Visualizing Climate Change and Sea Level Rise for Climate Communication

Md Sahadat Hossain and Ahmad Kamruzzaman Majumder

Abstract: *Visualization is a powerful tool or process of geospatial data and representation by means of a clear understanding, cognition and insight that can easily be achieved for any types of audiences. Accordingly, downscaled climatic visualization approach has been applied to scrutinize a specific area or local level data for an effective climate communication and decision support in context to local and regional adaptation and policy formulations. This study is such a downscaled approach which is aimed to visualize the change in climatic variables and sea level rise in Bangladesh. It is based on global historical bioclimatic data (1950-2000) and rcp 4.5 scenario data from HadGEM2-ES for 2050 projection. Besides, global topographic elevation data based on IPCC's ETOPO2 have been used for understanding the sea level rise. The study found that changing climate variables will be more intense in the north-eastern regions of Bangladesh while SLR will be more severe to the southern coastal zones. The geospatial visualization of vulnerable zones based on normalized values represent that northeastern districts are at high-risk ranking positions. Therefore, climate-induced socio-economic vulnerabilities in Bangladesh is not going to be uniformed and the diversified impacts will be dependent on future local changes. Consequently, this study may be helpful for ongoing climate adaptations, awareness and capacity building programs as an interactive and interesting tool of adaptation measures for achieving universal sustainable development goals.*

Key words: Climate change, climate variability, GIS, sea level rise, visualization.

Introduction

Visualization is a tool or process of data representation by means of a clear understanding, perception, cognition and insight of meaningthat can easily be achieved by a user (Johansson, 2015). It not only comprises quantitative but also qualitative data (T.-S. S. Neset & Glad, 2009). In climate science and policy, it isused as a potential tool for communication and decision support in relation to local and regional adaptation and policy formulations (T.-S. Neset, Opach, Lion, Lilja, & Johansson, 2015). As it actsas a powerfultool to represent data for geospatial and abstract visualization, therefore it is important to maintain its principles for effective communication. Thus, visualization based on identifying and designing for target users or audiences, accurate data and clear graphical representation with appropriate labeling help to accomplishunderstanding or communication, interaction, and disseminationto all types ofaudiences (dataviz, 2009; Stone, 2006).

The change in global climatic conditions with socio-economic development has been confessed in context to pre-industrial periods. This change is due to CO_2 emissions from anthropogenic activities which lead to global warming. It is containing huge information and has been communicating through the different emission scenarios, trends etc. including adaptation and mitigation options (T.-S. S. Neset, Johansson, & Linnér, 2009).

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These are basically report-based, mostly descriptive, hard to understand by layman i.e., the entire communication is ultimately changed for its complexity (T.-S. Neset et al., 2015). In this circumstance, climate scientists have been tending to use 'visualization' of this vast information as an effective tool for climate communication (Shaw et al., 2009).

The global temperature is projected to be increased from 1.5^{o}C-2^{o}C and annual precipitation might be changed inextreme events or intensification of longer dry periods by 21st century. Furthermore, global mean sea surface level is also projected to increase from 0.53-0.98 meter due to ice-caps melting by this time. But this change and its impacts are not uniform temporally and spatially (Ji, Wu, Huang, & Chassignet, 2014). Hence, assessing climate vulnerability is a complex process (Opach & Rød, 2013). In this vein, downscaled regional or local climate visualizationwith incorporating local community or stakeholder knowledge is more effective for risk-mapping and adaptive measures (Lotta Andersson, Wilk, Graham, & Warburton, 2013).

Climate is geospatially distributed and Geographic Information System (GIS) tools are widely used to underst and visualize its past and future scenarios for decision-making. This study has done to represent spatial data with such a computer-based software ArcGIS 10.1.3 by using two types of data i.e., vector and raster. Vector data represents the individual data consists of polygons, points and lines which are stored as X,Y pairs coordinates and which are discredited by boundaries. On the otherhand, raster data represents the surface into square pixels or grids or cells where each corresponds to a particular value. Although vector data used for 3D visualization but can not be used for describing topography, hence, geoprocessing tool (i.e., interpolation method) is used for creating the statistical trend surface. The interpolation process is also applied for estimating values of unknown points. It is also known as a spatial interpolation by which statistical surface can be attained for statistical calculation despite missing data (Dangermond & Artz, 2010). The study is aimed to visualize the change pattern in climatic variables and sea level rise in Bangladesh.

Methodology

This study is such a downscaled approach which focused on climate change and Sea Level Rise (SLR) visualization on Bangladesh. It is chosen from personal research interest as well as being figured out as the 5th most vulnerable countries to these consequences for its geographical location i.e., 80% of the landmass is below 1 meter of sea level and coastal disaster prone zones (Laden, 2015). The study is based on two climatic variables i.e., annual temperature and precipitation were selected because these two variables are considered as the most important indicator to understand the climatic conditions. Besides, SLR is also an important climate-induced issue which has adverse impacts on coastal regions all over the world.

Local data: The administrative shapefile, elevation, and population data in both vector and raster form for Bangladesh were downloaded from an open access online database of DIVA-GIS and Bangladesh Agricultural Research Council (BARC, 2015).

Bioclimatic data: Global historical (1950-2000) bioclimatic data for annual temperature and precipitation change were downloaded from WorldClim online rasterdatabase.

Besides future projected scenario data for 2050 (projection for 2041-2060) produced by the HadGEM2-ES for rcp 4.5 scenario were also downloaded from the same database (Hijmans, Cameron, & Parra, 2005).

Sea level rise data: Global topographic elevation data based on IPCC's ETOPO2 was downloaded from NOAA's online database in the form of 2 minutes raster cells (1 minute = 1.852 km)(NOAA, 2006).

Identifying the Risk Zones: High-risk zones were identified based on the extreme changes in two climatic parameters i.e., temperature and precipitation. This representation was done into two processes calculating changes and normalizing values. Change in annual mean temperature and precipitation was found by the raster layer subtraction method. As well, normalization was used to harmonize and making data as a similar value or category. The attribute data of mean annual precipitation change was joined into temperature attributes. After that, the following normalization formula (Equation 1) was used after adding afield by using field calculator.

$$Standardization = \frac{Mean_{Temp\ or\ ppt} - Minimum_{Temp\ or\ ppt}}{Maximum_{Temp\ or\ ppt} - Minimum_{Temp\ or\ ppt}} \text{ ………. Equation (1)}$$

By using this, there was a normalized data between 0-1 was created for the both of variables. Finally, both normalized data were summed up to have the numbers. The more summing values represented more at risk to climate change.

Sea level rise Visualization: The global elevation data 'Etopo2' extracted and used in ArcGIS 10.1 for visualizing 1m' and 2m' sea level rise.

Results and Discussions

The representation was done in consideration with principles of visualization i.e., understanding, interactivity, and dissemination. In these visual representations, audience perceptioni.e., communicative, easily understandable (dataviz, 2009) as well as avoiding colorblind (10% men and 1% women to red and green) and their combination i.e., red and green, blue and purple, blue and yellow etc. (Healey, 2015) were also carefully considered.

Visualization of Risk Zones

The study found the considerable change in climate variables in Bangladesh. A considerable increase in temperature has been revealed for eastern zones of Bangladesh. Figure 1(a) shows the drastical change in projected temperature where eastern parts of Bangladesh will experience comparatively be more warmer than the other parts of Bangladesh. Similarly, it has been found that precipitation pattern of Bangladesh will gradually increase from south-western part to north-eastern part (see Figure 1(b). Moreover, there are two areasi.e., south-eastern and north-western zones, will suffer from relatively low precipitation.

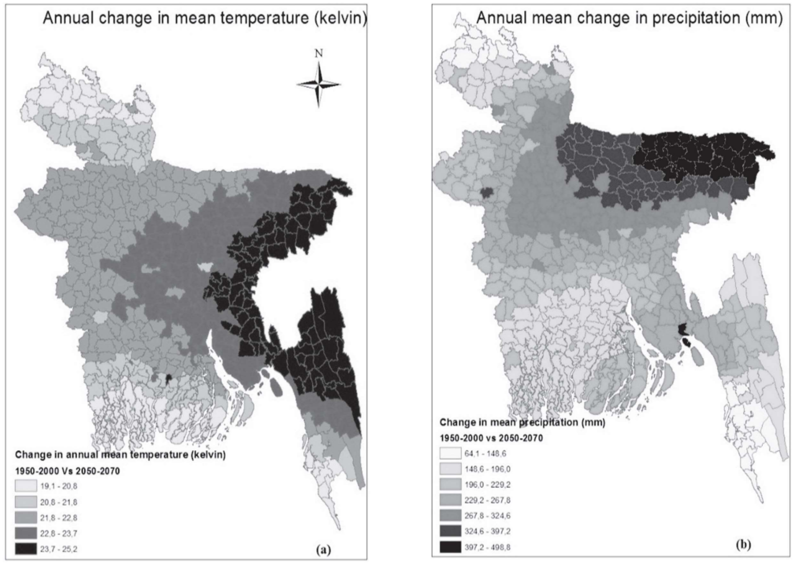

Figure 1. Projected change in climate variables in Bangladesh (a) temperature and (b) precipitation pattern (Color images conveying more interactive visualization)

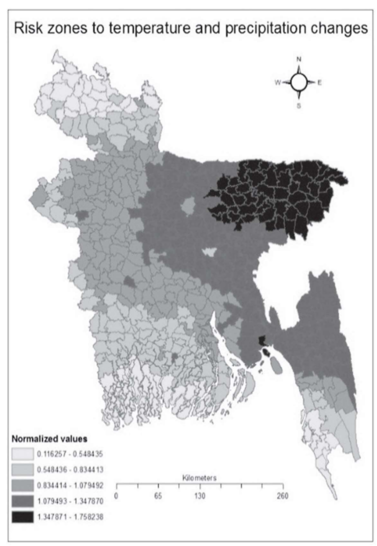

Figure 2. Projected (combined i.e., temperature and precipitation) change in climate parameters in Bangladesh (Color image conveying more interactive visualization)

Figure 2 shows that projected climate change during 2050-2070 in Bangladesh would not be similar in all areas even in the small geographical location i.e., district level. Change in both the climate variables (i.e., temperature and precipitation) would comparably be more distinct in the north-eastern part of Bangladesh. The study has found that change would gradually be intensified from south-western part to north-eastern part of Bangladesh.

Visualizing Sea Level Rise (SLR) and Impact of Human Habitat

Bangladesh is the second largest delta of which 80% is below 1 meter and entire landmass is below 10 meters in elevation (Laden, 2015). Its coastal areas comprise 32% of total landmass (Islam, 2004) providing habitat and daily livelihood to over 30 million people (Ahamad, Khondker, Ahmed, & Tanin, 2013). This study has revealed that coastal areas of Bangladesh specifically, southern and north-eastern part are more vulnerable to SLR. There are 2881577 and 5741571 people living in 1190 km and 2197.79 km of 1m to 2m elevation coastal areas would be affected due to 1m and 2m SLR respectively (Table 1. See also Figure 3 and Figure 4). There are about 12 million people in coastal area, are extremely poor and will be environmental refugees in future due to SLR.

Table 1: SLR and affected land area (in km) and population

SLR (m)	Land (km)	Population Affected
1	1190	2881577
2	2197.79	5741571

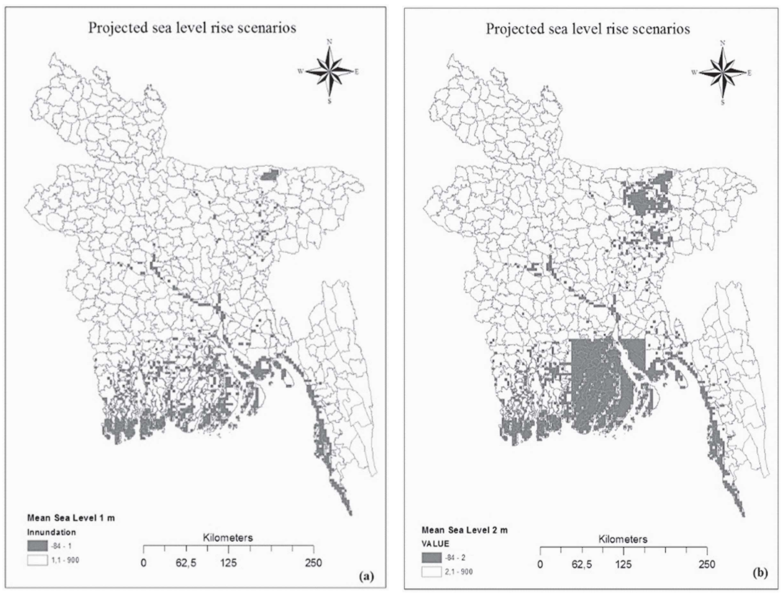

Figure 3. Projected SLR and inundation scenarios for Bangladesh (a) 1m SLR (b) 2m SLR (Color images conveying more interactive visualization)

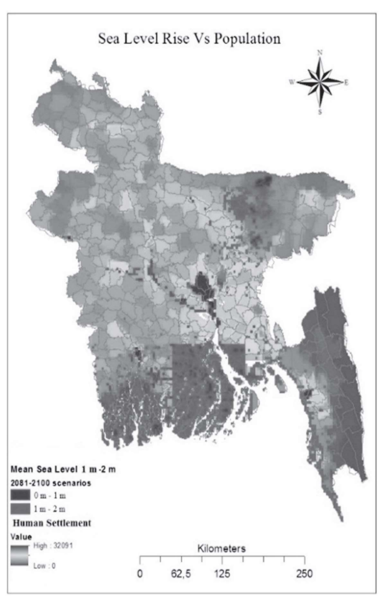

Figure 4. Projected SLR and affected land and population of Bangladesh

Conclusion

Climate change visualization should be a collaborative approach with the local community and individual participation, institutional engagement, and NGOs through the participatory process and framing local knowledge and information for effective decision making (L. Andersson, Jonsson, Wilk, & Olsson, 2010; Lotta Andersson et al., 2013). Hence, climate communication needs to be tangible, interactive, attractive, and understandable to all audiences. In Bangladesh, climate issues are currently communicated mostly in descriptive form. Colors convey the strong aesthetic perception to easily understand the insightful information, and group related color represents the similar importance for attention (Stone, 2006). Besides, representation of complex scientific data needs to be easily understandable, tangible and concrete to all community levels including laypeople (Sheppard et al., 2011; Wibeck, 2014). This study to visualize thechange in climate variability and SLR scenarios for Bangladesh may convey more vibrant information understandable to all types of audiences. As there are many climate adaptations, awareness and capacity building programs going on in Bangladesh, so visual presentation be an interactive and interesting tool for adaptation measures. Government official and policymakers may also be interested in formulatinga concrete policy in context to zonal vulnerability using such information. Besides, it might be included into the goals of "Digital Bangladesh, 2021" which has been practicing in union level (very local administrative level) through proving information on agriculture, livestock, fisheries etc. In this case, union center can be used as the digital workshop center. NGOs may use visualization as a tool for their capacity and awareness building campaigns, events, and gatherings. Educational and research institute may use based on their own interest e.g., agricultural, ecological, aquaculture, marine, protected areas zoning and mapping for sustainable resource mapping and development.

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