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The views and interpretations in this paper are those of the author(s) and do not necessarily represent those of the Bangladesh Development Research Center (BDRC).

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How Vulnerable are Bangladesh's Indigenous People to Climate Change?

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Abstract

This paper compares the vulnerabilities to climate change and climate variability of the indigenous people with the Bengali population of Bangladesh. It distinguishes between (a) individual vulnerabilities that are related to an individual's capability to adapt to climate change and; (b) spatial vulnerabilities, that is, vulnerabilities that are related to the location of a person (like the exposure to climate change-induced disasters). While an individual's capability to adapt to climate change is determined by many factors, some relatively simple approximation is to look at poverty, landlessness, and illiteracy. Spatial vulnerabilities are reviewed by looking at drought hazard maps, flood hazard maps, landslide hazard maps, and cyclone hazard maps. Hence, the paper compares levels of poverty, landlessness, illiteracy, and the more direct though also more subjective exposures to increased droughts, floods, landslides, and cyclones across the two population groups. The paper concludes with some broad suggestions on adaptation strategies of indigenous people as well as suggestions for policy interventions to reduce climate change-induced vulnerabilities for indigenous people in the Chittagong Hill Tracts (CHT).

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I. Introduction

Bangladesh is characterized by an extremely high population density, a low resource base, and a high incidence of natural disasters. Bangladesh is therefore recognized worldwide as one of the countries most vulnerable to the impacts of climate change and climate variability.[1] The climate change literature is mostly focusing on Bangladesh's geographic location, Bangladesh's geo-morphological conditions, and Bangladesh's low level of development. The usual assumption is that the coastal area and the large river delta will be the most severely affected areas while the elevated parts in the south east of Bangladesh are generally considered to be far less affected by climate change. Only more recently—largely due to the catastrophic landslides in Chittagong in June 2007—has it been recognized that the Chittagong Hill Tracts (CHT) may also be affected significantly by climate change-induced disasters. While flash floods and landslides in the CHT are related to mostly man-made soil erosion and deforestation, the frequency and severity of such disasters is likely to increase sharply due to climate-change induced increases in precipitation and storm surges.

Based on the contribution of Working Group II to the Fourth Assessment Report of the International Panel on Climate Change (IPCC) on the Impacts, Adaptation and Vulnerability in Asia,[2] the impact in Bangladesh can be summarized as follows:

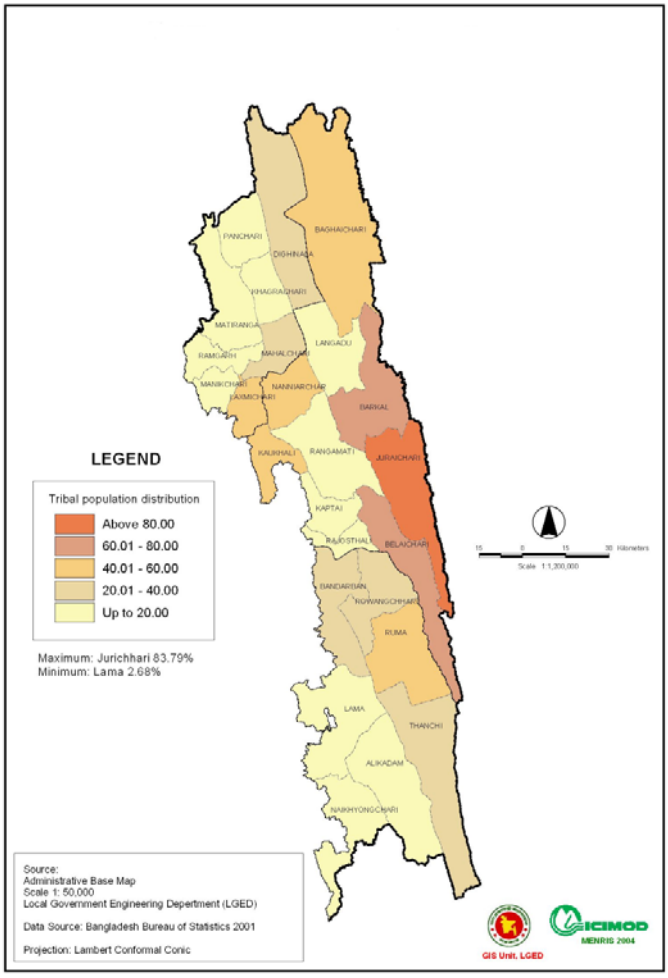
- Glacier melt in the Himalayas is projected to increase flooding and rock avalanches from destabilized slopes, negatively affecting water resources during the rainy season within the next two to three decades. This will be followed by decreased river flows as the glaciers recede.
- Freshwater availability is projected to decrease particularly in large river basins due to increased floods during the rainy season and increased droughts during the dry season. Bangladesh's coastal areas will be at greatest risk due to increased flooding from the sea and due to flooding from the rivers.
- Climate change is projected to impinge on sustainable development as it compounds the pressures on natural resources and the environment associated with rapid urbanization, industrialization, and economic development. It is projected that crop yields in South Asia could decrease up to 30% by the mid-21st century.[3]
- Taken together and considering the influence of rapid population growth and urbanization, the risk of hunger is projected to remain very high in Bangladesh. Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in Bangladesh due to projected changes in

[1] Subsequently, we refer to "climate change" as a short form for "climate change and climate variability".
[2] See Cruz, Harasawa, Lal, Wu, Anokhin, Punsalmaa, Honda, Jafari, Li and Huu Ninh (2007).
[3] Country-specific projections are available from Cline (2007), who has estimated that without taking any possible carbon fertilization into account, agricultural output in Bangladesh would be 22 percent lower in the 2080s, solely due to a climate change induced changes in temperatures and precipitation. Taking the possible carbon fertilization into account, agricultural output in Bangladesh would be 9.9 percent lower in the 2080s than in 2003. It is however important to stress that Cline's estimates have not taken into account any of the other likely negative impacts on Bangladesh's agricultural output, like for example the climate change induced reduction in arable land (resulting from increased floods, increased droughts, and increased salination, and sea level rise).

the hydrological cycle associated with global warming. Furthermore, increases in coastal water temperature would exacerbate the abundance and/or toxicity of cholera in Bangladesh.

This paper compares the vulnerability to climate change of Bangladesh's indigenous people with that of the Bengali population of Bangladesh. Given that there is no data available that disaggregates vulnerability by tribal and non-tribal populations, we make use of the fact that most of Bangladesh's tribal population is concentrated in the CHT and that there is some data from the 2001 census on the proportions of tribal and non-tribal populations at the upazila level (illustrated in Figure 1) to approximate vulnerability across the two groups. In cases where there is sufficiently detailed (i.e. upazila-level) data available for a specific vulnerability, we weight the vulnerability by the proportion of tribal population in the CHT. In the other cases the comparison is limited to the CHT population (serving as a proxy for tribal people) versus the population of the rest of the country (serving as a proxy for the non-tribal population).

Figure 1: Proportion of Tribal Population in the CHT (percent)



Source: Local Government Engineering Department (LGED) and International Centre for Integrated Mountain Development (ICIMOD) (2006).

II. Analysis of Individual Vulnerability to Climate Change

With regards to individual vulnerability, a recent Climate Change Cell (2007, p. 3) report has pointed out that the poorest are hit earliest and hardest by the impacts of climate change:

> "Poorer people are more susceptible to the destruction caused by hurricanes and flooding for a variety of reasons. The poor typically live in substandard housing that is more susceptible to damage from winds, heavy rain and floodwaters. Substandard or non-existent sewage facilities and lack of potable water in poor neighborhoods can result in greater exposure to water-borne diseases after flooding. Areas that are historically prone to flooding or mudslides are often inhabited by the poor."

Hence, being poor is by itself a useful vulnerability indicator. Taking into account that (a) poverty is a multidimensional concept that has many dimensions and (b) the poor are a heterogeneous group with large proportions of the poor moving into and out of poverty (see Baulch and Hoddinott, 2000), we look at a few poverty measures, including hard core food poverty (measured by the percentage of population with calorie intake lower than 1850 kcal/capita/day), as being at the margin of starvation leaves little capabilities to adapt to any negative shock.

Our second and third individual vulnerability indicators intend to reflect that vulnerability is related to (a) the inability to cope with climate change, (b) the property of lacking physical or mental strength to deal with climate change, and (c) the property of being helpless in the face of a climate change-induced disaster. Hence, we use landlessness (as a measure for potential food insecurity) and illiteracy (as a general measure for individual capability)[4] as our second and third individual vulnerability indicators.

There are typically high degrees of overlaps between those being poor, being landless, and being illiterate; however, given that we look at these vulnerability indicators subsequently, the overlap does not cause any bias. For comparison purpose, we also provide some information on a so-called "Socio-economic Vulnerability Index (SVI)" which had been taken from the UNDP's Millennium Development Goals (MDG) database, based on a study by Hi-Tech Info Processing Centre and Bangladesh Institute of Development Studies (BIDS) (2003b).

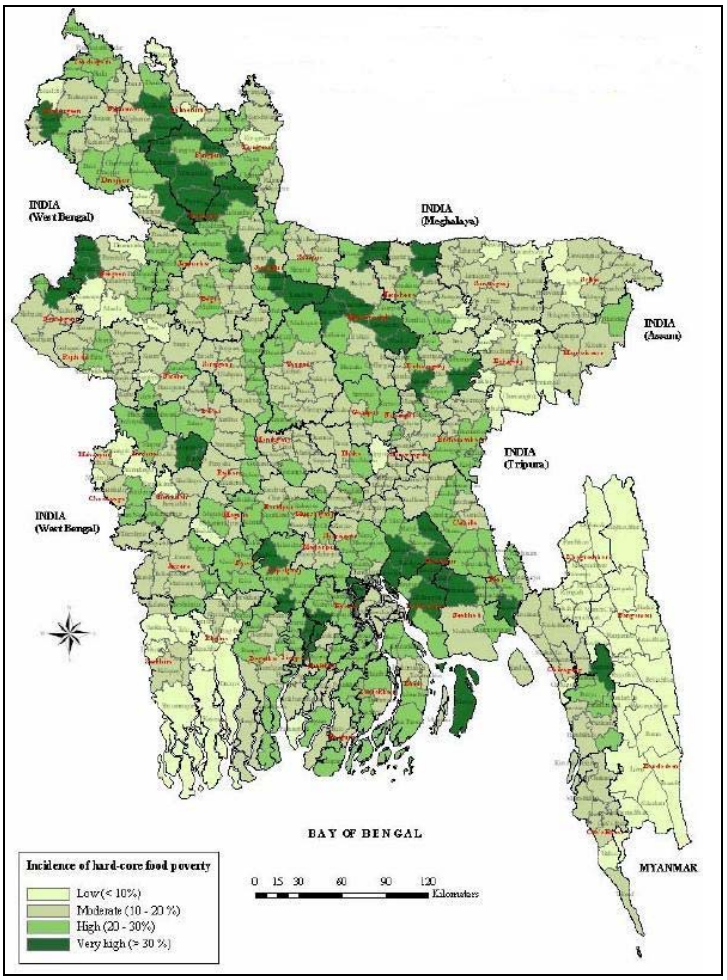
II.1. Food Poverty

Figure 2 shows the degree of hard core food poverty across the 490 upazilas in Bangladesh. While the levels of food poverty vary significantly across upazilas, ranging

[4] It should be stressed that we recognize the importance of indigenous/local knowledge in effectively adapting to climate change. Hence, some indicator reflecting indigenous knowledge would have been very useful for our analysis. However, given that the indigenous as well as the Bengali people have both some indigenous knowledge to adapt to climate change, we could not find an indicator (and its data) that would allow disaggregating such knowledge effectively between tribal and non-tribal people. For useful online resources on indigenous knowledge and climate change, see http://www.iges.or.jp/en/pub/eLearning/link/overview.htm and http://www.bcas.net/2nd-CBA/index.html. For issues related to indigenous knowledge and development, see Sillitoe (2000). Furthermore, Roy and Halim (2003) review the protection of forest commons through indigenous knowledge systems in the CHT.

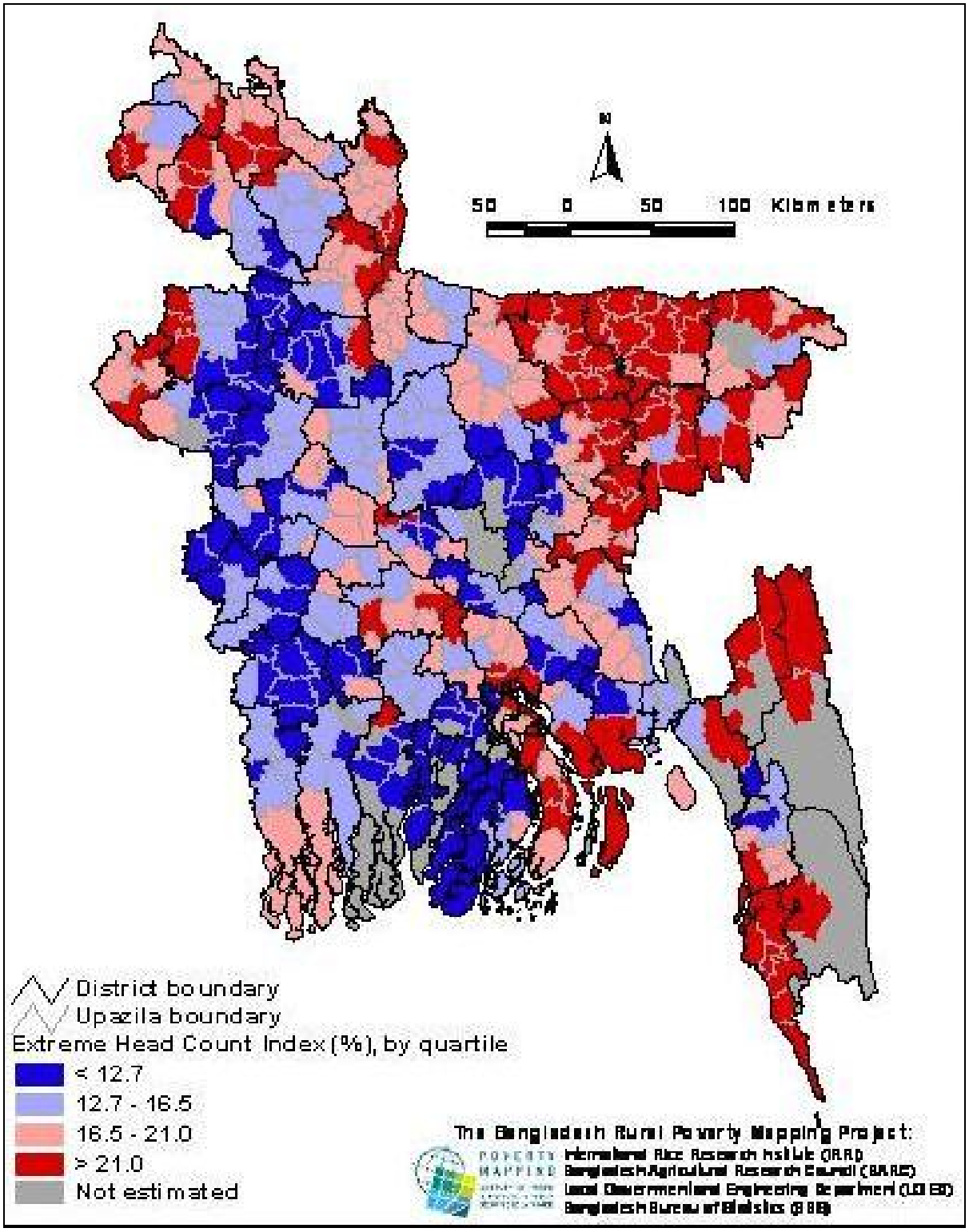
from below 10 percent to above 30 percent, the CHT seem to be the most homogenous and also the least food poor area. According to the map, hard core food poverty is below 10 percent for each of the 25 CHT upazilas. However, this most recent official data is not consistent with some previous poverty estimates. For example, Kam, Hossain, Bose and Villano (2005) provide some estimates on the incidence of extreme rural poverty in Bangladesh, including for seven CHT upazilas (Bagaichhari, Dighinala, Lama, Langadu, Manikchhari, Matiranga, and Panchhari), see Figure 3. All seven CHT upazilas exhibit the highest level of extreme poverty (which is supposed to be closely related to hard core food poverty).

Figure 2: Hard Core Food Poverty
(Percentage of population with calorie intake lower than 1850 kcal/capita/day)



Source: Ministry of Environment and Forest (2005), Figure 2.

Figure 3: Incidence of Extreme Poverty



Source: Kam, Hossain, Bose and Villano (2005).

Given the contradiction between Figures 2 and 3, Table 1 provides some additional data for three poverty measures as they are available for 21 regions of Bangladesh, including the CHT: (a) the Head Count Index, (b) the Poverty Gap Index, and (c) the Squared Poverty Index. Among the 21 regions[5] listed in Table 1, the CHT rank as the seventh least poor region; and are just slightly less poor than the national average of Bangladesh (shown in the first row).

Table 1: Poverty Measures by Region, 1999 (in percent)

Regions	Head Count Index		Poverty Gap Index		Squared Poverty Index	
	Lower	Upper	Lower	Upper	Lower	Upper
Bangladesh	38.8	50.1	10.0	14.4	3.5	5.6
Dhaka	25.4	36.9	5.6	9.0	1.8	3.2
Jessore	30.6	41.2	7.0	10.1	2.3	3.6
Patuakhali	30.5	40.1	7.6	10.7	2.8	4.1
Kushtia	30.3	44.2	7.2	11.1	2.7	4.2
Sylhet	37.5	43.9	9.7	12.3	3.6	4.8
Comilla	35.6	48.2	8.0	12.5	2.8	4.7
Chittagong H.T.	35.6	47.4	9.8	12.7	3.6	4.9
Khulna	35.6	46.8	8.8	12.9	3.1	5.1
Noakhali	33.7	43.0	9.4	13.2	3.4	5.3
Barisal	38.1	49.7	9.9	13.7	3.5	5.3
Dinajpur	42.5	50.6	11.2	14.2	4.2	5.6
Pabna	42.2	48.5	11.8	14.6	4.2	5.6
Chittagong	34.0	50.3	7.5	14.7	2.3	5.6
Bogra	39.3	48.4	11.5	14.8	4.7	6.3
Rajshahi	44.9	55.1	10.8	15.2	3.6	5.6
Tangail	36.8	57.7	8.6	15.7	2.7	5.7
Kishoreganj	36.7	51.1	9.9	16.1	3.9	6.9
Jamalpur	51.5	58.5	14.0	17.7	5.1	7.0
Rangpur	56.7	66.9	15.5	21.3	5.5	8.6
Mymensingh	62.7	72.4	18.4	22.7	6.8	9.1
Faridpur	49.9	65.4	14.4	22.9	5.4	10.2

Source: Adapted from Hi-Tech Info Processing Centre and Bangladesh Institute of Development Studies (BIDS) (2003a).

[5] Please note that these 21 regions do not reflect any official administrative partition of Bangladesh.

Though it is not unusual that different studies on and methods for assessing poverty come to somehow different results, the striking differences especially between Figures 2 and 3 make the poverty data more or less useless for our comparison.

II. 2. Landlessness

We use the corrected data on total households and landless households of 1997 (as provided in Appendix III of RDRS Bangladesh (2005)) for calculating the percentages of landless households in total households at the upazila level, which then combined with the proportions of CHT tribal population at the upazila level [as provided in LGED and ICIMOD (2006), see Figure 1 above] and the corrected 2001 census data for each upazila allow to estimate the percentages of landlessness for the two groups, see Table 2.[6]

Table 2: Landlessness, 1997

Average landlessness of tribal population	Average landlessness of all non-tribal Population
20.36%	34.20%

Memorandum items: Average landlessness of			
total national population	*total national, without all CHT population*	*total CHT population*	*non-tribal population of CHT*
34.16%	*34.28%*	*23.93%*	*25.11%*

For further comparisons (which also serve as consistency checks), the last row of Table 2 also shows the average landlessness rates for (a) the total national population, (b) the total national without all CHT population, (c) the total CHT population, and (d) the non-tribal population of CHT. Hence, as was the case at the national level, the tribal population is estimated to be less landless (by about 5 percent) than the non-tribal population living in the CHT. The numbers for (a) the percentage of average landlessness of all non-tribal population (34.20%) and (b) the average landlessness of the total national population (34.16%) are very close to each other as the CHT tribal population constitutes less than one percent of the total population of Bangladesh.

[6] The data has been checked and corrected for any mistakes given in the original sources. For example, the 2001 census data as provided on the BBS website (http://www.bbs.gov.bd/dataindex/census/ce_uzila.pdf) gives the total population of Gaibandha zila as 213,818, while the male and female populations are given as 1,085,097 and 1,053,084, respectively. Hence, it is obvious that the total population of Gaibandha is 2,138,181 (not 213,818). Furthermore, given that the combination of the data on landless households in 1997 with the population from the 2001 census may cause some bias, we also calculated the landlessness by using the population data from the 1991 census. However, given that this resulted in only very marginal differences in the landlessness values (e.g., the average landlessness of tribal population is 20.25%, while the average landlessness of the non-tribal population is 34.11%), the conclusion drawn about the difference in average landlessness of tribal and non-tribal remains valid.

II.3. Illiteracy

We use the corrected literacy and population data from the 2001 census combined with the proportions of CHT tribal population at the upazila level [as provided in LGED and ICIMOD (2006), see Figure 1 above], to calculate the average illiteracy rates for the tribal and non-tribal populations. As Table 3 shows, the average illiteracy of the tribal population is significantly higher than for the average non-tribal population.

Table 3: Illiteracy Rates, 2001

Average illiteracy of tribal population	Average illiteracy of all non-tribal Population
62.53%	53.78%

Memorandum items: Average illiteracy of			
total national population	*total national, without all CHT population*	*total CHT population*	*non-tribal population of CHT*
53.80%	*53.74%*	*59.60%*	*58.68%*

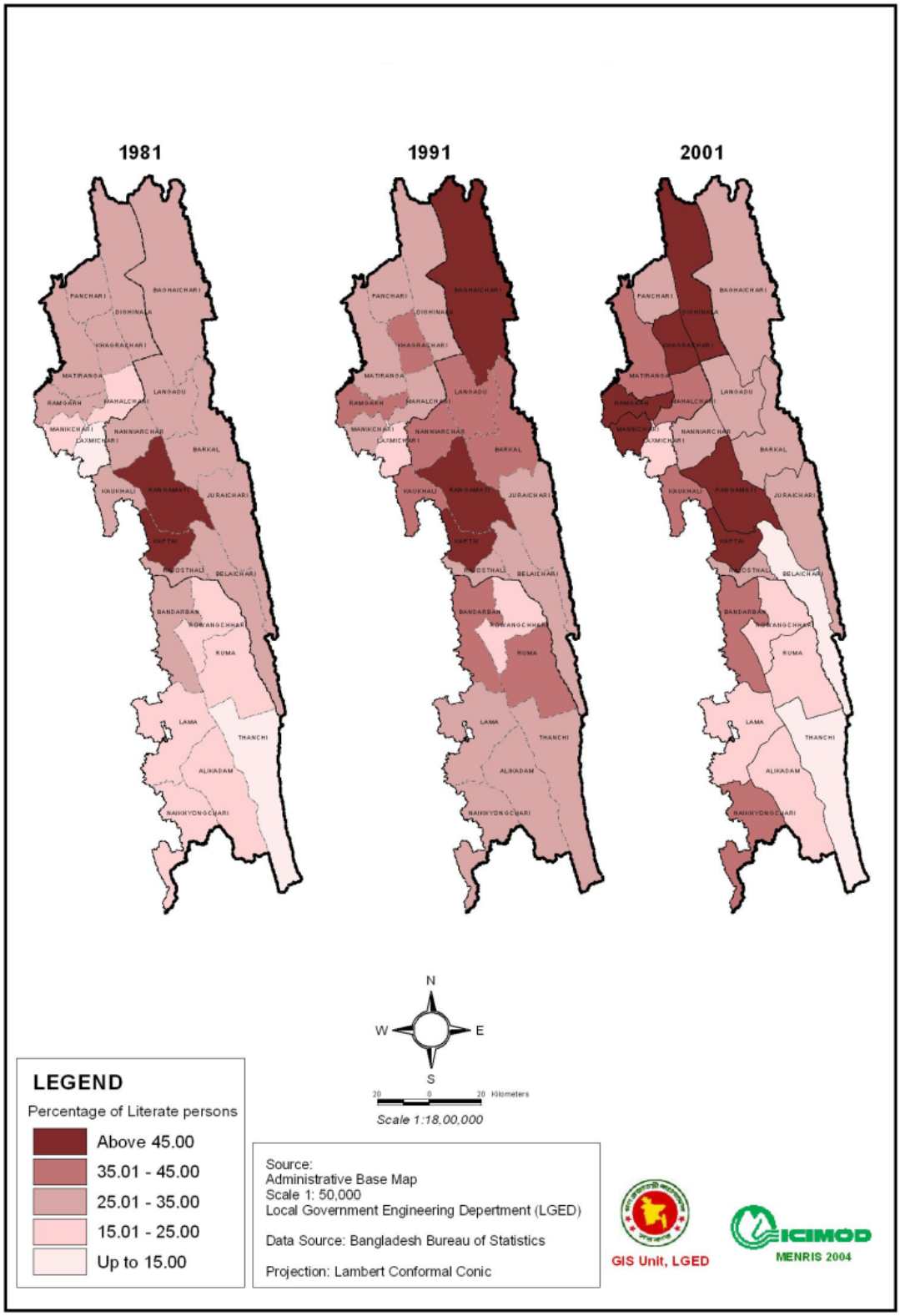
Like for Table 2, the last row of Table 3 shows the average illiteracy rates for (a) the total national population, (b) the total national without all CHT population, (c) the total CHT population, and (d) the non-tribal population of CHT. We can see that while the average illiteracy rate of the total CHT population is significantly higher than the national average, the tribal population is still more illiterate than the non-tribal CHT population.

Table 4: Illiteracy Rates, 1991

Average illiteracy of tribal population	Average illiteracy of all non-tribal Population
67.57%	67.60%

Memorandum items: Average illiteracy of			
total national population	*total national, without all CHT population*	*total CHT population*	*non-tribal population of CHT*
67.60%	*67.59%*	*68.54%*	*68.85%*

Figure 4: Total Literacy Rates, 1981, 1991, and 2001



Source: Local Government Engineering Department (LGED) and International Centre for Integrated Mountain Development (ICIMOD) (2006).

Comparing the illiteracy rates of the 2001 census (Table 3) with the 1991 census (Table 4), shows huge differences, as based on the 1991 census data, the difference in illiteracy between tribal and non-tribal populations is close to zero. We also show these differences in literacy rates over time (1981, 1991, and 2001) in Figure 4. Searching for an explanation for these large changes over time, it is useful to look at the population movements in the CHT between 1991 and 2001. For example, there have been significant in-migration and/or returns of refugees during 1991-2001 in two of the three CHT districts (zilas): Bandarban's population increased by 27 percent, Khagrachhari's population increased by 53 percent, while the overall population of Bangladesh increased by 15 percent.[7] It would be useful to have some more detailed data on who moved in and out of the CHT between 1991 and 2001, in order to explain the significant deterioration in the tribal population's literacy rates.

II.4. Socio-economic Vulnerability Index (SVI)

Some years ago, the International Development Research Centre (IDRC) of Canada had a large-scale program on assessing the Micro Impacts of Macroeconomic Policies (MIMAP) in Bangladesh, which also provided a variety of papers on measuring poverty in Bangladesh, see Figure 4 above. The MIMAP's Technical Paper No. 08, authored by Hi-Tech Info Processing Centre and Bangladesh Institute of Development Studies (BIDS) (2003b), used a so-called "Socio-economic Vulnerability Index (SVI)" for 21 regions of Bangladesh, including for the CHT, based on data collected for the 1999 Poverty Monitoring Survey (PMS) conducted by the BBS with support from MIMAP-Bangladesh. The socio-economic vulnerability is measured by the percentage of households facing crisis, both manmade and natural (e.g. death of income earner, large/unexpected medical expenses, crop/property loss due to flood, cyclone and other natural disasters, eviction, theft, litigation, extortion dowry payment, and other unforeseen events). The combination of manmade and natural factors makes this index only of limited use to assess vulnerability to climate change. Anyway, among the three levels of this index (low, medium, and high), the CHT are assigned a low socio-economic vulnerability index; see Figure 5 below. There is however no disaggregation available for tribal and non-tribal populations.

II.5. Conclusion

In conclusion, there are two individual vulnerability indicators that allow us to disaggregate between tribal and non-tribal population: landlessness and illiteracy. The estimates for landlessness indicate that the average tribal person is far less vulnerable than the average non-tribal person, while the estimates for illiteracy indicate that the average tribal person is far more vulnerable than the average non-tribal person. It should be stressed that these two results are not necessarily contradictory as different groups of the population may very well exhibit different vulnerabilities. The tribal population may have a lower proportion of landless people than the Bengali population at the national level (hence, this may be one of many explanations for the in-migration into the CHT);

[7] In Rangamati district, the population increased by 17 percent between 1991 and 2001, hence, just slightly above the national average. However, there may still have been considerable population movements or people moving in and out, cancelling each other out.

yet, the tribal population may—due to a variety of reason, like for example, civil conflicts before the peace accord of December 1997—be less literate than the Bengali people.

Figure 5: Socio-Economic Vulnerability

(Note: Given that the legend is a bit fuzzy, the green area reflects high vulnerability; the blue area reflects medium vulnerability; and the purple area reflects low vulnerability)

Source: UNDP's Millennium Development Goals (MDG) data website
http://www.mdgbangla.org/mdg_issues/poverty/poverty_data_bids.htm
[based on Hi-Tech Info Processing Centre and Bangladesh Institute of Development Studies (BIDS) (2003b)].

III. Analysis of Spatial Vulnerability to Climate Change

Looking at spatial vulnerabilities, we face severe data constraints to disaggregate between tribal and non-tribal people within the CHT. However, there are by now some very useful hazard maps, showing the vulnerable areas of Bangladesh to hazards that are very likely to increase in their frequency and severity, like droughts, floods, landslides, and cyclones. While these spatial vulnerability indicators have the advantage of being more directly related to climate change than individual vulnerability indicators, they typically also have the disadvantage of being much more subjective (i.e., based on some assumptions beyond the certainty of global warming). It should also be stressed that these hazard maps are not vulnerability maps, as hazard maps do not take any other vulnerability factors (like population density in the exposed area) into account. However, they are quite useful for our vulnerability comparison between tribal and non-tribal populations due to different spatial concentrations of these two populations.

III.1. Climate Change-Induced Increases in Droughts

As the climate change literature has pointed out, climate change will diminish already low rainfall in the dry season and will increase winter and pre-monsoon temperatures significantly, causing more frequent and more severe droughts in Bangladesh. The likely most affected areas of Bangladesh can be identified based on (a) historical drought hazard maps (see Figure 6) and (b) projections on climate change-induced drought maps (see Figure 7). We provide both hazard maps as they differ significantly in terms of affected area and some readers may prefer historical facts over more uncertain[8] projections. Based on historical data, the CHT have not been vulnerable to droughts, with exception of Mahalchhari and Lama upazilas (experiencing moderate droughts), and Bandarban upazila, Rajasthali upazila and the southern part of Kaptei upazila (experiencing slight droughts). However, based on climate change projections, the whole area of the CHT (except a small part of Lama upazila) is expected to experience moderate droughts during the Rabi & Pre-Kharif season (typically November to February) by 2030.

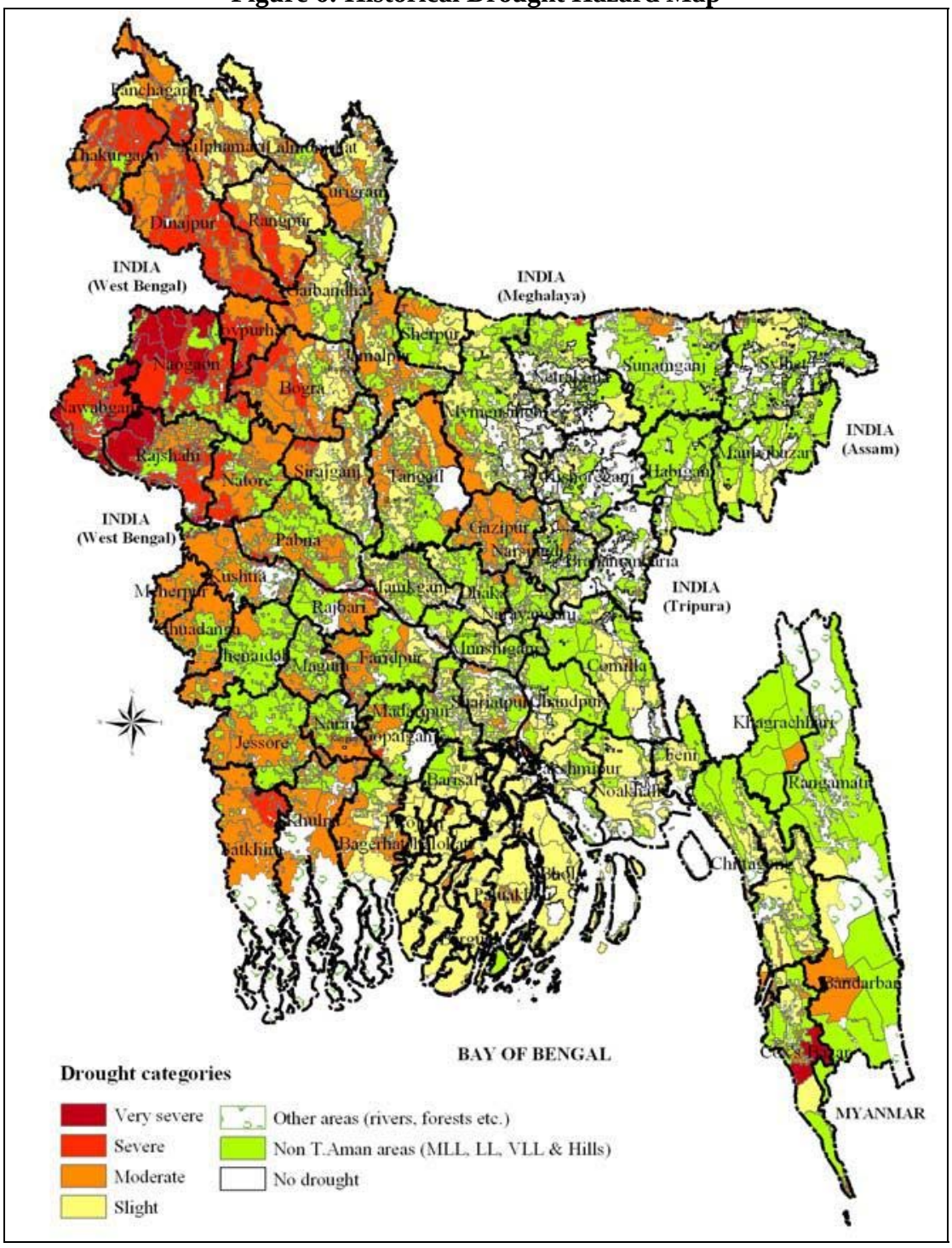
III.2. Climate Change-Induced Increases in Floods

Like for droughts, the Climate Change Cell's (2006) fact sheet and the Ministry of Environment and Forest's (2005) National Adaptation Programme of Action (NAPA) provide useful hazard maps based on current flood regimes and projected impact of water resources on arable land. Figure 8 shows the current flood regime. Figure 9 shows the flood regime and land type projected for 2075, based on Alam, Nishat and Siddiqui (1999), who assessed vulnerability of water resources considering changes in flooding conditions due to a combination of increased discharge of river water during the monsoon period and sea level rise. The analysis found that much of the impact would be for F0 land, followed by F1 land, where embankment played an important role in restricting the extent of flood affected areas. A combination of development and climate change scenarios revealed that the Lower Ganges and the Surma floodplain would become more

[8] To avoid any misunderstanding, it is by now certain that there will be an increase in frequency and intensity of droughts due to climate change, however, the exact location and severity is still somehow uncertain.

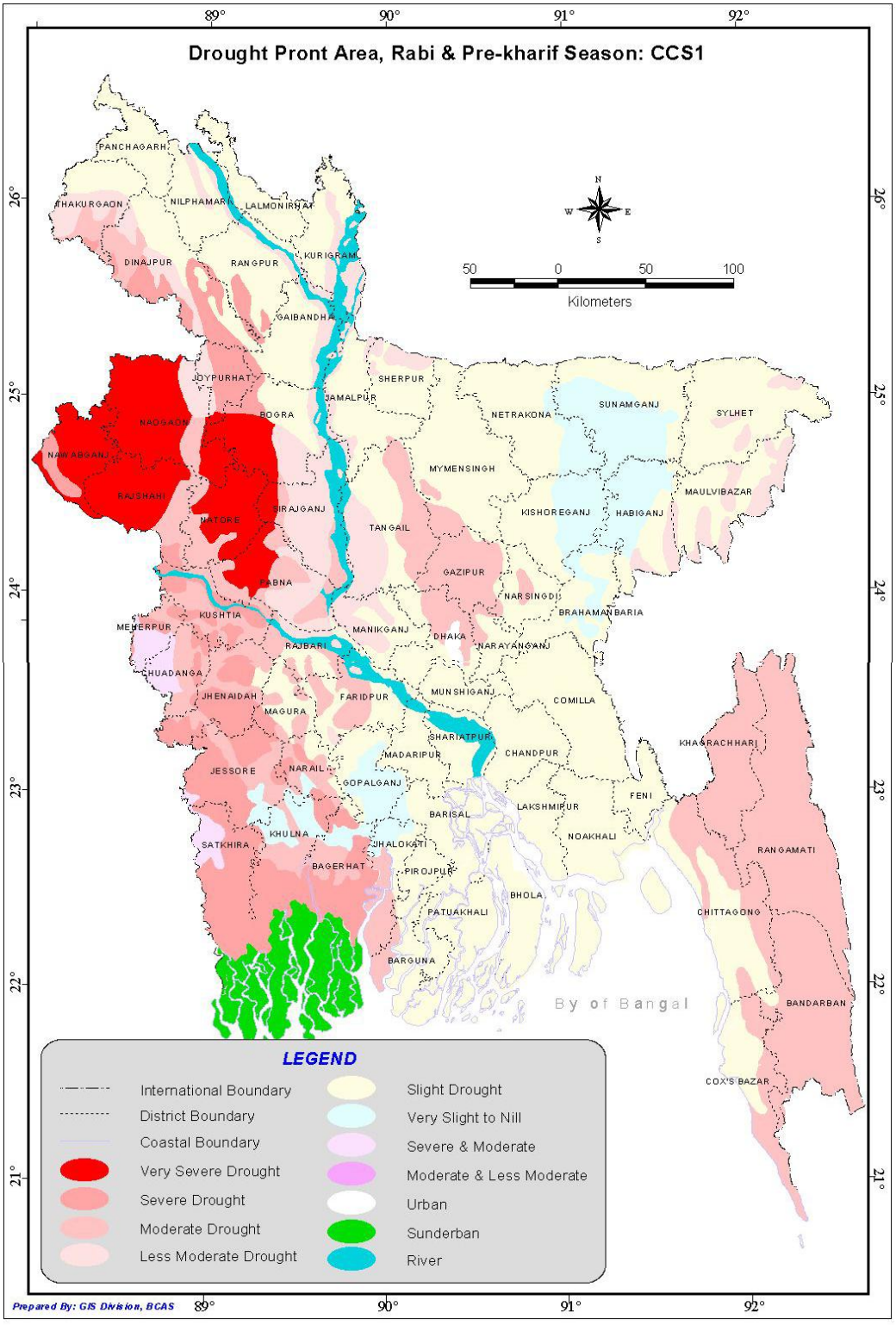
vulnerable compared to the rest of the study area. On the other hand, the north-central region would become flood free due to embanking of the major rivers; please see Alam, Nishat and Siddiqui (1999) for further details.

Figure 6: Historical Drought Hazard Map



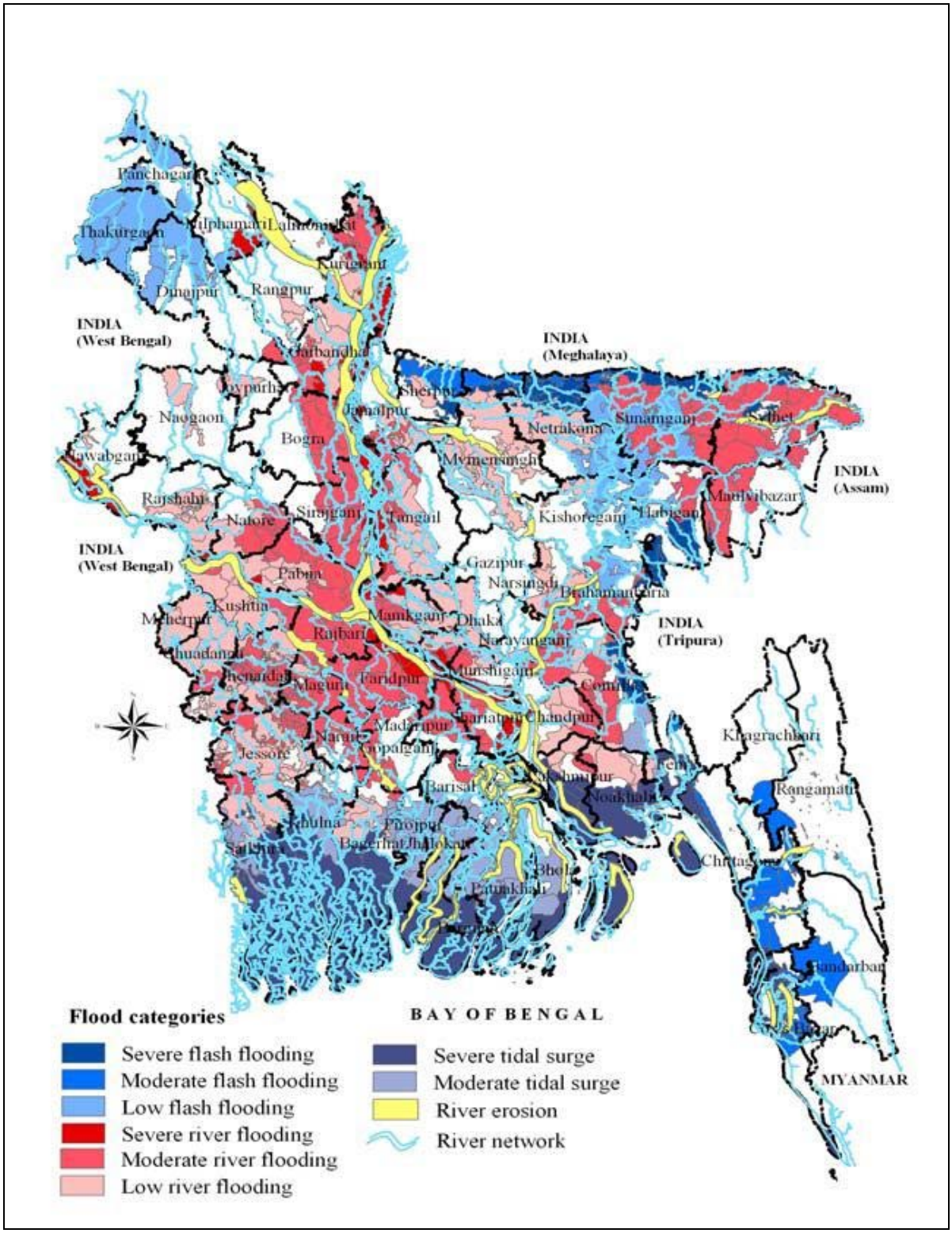
Source: Climate Change Cell (2006).

Figure 7: Drought Impact Area by 2030



Source: Ministry of Environment and Forest (2005), Figure 6, page 15.

Figure 8: Historical Flood Hazard Map



Source: Climate Change Cell (2006).

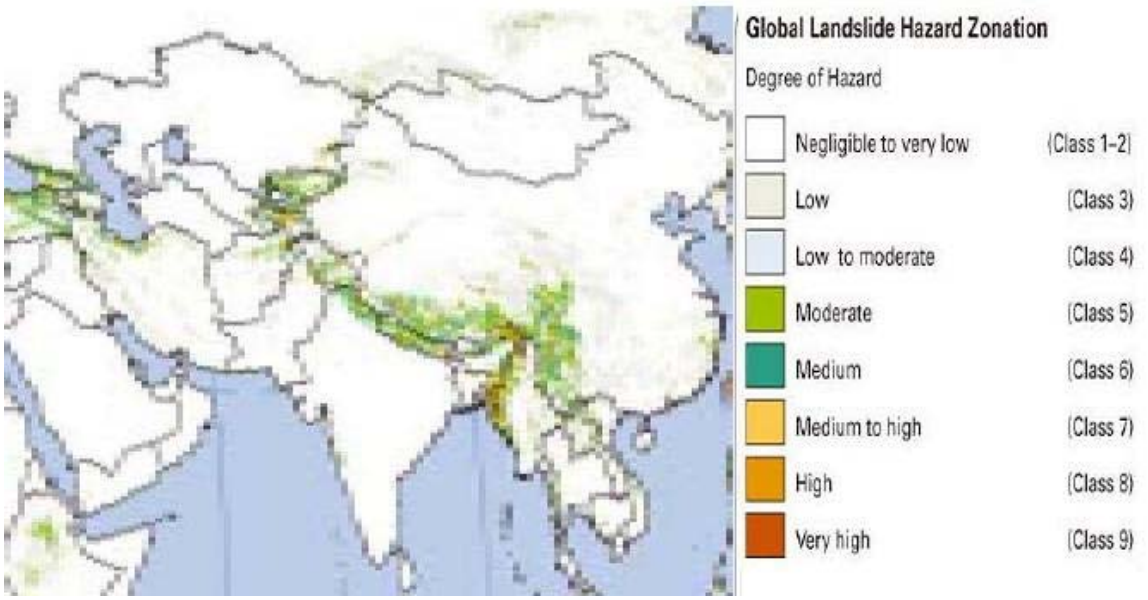
Figure 9: Flood Regime and Land Type in 2075

Source: Adapted from Ministry of Environment and Forest (2005), Fig. 4, p. 12
[based on Figure 7 of Alam, Nishat and Siddiqui (1999), p. 36].

III.3. Climate Change-Induced Increases in Landslides

Nadim, Kjekstad, Domaas, Rafat and Peduzzi (2006) provide one of the most comprehensive studies related to landslides around the world. They show that the landslide hazard level depends on a combination of trigger and susceptibility factors, whereby the precipitation and seismic conditions are triggers while the slope factor within a selected grid, the lithological (or geological) conditions and the soil moisture conditions are susceptibility factors. They provide a global landslide hazard zonation map, of which a small section (explaining the relatively bad quality) is represented in Figure 10. While the degree of landslide hazard is not clearly visible, it is clear that the whole Chittagong Division is within the medium to severe global landslide hazard zonation. Hence, based on this broad hazard map, the tribal and non-tribal populations are likely equally affected by landslides as long as these populations live in the hazard zone. However, comparing the exposure of the tribal population that is concentrated in the CHT to the Bengali population all over the country, the tribal population is due to their concentration in the CHT relatively more vulnerable to landslides than the Bengali population at the national level, even though a substantial part of the Bengali population (those living in the Chittagong Division) is equally vulnerable to landslides.

Figure 10: Landslide Hazard Map

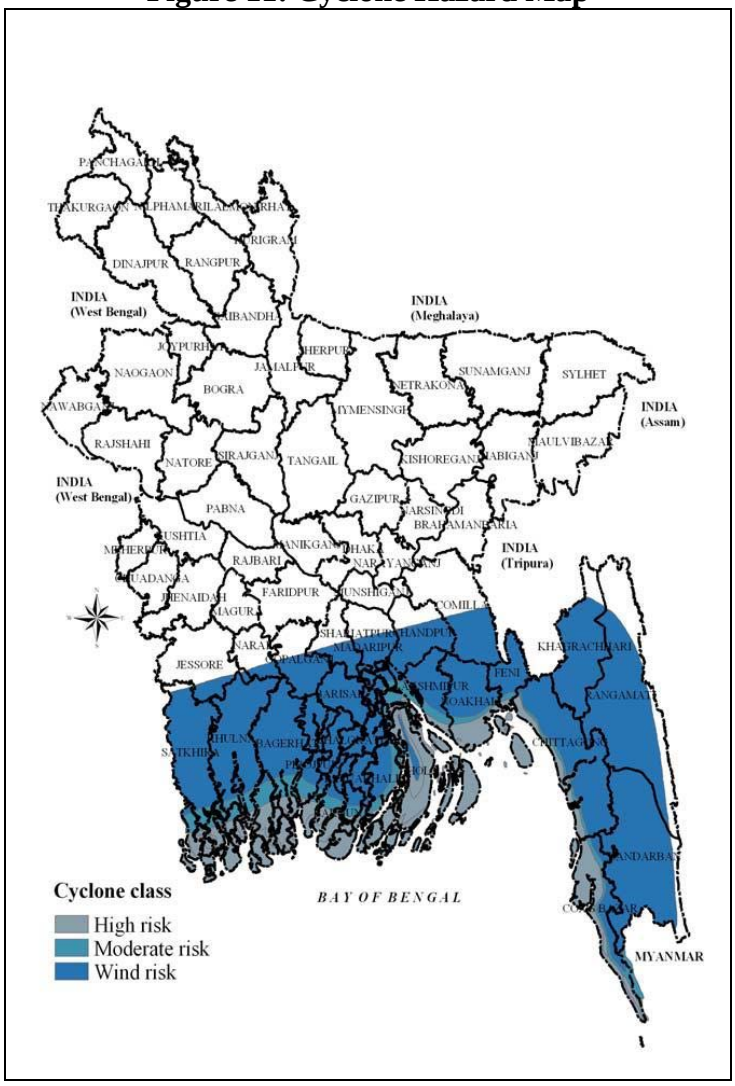


Source: Excerpt from Nadim, Kjekstad, Domaas, Rafat, and Peduzzi (2006), p. 56.

III.4. Climate Change-Induced Increases in Cyclones

While water-related hazards, including from floods and sea-level rise, have been looked at in Figure 9, Figure 11 provides the cyclone hazard map that looks mainly at storm damages resulting from cyclones. It shows clearly that even though the CHT are not within the area or high or moderate risk, most of the CHT are vulnerable to wind risk resulting from a climate change-induced increase in frequency and intensity of cyclones.

Figure 11: Cyclone Hazard Map



Source: Climate Change Cell (2006).

III.5. Conclusion on Spatial Vulnerability

In conclusion, looking at our six hazard maps, all of the tribal population and a significant part of the non-tribal population seem to be highly vulnerable to climate change-induced increases in droughts, floods, landslides and cyclones. The only other severe spatial vulnerability we have not analyzed is that related to sea level rise, though it

is obvious that (unlike a considerable part of the Bangladeshi population) the CHT are not directly vulnerable to sea level rise.

IV. Conclusions and Recommendations

Our analysis has shown that the average Bangladeshi's tribal household seems to be less landless than the average Bengali household. Hence, based on this indicator, the tribal population seems to be more capable to adapt to climate change than the non-tribal population. However, our analysis has also shown that based on the latest census data, the tribal population seems to be more illiterate than the non-tribal population, which is likely to make them less capable adapting to climate change. With regards to spatial vulnerabilities, the review of a variety of hazard maps seems to indicate that both tribal and non-tribal populations are highly vulnerable to climate change-induced increases in droughts, floods, landslides and cyclones.

Tempting as it is, we restrain from making any statements about which group is overall more or less vulnerable to climate change, for at least two reasons. First, the vulnerabilities we have analyzed and reviewed are not additive, i.e., we cannot add different vulnerabilities to come up with an overall vulnerability measure to compare vulnerability across the two groups. Second, there remain considerable uncertainties, especially with regards to the spatial vulnerability indicators on which area and ethnic group will be affected and to which degree. Yet, this does not mean that we cannot start with looking for preventive policies in form of mitigation and adaptation.

With regards to climate change mitigation, the options are clearly limited for Bangladesh as Bangladesh is contributing only marginally to climate change. Yet, Bangladesh has already implemented a variety of mitigation policies, like (a) switching from gasoline to natural gas for motor vehicles and (b) using solar energy, especially in rural areas (even though partly due to other reasons than climate change mitigation). Specifically for the CHT, one mitigation option is to limit the climate change-induced increase in frequency and intensity of landslides by stopping the ongoing deforestation, of which some is legal and some illegal (but not properly enforced).[9]

With regards to adaptation polices, the above climate change literature provides many of them, and nearly all of them apply as much to the tribal as to the non-tribal population. The following are therefore some recommendations as they can be drawn specifically from linking the results of our analysis with the literature on indigenous people in the CHT.

First, given the seemingly lower literacy rates of the tribal population, efforts should be intensified to increase enrolments to primary education and to improve the quality of primary education in the CHT. Looking at the evolution of literacy rates in the CHT (as

[9] As Smith and Vivekananda (2007, p. 16) point out: "about 400,000-600,000 people have moved within Bangladesh to the Chittagong Hill Tracts (CHT), where they have cleared trees on the steep hillsides and begun farming, resulting in soil erosion and unsustainable livelihoods".

displayed in Figure 4 above), it would also be useful to find out why literacy rates have dropped so severely in some CHT upazilas, especially in Belaichhari and Thanchi (where literacy rates seem to have dropped to below 15 percent). Moreover, in addition to basic literacy, it is important to provide market-relevant skills training (see Asian Development Bank, 2007)) to be less vulnerable to climate-induced impacts that are likely most severe in the agricultural sector.

Second, even though the average tribal household is estimated to be less landless than the average Bengali household, it is clear that the quality of land has been deteriorating rapidly in the CHT, largely due to short rotation slash and burn agriculture (also known as swidden cultivation or jhum chash). As Rasul (2006) has pointed out, polices and programs to promote alternative land use practices have largely failed; and while indigenous people are blamed for the problem, which is attributed to their conservatism and unwillingness to adopt alternative land use systems, Roy (2000) has pointed out that the dependence on swidden cultivation has—largely due to displacement—increased significantly during the political unrest of the 1980s and 1990s. Similarly, Thapa and Rasul (2006) have stressed that attempts to replace shifting cultivation with more productive types of sedentary agriculture have failed due to the absence of (a) secure land rights, (b) supportive trade policies, and (c) the required support services and facilities, including infrastructure. Hence, further improvements in these areas will also be useful for adapting to climate change.

Table 5: Average Annual Income of Indigenous Households (in Takas)

Source of Income	Bandarban	Rangmati	Khagrachari
Agriculture	10,251	4,116	5,316
Forest Products	2,092	5,267	1,988
Agri Wage Labour	6,756	4,138	2,231
Non-agri Wage Labour	1,336	1,816	1,589
Artisan Activities		28	73
Skilled Employment	15	60	1,100
Business	108	2,310	1,281
Wine-making	446	77	259
Fishing		50	1,743
Others	88	1,809	516
Total	21,092	19,673	16,101

Source: Table 9 of Roy (2000), based on a Preliminary Survey Report by CARE of March 1999.

Third, there is some indication that the tribal population remains more dependent on agriculturally- and forest-based income than the average Bengali population (see Roy, 2000), even though there are significant differences across the three CHT districts (see Table 5) and non-traditional employment is rising. There is some disagreement, especially among the tribal people, if a further increase in non-traditional employment is desired, as more monetary income does not necessarily come with better living

conditions, especially if taking the deterioration of social values into account. In any case, having more land (especially if being dependent on it) may at some point in the future become an indicator for being more vulnerable to climate change as most of the CHT land will be exposed to droughts, floods, and landslides. Hence, some strategy for the diversification of income sources for the tribal as well as the non-tribal people should be considered. However, one mistake that needs be avoided is that non-tribal people make the decision for tribal people. As Roy (2000, p. 111) has stated: "Externally-conceived development planning for the Chittagong Hill Tracts has done more harm than good to the indigenous peoples, and to their traditional occupational practices."

Fourth, while Bangladesh has made significant progress with building cyclone shelters and setting up national warning systems, Howell (2003) has shown that due to a combination of physical, economic and social factors, the most vulnerable people are the least forewarned and prepared. Reviewing a variety of indigenous early warning indicators, she suggests that some of the indigenous early warning indicators could be incorporated into locally managed warning systems, to increase the empowerment and resilience of poor and vulnerable people. Similarly, there is some indigenous knowledge like (a) indigenous floating cultivation (see Islam and Atkins, 2007), and (b) the protection of forest commons (see Roy and Halim, 2003) that will allow to cope better with climate change-induced hazards. Listening to tribal people and learning from them could in some cases be useful to promote alternatives that conserve indigenous values as well as reduce the vulnerability to climate change.

Finally, given that climate change impacts will inadvertently put stress on the peaceful coexistence of tribal and non-tribal people in the CHT (see Smith and Vivekananda (2007) for an outstanding analysis of the links between climate change and conflict and van der Molen and Rahman (2007) for disputes over water and natural resources in Bangladesh), it would be useful to undertake further measures to defuse the remaining ethnic conflict and social tensions.

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