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A GIS-BASED ANALYSIS ON "EMERGENCY DISASTER RESPONSE" -A CASE STUDY ON CHITTAGONG CITY CORPORATION

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ABSTRACT
Chittagong city is located on the south-eastern coast of Bangladesh and called the "commercial" capital of the country. It is vulnerable to natural disasters such as earthquake, flood etc. And for the compact urban populations, geographical location, and infrastructure, it creates an even higher risk. People and their property are often affected. If there is an emergency response plan, it will help people to take shelter in a secure place such as hospitals. Geographic information system (GIS) is used to identify probable areas of high, moderate and low risk in case of an earthquake occurs. High risk areas involve regions that are vulnerable to slope failure, close to the locations of transformers. It is mapped out the regions within Chittagong that are at high risk of slope failure, electrical surges and measure the best possible (least cost) routes for the city dwellers to reach the assumed safe destinations such as hospitals. Thus, the outcome of the research can be used for further research and analysis to make an android application of emergency disaster response.

Keywords: Vulnerable; Disaster Response; GIS Analysis; Risk Assessment; Least Cost Path;

INTRODUCTION
Climate change and its effects are the current burning issues in the world and the greatest warning to the humankind, its challenges are multi-dimensional, multi-sectoral, and have immediate as well as long-term effects. Natural disasters are defined to be environmental phenomena such as earthquake or flood that lead to the disruption of a community and its livelihood. Such catastrophes had led to the deaths of 22,773 people and 98.6 million people were affected (EMDAT & UNISDR, 2015). Every year Bangladesh faces many natural disasters like drought, flood, water-logging, cyclone and tidal surge, tornado, thunderstorm, river/coastal erosion, landslides, salinity intrusion, hailstorm, extreme weather events etc. Asia Pacific Disaster Report (2015) showed that Bangladesh is one of the most vulnerable among 15 countries with high exposure to and its risk position is 5th (Islam, 2016). In fact, about 97% of all reported disasters-related deaths occur in these developing countries (IFRC, 2004). Emergency management is the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies-preparedness, response, and recovery in order to reduce the harmful effects of all hazards, including disasters. The World Health Organization (WHO) describes an emergency as the situation in which normal activities are hindered, and instant solutions must be taken to prevent that situation forwarding a disaster. Thus, emergency management is crucial to avoid the disruption transforming into a disaster, which is harder to recover from (WHO/EHA, 2002). Chittagong city is located on the banks of the Karnaphuli River between the Chittagong Hill Tracts and the Bay of Bengal. It is vulnerable to natural disasters such as earthquake, flood etc. and for the compact urban populations, geographical location, and infrastructure of, it creates an even higher risk. Chittagong city is situated at Earthquake Zone II. An earthquake of a magnitude of 6.1 occurred in Chittagong at November 21, 1997 (DDM, 2014). If there is an emergency response plan of the city, it

will help city dweller to take shelter in a secure place such as hospitals. The goal of the study is to find least cost path during earthquakes from a random point to the nearest hospital. To fulfil the goal, certain objectives are taken. These are- to make hospital coverage area map, to make a risk assessment map and to measure least cost path from a random point to the nearest hospital. The outcome of the research can be used for further research and analysis.

METHODOLOGY

Data Collection

Primary data such as geographical locations of hospitals, transformers were gathered using GPS device. Secondary data e.g. geological data were collected from the Geological Survey of Bangladesh (GSB). Digital Elevation Model (DEM) dataset was collected from the USGS website. A Digital Elevation Model (DEM) is a specialized database that represents the relief of a surface between points of known elevation. GIS dataset was collected from the Chittagong Development Authority (CDA).

Methodological procedures for Hospitals

I. In this study, hospital is assumed a safe place for people during emergencies to turn back in case of injuries and other health issues. II. Buffer zones were created around hospitals to measure their coverage areas and distance adjacent from one another. So that, the city dwellers can make the right choices to go based on their locations. Thiessen polygon defines an area of influence around a point. Thiessen polygons can be used to demarcate geographical areas for facilities such as subway stations, and thus define the area's most accessible to each station (Caliper Corporation, 2018). Thiessen polygon was used in this analysis process. Since regular radial buffers tend to overlap a lot and hospital locations are almost clustered; this would make it hard to analyze because the overlaid buffers would cover some of the hospitals visually. When the Thiessen tool was applied, it did not cover the whole region of Chittagong because the automatic algorithm did not take in consideration water areas and coastlines of the Bay of Bengal. For this, it was manipulated using editor tool and covered those areas disregarded by Thiessen polygon calculation.

Methodological Procedures for the Multi-criteria Evaluation (MCE) Map /Risk Assessment Map

In order to identify most vulnerable and safe areas in Chittagong in case of earthquake occurrence, an MCE analysis was conducted within the scale and context of this work. Factors that were considered for the MCE analysis includes:

I. Transformer locations (high-risk location) II. Slope (slope > 35 degrees = high risk) (Doolin, J. E. 2011).

Weighted value: Slope: 50% (0.50), Geology & Transformer location: 25% (0.25)

The evaluation of the MCE was performed by using weighted sums where by:

I. Values below 0.5 were considered relatively 'safe'

II. Values between 0.5 and 1 were considered 'risk'

III. Values above 1 were considered 'high risk'.

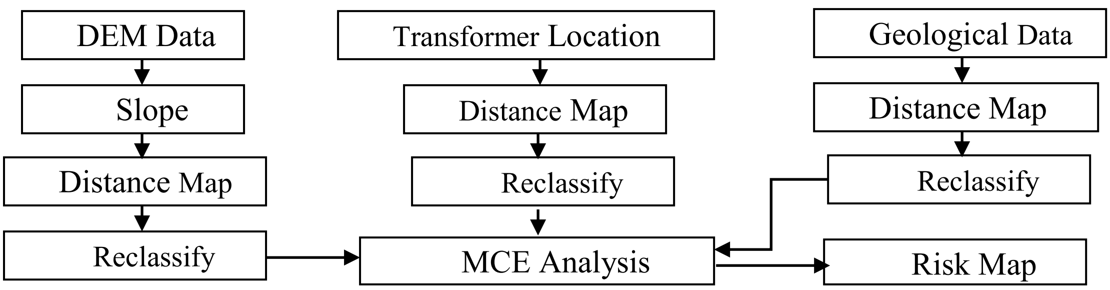

Fig. 1: Multi-criteria evaluation procedure with a flowchart.

Methodological Procedures for Least Cost Path Analysis

First of all, two arbitrary points were taken on the risk assessment map. Then cost distance analysis, cost distance raster and cost backlink were performed sequentially. After that, cost path analysis was done. At last, least cost path were determined.

STUDY AREA PROFILE

Chittagong is the largest port city of Bangladesh. Geographically, it lies at 22.3375° N latitude and 91.8389° E longitude. The area of the city is 168.07 square kilometres. The total population is more than 2.5 million. Chittagong City Corporation (CCC) is the responsible authority for governing municipal areas of the Chittagong Metropolitan Area. It is divided into 11 thanas, 41 wards and 211 mahallas (BBS, 2013).

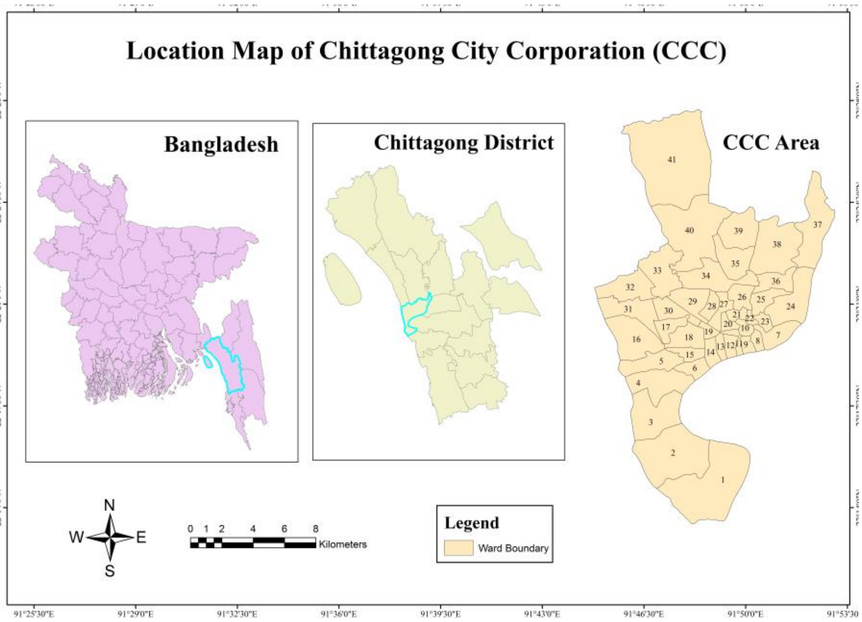

Fig. 2: Location ap of Chittagong City Corporation

RESULTS AND DISCUSSIONS

Hospital Coverage and Geology Mapping of CCC

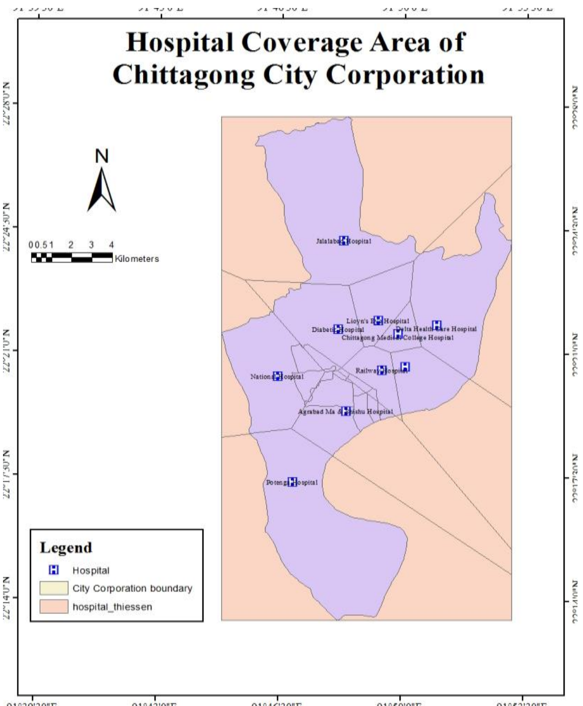

Fig. 3: Hospital coverage area

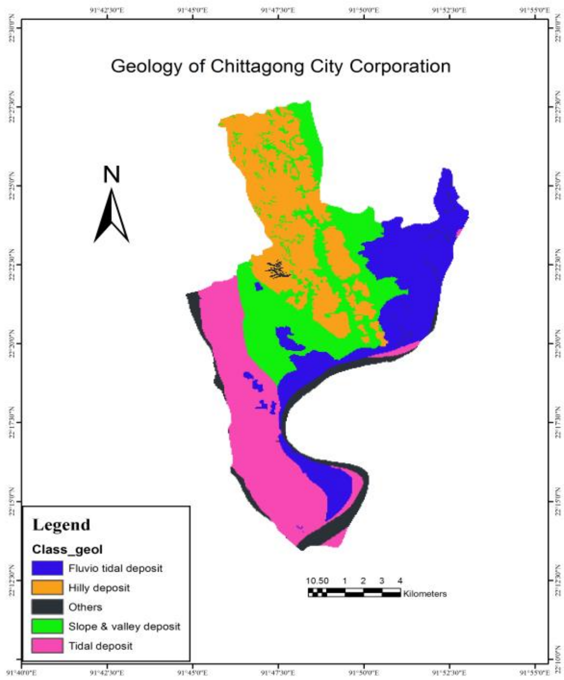

Fig. 4: Geological map of CCC

The hospital coverage area map was prepared using the Thiessen polygon tool. Geographical locations of ten hospitals were collected using Global Positioning System (GPS). There are 117 hospitals situated within the city (BBS, 2013). Only ten hospitals, which have adequate facilities during emergencies were considered in this study. Besides, these ten hospitals are considerably safe places because these are located at secure places. Fig. 3 shows the influenced geographical area of hospitals. Fig. 4 illustrates the geological map of the city. This map includes fluvial tidal deposit, hilly deposit, slope and valley deposit, tidal deposit etc. geological process in which sediments, soil and rocks are added to a landform.

Risk Assessment and Least Cost Path Analysis

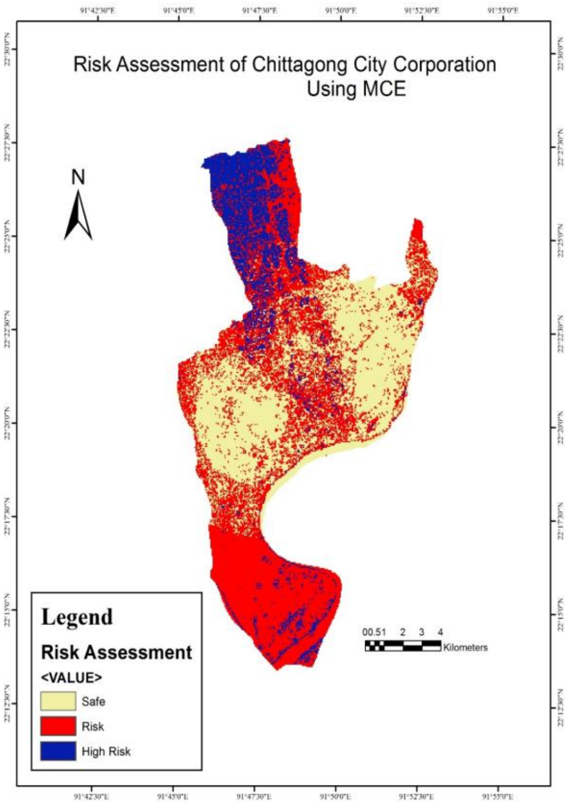

Fig. 5: Risk assessment map

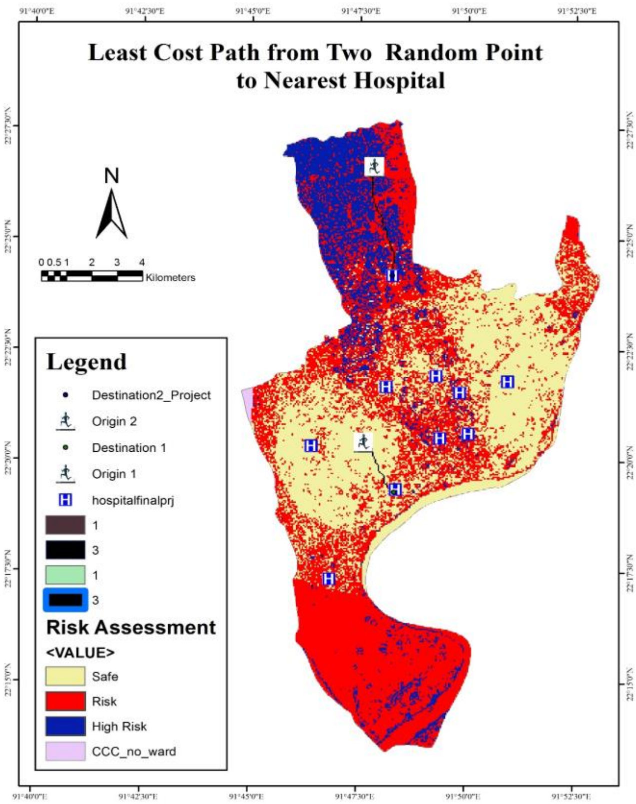

Fig. 6: Least cost path analysis

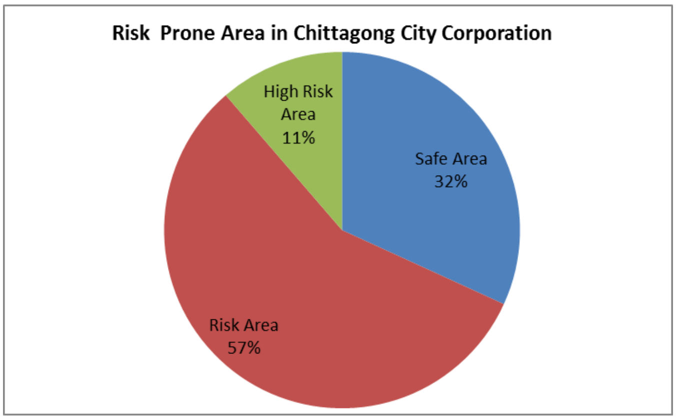

Fig. 7: Risk prone area in CCC

Fig. 5 illustrates a risk assessment map of CCC in three categories i.e. safe, risk and high-risk. Output values after using MCE analysis less than 0.5 were considered as ‘safe’ and coloured yellow in the map.

Again, values between 0.5 and 1 were considered 'risk' or kind of dangerous and coloured red in the map. In addition, values above 1 were considered 'high risk' or dangerous and coloured violate in the map. It is seen (from Fig. 7) that risk area is the largest portion and it is 96.84 square kilometers, which covers 57% area of total area. The safe area is 54.20 square kilometers which cover 32% area of the city corporation and the high-risk area is 19.31 square kilometers which covers 11% area. Fig. 6 demonstrates the application of the least cost path analysis of only two routes. In this study, two arbitrary points indicating as 'man' symbol in the map (the upper point on the map is 'origin 1' and lowest points is 'origin 2') were taken within the city boundary using the Arc Catalogue to generate two new point layer files and edit tool to add arbitrary points on the map. Then cost distance analysis was done from the created points. After that, cost distance raster and cost back link were generated. Subsequently, cost path analysis was performed after selecting the nearest hospital (Jalalabad hospital for origin 1 and Agrabad Ma & Shishu hospital for origin 2) using ArcMap tools. Finally, the output raster was converted into vector polylines for better optical depiction of measured least cost path routes. Specifically, it is asserted that this analysis idea could be used by Smart-phone application developers or any other GPS device developers to develop applications whose algorithms will be including this analysis to display a visual, live and interactive map that could be helpful to individuals to figure out which route to take to get to the nearest safe destination safely from a risky location using their GPS receiver devices.

CONCLUSIONS

An emergency disaster response plan may play a crucial role for people to take shelter to the nearest hospital during the earthquake and other natural disaster. One can easily reach secure place such as hospitals using a smart phone or GPS device based on the response plan. It will reduce the effect of the disaster. It may be expected that implementation of this study in field level might be a great blessing for the inhabitants of the city.

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