THE SOCIAL IMPACTS OF CLIMATE CHANGE IN SOUTH ASIA

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1. Background

Climate change is undoubtedly the most serious environmental crisis Earth has ever witnessed. As the planet enters what many are terming the 'Anthropocene' period in its geological history (Crutzen and Stoermer 2000) the impacts of climate change—along with the side-by-side destruction of ecosystems associated with the relentless industrialisation of the land and oceans—will transform forever its physical and biological properties. At smaller scales of time and space societies too are expected to undergo radical and irreversible changes. Indeed, in the context of South Asia, climate change is not only the biggest environmental threat faced by the region but also the likely cause of extraordinary social and economic problems in the course of this century.

While it is virtually impossible to forecast the physical impacts of climate change with great accuracy at the regional scale, given vast uncertainties in input parameters as well as non-linearities in system dynamics, there are several added difficulties in predicting its social impacts. One has to do with 'reflexivity' of human agency, i.e., the ability of people and societies to shift course based on their observation of how they are changing the world around them. Another, which counteracts the tendencies of the first, has to do with fundamental problems of collective action, i.e., the disconnect between individual rationality and social welfare, which in turn confounds expectations that 'rational' policies will take place in time to address social problems. The only reasonable solution to these difficulties is to use scenarios – a mix of internally consistent qualitative narratives with quantitative illustrations – to tell compelling stories about what could happen to societies under different pressures in the future.

In this paper, we focus on an especially important set of social impacts resulting from climate change in South Asia, namely the displacement of vast numbers of people as a consequence mainly of sea level rise along the coasts and secondarily from drought in rural areas. We examine these impacts through the use of scenarios involving alternative assumptions about whether or not effective policies will be developed in time, given what we know now about the physical changes that are likely to take place.

2. Estimates of climate impacts in South Asia

According to the Intergovernmental Panel on Climate Change (IPCC), Asia will be one of the most severely affected regions of the world as a result of "business-as-usual" global warming,

> Countries in temperate and tropical Asia are likely to have increased exposure to extreme events, including forest die back and increased fire risk, typhoons and tropical storms, floods and landslides, and severe vector-borne diseases. The stresses of climate change are likely to disrupt the ecology of mountain and highland systems in Asia. Glacial melt is also expected to increase under changed climate conditions. Sea level rise would cause large-scale inundation along the vast Asian coastline and recession of flat sandy beaches. The ecological stability of mangroves and coral reefs around Asia would be put at risk. (IPCC 2007: 472)

The IPCC goes on to estimate that even under its most conservative scenario, sea level in 2100 will be about 40 cm higher today, which will cause an additional 80 million coastal residents in Asia alone to be flooded. The majority of those flooded will be in South Asia, particularly in Bangladesh and India. A one metre sea level rise would result in nearly 6000 square kilometres in India alone being flooded, including parts of major cities such as Mumbai, Calcutta and Chennai. Sea level rise will affect the coastal zone in multiple ways, including the inundation and displacement of wetlands and lowlands, coastal erosion, increased coastal storm flooding and salinisation.

The impacts will vary by location depending upon the coastal morphology and the extent of human modification. Rapid urbanisation has led to the enlargement of natural coastal inlets and dredging of waterways for navigation, port facilities and pipelines, all of which exacerbate saltwater intrusion into surface and ground waters. Thus, built-up areas are more vulnerable than those protected by mangroves, and deltas, low-lying coastal plains, coral islands, beaches and barrier islands. Degradation of coastal ecosystems by human activity will generally aggravate the problems caused by sea level rise, increasing shoreline retreat and coastal flooding in cities. Moreover, protection by dikes needs to consider not just the extent of average sea level rise but also the effect of more frequent and intense storm surges. Protection from sea level rise using engineering solutions is in any case not a viable option, especially for increases greater than a few tens of centimetres. One study estimated that the minimum cost of protection against 1 metre sea level rise would be about ~$500,000 per km, but even then about 20-50% of vulnerable population would not be protected (Tol, R. 2002).

How much sea level rise is likely to take place in the course of this century is still in question. Several scientists have challenged the IPCC's projections of about a half-metre of sea level rise by the end of the century as an under-

estimate on account of its omission of any effect of ice-sheet dynamics. More realistic assessments, which take into account current understandings of business as usual conditions, suggest therefore that a 3-5 metre rise in sea levels is not out of the question with a 4-5 degree rise in average global temperatures, which will hasten the break-up of ice sheets in Greenland and Antarctica[1]. Such an increase, as we shall see, will almost entirely engulf densely populated regions all along the South Asian coast line.

In addition, the South Asian region will suffer from serious problems relating to water availability, substantial reductions in the yields of wheat and maize, increases in disease, flooding in some areas and drought in others, and potentially serious disruptions of the entire monsoon cycle. Substantial reductions in water availability are possible for large parts of North India, roughly 80% of whose water resource needs are met primarily by Himalayan snow-pack melt during the dry summer months.

The south-west monsoon is one of the most significant weather events in the world and delivers about 90 percent of the annual rainfall for the region. The onset, duration, spatial extent and total precipitation of the monsoon are all critical factors in determining the health of India's agricultural sector, which continues to play a dominant role in the country's economy. According to one estimate, 45 percent of the variation in India's gross domestic product over the last 50 years can be explained by the fluctuations in rainfall (FAO 2006). Of greatest concern is the possibility that the monsoon may shift its pattern abruptly and substantially, because of broader changes induced by global warming (Shukla, J. 2007).

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[1] For instance, James Hansen (2007), Director of the NASA Godard Institute for Space Studies writes:

> [A]s a physicist, I find it almost inconceivable that [Business as Usual] climate change would not yield a sea level change of the order of meters on the century timescale.

Similarly, in a recent study by the German Advisory Council on Global Change (WBGU 2006: 38):

> Rates for sea-level rise of up to 5m per century are documented, and these probably do not represent an upper limit. Thus climate history shows that a much more rapid rise than that expected by the IPCC for the 21st century is possible.

3. Human Impacts and Potential for Displacement

A. Sea level rise

Sea level rise will affect coastal populations in a variety of ways, including inundation itself, flood and storm damage, erosion, saltwater intrusion, rising water tables and impeded drainage wetland loss. These will together greatly reduce the ability of these regions to provide their inhabitants access to their land or to their means of cultivation, water resources and fodder, causing severe hardship in terms of livelihood and habitat loss. Worst of all, sea level rise and the associated changes in the coastal zone will add burdens to those already poor and vulnerable. The South Asian region is home to the largest number of people living in poverty, many of whom live in the coastal zone.

In the three South Asian countries sharing a coast line—Bangladesh, Pakistan and India—nearly 130 million people currently live in the area of about 160 thousand square kilometres known as the Low Elevation Coastal Zone (LECZ), which comprises the coastal region that is within 10 metres above average sea level. The bulk of the region's LECZ population (about 97%) resides in Bangladesh and India, with roughly equal numbers each. This is the result of Bangladesh being mostly in the low-lying delta region of the Ganges-Brahmaputra and India having a very long coast line with many major cities. Figures 1 and 2, respectively, show the spatial extent of the LECZ in the two countries. In Bangladesh, most of the vulnerable population (75%) is rural, whereas in India is almost equally split between both rural and urban groups (see Table 1).

	Area of LECZ (square km)	Population in LECZ	Urban Population in LECZ	Fraction of Urban Population in LECZ in Cities Exceeding 5 Million
Bangladesh	54,461	65,524,048	15,428,668	33%
India	81,805	63,188,208	31,515,286	58%
Pakistan	22,197	4,157,045	2,227,118	92%
Sri Lanka	5,536	2,231,097	961,977	0%

Table 1. Summary of Low Elevation Coastal Zone (LECZ) Statistics for 4 Countries in South Asia (*Source: sedac.ciesin.org*).

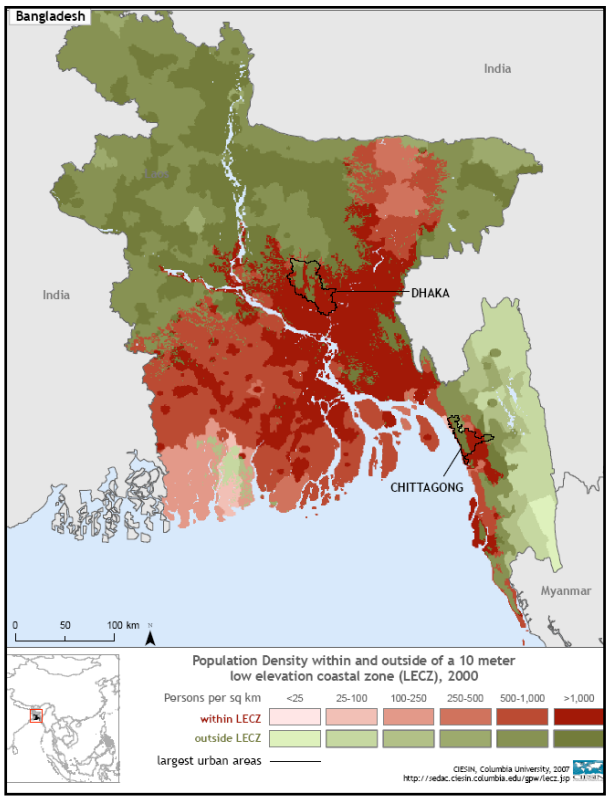


Figure 1. Population Density within and outside the 10m Low Elevation Coastal Zone in Bangladesh (*Source: sedac.ciesin.org*).

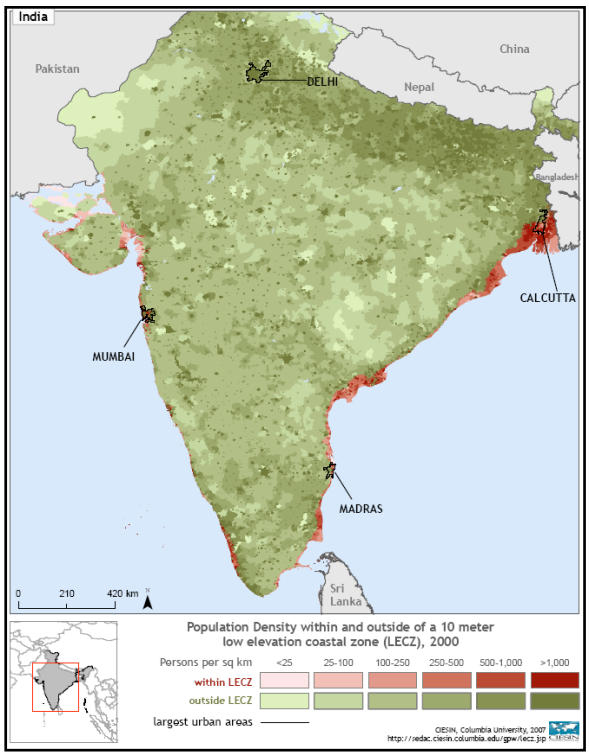


Figure 2. Population Density within and outside the 10m Low Elevation Coastal Zone in India (*Source: sedac.ciesin.org*).

The most vulnerable communities will include those having maximum exposure to the stresses as well as those with the least capacity to respond and ability to recover (Turner, B. et al. 2003; Adger, W. et al. 2005). The physical changes will themselves take place in abrupt, non-linear ways as thresholds are crossed. In turn, the least resilient communities (e.g., those dependent on subsistence fishing) will be the first to experience 'tipping points' in their life systems, so that the only livelihood option available to them will be to abandon their homes and search for better prospects elsewhere. As ever larger numbers of these people pass thresholds in terms of their ability to cope, societal tipping points will be crossed, resulting in the sudden mass movements of entire villages, towns and even cities in coastal regions towards safety.

While the actual triggers of migration are complex, historical evidence of migration from regions experiencing ecological or other stress indicates that population movements tend to take place in waves, often towards regions that are seen as being attractive because of pre-existing family or community contacts, job opportunities and cultural affinity (Myers, N. 2002; Henry, S. et al. 2004; McLeman, R. and Smit, B. 2006). More often than not, the largest recipients of migrants tend to be urban areas, either within or outside the country's borders. Frequently, the bulk of early migrants tend to relatively young, which creates additional stresses in the remaining

populations, thus increasing the likelihood of ever larger waves of migrants leaving the vulnerable regions.

In South Asia, large coastal cities such as Dhaka, Mumbai and Kolkota are at average elevations of 2-10 metres; overall, some 47 million live in urban areas in the LECZ, half of whom are in cities larger than 5 million in population. It is not inconceivable therefore that a 3-5 metre rise in average sea level by the end of the century could effectively de-urbanise the major population centres of the region along the coast. If that were the case, it is likely that significant population movements will occur towards other large urban settlements in the interior of the country rather than get dispersed in the hinterland of existing coastal cities. Under these circumstances, it is likely that large cities such as Delhi, Bangalore, Ahmedabad, Pune and Hyderabad, which will already have serious resource constraints of their own by the middle of the century, will have to be prepared to accommodate enormous numbers of migrants from the coasts. Meanwhile, the cities along the coast would have lost trillions of dollars in terms of their existing physical and social capital.

B. Drought and Water Scarcity

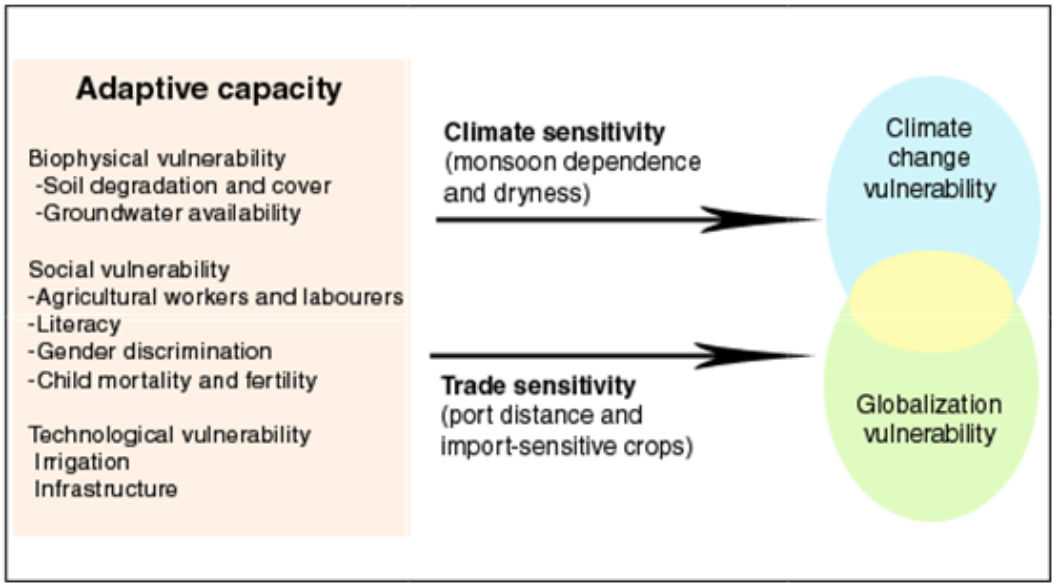
Meltwater from Himalayan glaciers and snowfields is a major source of water during summer months in Northern India. The loss of this resource as a result of climate change will have serious implications for water management and irrigated crop production, especially because it will come on top of unsustainable rates of groundwater pumping in the region. Rapid snow and glacier melt will also introduce additional hazards to highland communities by causing the terrain to become increasingly unstable.

Monsoon variability is too poorly understood for us to have a clear enough picture about the incidence of drought under climate change. The recent examples of the failure of the monsoon in July 2002 and the devastating Mumbai floods of August 2005 show that variations of monsoon intensity within the season can be severe. Climate models are quite poor in representing the spatial resolution of precipitation during the monsoon and the corresponding changes in crop yields, but indications are that even with a warming of 2^{o}C, the yields of both rice and wheat will fall in most places (DEFRA 2005).

In a recent study by The Energy Research Institute (TERI) in collaboration with the Centre for International Climate and Environmental Research (CICERO), Norway, and other researchers in Canada and the US, agricultural regions of India having special sensitivity to climate variability were identified in conjunction with regions vulnerable to the negative trade effects of globalization, providing a map of areas that are 'double-exposed' to both processes (O'Brien, K. et al. 2004). The most vulnerable such districts happen to be in western Rajasthan, southern Gujarat, Madhya Pradesh,

Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar (see Figure 3).

It seems likely that these areas will generate another category of climate migrants who happen to live largely within the interior of the country. As in the case of migrants due to sea level rise, migration from these regions will very likely take place in waves, except that the least resilient communities in this case will probably be landless agricultural workers and tenant farmers, who will be the first to experience serious enough threats to their livelihoods to be forced to leave their homes. Many of these people will also move towards urban areas, although ironically, several may end up seeking "safe" means of employment in the largest of these cities which happen to be along the coast and are especially vulnerable to subsequent sea level rise.



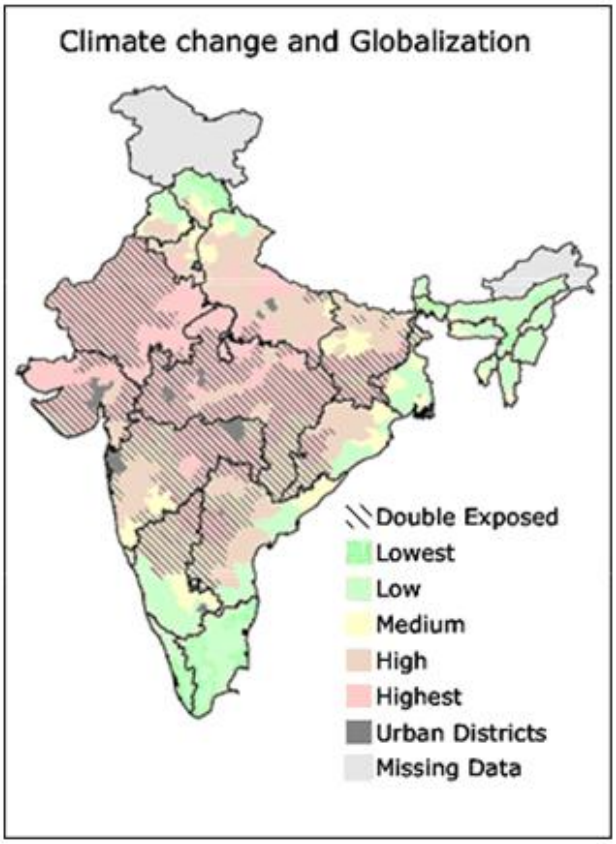


Figure 3. Climate change and globalization vulnerability profiles in India. Hatched areas are double exposed (*Source: http://www.teriin.org/coping/vulnerability.htm*).

4. Migration Scenarios

As indicated in the previous sections, climate change will likely trigger the mass migration of individuals and their families primarily because of livelihood loss but, in the case of sea level rise, also because of the direct loss of land and homes. While we can be reasonably certain about the broad trends in physical, social and economic changes over the next 50-100 years for different emissions trajectories, there are substantial uncertainties when we try to improve scales of spatial and temporal resolution beyond those obtained by most climate models (e.g., to square kilometres or specific months of the year). Furthermore, as we discussed earlier, there are non-linearities and threshold effects to consider when anticipating when and how much migration might occur as a result of the adverse impacts of climate change. The estimates that are made in this section should therefore be considered as being roughly indicative and by no means exact forecasts of numbers of people expected to be displaced from their homes under two different climate change scenarios.

The two scenarios we choose are first, a Business-as-Usual (BAU) scenario that results in atmospheric concentrations of CO2 that exceed 750 ppm (similar to A1 SRES scenario) by the end of the century and a Policy scenario that limits concentrations to below 450 ppm (more aggressive than B1). The BAU scenario causes average global temperatures to rise by 4-5^{o}C while the Policy scenario limits the increase in temperature to below 2^{o}C.

Various conservative assumptions were used to estimate the sea level rise associated with these global average temperature changes and the corresponding impacts on the residents of South Asia living in the LECZ. First, because of the uncertainty associated with the break up of land ice in the Antarctic and on Greenland, we consider three possible options for the BAU scenario, 1m, 3m and 5m of sea level rise in 2100, representing a low, medium and high estimate, respectively. For the Policy Reform scenario, we use an estimate of 0.3m sea level rise in 2100, which corresponds roughly to the mid-range of the IPCC B1 scenario.

Furthermore, we postulate that sea level rise will take place very gradually in early years, but will accelerate towards the end of the century, consistent with the understanding that various positive feedback processes will cause ice break-up and melting to gather speed only towards the middle to end of the century. We also assume that there is a similar non-linear response to rising average sea levels for communities living along the coast. For instance, at modest increases in sea level, the motivation to leave a coastal region may be relatively low, as people learn to adjust to changing physical and economic conditions. As the average sea level continues to rise, coastal inundation, saltwater intrusion and storm surges will become more intense and people will find it increasingly difficult to stay in their original homes and will look for ways to migrate inland. Figures 4 and 5 below show,

respectively, how we have modelled the increase in area affected by sea level rise and the way in which people's migration patterns are impacted. Thus, in the BAU cases, where the impacts of sea-level rise are expected to be catastrophic only in later years, we expect that coping strategies would break down quite soon in the flood zone regions, so that by 2045, the entire affected population would be forced to migrate inland, primarily to cities. In the Policy scenario, we also assume that a certain degree of adaptation is built into the framework, so that some form of evolving coastal protection is included to reduce the impacts of sea level rise.

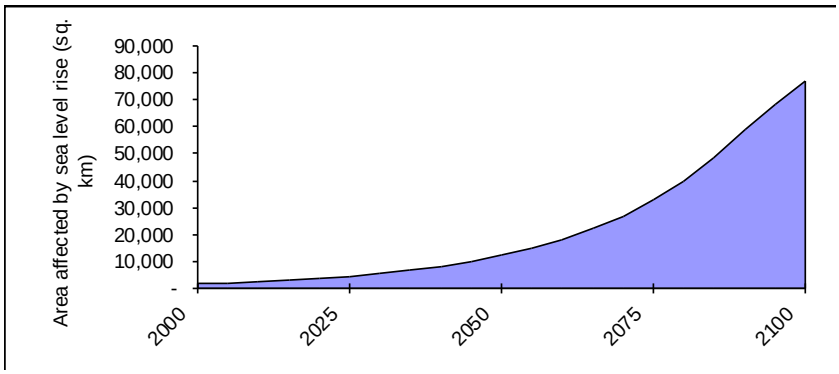


Figure 4. Area affected by sea level rise in Bangladesh for the BAU case where maximum sea level rise is 3m in 2100.

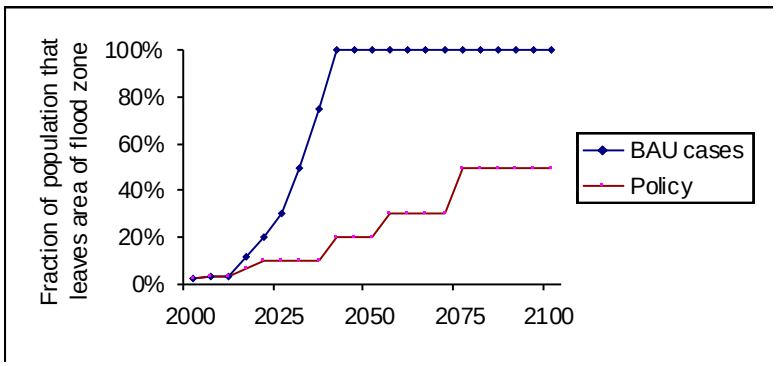


Figure 5. Modelled population response to rising sea level in BAU cases and in the Policy scenario.

The consolidated results for population out-migration in India and Bangladesh for the two scenarios, including the three cases of the BAU scenario, are shown in Figure 6 and Table 2.[2] Given the proximity of Bangladesh to India and the large land area that would be inundated, it is

[2] Since Pakistan and Sri Lanka's LECZ are relatively small, we have not included them in the analysis.

also likely that the bulk of these people (nearly 120 million in the worst case BAU scenario) will end up being migrants in India, particularly in large cities in the interior that are already likely to face resource stress due to climate change and over-exploitation of groundwater and other ecosystem services[3]. In contrast, in the Policy scenario, although there will still be some migrants associated with a 30cm sea level rise by the end of the century, we expect their numbers to be considerably fewer, about 5 million in 2100, also because the potential for local adaptation would far greater given the relatively modest increase in sea level.

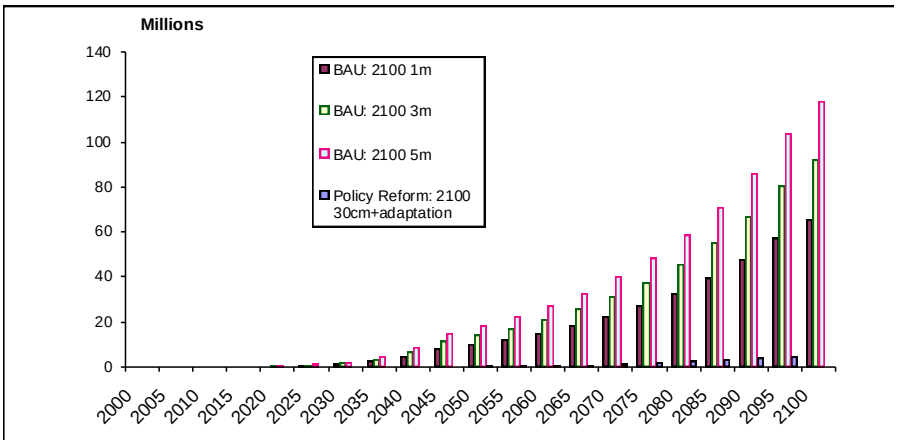


Figure 6. Consolidated South Asian (India and Bangladesh) population displaced due to sea level rise in 3 BAU cases and Policy scenario.

[3] In comparison, some 10 million Bangladeshis sought refuge in 1971 during the war of independence.

Table 2. Estimates of migrants displaced by sea-level rise from Bangladesh and India

	Migrants (assuming phased movement)		
	Bangladesh		
	2100 1m	2100 3m	2100 5m
2010	24,240	33,936	43,632
2015	38,723	54,213	69,702
2020	161,998	226,797	291,597
2025	353,660	495,124	636,588
2030	680,747	953,046	1,225,344
2035	1,445,265	2,023,371	2,601,477
2040	2,742,200	3,839,080	4,935,959
2045	4,593,159	6,430,423	8,267,686
2050	5,730,425	8,022,596	10,314,766
2055	7,110,810	9,955,134	12,799,458
2060	8,786,180	12,300,651	15,815,123
2065	10,819,467	15,147,254	19,475,040
2070	13,287,036	18,601,851	23,916,666
2075	16,281,550	22,794,170	29,306,790
2080	19,915,447	27,881,626	35,847,805
2085	24,325,165	34,055,231	43,785,298
2090	29,676,268	41,546,775	53,417,282
2095	36,169,659	50,637,523	65,105,386
2100	41,611,188	58,255,663	74,900,139
	India		
2010	23,723	33,212	42,701
2015	36,850	51,591	66,331
2020	149,675	209,545	269,416
2025	316,617	443,264	569,911
2030	589,419	825,186	1,060,954
2035	1,209,244	1,692,942	2,176,640
2040	2,221,491	3,110,088	3,998,684
2045	3,607,278	5,050,189	6,493,100
2050	4,365,833	6,112,166	7,858,499
2055	5,259,326	7,363,057	9,466,787
2060	6,313,208	8,838,492	11,363,775
2065	7,557,351	10,580,292	13,603,232
2070	9,026,801	12,637,521	16,248,241
2075	10,762,637	15,067,691	19,372,746
2080	12,812,968	17,938,156	23,063,343
2085	15,234,067	21,327,694	27,421,321
2090	18,091,665	25,328,331	32,564,997
2095	21,462,425	30,047,395	38,632,365
2100	24,027,847	33,638,986	43,250,124

As described in Section 3B, the double burden of globalization and drought associated with climate change could also cause migration out of several vulnerable areas in the country. While it is far less obvious how to identify the population most likely to migrate from these causes as opposed to the physical reality associated with sea level rise, one could make simplifying assumptions based on the TERI/CICERO study to focus on the most vulnerable regions and groups of people within them. In this analysis, we have looked at the subset of rural workers in agriculture, forestry, hunting and fishing from the 2001 Census living in the areas that the TERI/CICERO study identified as being doubly vulnerable to the forces of globalization and climate change.

We have further isolated those workers who are identified in the Census as being illiterate, with the assumption that these are the people (together with their families) who would have the least skills and resources at their disposal to shift occupations as the climate changes. One estimate of the

rural population likely to migrate to urban areas specifically because of their double exposure to climate change and globalization is shown in Figure 7. While the number of migrants identified using this method is substantially lower than in the case of sea level rise, they together constitute a significant strain on the resources of government and on urban centres.

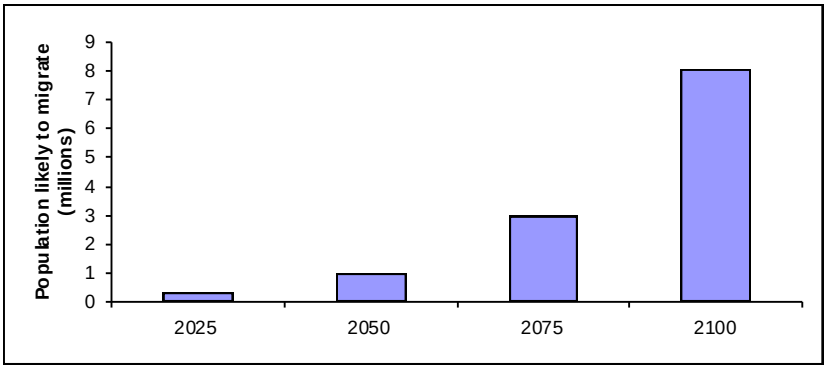


Figure 7. Estimate of rural population likely to migrate to urban areas specifically because of their double exposure to climate change and globalization under BAU conditions.

Finally, Table 3 shows the regions of India that are likely to experience the greatest numbers of out-migration because of sea-level rise as well as "double exposure" to drought induced by climate change and globalization.

Table 3. Regions in India that will likely experience the highest levels of out-migration due to sea level rise and drought/globalization.

Vulnerable Region	Migrant Levels in 2100
West Bengal	~10 million
Coastal Maharashtra (around Mumbai)	~10-12 million
Coastal Tamil Nadu	~10 million
Coastal Andhra Pradesh	~6 million
Gujarat	~5.5 million
Coastal Orissa	~4 million
Western Rajasthan	~1.4 million
Northern Karnataka	~1.3 million
Madhya Pradesh	~1.2 million
Interior Maharashtra	~1 million
Northern Andhra Pradesh	~1 million
Southern Bihar	~1 million

5. The fate of climate migrants

Worldwide, migrants currently make up about 175 million people, an estimate which includes anyone who was foreign-born in their current country of residence. *Migrants*, especially economic migrants, typically choose to move in order to improve the future prospects for themselves and their families. *Refugees*, who belong to a different category altogether, are forced to move in order to save their lives or preserve their freedoms and, as such, constitute fewer than 10 million (not including the 4 million Palestinian refugees in the West Bank region and neighboring countries, who probably deserve a separate category of stateless exiles given their unique situation).

Under international law, refugees are strictly considered to be those who have been forced to flee their homes as a result of war or persecution and have the possibility of return when things get better in the future. They seek asylum under the condition that they cannot obtain protection from their own state; often their own state is responsible for their vulnerable situation. But when a person's home, land or indeed entire country is wiped out by a phenomenon such as rising seas there is no hope or chance that the person will ever be able to return home. Such individuals will therefore essentially have become "climate exiles" who will have no legal status and few options

other than to become permanent boat people unless the international community develops early strategies to address their legal needs.

The climate crisis that is likely to unfold in South Asia will create profound challenges. With a 5-metre sea level rise, there will be about 125 million climate migrants in this region alone with little or no legal standing under current international law. In fact the 75 million or so from Bangladesh will be especially vulnerable, as their entire nation-state becomes non-viable as an entity, with most of its land inundated and its economy defunct.

Unless South Asia and the rest of the world are seriously committed to addressing climate mitigation so that they only need to adapt to modest climate change impacts, the severity of the effects will profoundly damage the social and economic fabric of societies for many generations to come. Climate change is a collectively induced problem, the result of the accumulated emissions of greenhouse gases generated by countries around the world. While India is still a relatively small contributor to the problem, it has an important responsibility to reduce its own emissions—as well as the rate of its emissions growth—and to participate in international negotiations with vision and leadership. The alternative could be a slow, but still dramatic destruction of South Asia similar to the manner in which climate change accelerated the demise of the Akkadian, Mayan and other civilizations of the past.