economic and social consequences. Even though, in 2009, the armed conflict ended after a decisive military victory by the military forces, a lot of development issues are remained to be addressed in the post-conflict situation. For example, the cessation of hostilities did not alter the situation greatly, as the rural communities could not benefit from the better access to the essential services due to the lack of transportation facilities. Since most of the roads had been subjected to demining for several years, maintenance of the rural road network was totally neglected.

Still the Jaffna district remains the urbanization just only 13.4% and it represents some of the poorest areas of the country. The World Bank reports (2018) that six of the eight districts in the Northern and Eastern Provinces exhibit poverty rates that are above Sri Lanka's national average of 6.7 percent. In particular, the districts of Mullativu, Mannar and Batticaloa, with poverty rates of 28.8, 20.1 and 19.4 percent, respectively, are some of the highest rates in the country. Taken together, the Northern and Eastern Provinces represent some of the poorest areas of the country. More recent preliminary poverty data show that, while overall poverty has declined in Sri Lanka, the Northern and Eastern Provinces continue to exhibit poverty rates of 7.7 and 7.3 percent, respectively. However, with the end of the armed conflict, Government of Sri Lanka launched programs to fast-track the recovery of the Northern Province through resettlement, poverty reduction and economic development. These programs included: 180 day Programme "Vadakkin Vasantham" - to facilitate resettlement of IDPs. It addressed the specific regional development initiatives to rebuild the Northern part of Sri Lanka. Northern Spring 3-year Development Plan "Uthuru Wasanthaya" - operated under the Economic Development Ministry is a development program catering to the needs of the five districts. The program targets large infrastructure such as roads, railways, schools, hospitals, urban centres; social development; livelihood enhancement; human settlements and revitalizing productive sectors.

Figure 01: Total Length of Each Road Types in Jaffna District



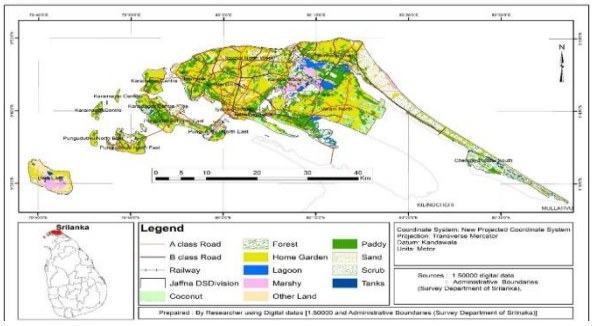
Source: Statistical information of the northern province, 2014.

One of the five strategies of regional physical plan (2012) is to develop infrastructure to connect people, towns and villages through effective transportation and communication networks across the Province. It further says "The Northern Province will be a safe and healthy, prosperous, culturally rich, and sustainable region with a network of well-serviced and accessible urban centres which are well-connected to each other, to their markets and to the rest of the country. Even after a decade most of the project aims couldn't reach their targets due to lack of proper system for implementation. Even today Jaffna district only has less than 700km total length of A and B class roads while comprising only 3040.06 km length rural roads (Figure 01).

METHODOLOGY

In order to achieve the objective of the study, Jaffna District was selected as the research site which is one among the five districts of Northern Province consists 15 DSDs and 435 Grama Niladhari Divisions (GNDs). Main Data sources were secondary consists of spatial and attribute data associated with locations and those were collected by using Open Street map, GPS, digital cameras and field direct observations etc. Vector data of administrative boundaries, road network layers, Land use and other location data collected from Survey Department of Sri Lanka and Road Development Authority. Attribute data such population, house hold, agriculture and fisheries were born from census and statistical department report (2012) and District secretariat of Jaffna report (2018). Fifteen services selected to identify the service accessibility regions in Jaffna district, namely; "A" Class roads, "B" Class roads, Rail Roads, Markets, Super Markets, Health centers, Banks, Education Centers, Town centers, Divisional Secretariat offices, Bus Stands, Railway Stations, Post offices, Tourist places and Worship places. Based on these fifteen-service accessibilities, five major regions have been developed from entire Jaffna district. Euclidean distance Analysis, Kernel Density Analysis and Weighted overlay Analysis were the key spatial analysis techniques applied by this research for demarcating accessible regions first and categorize them as High, Good, Moderate, Poor and Very poor service accessible regions.

Figure 2: Location of the Research Site: Jaffna District



The 15 variables mentioned above were analysed by using Euclidean Distance Analysis and Kernel Density Analysis. Then, all vector data converted into raster data. All distance analysis raster data was discrete into four categories such as within 2Km, 2-5Km, 5-10Km, more than 10Km distance from each service locations. Density analysis raster was also discrete into four categories as defaulted parameters based on density of points. Under spatial analysis method, reclass technic, reclassify function has been used to make discrete of 15 raster data. Five types of service- accessible regions identified based on the weighted overlay analysis. Developed five regions have been applied for each DS division and GN divisions to identify the level of service-accessibilities by using spatial join and Clip function of overlay and extract method. With the overlay facility of spatial data, the connectivity of main roads and poor development regions have been identified and proposed the area where the rural road should be developed in prioritized wise (Figure 03).

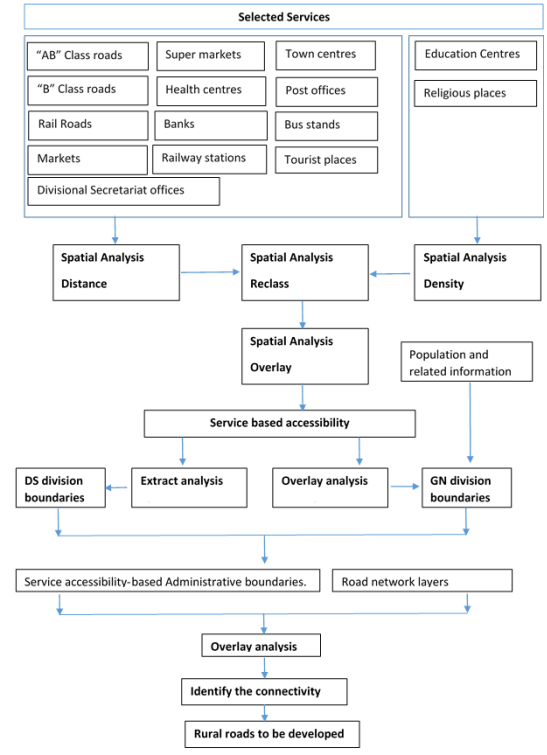


Figure 03: Flowchart of data analysis

The Euclidean distance output raster contains the measured distance from every cell to the nearest source. The distances are measured as the crow flies (Euclidean distance) in the projection units of the raster, such as feet or meters and are computed from cell centre to cell centre. The Kernel Density calculated the density of features in a neighbourhood around those features. Religious places were analysed by this tool because of the high density of worship places in the study area. Based on this calculation, the default search radius (bandwidth) algorithm was applied as follows.

$$SearchRadius = 0.9 * \min\left(SD, \sqrt{\frac{1}{\ln(2)}} * D_m\right) * n^{-0.2}$$

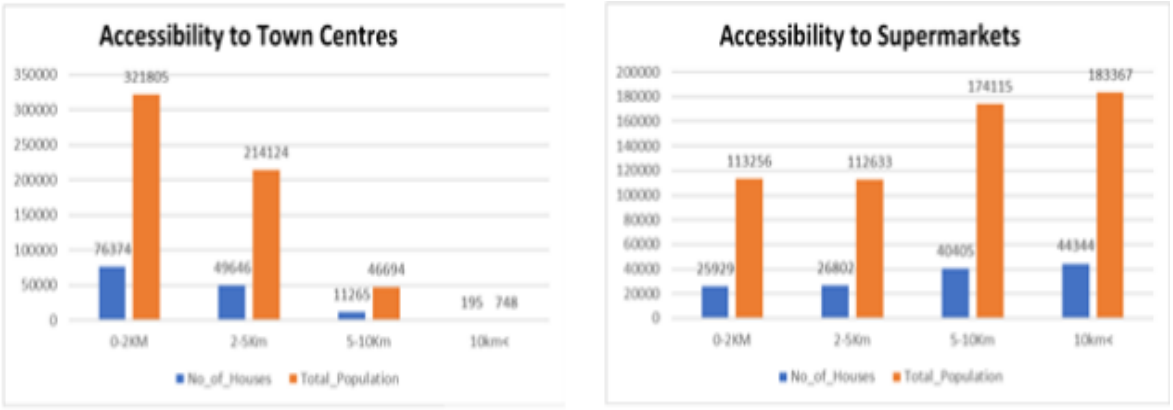
Where:

SD = standard distance D_m= median distance

n = the number of points if no population field is used, or if a population field is supplied and the sum of the population field values

RESULTS AND DISCUSSION

First step of the data analysis in this research was to identify the level of accessibility to each services from the selected households. A significant variation of accessibility can be seen in Jaffna District accordingly. The results of the individual calculations on accessibility to each service in Jaffna District highlight very interesting dynamic pattern. For instance, most of the people can have accessibility to town centres within 0-5km distance but in the case of supermarket, the majority of people located more than 10 km away of the service (Figure 04). Similarly, there are some services to which majority has good accessibility such as health centres, markets, bus stands, tourist places while some of services like education centres, rail stations, post office, banks have marked as less access points from the majority of households in the District.



Source: Census data 2012

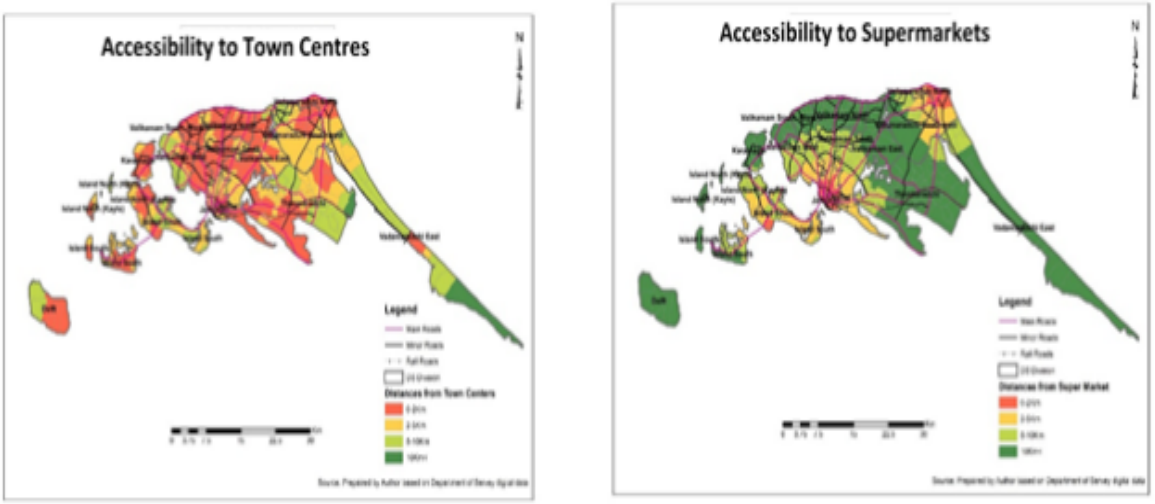


Figure 04: Accessibility to Town Centres and Super Markets

Sources: Prepared by authors based on digital data of survey department, Sri Lanka

TABLE 01:**Accessibility Based Regions in Jaffna District**

DS Division Name	Developed DS division	Less Development DS division	Poor Developed DS division	Mixed DS division	Accessibilty				
					High	Good	Moderate	Poor	Very Poor
Jaffna					95%	5%			
Valikamam South					18%	80%	2%		
Valikamam East					43%	51%	3%	3%	
Valikamam South West						84%	10%	6%	
Nallur					60%	19%	14%	7%	
Valikamam North						68%	32%		
Vadamarachi North						56%	43%	1%	
Valikamam West						46%	54%		
Vadamarachi South West						37%	50%	13%	
Thenmarachi						25%	60%	15%	
Karainagar						11%	89%		
Island South						1%	83%	16%	
Island North							80%	20%	
Delft							20%	78%	2%
Vadamarachi East							11%	51%	38%

Sources: field data 2019

Altogether, the result of the overlay analysis of accessibility to selected 15 service centres, the entire Jaffna district can be divided into five categories of geographical regions based on service accessibility. Accordingly, five distinct regions such as High service accessible region, Good service accessible region, Moderate service accessible region, Poor service accessible region and Very poor service accessible region have been created as one of the main outcome of the data analysis. The first two regions can be categorized as developed areas when compare to the other regions. As Table 01 shows all DSDs have been valued according to the level of accessibility. The percentage of accessibility varied from 2% - 95% and Jaffna Division records 95% while delft and Vadamarachchi East represent only 2 and 38 percent respectively.

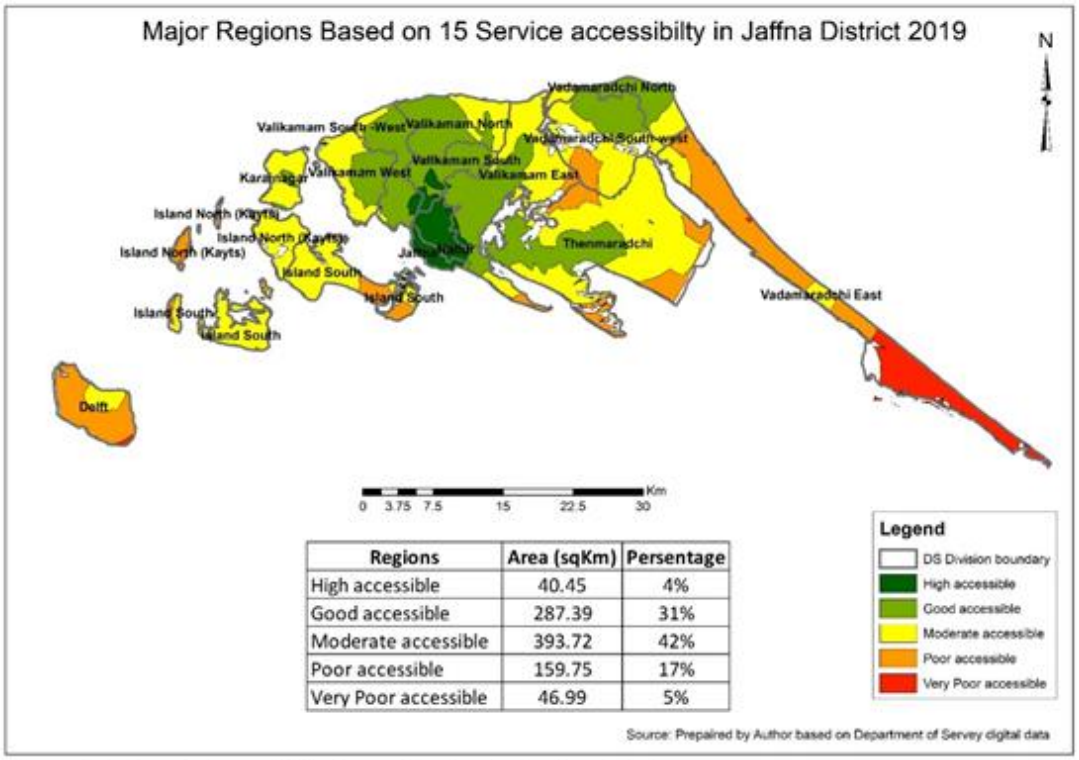


Figure 05: Service Accessibility based Regions in Jaffna District

Sources: Prepared by authors based on digital data of survey department, Sri Lanka

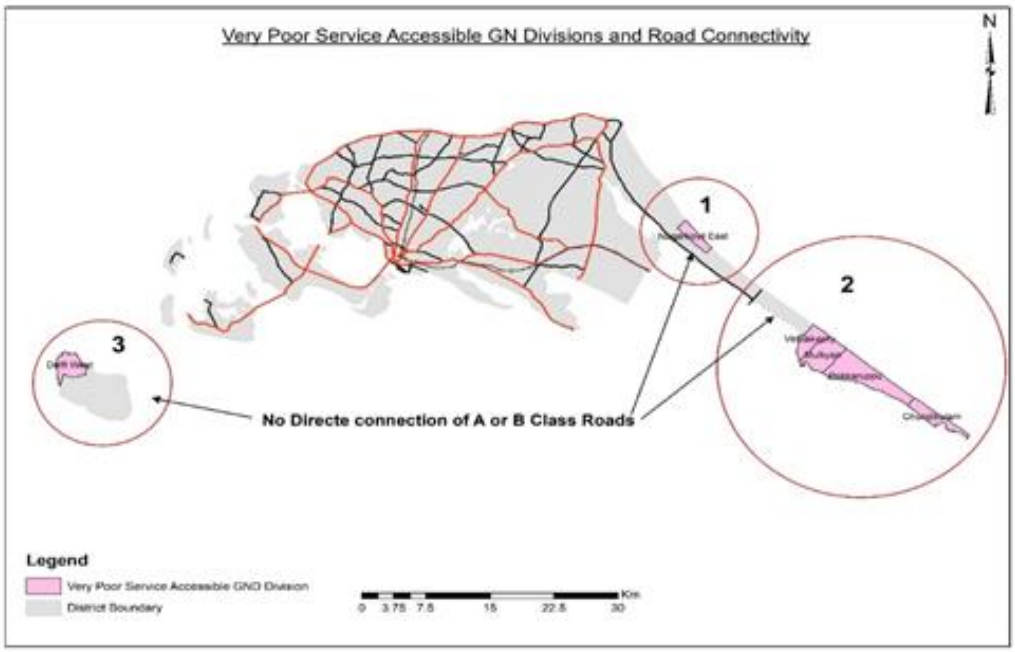


Figure 06: Accessibility of Poor Developed Regions to the Main Road Network in Jaffna District

Sources: Prepared by athors based on digital data of survey department, Sri Lanka

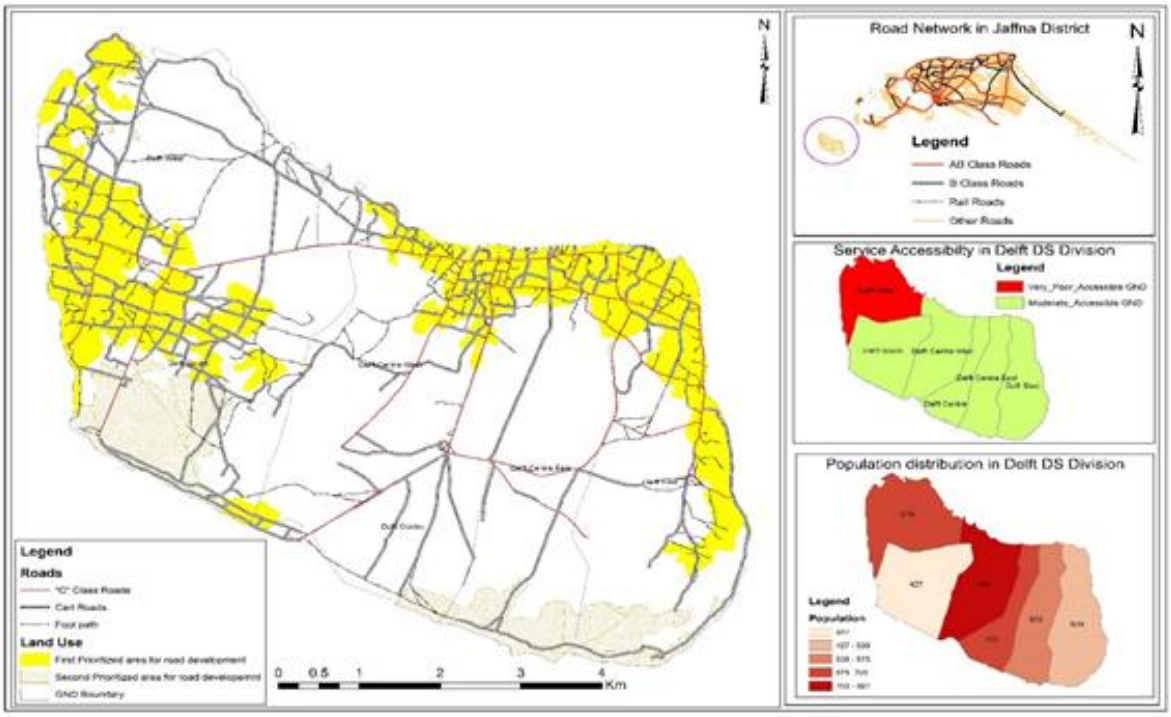


Figure 07: Rural road condition in Delft West GN Division

Sources: Prepared by authors based on digital data of survey department, Sri Lanka

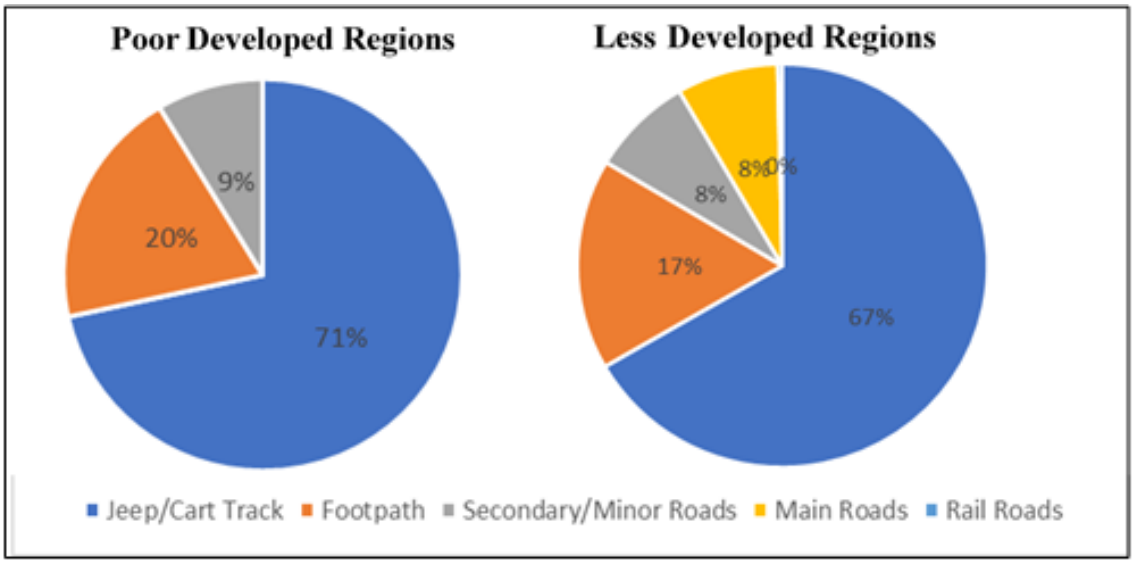


Figure 04: Compopsision of Road Types with their Total Length in Poor and Moderate Developed Regions of Jaffna District

Sources: Prepared by authors based on digital data of survey

As figure 05 shows only 04% (40.45km2) of the total land belong to Jaffna District has a high accessibility and the majority of the territory has not in a satisfactory level of accessibility. Only five DSDs among 15 are achieved the status of development since they cover only high and good accessibility. Jaffna, Nallur and Walikamam Divisions are only regions which records high access to all services. Over 64% of the total area of the District has marked as less developed when consider to the accessibility level. By considering the underdeveloped three regions as shown in Figure 02, all most all of those regions do not have accessibility to the main road network in Jaffna District.

"A" class and "B" class roads are not directly connected with very poor accessible Divisions. In the figure 02, Zone1 and 2 are not connected directly with main roads. But it has an access to B Class roads. Zone 3 shows the island it doesn't have any access to "A" or "B" class roads. For example, Delft Division can be further examined to understand the accessibility and services within a division too. According to Figure 03, every road of the delft is in very poor condition. There are only C class roads connected to cart tracks and foot paths mostly damaged. Based on this result, it can be suggested to prioritize the regions particularly residential and coastline by road development projects.

As road density is one of the main key indicator of the regional development, analysing relationship between the level of development and the nature and quality of the rural roads are very important. As shown in figure 08, both poor and less developed regions possess mostly Jeep or Cart tracts; 71% and 67% respectively. No any main road connectivity in poor developed regions while only 8% of main roads can be seen in less developed regions. This once again proves that the poor condition of roads has impacted to keep rural areas under developed for several decades. Therefore, rural road development should bring into the fore in any regional development programme.

The existing system of selection of rural roads for development has not based on any logical method or approach. Hence, the imbalance of regional development has still been existed even after a decade of civil war ended. This paper has introduced a GIS-based approach for identifying the regions which should be given priority in regional development. Findings of this paper clearly confirmed that the zonation based on accessibility to services is a real practice for identifying development regions in Sri Lanka. In the case of Jaffna district, two main regions; Delft and Vadamarachchi east are highly recommended for giving priority in road development projects in the future. Further, the attention should focus to the intra-regional disparities too because within the above two regions there are particular regions need to be given the first priority in the development process. For example, as most of the agricultural lands are located in the regions where less accessibility recorded, development of road system should become first in development strategies focussing agricultural development. It can be suggested that most of the low level of accessible regions can be developed as agricultural production hubs and tourist attractions if the road network of these regions are upgraded and developed accordingly.

FURTHER RESEARCH AND DISCUSSION

The present research mainly based on the secondary data sources. Service accessible locations were taken from google earth and open street map, which have no all locations. Therefore, manually missing location data collected by using GPS, which is time intensive. Though only limited 15 services selected due to the time frame, the process of selection should be expanded in a further research. In reality, the accessibility does not only mean the distance from one place to another but the time consumed for the purpose too. Hence, empirical part for this kind of research is recommended.

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