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Climate Change and Agrarian Systems: Adaptation in Climatically Vulnerable Regions*

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I

INTRODUCTION

Risks faced by agriculture and agrarian economies are driven by three forces: market risk, yield or production risk, and event risk. Event risk is the broad umbrella under which risks associated with weather-related events (e.g. rainfall or temperature variability or extreme events), labour and health risks, policy shocks, wars and conflicts, etc. are classified. Yield or production risk often becomes a function of event risks in the forms of changes in weather conditions, but may also be results of changes in practices, inputs, etc. Market risks, in contrast, are intrinsic to the market system, though they may be affected by events and production risks. In all cases, market risks manifest themselves in the form of price risks.

In this paper, I talk of vulnerability of the agrarian economy or the agricultural sector to forces of global warming and climate change, which may be classified as event risks. The sudden shocks or increasing frequencies of extreme events or the long-term changes in trends in temperature and rainfall, which have often been attributed to global warming and climate change, have posed substantial risks not merely to agriculture and the livelihoods associated with this sector, but also to a broader agrarian habitat in the vulnerable areas. It is in this context, I take up two types of risks that may be attributed to the forces of global warming and climate change: one is related to water availability risk of Indian agriculture due to variability in monsoonal patterns; the other is related to the very existence of agrarian economies in the coastal regions in the face of sea-level rise and salinity ingression. In each case, I present agrarian society's vulnerability posed by the climatic forces and eventually an adaptation mechanism to work on.

In Section II of this paper, the case of vulnerability of the agricultural sector to water availability is presented. The risk of water availability is a painful reality not only in Indian agriculture, but south Asian agriculture as a whole. Crop failure, more often than not, has been a function of drought conditions, than anything else. The variability of precipitation has proved to be a major risk for the agricultural economy.

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In order to combat this risk, this paper proposes the formation of water futures exchange, with futures trading in water index to be a tool for mitigating the risk. In Section III, the case in favour of "planned retreat" of population from regions whose existence is under threat due to forces of global warming and climate change is studied. Incidentally, all these regions are dependent on primary activities like agriculture, fishery or forests. It is shown here how a planned retreat or organic movement of the community from the vulnerable region to a stable region proves more advantageous as a long-run adaptation strategy than the business-as-usual mode of *in-situ* adaptation. In the process, an ecological economic argument in favour of changing face of adaptation by combining the dual phenomena of planned retreat and ecosystem restoration in one of the most vulnerable mangrove forest regions of the developing world, the Indian Sundarbans Delta (ISD) is dealt with. This is also one of the poorest regions of the world, apart from having low rank in most of the human development indicators. This section draws from a WWF-India publication authored by me with a few colleagues (see Ghosh *et al*., 2016). Section IV presents the policy implications, and the changes needed in paradigm thinking if both such adaptation schemes to combat two different vulnerability problems have to be effective. This is also the concluding section of the paper.

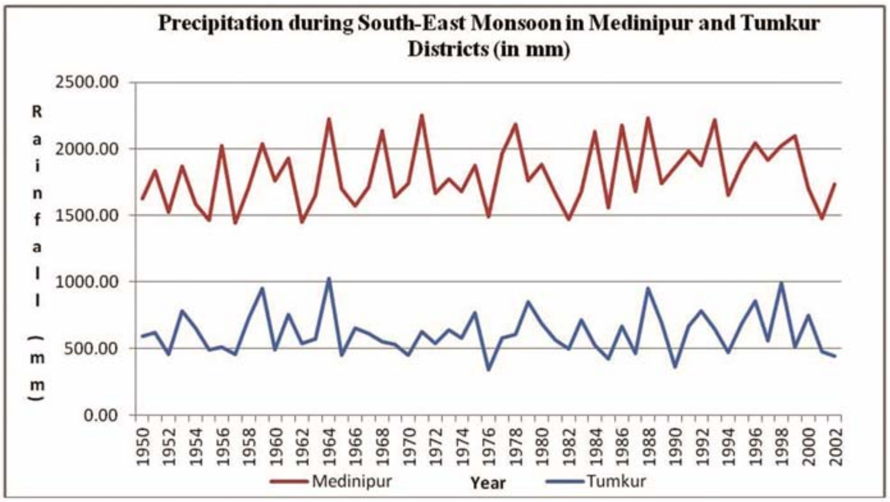
II

AGRICULTURAL VULNERABILITY TO THE RISK OF WATER AVAILABILITY: THE ROLE OF WATER FUTURES MARKET

With south Asian agriculture being dependent on the timely occurrence of the monsoons, any deviation from the scheduled arrival of the monsoon causes problems not only for the farmers, but is also a threat to the food security of the region. This risk, undoubtedly, is becoming alarming as concerns of climate variability in the region are growing because a large part of south Asian agriculture is dependent on precipitation from the Southwest monsoon (June to September) (Ghosh, 2014).

Figure 1 reveals the pattern of precipitation during the Southwest monsoon from 1950 to 2002 in two districts in India, namely, Medinipur district in West Bengal in the eastern part of India, and Tumkur district in Karnataka, which is a south Indian state. Both the districts are located on two critical river basins of India: Medinipur is on the Ganga sub-basin, while Tumkur is on the Cauvery basin.

Figure 1 shows the variation in rainfall in the two districts. The inconsistency in the precipitation pattern is quite perceptible here. What has become alarming is that the variability in precipitation has actually increased in recent years. When the period of analysis is divided into two phases, namely, 1950–1975 (Phase I) and 1976–2002 (Phase II), it has been found that in both the districts the standard deviation of precipitation during the Southwest monsoon has increased in Phase II, thereby revealing an increased risk to water availability for rain-dependent agriculture (Table 1).



Source: www.indiawaterportal.org

Figure 1. Variation in Rainfall in Medinipur and Tumkur Districts.

TABLE 1. STANDARD DEVIATION OF PRECIPITATION DURING SOUTHWEST MONSOON IN TUMKUR AND MEDINIPUR DISTRICTS

(*mm*)

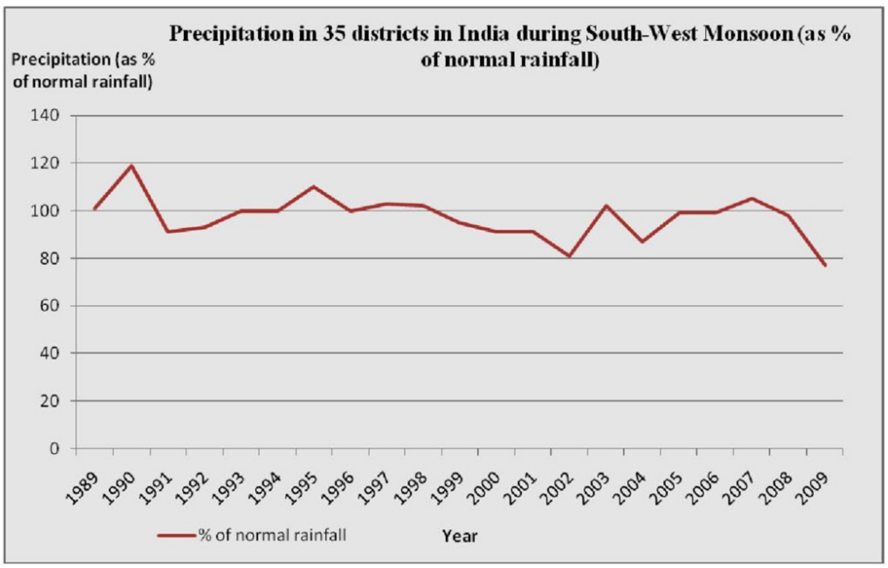
Standard deviation of precipitation during Southwest monsoon in two districts		
	Tumkur	Medinipur
(1)	(2)	(3)
1950–1975	147.85	188.18
1976–2002	170.73	214.44

Source: Computed by the author from IMD data.

Fertiliser Association of India data for 35 select districts across India show that the precipitation in India over the 21 years from 1989 to 2009 has varied between 77 per cent (in the worst case) to 119 per cent (in the best case) of normal rainfall (defined by long-term average value) (Figure 2).

Interestingly, in the 10 years from 1989 to 1998 (Figure 2), rainfall has been normal or more than normal for eight years, except for 1991 and 1992. However, between 1999 and 2008, rainfall has been scanty, and for eight years the precipitation has been less than normal (with normal being defined as the long-term average by the Meteorological Department); only 2003 and 2007 had more than normal rainfall. Because of this erratic nature of the Southwest monsoon, water availability risk has increased, thereby causing concerns of water conflicts in various basins in India, as also south Asia (Ghosh and Bandyopadhyay, 2009; Bandyopadhyay and Ghosh, 2009).

Reservoirs often fail to obtain and release waters in a timely manner, which causes havoc for agriculture. An example of the Mettur Dam in Tamil Nadu in India is given in Table 2. Karnataka and Tamil Nadu are co-riparian states in India sharing the Cauvery waters, with Karnataka being the upstream state; the first barrage to receive waters from the Cauvery after the river crosses the Karnataka boundary is Mettur. In case of a failed monsoon in the basin, Karnataka might fail to release the stipulated amount of water to Mettur Dam, as was warranted in an interim order of the Cauvery water tribunal in 1991. This often turned out to be the cause of graver inter-state water disputes.



Source: Fertiliser Association of India.

Figure 2. Precipitation in 35 Districts in India during South-West Monsoon.

TABLE 2. PERCENTAGE DEVIATIONS FROM NORMAL FLOW TO THE METTUR DAM IN TAMIL NADU DURING SOUTHWEST MONSOON

Year (1)	Deviation from normal flow to the Mettur in Southwest Monsoon*** (2)	Crop failure/Water dispute? (3)
1992-93	64.06	—
1993-94	- 20.73	Yes. Crop failure in many Tamil Nadu districts.
1994-95	65.06	—
1995-96	- 28.14	Yes. Inadequate rainfall; Tamil Nadu moves to court.
1996-97	- 26.27	Yes. Inadequate rainfall; crop failure in Tamil Nadu districts.
1997-98	1.72	—
1998-99	- 16.26	Yes. Crop failure and Tamil Nadu moves to court.
1999-00	- 26.83	Yes. Crop failure in various districts in Tamil Nadu.

Source: Estimated by the author from dmc.kar.nic.in; *Season and Crop Report,* Department of Economics and Statistics, Government of Tamil Nadu, Chennai; Menon and Subramanian (2002); Ghosh and Bandyopadhyay (2009).

Quite evidently, the existing risk of water in Indian agriculture is a threat to food security and many other associated businesses of agriculture. Risk mitigation strategies, so far, have primarily been confined to supply-augmentation plans and demand-management mechanisms. It is difficult for supply-augmentation plans (like construction of big dams, water transfers, and river interlinking) to succeed as water has already been fully allocated, and further tampering with nature might even prove to be economically unviable and ecologically unsustainable (Mirza *et al*., 2008; Alagh *et al*., 2006).

Demand side management through adaptation mechanisms also needs innovation. More importantly, none of the current risk-mitigation strategies financially compensate in those instances where water is unavailable. Rather, there is a value loss due to unavailability of water, and the cost of adaptation (through shifting of crops, or construction of storages) is not less either! Informal water forward markets are in vogue to a certain extent in many parts of south Asia, though they have not been successful enough to mitigate the risk of water availability on a scale as that of the river basin. Presently, there is no market-based institution in South Asia where users and investors exposed to water availability risk can effectively hedge against such a risk.

Parties with exposure to water availability risk are not merely irrigators. Rather, to regard water availability risk as a risk borne only by irrigators fails to appreciate the fundamental nature of the risk to the entire economy. Investors and financial market participants have no desire, ability, or interest in acquiring physical water to offset that risk; neither do they have any incentive to take up the hedger's risk and take physical delivery of water.

Yet, lending institutions like banks might bear an inherent risk with water availability. A bank may lend money to a farmer to invest in planting a crop, and it faces an inherent risk when the crop fails due to no rain. An agricultural processor also faces the risk as unavailability of water will prevent him from getting the raw produce for processing. Even re-insurers do not have any means of covering their exposure to a flood (Australian Stock Exchange, 2006). None of these parties have any incentive in trading of physical water rights because of two reasons. First, they cannot use the physical water once purchased. Second, physical water rights do not mitigate the risk associated with water availability (Australian Stock Exchange, 2006). There is no doubt that south Asia presently requires a different institution to hedge against this risk.

Such an institution can be the water futures market. The development of any market is based on the identification of the commodity or the index with which trading should take place. When water futures contracts will be traded, they should be traded in terms of indices, rather than being traded physically. Physical delivery might not make sense here, and might even act as a deterrent to trading for two principal reasons. First, the cost of physical delivery might be so high (due to construction of infrastructure, movement costs, and so on) that it will clearly deter participation and inhibit liquidity in the market. Second, as stated earlier, a majority of the stakeholders (banks and other lending organisations) are not concerned with the physical availability of water, but more with value loss due to water scarcity. They are least interested in taking physical delivery of the resource, but more interested in locking in the value with which they are facing the risk. Hence, there is a crucial need for developing an index with which trading can take place, and the final settlements of trade need to be settled in cash. It is important that the water availability index (henceforth WAI) be independently and objectively priced, with minimum scope for artificial manipulation. However, for India, it is important to develop a contract for each major river basin in a given state.

There can be numerous advantages of the futures market for water:

- Water futures market will help discover price (through the scarcity value of the resource), thereby leading to an efficient use of the resource.
- Water futures contracts will provide a price indicator for future stored water. This will assist investment decisions and also forward risk management.
- The price realised at the futures market will be an objective instrument of decision-making for project prioritisation.
- Pricing of natural resources can raise public and political awareness of the importance and availability of the resource. A high value of a natural resource might imply its high importance to the community.
- Irrigated as well as rain dependent agriculture, dependent on the availability of water will be able to use the market (or products derived from the market) to insure themselves against droughts by locking in prices in the water futures market.
- Water futures market will provide the financial tools required by investors and banks to confidently invest in the rural sector. This would result in long-term planning and investment that will actually deliver water to areas that need it rather than simply insure against its absence.
- A water futures market will help in promoting the best water-efficient technology. This will further stimulate research on water resources and will eventually help in the crisis management for the future.

2.1 *Using Futures Market to Hedge Water Availability Risk*

Let us consider a farmer in the drought-prone Birbhum district in West Bengal. In January 2018, the farmer plans to plant paddy in May 2018 on the expectation that there will be good rains during June to September 2018. However, he is concerned with the possible dry conditions that might make water unavailable for his paddy. He calculates that the loss from a failed crop will be Rs. 100,000 (Rs. 1 lakh), while the profit from a successful crop will be Rs. 5000,000 (Rs. 5 lakh).

Assume that the current level (January 2018) of the WAI in that node of West Bengal over the Ganges is 70.2 per cent, with August 2018 water futures contract trading at Rs. 50 on the expectation that there will be good rain during Southwest Monsoon, the WAI will increase to around 85 per cent. The farmer, therefore, decides to buy 200 August 2018 WAI Farakka node contracts (the water of the Ganges gets diverted to resuscitate the Kolkata port through the Farakka Barrage in West Bengal, which was constructed in 1975) at Rs. 50. We ignore the existence of margin for the time being.

Scenario A: Drought prevails due to failure of the Southwest Monsoon, and the paddy crop fails. The WAI goes down to 50 per cent, with its price increasing to Rs. 100 during expiry. As the contract expires on a particular day in August, the farmer cash-settles his position and earns a profit of Rs. {200 x (100-50)} = Rs. 100,000, thereby recovering the loss incurred due to a failed monsoon.

Scenario B: If there are good monsoons and WAI crosses the 85 per cent mark, the farmer earns a profit of Rs. 500,000 by selling his crop. On the other hand, because the WAI is also high, with its price declining to Rs. 25, on the day of the expiry of the contract the farmer incurs a loss of Rs. {200 x (50-25)} = Rs. 50,000. But this loss gets adequately offset by his profit earned by selling his crop.

Though, this exposition takes up the case of a representative farmer, probably in the same manner, one may illustrate how other stakeholders like banks, development financial institutions, hydro-power producing units, institutions providing agricultural credit, and so on may hedge against the vagaries of water availability risk. Such hedging will, eventually, smoothen out profits and losses by minimising the uncertainties in the outcomes. While apparently this mode of hedging is prevalent in commodities, hedging in water should be treated more as hedging in "inputs" rather than the hedging in "outputs".

Ghosh (2010 and 2014), by estimating the scarcity value of water in the Cauvery basin, exhibited that the futures markets can help a participant exposed to water availability risk to not only hedge, but in the process it also compensates the participant of the value loss due to scarcity. In other words, such a market has the potential to reduce the scarcity value of water, and eventually help in the process of resolution of water conflicts.

2.2 *A Water Futures Exchange beyond National Boundaries*

The water futures market may also extend beyond national boundaries. This is because waters of south Asia cross national boundaries, and hence, there is a need for various participants from various nations to emerge in the futures market and trade. On the one hand, the waters of the Indus is being shared by India and Pakistan, while on the other hand, the Ganga-Brahmaputra-Meghna basin is shared by Nepal, India, Bhutan, Bangladesh, and China. Each of these nations faces the water threat, which is getting aggravated due to climate change. On the other hand, the respective national problems are also there. Hence, water scarcity leading to water politics is a two-level game in south Asia. Under such circumstances, there is a need for a trans-national exchange with an electronic trading platform. However, such a dream can only be dreamt when geo-political differences are also erased.

III

VULNERABLE REGIONS AND FAILURE OF "IN-SITU" ADAPTATION

Like many parts of the underdeveloped regions of the world, large parts of coastal regions of south Asia are vulnerable to the impacts of global warming and climate change. Consequently, various adaptation and mitigation mechanisms are already in vogue to combat such forces all across the world. Planners and managers have focused on defending development in vulnerable regions, by shielding infrastructure and habitat from damage caused by climate risks. These are essentially reactive mechanisms, such as building structures to protect shorelines. Over time, this was found to be unsustainable, in the face of the ferocity and increasing frequency of extreme events. Similar was the fate of mechanisms like accommodating infrastructures, which include techniques such as redesigning, rebuilding, or elevating the existing developments and infrastructure (Niven and Bardsley, 2013). Lately, planned retreat of the population from a vulnerable region (where in situ adaptation is no longer possible or is exorbitantly expensive), and subsequent restoration of the ecosystem in that region, have been thought of as a major breakthrough in the domain of adaptation practice.

A "planned retreat" is not a reactionary measure, but a proactive management action encompassing the application of management and alleviation drivers developed to move the existing development back from vulnerable regions to safer or comparatively stable regions. This approach allows for the use of land until it is deemed unsafe for property and/or life, after which methods are applied to withdraw assets and communities back from vulnerable zones. Specific retreat methods include: abandonment; relocation to other areas; setbacks further from shorelines; land acquisition from foreshore owners; and the avoidance of further development on the foreshore.

Scientific literature acknowledges the importance of restoring valuable coastal systems—such as salt marshes, oyster and coral reefs, mangroves, sea-grass beds, and beaches—and other landforms that act as natural barriers (Arkema *et al*. 2013, Barbier, 2014). The advantage of this phenomenon is not merely protection from extreme events, but also accrual of other ecosystem services.[1]

In this backdrop, it is believed that phased movement as a component of planned retreat combined with ecosystem restoration will bring about an improvement in human development, prevention of avoidable loss of life and livelihood, partial reversal of ecosystem degradation, and improvement in ecosystem services. These will unfold themselves in the form of enhanced livelihood opportunities, and increased provisioning and regulating services of the ecosystem. However, while there are benefits for the society through the ecosystem-society interactive processes, there are certain costs that are also involved.

Given the nature of the costs and the benefits, the questions that arise here are the following: if the planned retreat with eco-restoration is implemented, what are the streams of benefits and costs? How are the net benefits (benefits minus costs) altered, as compared to the business-as-usual (BAU) scenario? This has been exhibited in the context of the Indian Sundarbans Delta (ISD).

3.1 *Indian Sundarbans Delta*

The ISD is one of the most vulnerable agrarian delta regions in the world, being prone to extreme events, growing population pressures, and depleting ecosystem services. Part of a critical ecosystem in the Ganga-Brahmaputra-Meghna (GBM) basin in South Asia, this densely forested wetland (Ramsar Site number 560; Sundarbans Reserved Forest in Bangladesh) is dominated by mangrove forests (one of the three largest single tracts of mangrove forests in the world). The ISD spreads over an area of about 9630 sq. km in the state of West Bengal in India, bordering Bangladesh. The landscape is characterised by a web of tidal channels and islands with the land being under a continuous formation stage**.**

The Sundarbans consists of exceptionally rich diversity of aquatic and terrestrial flora and fauna, and is the only mangrove tiger habitat in the world (Figure 3). The forested parts of Sundarbans were declared as reserved forest in 1878 by the British

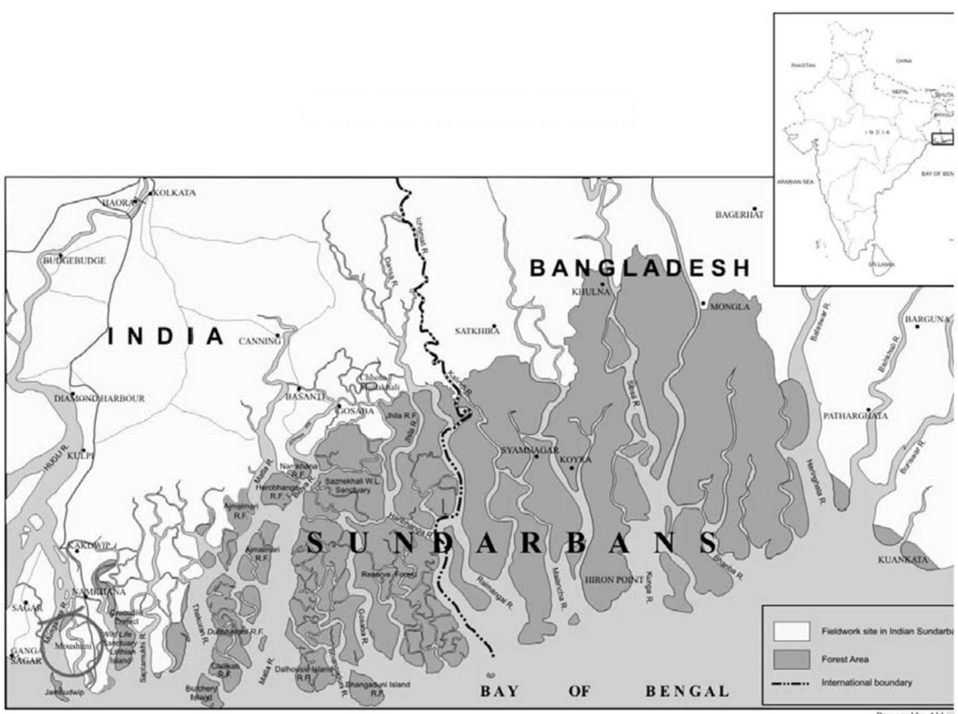


Figure 3. Sundarbans Eco-Region.

colonial administration. In 1973, a part of the forest spread over 2585 sq. km was construed as the Sundarban Tiger Reserve (STR). Within the Tiger Reserve, an area of 1330.12 sq. km was declared as Sundarban National Park in 1984. In 1987, the Sundarban National Park became a UNESCO World Heritage Site,. The whole of ISD comprising the forested and inhabited parts (19 sub-districts spread across two districts in West Bengal) was declared as Biosphere Reserve in 1989.

3.2 *Ecosystems-Livelihoods Linkages*

The Sundarbans presents an example of an endangered ecosystem, both fragile and economically valuable, that is subject to growing population pressures due to deep-rooted linkages of livelihoods with ecosystem services. While half of the over 4.5 million population are landless, they are almost entirely dependent on agriculture. This is in light of the fact that other livelihood options barring fishing and agriculture are practically non-existent in the Sundarbans.

Rain-fed agriculture forms the mainstay of the economy in the ISD. Erection of earthen embankments, to keep brackish tidal water at bay, is regarded as a prerequisite for sustaining the rain-fed freshwater based agro-ecosystem. Despite receiving substantial average rainfall of about 1800 mm during the monsoon months (June through September), agricultural productivity of the delta region is low due to (a) saline water intrusion, and (b) no more than 20 per cent of agricultural land of about 2,91,682 hectare produces a second crop in the absence of irrigation facilities.

With natural calamities like storm surges destroying livelihoods and property there has been a propensity among the population, especially the landless, to exploit the ecological resource base rather indiscriminately (Danda *et al*., 2011).

3.3 Impacts of Global Warming and Climate Change

Bio-physical changes in the form of increase in sea surface temperature, sea level rise, changes in the precipitation patterns, and increasing frequency of cyclone events are prevalent in the ISD. During 2002-2009, Relative Mean Sea Level (RMSL) increased at the rate of 12 mm/year. Considering the record of past 25 years, the rate of relative sea level rise comes close to 8 mm/year, which is significantly higher than the rate of 3.14mm/year observed during the previous decade (Hazra *et al*., 2002; Hazra, 2010). Analyses of cyclonic events over a period of 120 years indicate a 26 percent rise in the frequency of high to very high intensity cyclones over this time period (Singh, 2007).

3.4 *Vision 2050: Planned Retreat and Ecosystem Restoration*

In view of the prevailing challenging situation, an alternative scenario – a vision for 2050 – has been envisaged by colleagues from WWF India (see Danda *et al*., 2011, Ghosh *et al*., 2016). This vision is about an adaptive management system to not only cope with the onslaught of devastating predicted changes, but also to convert adversity to an opportunity for improving the quality of life of the people and to rehabilitate the ecological health of the ISD.

The main points of this vision are: encouragement of phased and systematic outmigration from the vulnerable zone (planned retreat), and restoration of mangrove forests in the vulnerable zone. It is believed that only when a safer habitat is provided to the people of the region along with proper source of livelihood will it be possible to restore mangrove forests in the vulnerable zone and thereby bring about partial ecological rehabilitation of the region.

Phase I of the Vision involves a clear-cut identification and demarcation of the area of the ISD as a single administrative unit with restrictions on outsiders from acquiring land and thereby obtaining permanent residence in the area.

Phase II focuses on the development of adequate physical infrastructure in the stable zone, away from the high vulnerability zone. It is expected that population from within the vulnerable zone would gradually immigrate to the nearby stable zone. Thus, adequate infrastructure is necessary to absorb these people in the stable zone.

Phase III envisages preparing the residents for this change in order to minimise their psychological barrier towards the movement from the vulnerable to the less vulnerable zone. However, the people of the region should have the choice to decide whether they want to relocate or live in their current location. The movement is envisaged as voluntary and "organic".

Phase IV visualises relocation of the population from the high vulnerability zone to the newly developed areas in nearby stable zone. The unused lands are restored as mangrove forests. It is estimated that by 2050, the total restored area should be around 1190 sq. km. However, land ownership over vacated land remains with the people who have relocated and will be entitled to benefit flows.

The question that arises is whether pursuing such a vision can prove beneficial over the current or the Business-As-Usual scenario. This is where the economic argument through arriving at the various costs and benefits, and eventually net benefits that are associated with either of the scenarios, described as *Business-As-Usual (BAU)* and Vision scenarios are brought in, as has been documented by Ghosh *et al*. (2016)**.**

3.5 *Description of the Scenarios*

*Business-As-Usual (BAU) Scenario***:** This is a scenario where the community does not relocate and stays back in the vulnerable region. While assuming that the economic condition of the vulnerable zone remains as prevalent, we present the figures of the stream of benefits that may be accrued from 2050 to 2100. We assume that the BAU scenario is affected by natural disasters, and estimate what might happen if a moderate disaster affects the zone during this period. Of course, the limitation of this analysis is that the intensity of an event has been evened out by considering an "average" position between "high intensity" and "low intensity" events.

Vision 2050 scenario: Vision 2050 unfolds itself as a state that prevails in the year 2050 with the population from vulnerable zone having moved to the stable zone, and the mangrove forests have been restored in the former. In the process, the costs to be incurred are not going to be incurred at the same time, but will be incurred over a period of time. The same is the case for the various benefits. It needs to be borne in mind that it is not the same generation that may eventually obtain the benefits. It is possible that over the interim period, only certain proportions of a population might choose to move to the newly developed area. The vision scenario envisages that the impacts from natural calamity in their current form have been eliminated. Therefore, in this scenario, there is a host of costs that arise from building infrastructure, re-skilling, mangrove restoration, corpus creation, etc. The benefits will entail the incomes from the alternate employment, incomes from eco-tourism, incomes from ecosystem services of mangrove, possible incomes from access to the regenerated mangrove forest thus created, etc.

3.6 *Costs and Benefits associated with Vision 2050*

For the implementation of the Vision 2050, the community will have to relocate, and proper infrastructure will have to be constructed in the zone of relocation. Re-skilling of those willing to relocate has to happen so that they may find alternative employments. While most of those in the vulnerable zones are engaged in agricultural activities, one may safely assume that there will be two members of each household who would be working in the stable zone: one in the service sector, and the other finding skilled employment. While mangrove regeneration gets implemented in the vulnerable zone, there are various associated costs with the process. Mangrove forest, by itself, has its associated ecosystem benefits. At the same time, the income from the BAU scenario also emerges as the opportunity cost, as that benefit will no more be obtained.

Therefore, the following ecosystem services from the regenerated mangroves have been considered: carbon sequestration (regulating service), fishery (provisioning service), storm surge protection (regulating service), tourism (recreational service), honey (provisioning service), prawn larva (provisioning service), and crab (provisioning service). Standard valuation methods in the form of surrogate pricing, indirect values, and benefit transfer have been used obtain the values.

On the other hand, there will be incomes generated through employment in service sector, and skilled employment. With field data and necessary WPI adjustments, those figures have been arrived at. Under the net benefit flows, the total value of the flow of the economic and the ecosystem benefits generated from 2050 to 2100, the total value of the flow of incomes from employment in the services sector, the total value of the flow of incomes from skilled employment in the benefit stream have been presented.

3.7 *The Comparative Figures across the Two Scenarios*

Table 3 presents the comparative figures of net benefits across the two scenarios.

TABLE 3. CURRENT EXPECTED VALUE OF FLOW OF NET BENEFITS FROM 2050 TO 2100

Scenario (1)	Current Value of Net benefits (Rs 000 billion) (2)
Business-as-usual	172.31
Vision 2050	2202.76

Source: Ghosh *et al.* (2016).

As evident, given our present assumptions, the current value of the net benefits from in the Vision scenario (Rs. 2202.7 thousand billion) is 12.8 times of that of the BAU scenario (Rs. 172.3 thousand billion) during 2050-2100. This clearly shows that in the long run, planned retreat from the vulnerable region, and ecosystem regeneration under the given circumstances result in manifold net benefits over a situation of allowing the status-quo to continue. One also needs to note here that if one takes the rate of land subsidence into the sea over the last 50 years, and a higher rate of temperature rise to 2.5^{o}C, the vulnerable regions of the ISD might not exist anymore being taken away by the Bay of Bengal. In that case, the value of net benefits will be reduced to zero from a particular point in time.

IV

CONCLUDING REMARKS

The objective of this paper is to present two different adaptation mechanisms under two different conditions of vulnerability of the agrarian economy to climate change. In the first case of water futures market, the idea is to combat the profit or revenue risk associated with the agricultural sector. As rainfall and water availability become uncertain, and water-related conflicts intensify, a futures market for water seems to be an institutional response. The water futures index essentially acts as an insurance product, and the valuation of the loss due to water risk is as per the price discovered in the futures market, and not fixed by the certified valuation expert. It is expected that the price of the index will reflect the scarcity value of water as shown by Ghosh (2010 and 2014).

However, a lot needs to be done for such an institution to be effective. The most crucial one is creating adequate infrastructure to bring about real-time flow data in the public forum. For most transboundary river basins in south Asia, water flow has remained *classified*, and hence out of the public domain. The reasons, of course, are political. This has deterred independent research on international river basins. The most crucial one is creating adequate infrastructure to bring about real-time flow data in the public forum. It needs a concerted effort of the south Asian nations to think of cooperation for setting up a water exchange for the south Asian region and bring in classified data in the public forum. The bureaucratic core of south Asia has to understand that at the core of hostile hydropolitics of the region lay the non-realization of the real value of water that has been lost in the mire of subsidization. Water conflicts have arisen as water has been treated almost as a free good, leading to reprehensible exploitation of the resource—mainly in agriculture (Ghosh 2009). It is the futures markets for water that can make the common man understand the real value of water by discovering prices.

The critical element here is definitely the role of regulator. Financial scams have often arisen in exchanges and there is no doubt that there is a need for a very strong regulator and regulatory mechanism. However, for a South Asian exchange, there is a need for a trans-national regulator, whose organisational structure, powers, duties, and responsibilities may be taken up in future research. At the trans-national level, a trans-disciplinary knowledge base for water resource economics, institutions, and hydrological engineering has to be created, and the regulatory authority's expertise should not only be confined to the working of the markets, but should extend to an understanding of the trans-disciplinary knowledge base, as well as regulatory problems. The regulatory authority should adequately consist of specialists in various aspects of water resource management, rather than merely having bureaucrats, and should have their regional offices in various capital cities of south Asia. Therefore, to sum up, one may state that from the policy perspective, there are two broad benefits of setting up a water futures exchange in south Asia. First is the social dimension of reducing social cost of water conflicts. Second is the creation of wealth from the markets, thereby ensuring regional development.

On the other hand, we have also discussed about planned retreat as another mode of adaptation under situations where the costs of sustaining the population in the business-as-usual mode is higher than every other form of adaptation. The approach and the framework have policy implications for all such places that are faced with the situation where the combined value of assets, produce and services, due to impacts of climate change, have already fallen or will fall in a meaningful future timeframe, below the cost of protecting the place. One needs to take into cognizance that moving population from vulnerable zones has been an accepted mode of adaptation, and is not an aberration (Sherbinin *et al*., 2011). Worldwide, population movement has been an integral component of large infrastructure development projects. At times, movement of population has been conflict-free and has led to development of the affected population (Cernea, 2004). The examples countering this are also galore. In the scheme of planned retreat and ecosystem regeneration scenario, the framework essentially talks of a conflict-free organic movement resulting in human development. However, for that to happen, the various stakeholders involved in the process need to be convinced of the same by properly highlighting the financial gains, as has been shown in this analysis. The use of the approach and framework has the potential to replace a chaotic and deteriorating situation with the opportunity for ecological rehabilitation along with human wellbeing, in effect, turning adversity into opportunity.

To sum up, both these modes of adaptation require paradigmatic changes from the traditional modes of thinking in adaptation in south Asia. The emerging challenges are such that the business-as-usual modes of thinking are not going to be sufficient to combat the forces of climate change. With the two adaptation strategies presented here, I would emphasise we need to change the way in which adaptation under climate change has been perceived so far. I summarise the implications of this paper by drawing the analogy of *controllable internal, non-controllable external* (CINE) matrix. A large part of the vulnerability has to be attributed to the non-controllable external factor. The *controllable internal* lies with institutional changes either in the form of creating institutions for adaptation, or even thinking of adaptation not from the perspective of creating resilience through brick-and-mortar infrastructure development like embankments, bridges, etc, but from the perspective of sheer withdrawal from modes of "*in situ* adaptation". Such a solution is more sustainable in the context of sustenance of human life, property, and environment.

NOTE

1. For classification of ecosystem services followed in this paper, please refer to *Millennium Ecosystem Assessment* (MA, 2005).

REFERENCES

Alagh, Y.K.; G. Pangare and B. Gujja (Eds.) (2006), *Interlinking of Rivers in India: Overview and Ken-Betwa Link*, Academic Foundation, New Delhi.

Arkema, K.K.; G. Guannel, G. Verutes, S.A. Wood, A. Guerry, M. Ruckelshaus, P. Kareiva, M. Lacayo and Jessica M. Silver (2013), "Coastal Habitats Shield People and Property from Sea-Level Rise and Storms", *Nature Climate Change,* Vol.3, pp.913–918.

Australian Stock Exchange ASE (2006), "Establishing a Futures Market in Water Availability Risk," Discussion Paper.

Bandyopadhyay, J. and N. Ghosh (2009), "Holistic Engineering and Hydro-diplomacy in the Ganges-Brahmaputra-Meghna Basin", *Economic and Political Weekly*, Vol.44, No.45, 7 November, pp.50-60.

Barbier, E.B. (2014), "A Global Strategy for Protecting Vulnerable Coastal Populations", *Science,* Vol.345, No.6202, pp.1250-51.

Cernea, M. (2004), "Impoverishment Risks, Risk Management, and Reconstruction: A Model of Population Displacement and Resettlement", Paper presented at the UN Symposium on Hydropower and Sustainable Development, Beijing.

Danda, A.A.; G. Sriskanthan, A. Ghosh, J. Bandyopadhyay and S. Hazra (2011), *Indian Sundarbans Delta: A Vision,* World Wide Fund for Nature-India, New Delhi.

Ghosh, N. (2009), *Economics of Hostile Hydropolitics over Transboundary Waters: Scarcity Values and Interstate Water Conflicts in India and US,* VDM Verlag, Saarbrucken, Germany.

Ghosh, N. (2010), "A Conceptual Framework of South Asian Water Futures Exchange", *Commodity Vision,* Vol.4, No.1, pp.8-18.

Ghosh, N. (2014), "Water Scarcity and Conflicts: Can Water Futures Exchange in South Asia Provide the Answer?" in Chapter 11 in Ghosh, N. and A. Goswami (authored) *Sustainability Science for Social, Economic, and Environmental Development,* 147-173 IGI Global, Pennsylvania.

Ghosh, N. and J. Bandyopadhyay (2009), "A *Scarcity Value* based Explanation of Trans-Boundary Water Disputes: The Case of the Cauvery Basin in India", *Water Policy,* Vol.11, No.2, pp.141-67.

Ghosh, N.; A. A. Danda, J. Bandyopadhyay and S. Hazra (2016), "Away from the Devil and the Deep Blue Sea: Planned Retreat and Ecosystem Regeneration as Adaptation to Climate Change." Policy Research and Innovation Group, Issue Brief No. 1, WWF-India, New Delhi, January 2016.

Hazra, S. (2010), *Temporal Change Detection (2001-2008) of the Sundarban*. Unpublished Report, WWF-India.

Hazra, S.; T. Ghosh, R. Das Gupta, and G. Sen (2002), "Sea Level and Associated Changes in the Sundarbans", *Science and Culture*, Vol.68, No.9-12, pp.309-321.

MA (2005), *Ecosystems and Human Well-being: Synthesis. Millennium Ecosystem Assessment,* Island Press, Washington.

Menon, P. and T.S. Subramanian (2002), "The Cauvery Tussle", *Frontline*, Vol.19, No.19.

Mirza, M.M.Q., A.U. Ahmed and Q.K. Ahmad (Eds.) (2008), *Interlinking of Rivers in India: Issues and Concerns*, CRC Press/Balkema, Leiden.

Niven, R.J. and D.K. Bardsley (2013), "Planned Retreat as a Management Response to Coastal Risk: A Case Study from the Fleurieu Peninsula, South Australia", *Regional Environmental Change*, Vol.13, pp.193-209.

Sherbinin, A. de; M. Castro, F. Gemenne, M.M. Cernea, S. Adamo, P.M. Fearnside, G. Krieger, S. Lahmani, A. Oliver-Smith, A. Pankhurst, T. Scudder, B. Singer, Y. Tan, G. Wannier, P. Boncour, C. Ehrhart, G. Hugo, B. Pandey and G. Shi (2011), "Preparing for Resettlement Associated with Climate Change", *Science*, Vol.334, pp.456-7.

Singh, O.P. (2007), "Long-Term Trends in the Frequency of Severe Cyclones of Bay of Bengal: Observations and Simulations". *Mausam*, Vol.58, No.1, pp.59-66.