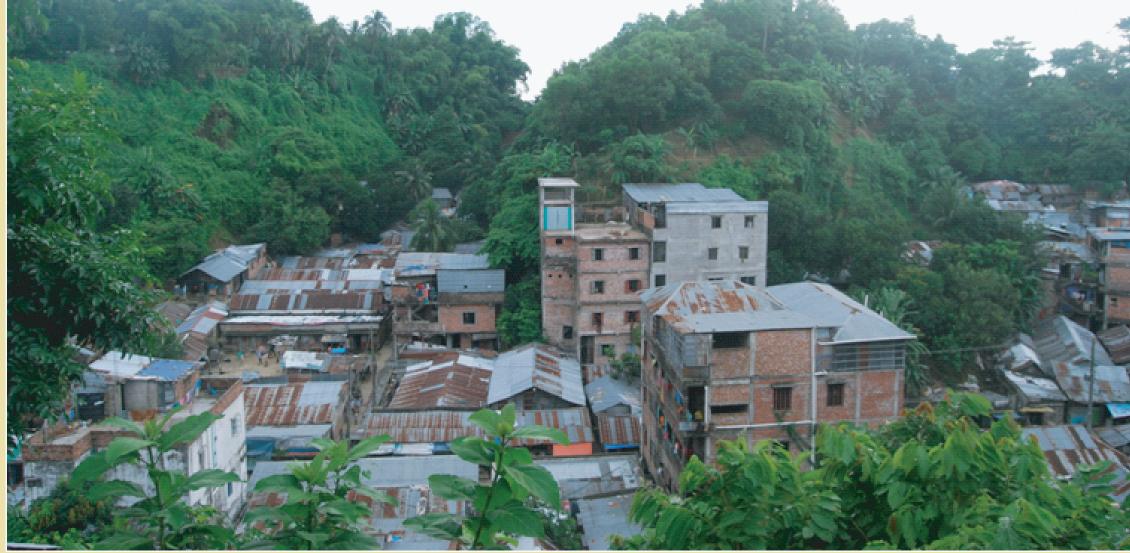
DEVELOPING DYNAMIC WEB-GIS BASED EARLY WARNING SYSTEM FOR THE COMMUNITIES AT LANDSLIDE RISKS IN CHITTAGONG METROPOLITAN AREA (CMA), BANGLADESH

INTRODUCTION

Landslides are one of the most significant natural damaging disasters in hilly environments. Chittagong Metropolitan Area (CMA), the second largest city of Bangladesh, is vulnerable to landslide hazard with an increasing trend of frequency and damage. Devastating landslides have hit CMA repeatedly in recent years. The major recent landslide events were related to extreme rainfall intensities within short period of time. Landslide events occurred at a much higher rainfall amount compared to the monthly average. Moreover, rapid urbanization, increased population density, imprope land-use, cutting of hills, indiscriminate deforestation and agricultural practices are aggravating the landslide vulnerability in CMA. Against this backdrop, it is essential to develop an early warning system for the hilly communities of CMA incorporating local knowledge.

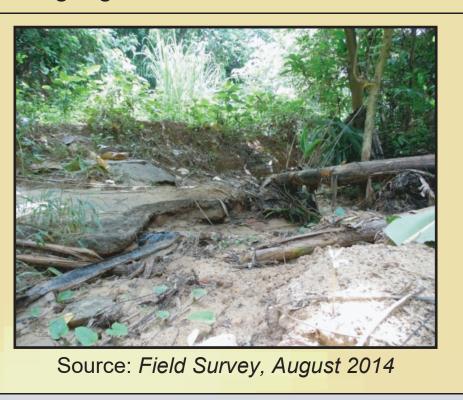


he people residing at the hill s are most vulnerable. It i n uraent necessity of these people to have a scientific early warning before the disaster ccurs, so that the people ased early warning system

OBJECTIVES

- To establish the nature of relationships among land-cover change, rainfall, climate change and landslide disaster. To produce landslide susceptibility maps of CMA.
- To study human adaptation to landslide risks under the condition of rapid urbanization and torrential rainfall.
- To assess community needs for effective implementation of early warning system for landslide.
- To create a web-based dynamic model to generate early warning for people living in landslide vulnerable zones of CMA

CASE STUDY LANDSLIDE 2007

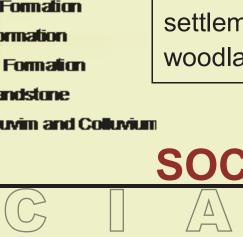


Land Slide History and Future Risk of Landslide

Landslide Location

Beach and Dune Sand Boka Bil Formation Dihing Formation Dupi Tila Formation Tipan Sandstone





Valley Alluvim and Colluvium

people never heard the name of the areas (Chittagong Cantonment Area, University of Chittagong Area). The

LANDSLIDE INVENTORY

It was a real challenge for the project team to

identify the exact locations of the previous

andslide occurrence. In some cases, the areas

were demolished/ lost in such a way that even local

collected from newspapers was websites/online documents and different organizations of CMA. A draft list of vulnerable hills to study was made with the help of the information from Department of Environment (DOE) and Chittagong Development Authority (CDA).

The coordinate values of landslide locations were collected by using GPS. In case of some restricted/ unreachable places information was collected through interpreting the Google Earth Image. The displacement of mass has also Besides, Location name, landslide mechanisms, causes of movement, landslide history and consequences have been collected from the local people and the affected people to some places. The future risks have been determined, after over viewing the previous consequences of landslide and the opinion of the local people. Throughout the field survey photographs of the landslide areas considering different issues were collected by the project team.

Total 57 landslide locations are identified. From the Landslide Inventory Map it is seen that landslide areas are located at the northern-western part of CMA. Analyzing landslide locations with respect to geology it is seen that most of the landslide locations are located in Dupi tila formation and Tipam sandstone geological class





Ground Measurement

GPS Point Collection

SOIL INVESTIGATION

know the texture, soil type and moisture nt. the soil sample was collected from Golpahar. Tankir pahar. Goachibagan an lalpahar for testing. Liquid limit and plastic limit tested to calculate the plasticity index. Moreover, the specific gravity of soil and the table shows the result from soil testing.

Site	Specific	Liquid	Plastic	Plasticity	Sand (%)	Silt &
Site	Gravity	Limit	Limit	Index	Sanu (70)	clay (%)
Lalpahar	2.69	42	23	19	34.1	65.9
Tankir Pahar	2.71	37	23	14	18.2	81.8
Golpahar	2.69		Non plastic		58.4	41.6
Goachibagan	2.71		Non plastic		64.5	35.5



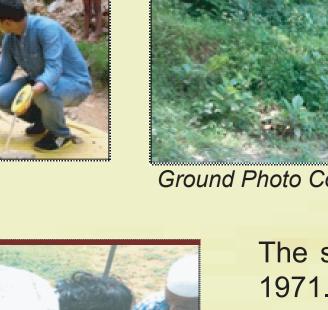
The settlements in hills were established after the liberation in 1971. The people living in the hilly areas of Chittagong are mostly migrated from nearby areas for better employment. Most of them are shopkeepers, bus / auto rickshaw drivers, garment workers, rickshaw pullers. Despite some severe social problems (drug or illegal business, lack of utility facilities, political violence, social insecurity, theft and terrorism), they live in these illegal settlement for low living cost.

The people are warned by announcement through mike, when there is continuous rainfall for According to the local people, the landslide occurrence is 3-7 days. Most of the cases, the warning do not reach to the people. 81.25% respondents stay increased significantly in the last 10 years. The community at their houses after getting warning. Moreover, same amount of rainfall may not cause people identified the vulnerable locations on a map through landslide in all places, so it is a must to identify the probable location of landslide. Most Participatory Rural Appraisal (PRA) Techniques during interesting thing is that 84.41% respondents do not have contact number of the nearest fire community survey. service/ police station/ volunteer groups/ emergency services/ relevant agencies for emergency



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asic Information

andslide ID:11-18 _andslide Location: Lebubagan Kaicchaghona, Sekandar Para at Chittagong Cantonment

Datum: WGS 1984 Total Area of Displaced Mass (sqm)

1061.39 Rainfall: 88 mm



Source: Department of Environment (DOE), 200

Landslide Mechanism

f Move	eme	ent:	Slide	e, Fall	
Dorma	nt,	Sta	bilize	d.	
ution:	Со	nfin	ed		

Land Cover/Use Type (%):

Forest/ woodland is the Primary land cover of these areas. Herbaceous vegetation is also visible in these hills.

Style: Single

Water Content: Moist

Material: Soil/Earth

Causes of Movement:

Excessive rainfall is the main cause of movement.

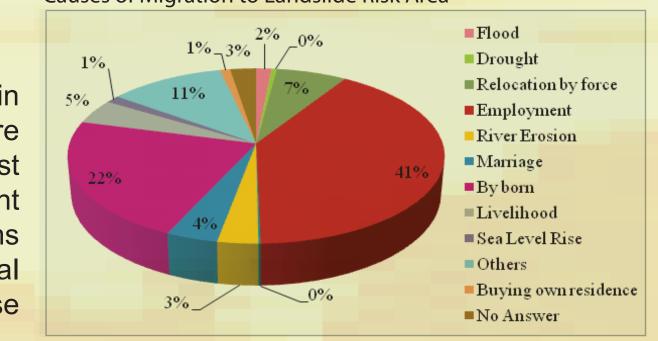
Lebubagan and Kaicchaghona: 658 mm rainfall for 9 consecutive days. Sekandar Para: 268 mm rainfall for 7 consecutive days.

A massive landslide occurred in these three areas at a time on 11 June, 2007. Almost 65 persons were killed and 188 people were injured in this event. The heavy rainfall saturated the hill sides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of morning between 7:00 am to 7:30 am), burying whole families under mud and debris while they were sleeping. The powerful current simply washed others away. At a place, 19 people were killed while recuing 1 people trapped into the mud. At present, there exists no settlement. People were moved from these places. Now this place has become woodland area. Future risk of landslide is low.

SOCIAL ASPECT



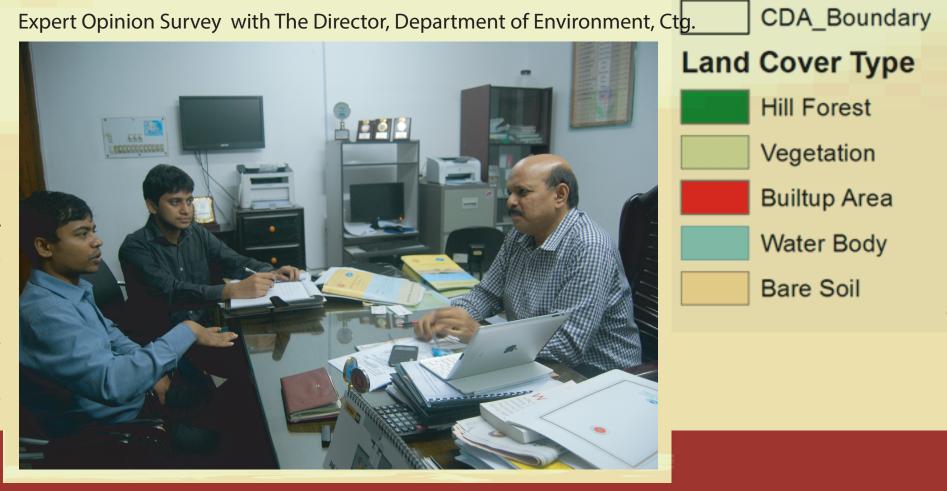
A household survey was conducted to have an idea about the physical aspects socio-economic condition, experience related to landslide and its risk management of the people residing in the hilly areas in CMA. A total of 590 respondents have been surveyed in four different communities (Moti Jharna, Batali Hill, Golpahar and Goachibagan Medical Hill), where landslide occurrence rate is high. Causes of Migration to Landslide Risk Area





Social Survey with Community People

Though living in this area for so many years the respondents gave some suggestion to reduce the risk of landslide of Chittagong Metropolitan Area (CMA). They mentioned permanent relocation, awareness building, stop hill cutting, engineering measurement through constructing retaining wall, tree plantation as mitigation measure.

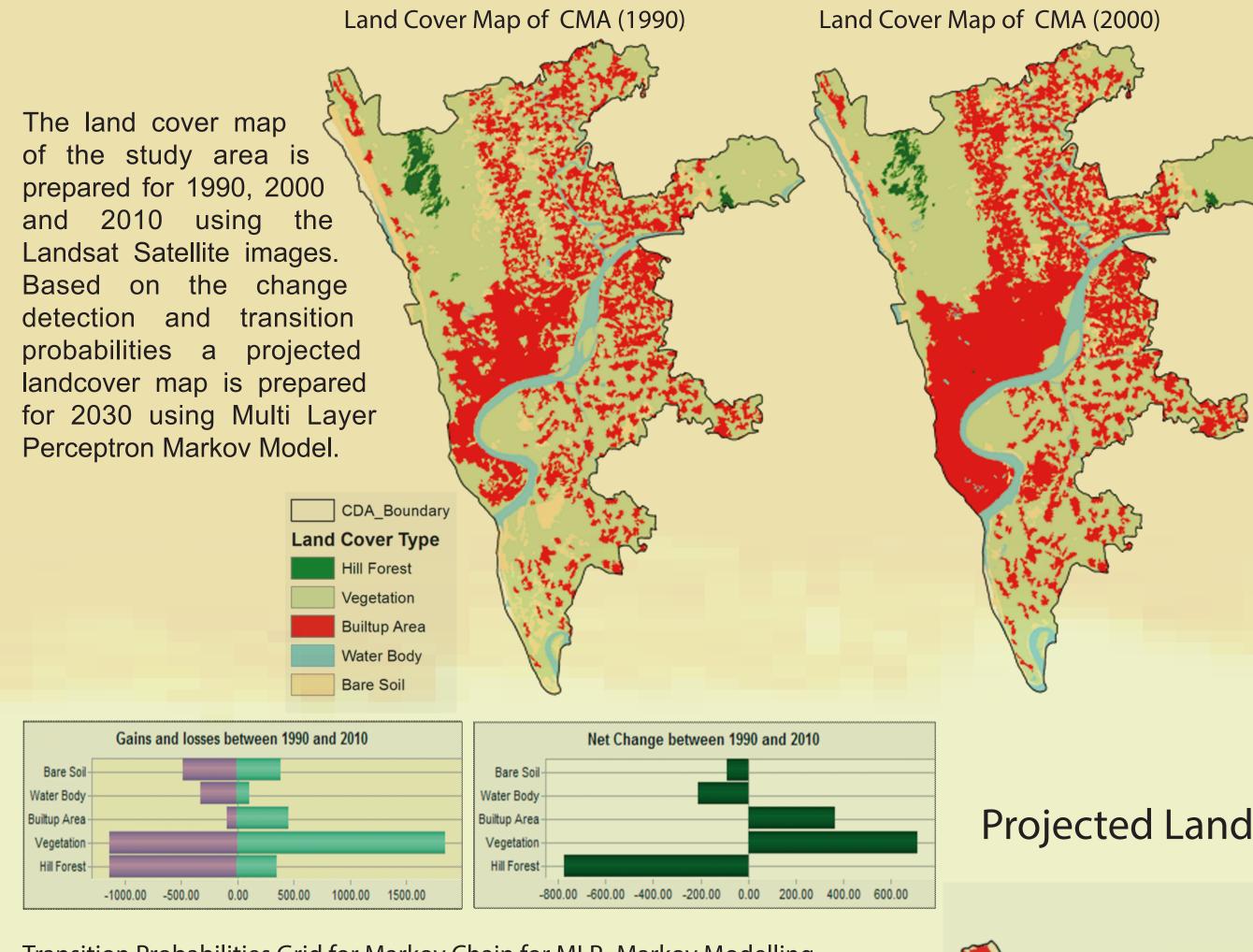


RAINFALL PATTERN MODELLING

The mean annual precipitation map is prepared from rainfall **Daily Precipitation Intensity** data of Bangladesh Meteorological Department (BMD). After reviewing the rainfall data of last 60 years we found that in Chittagong City, the intensive rainfall is decreased but the number of rainfall days in a year is increased.

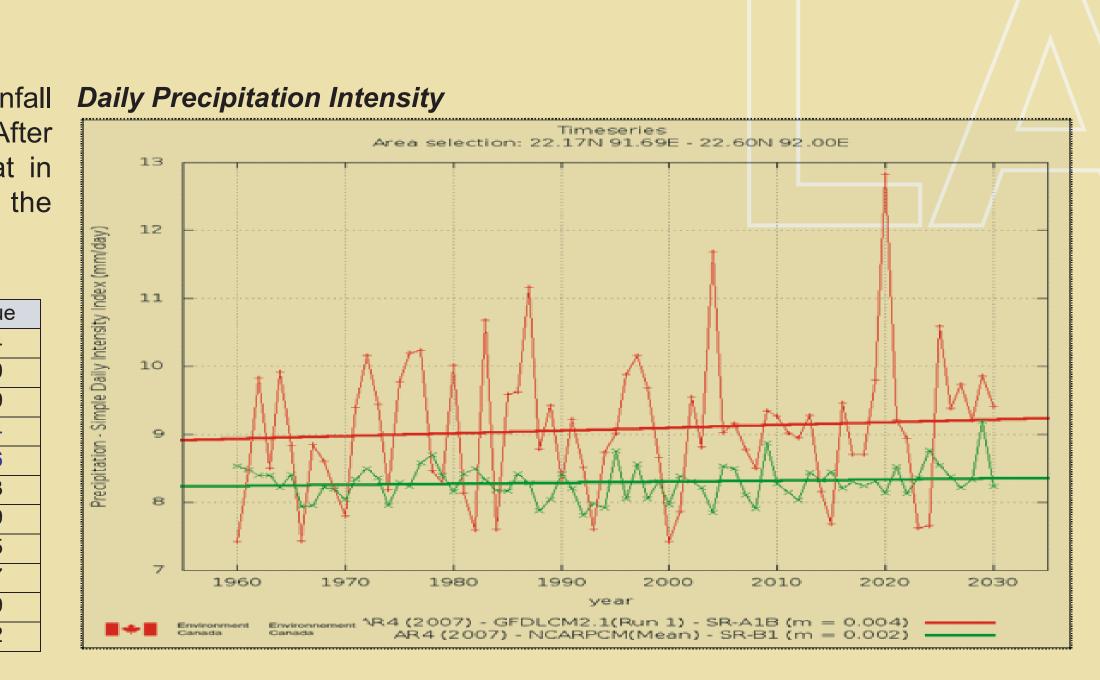
Indices	Starting Year	End Year	Slope	Slope Error	P_Value
Rx1day	1950	2010	0.335	0.564	0.554
Rx5day	1950	2010	-0.030	1.189	0.980
SDII	1950	2010	0.001	0.032	0.969
R10mm	1950	2010	0.053	0.062	0.394
R20mm	1950	2010	0.054	0.051	0.296
R50mm	1950	2010	-0.005	0.033	0.883
CDD	1950	2010	0.045	0.187	0.809
CWD	1950	2010	-0.025	0.034	0.465
R95p	1950	2010	-2.552	3.486	0.467
R99p	1950	2010	-1.770	2.543	0.489
DronTot	1050	2010	0.762	4 071	0 052

LAND COVER MODELLING



sition Probabilitios Grid for Markov Chain for MLP. Markov M

Transition Probabilities Grid for Markov Chain for MLP_Markov Mod				
Landcover	Hill	Vegetation	Builtup	Wate
Categories	Forest	vegetation	Area	Bod
Hill Forest	0.9020	0.0974	0.0001	0.000
Vegetation	0.0552	0.8204	0.0667	0.013
Builtup	0.0001	0.1892	0.8070	0.002
Area	0.0001	0.1092	0.0070	0.002
Water Body	0.0140	0.2345	0.0031	0.623
Bare Soil	0.0027	0.6816	0.0554	0.044



Projected Land Cover Map of CMA (2030)

Land Cover Map of CMA (2010)

>	
	CDA Boundary
	MLR Susceptibility
	0.000383989 - 0.101581253
	0.101581253 - 0.247755079
	0.247755079 - 0.416417186
	0.416417186 - 0.626307808
	0.626307808 - 0.952387882

OUTREACH AND USER ENGAGEMENT ACTIVITIES



Stakeholder Meeting with Chittagong Development Authorit



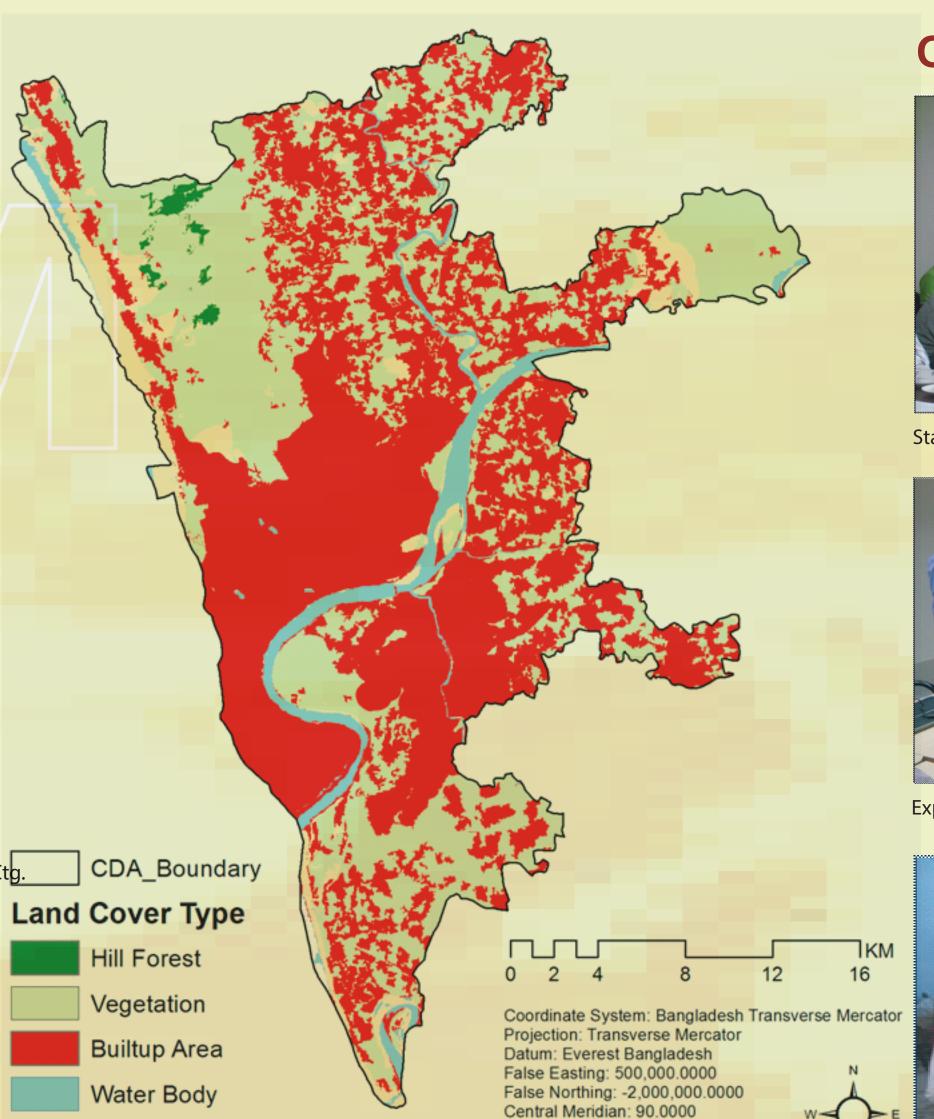
Expert Knowledge Sharing Meeting in Chittagong



0.0018

Bare Soil

Author: Bayes Ahmed



Scale Factor: 0.9996

Units: Meter

Latitude Of Origin: 0.0000

LANDSLIDE SUSCEPTIBILITY MAP



ordinate System: Bangladesh Transverse Mercator ection: Transverse Mercato atum: Everest Banglades e Easting: 500.000.0000 Northing: -2.000.000.000 al Meridian: 90.0000 Factor: 0.9996 Author: Bayes Ahmed

Throughout the project period, the people were so cooperative. They discussed openly about their problems, wish and future plan. They gave idea about their landslide etc. They emphasized expect that government and torward early warning system should be warning of a landslide earlier, it will be easy for them to access the warning from him.



For Landslide Susceptibility Mapping (LSM), 9 different GIS layers have been produced. They are: land cover map, precipitation map, landslide inventory map, elevation map, slope map, Normalized Difference Vegetation Index (NDVI) map, distance to road map, distance to drain map, distance to stream map and soil permeability map. Multinomial Logistic Regression (MLR) Method is used to produce the landslide susceptibility map. This map will contribute to the risk sensitive landuse planning of Chittagong City.

WARNING ZONE CLASSIFICATION

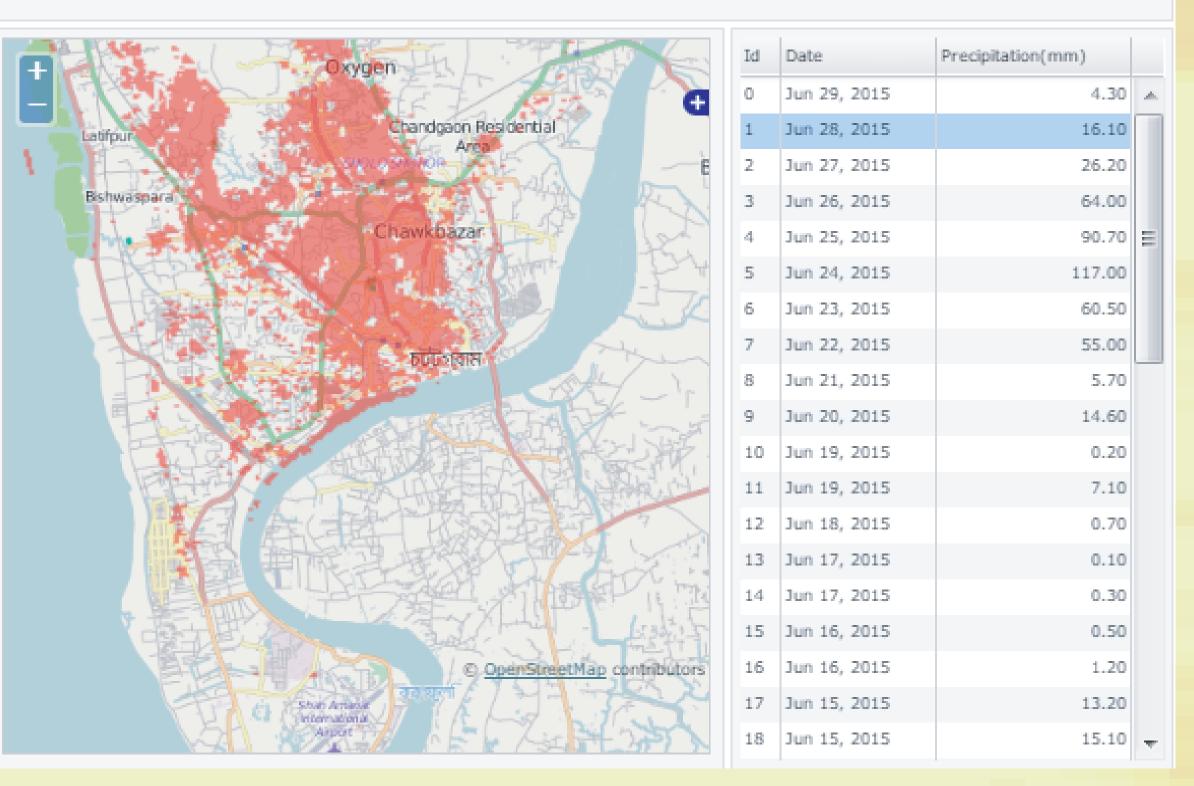
Based on the rainfall pattern analysis results, the following 5 classes were created for developing the Web-GIS based landslide early warning system:

Rainfall Threshold
> 250mm in 1 day
> 100mm in 1 day
> 40 mm in 1 day or > 200mm in continuous 3 days
> 25 mm in 1 day or > 50mm in continuous 3 days
>= 15mm in 1 day or > 30mm in continuous 3 days

EARLY WARNING SYSTEM

📄 Receive alerts 📄 Last 30 days 📄 Forecast

(www.landslidebd.com)



The major outcome of this project is to develop a website (www.landslidebd.com) where anyone can access the project related information such as study area, reports, photographs, rainfall forecast data etc. If anyone enters to the website, he/ she can see the precipitation data (in mm) of the last 30 days and also the rainfall forecast for the next five days. The nstruct retaining wall etc. They website will give warning for landslide, based on the updated precipitation data from worldweatheronline.com. In this dynamic model, the vulnerable zones of a certain area will be changed based on the intensity of rainfall and the soil characteristics of that particular area. One has to register simply entering name and e-mail address to the website. After completing the registration he/ she will get the early warning through that e-mail address. The authority and the stakeholder can get a scientific early warning in this process.

> web based early warning system is working as a pilot project. We hope that if this web-GIS based early warning system is successful, the local people will be benefitted and there will be no more death loss and property damage due to landslide.