White Paper

Climate Change and Water Vulnerability

Strategies and Practices for Emerging Water Management and Governance Challenges

EXECUTIVE SUMMARY

This is the executive summary of the white paper prepared by TERI in collaboration with Yale University to be released during the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC), 7–18 December 2009, Copenhagen, Denmark. The white paper was developed with support from The Coca Cola Company.

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The Intergovernmental Panel on Climate Change (IPCC) in its *Fourth Assessment Report* (AR4) assessed, in depth, the complex linkages between climate change and water. Warmer climate is likely to change the hydrological system and the shifting pattern of the rainfall would affect the spatial and temporal distribution of runoff, soil moisture, and surface and groundwater reserves. Melting of glaciers, snow and ice sheets further contributes to increases in sea level. This in turn would have worldwide impacts on ground and surface water supply. Based on projections of the IPCC it is clear that in the near future, some parts of the world would have a large number of people living under water stress. There is, therefore, an urgent need to assess the impacts of climate change on water and devise adaptation measures including management structures and processes by which one can deal with this challenge.

The white paper is an initiative in signifying the critical role of global and regional water security towards sustainable development. It also highlights the importance of good governance within and across nations for efficient management of water resources. The paper draws attention to the looming challenges related to climate change induced water vulnerability, water allocation and water use across sectors and countries and also showcases the multitude of ripple and distributional impacts across various systems on account of changes in water availability and quality. Scientific and observational evidence has projected several cases of policy and institutional failures that have aggravated water security crises. It has also provided insights on international best practices and strategies for coping with water resource depletion and degradation in the climate change realm. Adaptation and mitigation strategies in the water sector have several overlaps with other sectors that might lead to mal adaptation unless the strategies are evaluated in their entirety before propounding these as policy recommendations. Considering the important linkages among water, food and internal securities, a discussion on the need for integrating water concerns in climate change negotiations is addressed in this paper. Research and policy gaps have been identified through a comprehensive and scientific documentation of issues and problems in the water sector across the world and recommendations are based on historically proven successful strategies including the lesser recognized traditional knowledge.

Structure of the white paper

The main paper is structured into three sections. The first section deals with the global overview of climate change impacts on water, supported and substantiated through scientific evidence drawn from IPCC reports and other relevant documents. The second section provides a comprehensive and in depth assessment of the water security and resource management challenges including transboundary geopolitical concerns documented across the world and emphasizes the importance of an integrated governance framework for adaptive policy making. The third section examines the viable water resource management options for various sectors and regions and showcases some of the international best practices in adaptation and mitigation. The paper also highlights the complementary role of traditional knowledge in coping with climate change risks and uncertainties and the need for a balanced view in designing adaptation and mitigation strategies. Drawing upon the scientific evidence of climate change, identified key challenges and the best practices options, sector wise recommendations are propounded. The executive summary briefly discusses the key issues which are discussed in detail in the main paper.

Water resource vulnerability: global overview

About 700 million people in 43 countries presently live in water-stressed conditions with the Middle East being world's most water-stressed region having an average annual availability of only 1200 m^3 per person (Iraq, Iran, Lebanon and Turkey are above the critical threshold). It is projected that by 2030, 47% of world population is expected to dwell in areas of high water stress (per capita water availability less than 1700 m^3). Around 60–90 million hectares in Africa will be under arid and semi-arid climatic regime and this will have serious implications on food and water security in the region. By 2025, water availability mainly in eastern and southern Africa would be less than 1000 m^3 per person per year, and up to 460 million people could be water stressed primarily in western Africa. Globally, locations most at risk of freshwater supply problems due to climate change are small islands, arid and semi-arid developing countries, regions where freshwater is supplied by glacial fed rivers and countries with a high proportion of coastal lowlands and coastal mega cities, particularly in the Asia–Pacific region. Reliable and accurate water resources information and data help decision makers make more reliable assessments of water risks and vulnerabilities.

Intra and inter regional vulnerability

Regional vulnerability assessment is very critical and will provide greater impetus to international cooperation and inclusive management planning for ensuring water security at micro, meso and macro levels; this will also aim at bridging the divides globally.

Water resource endowment and distribution across the world are spatially and temporally non-uniform and exhibit variations in availability across and within regions. There are more problems with inequitable resource endowment than with water scarcity in many regions. Variations in intra and inter regional vulnerabilities are due to the geographical positioning of the regions, whereby there will be a projected increase in runoff in high latitudes and wet tropics (for example, China, Finland, high latitudes and large parts of the USA) and a decrease in runoff in the mid-latitudes and some parts of the dry tropics (parts of West Africa, Middle East, southern Europe and southernmost South America

and Central America). Ironically, nearly two-thirds of the world's population resides in areas receiving only one-quarter of the world's total annual rainfall. The Amazon Basin, with fewer than 10 million people, accounts for about 20% of the global average runoff each year. In Peru, the dry western part of the Andes (where only less than 2% of the country's water flows) supports more than two-thirds of the country's population while only one-fourth live in Amazonia, which gets more than 80 inches of rain a year. Intraregional/national variation is also evident in Mexico, where less than 10% of the land area receives more than half of the national annual rainwater runoff. The estimates on water resources availability often are based on per capita water availability and this regional and geographical variability is not reflected in the statistics leading to erroneous assessments and projections. This will lead to an over estimation of the actual per capita availability.

The regions with good governance ensure water use efficiency and this strengthens the water security of the region irrespective of the resource endowment

Resource endowment (RE) and resource use efficiency (RUE) determine the water security of the region where resource use efficiency is a function of good governance. The matrix below provides the potential combinations of the water scenario of any given region. The four options are high RE-high RUE, high RE-low RUE, low RE-high RUE and low RE-low RUE. The regions with good governance ensure water use efficiency and this strengthens the water security of the region irrespective of the resource endowment. This indicates that water security is a function of good governance.

High resource endowment	Low resource use efficiency
Low resource endowment	High resource use efficiency

Vulnerability and water security Water secure regions satisfy the socio-economic and cultural requirement of water while making available required quantity for sustenance of the ecosystems. Water security hence requires good governance, since water allocation systems, through proper governance and institutional structure, influence the economic productivity, social and cultural well being and ecosystem quality in a country by prioritizing the access to water resources for consumptive uses such as drinking water, agriculture, and industry and for non-consumptive uses such as hydropower, recreation/tourism and environmental protection. Burgeoning water vulnerability due to climate change threatens the water security of a region as demand often exceeds supply.

Water security concerns are different in areas of physical scarcity and economic scarcity. In areas with physical scarcity, the primary water supply of a country exceeds 60% of its potentially utilizable water resources and this condition naturally prevails in arid regions while it may be manifested through man made interventions as in sustained overuse. In such regions ensuring water security is a major challenge even with high water use efficiency and productivity, as the demand exceeds supply. The main strategies for such regions would be to restructure the water allocation pattern, importing food and adopting technologies such as desalination. In the case of economic scarcity the water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for use by human beings. Although economic water scarce countries have enough water resources to meet the primary water supply, they

do not have the financial and infrastructure development capacity to utilize the available water (much of sub-Saharan Africa suffers under the effects of this type of water scarcity). This could be addressed with proper infrastructure, investments and polices. For instance, access to clean water could be enhanced through dams or improving rainwater harvesting and storage.

Resource use conflicts: transboundary and inter state

With decreased water availability, conflicts arise among users from different sectors, that is, domestic, hydropower, irrigation, industries, recreation and also ecosystem functions within the river basins. In addition, there are intra sectoral conflicts (for example, crop production and fisheries, cash crops and subsistence crops). These further intensify the transboundary conflicts which occur at the scale of large national river basins (multistate Indian rivers such as the Cauvery and the Krishna) or transnational river basins (the Jordan and the Nile). Conflicts have occurred on the Columbia River, in the north-western United States, where intensive river damming has affected salmon and other species. Conflict has been reported from dams planned or under construction in the Mekong river basin. The governance and management challenges are in prioritizing the country's/region's water requirements and planning resource allocation strategically.

River basin closure River water discharge for ecosystem uses, that is, flushing-out sediments, diluting polluted water, controlling salinity intrusion and sustaining estuarine and coastal ecosystems is not met as there is increased allocation for agriculture, industry and domestic uses. This is exacerbated by climate change induced stress. Water no longer flows out from the basin as is the case of the Jordan River. There is an urgent need for identifying the closed basins and evaluating the various adaptation strategies for maintaining the environmental flows. The closed basins pave way for water resource conflicts among sectors and countries.

Water stress in productive systems

Water, agriculture and food security Water is a key challenge for food production due to the extreme variability of rainfall, long dry seasons, and recurrent droughts, floods, and dry spells. The arid, semiarid, and dry sub-humid regions of the world cover around 40% of the world's land area and host roughly 40% of the world's population. The water-food security challenge in rainfed areas is to enhance yields by improving water availability and improving crop water productivity. The risk posed by high rainfall variability is that there is not enough infrastructure to capture and utilize the available rain water for future use. Investments are to be made for better capture, storage and delivery of water. Agriculture accounts for nearly 70% of freshwater withdrawals from rivers, lakes and aquifers for irrigation; up to or more than 90% in some developing countries. Irrigated agriculture covers around 275 million hectares of land and about 20% of cultivated land. This accounts for 40% of global food production. Irrigated agriculture projects high inefficiency and huge wastage. Land-water management should be promoted for sustainable water use. Other agriculture systems like fisheries and livestock are also affected due to climate change induced water stress. For example, warmer water will affect indigenous fish species and lead to a greater introduction of exotic species, creating ecosystem imbalances and threatening the food security of the poor in coastal areas.

Policies on intra sectoral water reallocation should be weighed against regional food security

Embedded water in food chain Value chain analyses indicate that it takes 70 times more water to grow food than that which is needed for drinking, cooking, bathing and other domestic needs. With the advent of urbanization, purchasing power has increased, leading to a shift in consumption patterns towards water-intensive diets and high-value crops that consume more water. The interest in the embedded water in the food chain has lead to the emergence of the concept of virtual water, which encourages reduced water use by vulnerable countries and making use of comparative advantage by water rich countries. Although there have been several virtual water models projecting the beneficial water trade between water rich and water poor countries, issues related to food security and self sufficiency are seldom discussed. Virtual water models need to be developed at the intra country level taking into account the differences in resource endowments in the country. Inter country virtual water trade has far reaching political dimensions which may not be beneficial for some of the trading countries in the long run. Policies on intra sectoral water reallocation should be weighed against regional food security.

Settlements and infrastructure Infrastructure associated with settlements include buildings, transportation networks, coastal facilities, water supply and wastewater infrastructure, and energy facilities. Infrastructure impacts include both direct damages, for example, as a result of flood events or structural instabilities caused by rainfall erosion or changes in the water table, as well as impacts on the performance, cost and adequacy of facilities that were not designed for the climate conditions projected to prevail in the future. The populations that will be most affected by climate change are those located in the already water-stressed basins of Africa, the Mediterranean region, the Near East, southern Asia, northern China, Australia, the USA, central and northern Mexico, north-eastern Brazil and the west coast of South America. Those particularly at risk will be population living in megacities, in rural areas strongly dependent on groundwater, in small islands, and in glacier or snowmelt fed basins (more than one-sixth of the world's population lives in snowmelt basins).

Water supply and sanitation Climate change exacerbates the pressure on water utilities in providing water services. Although it is difficult to identify climate change effects at a local level, the observed and projected impacts and stress provide a useful framework for utilities to plan their future services. This includes integration of climate change polices in existing systems and strategizing supply side and demand side options. The demand side options are to be focused in the years to come since supply side options are limited by the carrying capacity and resource endowment constraints. Urban distribution networks lose large amounts of water through leakage (unaccounted for water loss) resulting in significant financial costs and additional environmental and health risks. Technology can often solve part of the problem, but a large part of the losses are due to management or regulatory flaws. Adaptive capacity of the utilities determines the ability to cope with climate change.

Transportation networks Transportation networks are threatened due to flooding due to sea-level rise and increases in the intensity of extreme weather events such as storms and hurricanes. Urban flooding including street flooding, flooding of subway systems, and flood and landslide-related damages

to bridges, roads and railways are a few examples. In London, which has the world's oldest subway system, more intense rainfall events are predicted to increase the risk of flooding in the underground and highways. This would necessitate improvements in the drainage systems of these networks.

Migration The IPCC report estimates that by 2050, 150 million people could be displaced by climate change related phenomenon like desertification, increasing water scarcity, floods and storm, and so on. Climate induced migration will primarily impact South Asia, Africa, and Europe. Such migrations put stress on areas where there is less water and food scarcity, and can also lead to ethnic and cultural tensions. Water shortages and in turn food shortages can also result in conflict over water supplies and high levels of migration, putting further stress on the scarce resource.

Human Health Reduced river flows will lead to reduced effluent dilution resulting in increased pathogen or chemical loading. This could represent an increase in human exposures or, in places with piped water supplies, an increased challenge to water treatment plants. During the dry summer of 2003, low flows in the Netherlands resulted in apparent changes in water quality. The marked seasonality of cholera outbreaks in the Amazon was associated with low river flow in the dry season. Drainage and storm water management are important in low income urban communities, as blocked drains can cause flooding and increased transmission of vector-borne diseases. Climate change is expected to increase water scarcity, but it is difficult to assess what this means at the household level for the availability of water, and therefore for health and hygiene. There is a lack of information linking large-scale modelling of climate change to small-scale impacts at the population or household level. The salinization of water supplies from coastal aquifers due to sea-level rise is an important issue, as around one-quarter of the world's population lives in coastal regions that are generally water-scarce and undergoing rapid population growth.

Good governance strengthens institutional adaptive capacity and fosters societal resilience to climate change

Industry: risks and challenges

Industry uses less than 10% of total water withdrawals, but there are large differences in efficiency of use across industries and across regions. Industry creates more pressure on water resources from the impacts of wastewater discharges and their pollution potential than by the quantity used in production. Business risks due to water stress force countries to shut down their plants. For instance, France, Germany and Spain were forced to shut down dozens of nuclear plants due to a prolonged heat wave and low water levels. Some industries, such as tourism, show large seasonal variations in water use that can lead (on coastlines, islands and mountain areas) to supply difficulties in peak seasons. Around the Mediterranean Sea, seasonal water demands from the tourism industry increase annual water demand by an estimated 5–20% with competition from agriculture and the drinking water sector.

Corporate facilitation is called for enabling multi-stakeholder consultations on collective water management actions and transboundary cooperation

Water scarcity directly affects business operations, raw material supply, intermediate supply chain, and product use in a variety of ways. Declines or disruptions in water supply can undermine industrial and manufacturing operations where water is needed for production, irrigation, material processing, cooling and/or washing and cleaning. As water scarcity becomes a serious problem in many parts of the world, there may be corollary pressure, both regulatory and reputational, on products that require a significant quantity

of water. Products and services that require large amounts of water or energy to produce or to use may be phased out by law, lose market share to less water-intensive products, or cause reputational damage for the company. Water conservation and management should go beyond the Corporate Social Responsibility (CSR) framework and corporates should take proactive involvement in addressing the global water crises. Corporate facilitation is called for enabling multi-stakeholder consultations on collective water management actions and transboundary cooperation.

Climate change and water security: emerging governance and management challenges

Policy and institutional failures Indiscriminate use of water by stakeholders can be attributed to distorted sectoral policies, that is, irrigation subsidies and zero/low water tariffs. Since all the key sectors are water dependent, inter sectoral policy implications also assume significance. For instance, energy subsidies and improper pricing might lead to over exploitation of water resources. Win-win polices for interlinked sectors should be devised after evaluating the sectoral implications in their entirety, and this can be achieved only through good governance at micro, meso and macro levels. Pricing of water is one of the key components in good governance and management of resources.

Institutional dynamics Governance of the water sector is complex and involves actors beyond the water sector, more often than not leading to overlapping of responsibilities and culminating in sub optimal institutional operational dynamics. The actors can be national legislatures and governments, other sector agencies, local governments, river basin authorities, representatives of indigenous peoples, consumer bodies, private companies and others. Concerted efforts and a strong regulatory framework are crucial for effective stakeholder coordination. Water literacy fosters understanding of the resource and this should be ingrained in the educational framework of the country. Water religion concept should be promoted as a way of life with guidelines on code of water conduct.

Inter-sectoral policy dynamics is decisive for judicious water use and sustainable water governance

Integrated governance framework The institutional policy framework for water governance should also integrate the region's customary practices. Participatory management and development processes should be ensured which recognize the social, economic and cultural characteristics of the country or community. Effective enforcement is the key to successful governance and the system should be adequately supported through proper laws, legislations and acts.

Water religion, water literacy and water conduct will promote wise use of water

Traditional knowledge There is already a long record of adaptations to climate variability practiced by people which may ultimately enhance their resilience. Examples of such traditional and innovative adaptation practices include: shoreline reinforcement, improved building technologies, increased water quality testing, rainwater harvesting, supplementary irrigation, traditional farming techniques to protect watersheds, changing hunting and gathering periods and habitats, crop and livelihood diversification, use of new materials, seasonal climate forecasting, community-based disaster risk reduction and so on. Traditional knowledge complements existing measures of coping with climate change and improves the adaptive capacity of the society.

Traditional knowledge acts as complementary measures to cope with climate change and improves the adaptive capacity of the society

Right to water and water rights The right to water and water rights have to be recognized within the region after evaluating the implications on the socio-economic, cultural and livelihood/food security. Proponents argue that the realization of the right to water is indispensable to the realization of many

Right to water vs water rights

other internationally recognized human rights, including the right to food, the right to health, and the right to adequate housing. This right is different from the Land Easements Acts in some developing countries where water rights are embedded in the property rights of the land. The land rights provide the stakeholders unlimited access to water withdrawal from their land which might cause irreversible impacts to the ecosystems if unchecked. Market failure of agriculture and other livelihood options generates an interest in water markets the implications of which are not well studied.

Privatization of water An informal water market is the precursor to privatization of water where water is traded as an economic good. This might lead to conflict of interest among the various stakeholders who cannot afford to pay a high price for water. Privatization has its advantages and disadvantages and it can only be promoted in select regions where it can bring forth observable differences in service delivery mechanisms at an affordable price. Experimentation with water privatization pilot models in different regions with varying resource endowments and socio-economic features will reveal the operational dynamics and constraints. Public–private partnership in the water sector has been highly successful in many regions and should be widely promoted.

Transnational cooperation and governance

Inter-state and inter-country conflicts on surface and ground water (transboundary aquifers) are prevalent among the riparian countries in shared river basins. Conflicts and regional instability (or stability) can influence water demand and use, particularly in water-scarce regions. This is the case where competition arises between different water uses within a country or where water disputes exist between countries, as between Bangladesh and India over the Ganges River and among the riparian countries along the Danube River. Conflicts in Aral, Nile, Amazon, Mekong and the Parana-LaPlata basins are also widely reported and the main concerns are related to an appropriate framework in addressing the challenges related to water use and allocation in each riparian state. Conflict resolution mechanisms are in place either in the form of international treaties and conventions or alternative dispute resolution mechanisms. One of the noted intergovernmental initiatives is the United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes, convened in Helsinki in March 1992 which has been ratified by 35 countries. Intra country conflicts are also reported widely and several joint management models have been tried without much success. Successful conflict resolution models need to be devised at the intra country micro level which would showcase different scenarios for joint successful management. Countries should work within their territory in solving the inter state water conflicts under different management scenarios which could act as a good governance model for transboundary water management. Interested and willing stakeholders need to be a part of dispute resolution and water tribunal appellate authorities.

The marginal costs of adaptation will be high in the water sector and the incremental increase will exponentially grow as there are inter-sectoral ripple/distributional impacts in water and allied sectors

Cost of water adaptation The marginal costs of adaptation will be high in the water sector and the incremental increase will exponentially grow as there are inter-sectoral ripple/distributional impacts in water and allied sectors. The need for sustainable financing is one of the most persistent concerns in water resources decision-making. Several key initiatives over the past five years have shaped the agenda of water financing, including the World Panel on Financing Water Infrastructure, the Task Force on Financing Water for All and the UN Secretary General's Advisory Board on Water and Sanitation.

Strategies and practices for emerging water management and governance challenges: key points

Assessing economic and physical scarcity

- Programmatic approach for resource evaluation (resource endowment and water use efficiency)
- Institutional mechanisms to upgrade the systems
- Investment options: domestic and international
- Location specific potential water harvesting and water savings programmes

Supply and demand side management

- Increase, upgrade and restore storage structures judiciously
- Alternative source augmentation strategies namely desalination, waste water recycle and reuse, rainwater harvesting, artificial recharge
- More focus on demand management, capacity building, information communication and education/information technology
- Prevent leakage and unaccounted for water loss (UFW); Water efficient fixtures
- Transfer of technology

Ecosystems

- Ensure minimum ecological and environmental flows and mandatory minimum ecological area preservation
- Conserve wetlands: 'kidney of ecosystems'
- Promote river basin management and develop indicators for water health
- Integrate livelihood and adaptive capacity in coastal zone management
- Promote strategies for harvesting and wise use of floodwaters; upgrade flood protection infrastructure (structural and non-structural measures)
- Flood resistant crops and minimum tillage practices in agriculture
- Payment for environmental services

Agriculture

- Promote efficient use of water in rainfed and irrigated agriculture; more crop per drop
- Promote low external input sustainable agriculture; less water intensive crops, system of rice intensification, drip irrigation
- Soil and water conservation measures
- Conjunctive use of surface and ground water; grey/wastewater irrigation options
- Participatory irrigation management
- Water pricing; target/package subsidies

Business/industry

- Measure water and carbon footprint throughout the value chain
- Assess physical, regulatory and reputational water risks associated with climate change
- Integrate water and climate issues into strategic business planning and operational activities
- Engage key stakeholders as a part of water and climate risk assessment, long-term planning and implementation activities
- Disclose and communicate water and carbon performance and associated risks
- Seek opportunities for collective action

- Promote water conservation through partnerships (for example, Coca Cola-WWF)
- Adopt water positive technologies; promote zero water discharge
- Waste water recycle/reuse
- Proactive role in public private partnerships
- Public–private partnership

Adaptive capacity

- Good governance, improved water use efficiency; technological options
- Institutional adaptive capacity; improve the system's access to risk-spreading processes
- Improve the stock of social capital including the definition of property rights
- Good information management
- Adaptation funds
- Water literacy, religion and code of conduct

Integrated water resource management

- Water resources protection and conservation, with specific emphasis on improving water quality, environmental health conditions and sanitation (urban and rural areas), institutional and legal linkages within an ecosystem approach. Particular attention should be devoted to the spread of water-related diseases and of aquatic weeds in large water bodies
- Mechanisms for prevention and resolution of water-related conflicts at local and national levels

Institutions, policies and governance

- Regulation through market based and regulatory (command and control) approaches
- Water metering, water pricing
- Incentivising through tax rebates; water conservation; demand management
- Promote water efficient fixtures
- Policy framework and guidelines (for example, EU directive)
- Transboundary surface water governance; transboundary ground water aquifer governance
- Promote community/stakeholder consultations; promote private participation
- Promote water boards; recognize customary water rights
- Differentiate and recognize right to water and land based water rights; recognize informal institutions in governance
- Assess investment and financial flows for future climate scenarios
- Integrate and mainstream climate change concerns in water and related policies
- Coordinated efforts to manage the resource

Research and development through knowledge networking

- Promote regional and transboundary research and networking
- Promote advanced scientific tools for data generation; transfer of technology
- Database management; promote sharing of water expertise; interactive websites
- Common platform to promote shared vision and cooperation

Traditional knowledge

- Recognize traditional knowledge in coping with climate change
- Integrate traditional knowledge in all the climate change strategies
- Promote traditional-modern hybrid strategies for water management

Conclusion

Climate change impacts on water are wide ranging with far reaching implications, both known and unknown. The water stressed regions are vulnerable to climatic and non climatic pressures which threatens the water security in these regions. Water security determines the economic, social and cultural development of a region and climate change impacts threaten the very existence of many water vulnerable regions. The main challenge in sustainable water resource management is good governance, which ensures best practices in water use through efficient use and wastage minimization. Such good governance practises will foster water security even in poor resource endowed areas. Under the climate change realm, for each key sector, water use needs to be redefined and re-evaluated so as to integrate water religion/culture in the entire value chain. Similarly, sectoral policies and institutional structure are to be evaluated and revisited giving appropriate weightage to food and water security linkages and effective enforcement measures. Inefficacies in water use, management and governance make the countries/regions more vulnerable to climate change induced water stress. Many regions are highly vulnerable with limited adaptive capacities to deal with climate related extreme events and other risks. One of the main challenges in adapting to climate change is the investment requirement which is very high in the water sector. Besides, the marginal costs of adaptation in the water sector are very high. The thoughts propounded in the paper primarily aim at understanding the complexities in addressing water security, food security and good governance for helping countries in framing integrated and adaptive water governance polices. Since there are regional variabilities in resource endowments, transboundary cooperation and shared vision are envisaged for river basin and aquifer management which help in bridging the divides. On the adaptation front, various advanced and traditional coping strategies are documented across the world which have the potential to be replicated and scaled up. The concept of water religion which provides a guideline for wise use of water has to be practiced as a way of life and water literacy is to be promoted through targeted programmes. Stakeholders including corporates can play an active role in facilitating inter governmental talks, and public–private partnership needs to be promoted at all levels. The main paper discusses in detail all the challenges and analyses the various sector specific strategies suited for water vulnerable regions.

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