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A Reliable Road Network to Supply Necessities in a Flood situation: The Case of Biyagama Divisional Secretariat, Sri Lanka

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1. Introduction

According to the disaster profile of Sri Lanka by Disaster Management Centre, (2013) the most frequent disasters and the highest number of victims arise in relation to floods. Disaster management is categorised into four phases as mitigation, preparedness, response and recovery by the National Governors' Association in America to help to be prepare for and respond to disaster. The necessity for distribution in terms of food, water, shelter and sanitation come under disaster response and recovery phases. The study conducted by Esposito, Elefante, and Iervolino (2013) point out that the reliability of a road network is evaluated in order to handle the disaster situations. The main types of reliability are defined as connectivity, travel time and the alternative reliability approaches, together considered as capacity and accessibility concerns.

The reliability of the road network used to supply necessities in a flood situation is assessed using Biyagama Divisional Secretariat. It has 49 Grama Niladhari Divisions of which 27 are situated in close proximity to Kelani River and are prone to flooding. Data relating to the recent flood occurred in May 2016 has been considered for the study.

2. Research Objectives

The main objective of the study is to identify reliable road connections linking the demand and supply points for necessities. This study is conducted to identify the demand and supply points for necessities of flood victims in Biyagama. The establishment of a road connection by reliability analysis has been done focusing on the identified demand and supply points. Critical links within the road connections have been identified and a distribution sequence of necessities has been calculated for the network.

3. Methodology

The data is derived mainly from secondary sources. The shelter point locations of flood victims are identified using data gathered from the Biyagama Divisional Secretariat Office and the respective Grama Niladhari. The flood-prone area map prepared by Survey Department of Sri Lanka regarding the recent flood occurrence in 2016 has been used to identify the road connections which have not been flooded. This indicates the connectivity and reliability of road connections defined as the probability of maintaining nodes connected in a transport network.

According to the study conducted by Neufville, Barros and Belin (2002) passenger travel analysis is done by using the product of two matrices; the impedance matrix of travel distance and the passenger flow matrix for a given configuration. The similar approach has been used in the study to identify reliable road segments to link supply and demand points in terms of distance and travel time. The distance-travel time impedance matrix is used to decide the paths for necessity distribution with minimum distances and travel time weighting. The Figure 3.1 illustrates the method used to select the road links.

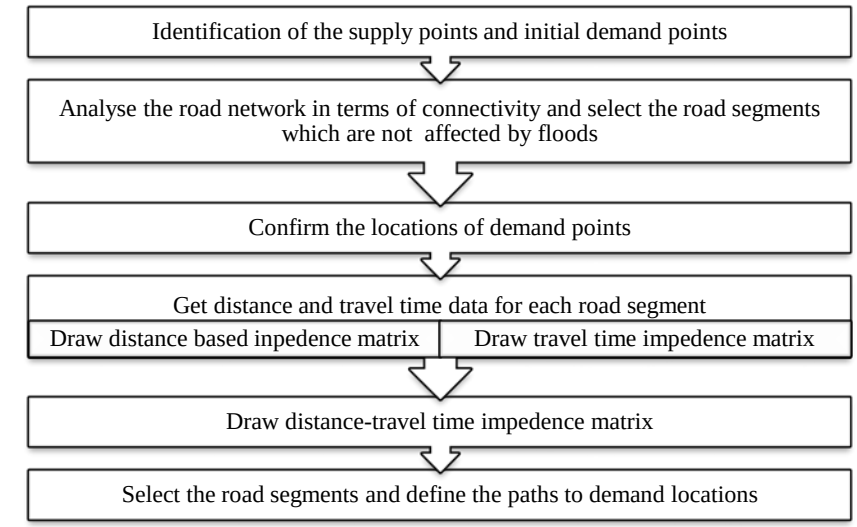

Figure 3.1: Steps to select the road links

Giovinazzi and Nicholson (2010) have explained that the accessibility reliability can be used to identify the importance or the criticality of network links and nodes. A particular network link or node is regarded as critical if its degradation significantly diminishes the accessibility of the network. According to a study conducted by Adikariwattage (2008), a connecting length ratio has been used to evaluate the critical links within the network. It represents how a particular link is connected to the network in terms of distance.

$$Connecting\ Length\ Ratio: \frac{\sum Lr\ \ (\sum \beta i)}{\sum Lr}$$

$$Lr\ =\ Length\ of\ the\ rth\ link$$

$$\beta i : \frac{Direct\ distance\ between\ the\ OD\ pair}{Path\ Distance\ between\ the\ OD\ pair}$$

The connectivity link ratio for the identified network has been calculated. Recalculating the connectivity link ratio for each of the link failures has been done by eliminating a particular link in the network and calculating for the new network which has created without that link. The percentage reduction of connectivity link ratio is taken and if the value is 100%, the indication is taken as the network is disconnected as indicated in Figure 3.2.

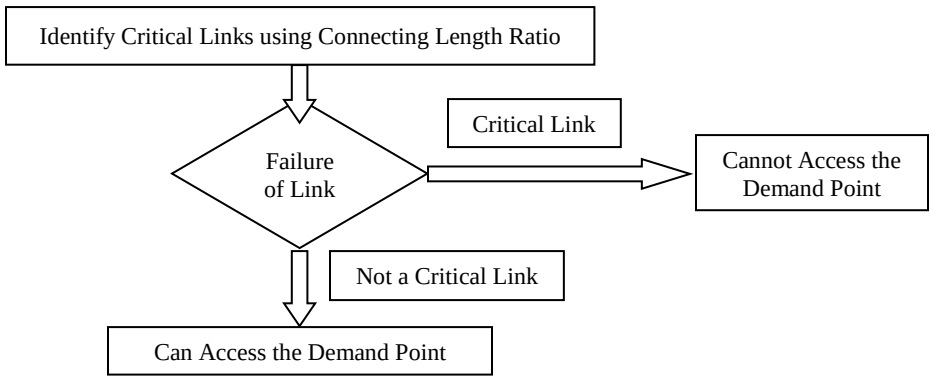

Figure 3.2: Method to decide the accessibility of the demand point

A distribution sequence of necessities for shelter locations has determined using 'the travelling salesman problem' which is used to find the shortest route which passes through each of a set of shelter points once.

4. Results

Biyagama Secretariat Office has been identified as the main supply point and 13 demand locations have been identified where there were shelter points by using data provided by Biyagama Divisional Secretariat Office and Grama Niladhari. The main B and C-type roads and the E02 expressway have selected for the analysis. Connected roads are derived using the flood prone area map and these selected roads are used for the impedance matrix. The distance-travel time impedance matrix is drawn using Google map data.

The selected roads are shown in Table 4.1 which is based on connectivity and minimum distance with travel time weighting to reach shelter locations from the Biyagama Divisional Secretariat Office.

Table 4.1: Selected path from Divisional Secretariat Office to shelter point area

GN (Grama Niladhari) Division Name	Shelter Point Name	Path from Divisional Secretariat Office to shelter point area nearby using B and C type roads and the E02 expressway
Gonawala West	Sri Wardanaramaya	B362 Pattanwila - Makola
Pattiwila	Pattiwila old Temple	
Thalwatta	Sri Sunandarama Viharaya	B214 Biyagama Road, B362 Pattanwila - Makola
Bollegala	Bollegala Maha Vidyalaya	
Mabima West	Sri Shailathalarmaya	B632 Oil Refinery Junction- Free Trade Zone Rd, E02-Outer Circular Expressway + B214 Biyagama Rd
Biyagama North	Sri Sudharmaramaya Maha Viharaya	B632 Oil Refinery Junction- Free Trade Zone Rd
Yabaraluwa North	Grama Niladhari Office	B262 Makola Udupila Rd, B214 New kandy Rd, Yatiyana Road, B632 Oil Refinery Junction- Free Trade Zone Rd, B214 Biyagama Road
Yabaraluwa South	Sri Bodhiraja Ramaya Temple, Ananda College, Yabaraluwa	
Biyagama South and East	Bodirajaramaya	
Malawana Town	Raxapana Jumma Masjid Church, Mubarak International Academy, Yathama School	B262 Makola Udupila Rd, B214 New kandy Rd, Yatiyana Road, B632 Oil Refinery Junction- Free Trade Zone Rd

The necessity distribution is initiated from Biyagama Divisional Secretariat Office in three road links named as B362 Pattanwila - Makola, B262 Makola Udupila Rd and B632 Oil Refinery Junction- Free Trade Zone Rd. Connecting length ratios have been calculated for the road networks initiated from above road links. The percentage reduction of connecting length ratios for these three main critical links is 100%. And the closure of road link B214 Biyagama Road is having a medium effect to the network and the percentage reduction of connecting length ratio is 67%.

The minimum distances with travel time weighting are used to calculate the distribution sequence of necessities using travelling salesman problem. A sequence identified for the link B262 Makola Udupila Rd whichstarts from Sri Bodhiraja Ramaya Temple and go to Ananda College-Yabaraluwa, Raxapana Jumma Masjid Church, Mubarak International Academy and to Yathama School.

5. Conclusion

The method introduced is applied to distribute necessities in situations where there is a defined area of demand and a known supply point/s. The connectivity reliability of the road network can be determined using the flood prone area map. The distance-travel time impedance matrix is used to decide the paths for necessity distribution with minimum distances with travel time weighting. The accessibility reliability

measure is used to decide the possibility to reach to the demand point in the event of a link failure. Travelling Salesman Problem can be applied to identify the sequence of distribution. Future research can be done on a more detailed level for the network by considering access roads to reach shelter locations.

6. References

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***Keywords**: critical link, connectivity link ratio, reliability, necessity, shelter point*