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The Water and Sanitation Program (www.wsp.org) is a multi-donor partnership administered by the World Bank to support poor people in obtaining affordable, safe, and sustainable access to water and sanitation services.

October 2010

Field Note

Climate Risk Screening of the WSP Portfolio in India

Identifying Key Risk Areas and Potential Opportunities

This Field Note discusses the risks of climate change and the adaptation measures that need to be taken to minimize these risks. Adaptation can be seen as an opportunity to improve current systems of working, enhance policy and design procedures, and bring communities together as they face a common problem.

Background

The 2009 Conference of the Parties to the United Nations Framework Convention on Climate Change meeting in Copenhagen, and the latest Intergovernmental Panel on Climate Change (IPCC) Report (2007), has confirmed the consensus amongst scientists and policy makers that human-induced global climate change is now occurring. The Copenhagen meeting also confirmed the need for action to mitigate and adapt to climate change. India has recently signed the Copenhagen accord, agreeing to work with other nations to address the issues and threats posed by climate change.

The threats of climate change to the global and local water balances are expected to be significant. The donors who provide aid to countries such as India are now concerned that the aid given may not deliver the expected benefits. Thus the risks posed by climate change need to be assessed and practical adaptation measures are required to minimize the threats of man-made climate change.

In this report, the major issues of climate change as they affect rural and urban water supply and sanitation in India are addressed through a risk screening of the Water and Sanitation Program's (WSP's) work during 2009–10. Also, the potential to adapt to climate change is going to be a key issue for the future and so recommendations on adaptation measures are presented. Finally, a draft action plan is developed to achieve these adaptations.

Box 1: Terms of Reference

The Department for International Development is one of the Water and Sanitation Program–South Asia's (WSP-SA's) main donors in India and has requested a climate change screening exercise throughout the WSP India portfolio identifying key risk areas and potential opportunities. Specifically, the deliverables for this risk screening are:

- Review the India FY10 business plan project sheets in the areas of rural and urban water supply and sanitation.
- Prepare a short report identifying the risks posed by climate change to activities in the project sheets, as well as opportunities in the form of mitigation or adaptation strategies.
- Provide recommendations on how to address the risks and opportunities.

Based on findings from the above study, an action plan is also needed on how to take forward the various recommendations (addressing key risks and opportunities).

Box 2: The Water and Sanitation Program

The Water and Sanitation Program (WSP) is a multi-donor trust funded program that operates through four regional offices in Africa, East Asia, Latin America, and South Asia. The mission of WSP is to help poor people gain sustained access to water supply and sanitation services. It achieves this in partnership with client governments and other agencies through analysis of sector problems, identification of solutions, and documenting and sharing lessons from the field. This provides the evidence needed for WSP to support its government clients as well as to develop and implement policies, strategies, and investments. All of these are aimed at achieving the Millennium Development Goals. There are four specific projects considered in this report, concerning WSP's work in India:

SA/IND/55: Improving sustainability of rural drinking water supply.

SA/IND/56: Scaling up and sustaining rural sanitation outcomes.

SA/IND/57: Improving urban water service delivery in India.

SA/IND/58: Improving urban sanitation and municipal solid waste management services.

Potential Impacts of Climate Change In India

As part of the process to understand the potential impacts of climate change, there has been extensive research by many leading research groups across the world (IPCC 2007). As part of this process and other initiatives, there have been extensive studies of the potential impacts of climate change on India and South Asia. A recent Department for International Development (DFID)-funded report on climate change (Nair et al. 2007) presented a comprehensive review of the likely impacts of climate change on India and South Asia.

Some key points that emerge from that analysis are:

- Surface temperatures in India already show a warming of about 0.3 degrees Celsius between 1901 and 2000, with considerable regional variation with warming occurring in all four seasons.
- Future temperatures will increase by 2 to 3 degrees Celsius by 2100 (assuming a greenhouse gas emission scenario which allows for extensive regional development and quite strong economic growth).
- Warming across India will be highest in post-monsoon periods (October–November). Warming over Northern India will be highest over the winter seasons (December–January–February).
- There will be wetter and more variable monsoon conditions. These are likely to be associated with higher rainfall intensities causing higher peak flows in rivers and increases in flood magnitude and frequency. Tanner et al. (2007) suggests drier winters in addition to wetter monsoon summers with these effects becoming larger by the 2050s.

More recent research studies by Turner and Slingo (2009) at the Walker Institute at the University of Reading also show that the summer monsoon rains over India could become less reliable as a result of climate change. Very heavy rainfall events over India could occur twice as often in the future as a result of climate change and so increase the risk of flooding. Periods when the rainfall fails during the monsoon could also become more prolonged. This recent study indicates that climate change is likely to bring heavier rainfall bursts over India (that is, storm events when significant rain falls over a short time period, say, a few hours). This increases the risk of the sort of devastating flooding seen in Mumbai in July 2005 when nearly 1 meter of rainfall fell and many hundreds of people died. Over India, these extreme events typically occur only once every few years. If levels of carbon dioxide in the atmosphere reach double their preindustrial level (something that is almost certain to happen this century), then rainfall events like this could be around 10-15 per cent heavier. Moreover, the research reinforces the earlier findings that breaks in the monsoon, when the rains fail, are likely to become more prolonged. This would lead to reduced irrigation water for agriculture and also reduced water for public supply. As an example of this, the extended monsoon break of July 2002 led to a reduction in both agricultural output and economic growth in India.

A new report by Wilby et al. (2010), funded by the DFID, states that climate-driven changes in water quantity, water quality, and biology will affect the performance and operation of existing water infrastructure—including hydropower, structural flood defenses, drainage, and irrigation systems—plus water management practices. These impacts will be exacerbated by nonclimatic pressures arising from population and economic

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growth, as well as by trends towards greater urbanization and agricultural intensification. There is evidence that variability in the timing and strength of the monsoon are already affecting hydropower and production of staple crops in the region. However, perhaps the greatest concern is that long-term wastage of the region's snow and ice stores (the 'water towers' of the continent) will have a profound impact on water security. Mountain communities also face increased risks associated with glacial floods, thawing permafrost, slope instability, soil erosion, and associated impacts on rural infrastructure. Coastal and island communities are threatened by water scarcity (due to physical shortage or saline intrusion) as well as by the combined effects of sea level rise, changes in the frequency and severity of cyclones, and associated fluvial flooding and tidal surges. The incidence of water-related and waterborne diseases is expected to increase and the distribution of vectorborne diseases may change, in terms of the timing and new zones of infection. The report concludes that the Eastern Ganga basin (including parts of India, Nepal, and Bangladesh) is susceptible to glacial melt, flooding, and drought due to delayed onset or weakening of the monsoon. The report also points out that the densely populated mega-deltas of the Indus, Ganga-Brahmaputra and Cauvery rivers are susceptible to flooding, sea level rise, saline intrusion, and wetland degradation.

Finally, climate change will have impacts on river water quality and ecology. A summary of the likely impacts are given by Whitehead et al. (2009), and illustrate that low flows in droughts will increase pollutant concentrations, possibly affecting public water supplies. In addition, temperature-dependent hydrochemical processes will be affected which could have deleterious consequences for water quality, such as the release of mineralized nitrogen in rivers or the lowering of dissolved oxygen levels, with subsequent damage to fisheries. Also, increased rainfall could lead to enhanced erosion of sediments and increased sediment concentrations in rivers.

Climate Risks and Development

From floods and cyclones to drought conditions and water scarcity, poor people in India are already vulnerable to climate-related shocks and stresses. Despite the limited contribution to the causes of climate change, India is amongst the most adversely affected by its impacts.

Climate change is raising average temperatures and is likely to exacerbate extremes, as well as causing new hazards such as sea level rise. The achievement of the Millennium Development Goals (MDGs) is threatened by climate shocks and stresses, and development agencies are increasingly aware of the significance of these risks to poverty reduction. A recent Organization for Economic Co-operation and

Development study estimated that over half of the aid flows to countries such as India, Bangladesh, and Nepal may be at risk. Extreme climate events have frequently set back the development process for decades. Humanitarian responses to disaster impacts already cost donors an annual US$6 billion or 7 per cent of Official Development Assistance flows and this proportion is rising. In many cases this funding is reallocated from ongoing development activities.

Development agencies such as the DFID are committed to reducing climate-related vulnerability by integrating adaptation and risk reduction into development cooperation. To tackle these issues, the DFID has piloted the use of climate risk management through a process to assess and address climate risks to development programs. This process called ORCHID (Opportunities and Risks from Climate Change and Disasters) emphasizes the need to raise awareness and interest among staff and partners, as well as recognize the complexity of decision making where information is often uncertain and data gaps are frequent. While it will not be feasible to reduce all climate risks, this allows for systematic risk consideration in the context of development assistance. The process may also help to determine some of the limits of adaptive risk reduction responses. ORCHID provides country-based portfolio screening of projects and programs, as well as a broader strategic assessment that relates donor activities to national priorities and plans. Based on profiles of climate and future hazard and vulnerability, the process prioritizes key planned and ongoing activities that are high risk and present good opportunities for risk and vulnerability reduction. Recommendations are made for integrating disaster risk reduction and climate change adaptation within program activities. These recommendations draw on further inputs on hazards, vulnerability and existing assessments, and plans and practices. Also, these recommendations are assessed for impact, cost-effectiveness, and feasibility prior to the integration of measures into planned and ongoing DFID-funded activities. Recent DFID ORCHID reports cover whole countries such as Bangladesh (Tanner et al. 2007) and India (Tanner et al. 2007).

In this report, the ORCHID type screening process has been adopted and applied to the four specific WSP projects listed in Box 2. The key to the ORCHID methodology for the current work is to undertake risk screening of climate-related events on the four poverty reduction programs. It also addresses the need for adaptation to reduce the risks posed by climate change to people's lives and livelihoods. The DFID integrated report on India (Tanner et al. 2007) produced an overall summary table for the WSP program as a whole and this is shown in Table 1. These give a broad indication of the WSP area.

Table 1: Climate risks, management, and adaptation strategy for the Water and Sanitation Program

Identified climate risks	Climate risk management and adaptation	
	Current practices	**Additional opportunities**
Damage to drinking water pipelines and sewage lines	Help central government with management of technical and financial frameworks for maintenance of WSP services	■ Improve compliance and build awareness of planners on building codes and best practices ■ Conduct vulnerability and risk assessment to inform building codes prior to infrastructure development in low-lying areas ■ Analyze spatial and temporal changes in drinking water supply and incorporate the results in contract documents of local service providers ■ Ensure integrated flood or disease warning and rapid evacuation procedures for vulnerable areas
Changes in water supply demand and supply	Help central government with development of best practices for water resource management	
Occurrence and spread of waterborne diseases	State-level water quality monitoring and surveillance to check the nature of secondary order impacts	

The issue of water security is fundamental to government policy on rural water. WSP is currently working on activities that include integrated water resources planning, water safety planning, periodic review of improvement programs, introduction of standard operating procedures and operator service agreements, as well as inputs to government policy, strategy and capacity building.

Climate Risks, Adaptation, and Opportunities for WSP India

In this report we are concerned not only with the risks of climate change but also the adaptation measures that need to be taken to minimize these risks. In many ways adaptation can be seen as an opportunity to improve current systems of working, enhance policy and design procedures and, perhaps, bring communities together as they face a common problem.

Improved Sustainability of Rural Drinking Water Supply (SA/IND/55)

The issue of water security is fundamental to government policy on rural water. Government policy can be broken down into (a) ensuring a good source in terms of quantity and quality; (b) source conservation and protection measures; (c) water quality management; and (d) effective operation and maintenance including investments in minor repairs as well as major renewal, replacement, and expansions. Whilst policies and financing are moving in the right direction, establishing effective implementation approaches for new approaches are still a challenge. WSP is currently working on activities that include (a) integrated planning (district water security planning) including periodic review and ongoing financing for new infrastructure and maintenance; (b) water safety planning; (c) standard operating procedures including key operating tasks and assessment of cash flows; and (d) operator service agreements. The approach to the project has been to develop the district planning function as a means of matching bottom-up determined needs and delivery with top-down overall policies and financing. The large size of the districts (on average there are 1,000 villages per district in India) provides for consideration of integrated water resource planning covering surface water, groundwater and rainwater harvesting, and convergence of different development programs. The approach moves away from top-down infrastructure provision to service provision considerations. In the context of climate change it is instructive to consider what should be included in the advice provided to gram panchayats[1] by states through the district planners, and what measures the gram panchayats should include in their plans.

In practice the gram panchayats will require a lot of technical support and training in applying advice. So, for example, state policy advice would be required along the following lines:

- Water resources: Minimum acceptable per capita amounts, minimum acceptable conditions for access, required water storage (in days) based on estimates of rainfall predictions, codes of practice for rainwater harvesting and aquifer recharge, multivillage scheme options.
- Drinking water quality: Interim standards (based on Bureau of India Standards IS 10500 and the World Health Organization) with emphasis on microbiological quality and known key contaminants such as arsenic and fluorides, drinking water safety plans, recommended treatment approaches according to type of water source, sampling and analysis on occasional checks against interim standards.
- Operations: Technical surveys to establish current technical and financial situations and advice on how to protect water supplies against flooding including protection of sources and treatment and consideration of the state of drainage channels, maintenance of distribution systems including leakage control.

It is not for each gram panchayat to try to make its predictions on climate change but to respond to the advice coming down from the districts based on state policy, and prepare plans for submission to the districts. However, they know what problems are being experienced now, whether from droughts or flooding, and should aim to optimize their current operating systems to minimize the impacts. The risks posed by climate change to these policies and to the sustainability of rural drinking water supplies are considerable. Climate change will impact rural water supplies in several ways.

Flooding

The warmer temperatures are likely to increase evaporation and trigger higher magnitude precipitation events, leading to larger floods (Wilby et al. 2010). If a well has been flooded there is a risk of contamination causing diseases such as diarrhea, dysentery, cholera, typhoid, and so on. It is critical that the well is disinfected by chlorination or drinking water is boiled before consumption. There may also be contamination of the well by chemicals such as pesticides or the

[1] A 'gram panchayat' is the lowest tier of local government.

well may be filled with sediment. It will not be easy to deal with devastating floods as the damage could be quite severe; however, it is possible to mitigate the effects of most floods by reviewing the construction of infrastructure such as well aprons and drainage, well heads, storage and treatment facilities, local dams, water storage ponds and irrigation systems. This has to be done at the local level but there is a need for state and national policy to refine the guidelines for construction, engineering design, and hydrological management rules. Models of catchment hydrology can also be used to give advance warning of floods using rainfall gauge networks or weather radar systems. Such models have considerable utility in providing flow and flood level forecasts, which can save lives and also restrict damage. Also, an analysis of the threats of low-lying areas to flood could assist in preventing construction in these areas, thereby saving lives and the costs of flooding. Flooding is also an opportunity, in that the surface waters can be encouraged to recharge the groundwater, as described in the next section.

Droughts and Extended Breaks in the Monsoon

The expected increase in droughts and the likely extended breaks in the monsoon rains will create problems for water supply in rural areas, which rely heavily on groundwater and local storage of water. In many areas groundwater is being drawn from fossil sources or in exceedence of recharge rates with the consequence that there are excessive draw downs and removal from storage; this has recently been graphically demonstrated from remote sensing (GRACE satellite) by Rodell et al. (2009). Groundwater levels will fall as continued abstraction depletes the resource; local wells, dams, and ponds will dry up. This will obviously create problems for domestic and public water supply.

Measures to improve the sustainability of these water sources include more extensive local small dams to give increased storage and also systems to encourage groundwater recharge such as Managed Aquifer Recharge (MAR). This is crucial for drought-prone areas where it is imperative that a proportion of the surface run-off is encouraged to infiltrate the soil and recharge the groundwater, rather than run off into rivers. This can be achieved using agricultural techniques such as contour plowing or bunds to prevent run-off so that surface ponding and, hence, enhanced infiltration into the soil, is achieved.

There are some impressive case studies which demonstrate the efficacy of present day small scale water harvesting, especially in Rajasthan. These studies emphasize the importance of reintroducing concepts of traditional ideas with proven success over centuries. These successful studies have typically been bottom-up and facilitated by nongovernmental organizations. Good examples of these are coordinated by Wells for India (see www.wellsforindia.org) and the Alwar project initiated by Rajendra Singh (Sharma 2006). In such examples, community participation has been the key to success which has led to perennial water access and two or even three crops per year. The successful impact of water harvesting projects has been proven by satellite images and by field studies (Sharda et al. 2006; Stiefel et al. 2009). Such initiatives are now being promoted and encouraged by the Government of India. It is strongly recommended that such initiatives be expanded to improve the understanding and validation of rainwater harvesting as a means of stabilizing rural populations and redressing urban drift.

However, increasingly, lower groundwater tables are leading to a shift from shallow tube wells and handpumps, to piped water supplies such as mechanized mini water supply systems (tank and tap), single village mechanized piped water supply, or bulk supply for multivillage schemes based on surface water. Many states (such as Karnataka) are discussing the possibility of large regional bulk water supply (as is already found in Gujarat, for example, and the Churu scheme in Rajasthan).

Thus, there seems to be a move towards replacing traditional groundwater supplies with surface water storage and supply. States that adopt such a strategy will need to ensure that there are adequate good quality surface supplies sufficient to supply public needs. In addition, the costs are significantly higher that local rain-fed systems.

Therefore, in many ways, the climate change issue provides a stimulus and an opportunity to improve the level of service and sustainability of rural water supplies.

Waterborne Diseases

One of the likely effects of climate change will be to increase the presence of waterborne or water controlled diseases. For example, enhanced contamination of wells and water supplies by E. coli will cause more stomach infections and food poisoning. E. coli bacterial growth increases in warmer conditions and

Scaling up and sustaining rural sanitation outcomes involves the promotion of 'total sanitation', focusing on achieving open defecation free communities through behavior change. Improved drainage and solid waste management are critical, especially with urbanization of rural communities.

this, coupled with flood events following drought conditions, will flush higher concentrations of bacteria into wells and public supplies. There could also be increased crosscontamination from human and animal waste disposal, leaking into water supply pipelines. Again, the resolution of this is a design and policy issue to ensure pipelines are adequately separated for sources of waste and also that adequate testing at well heads is undertaken to prevent drinking contaminated water. Other diseases such as schistosomiasis are also spread by irrigation and water movement (Maszle et al. 1998) and there may be an enhanced exposure of rural people to such diseases. Again, it is possible to take measures that reduce the risk of the spread of such diseases.

Policy and Education

Policy and education are also key aspects of the WSP project and these have a big role to play in combating the effects of climate change. Mention has already been made of the need for new design codes for water infrastructure, and these need to be agreed and instituted at national, state, and local levels. This is a big task, and beyond the specific scope of the WSP program, but could help in achieving more sustainable rural supplies. Similarly, education can play a major role in informing people of how to improve local management of water supplies, to enhance groundwater recharge, and to minimize the risks to infection and disease. This education can start in schools and local community groups and be supported by research in colleges and universities, and also make use of media such as the internet, mobile phone system, television, and radio. Adequately funded research is a key requirement to redesigning engineering codes, to evaluate the impacts of climate change across India and to improve flood forecasting techniques. Again, large scale research is beyond the remit of the WSP, but WSP should support externally funded new research initiatives where they can provide additional information for WSP projects. One good example of this is the need for a regional climate model, based on say a 25-km grid, which could provide more local information. Such a model has been set up by the Walker Institute at the University of Reading for the Middle East region and applied to assess climate change, drought, and flooding in the Jordan Valley (www.waterlifecivilisation.org). Such a model could be set up and applied across India, providing much better estimates of the impacts of climate change in regions and local areas in India.

Task Action Plan

The adaptation measures and opportunities highlighted earlier for rural water supplies could give rise to a significant set of tasks and potential actions, including:

- Redesigning the engineering codes for pipelines, water treatment, water supply systems, local dams,

and irrigations systems. This is beyond the scope of WSP's activities, but WSP can support government policy to achieve this.
- Increasing use of rain-fed systems to enhance the sustainability of local water supplies.
- Introducing measures to enhance groundwater recharge following all rainfall events.
- Providing improved flood forecasting measures based on measure precipitation gauges or weather radar systems, linked to catchment models.
- Helping refine policy at national, state, and local levels to incorporate the above four tasks.
- Supporting educational systems to inform local people and also encourage research funded outside of the WSP project to support the above five tasks, as well as the development of a regional climate model which can be linked to local water use patterns, thus helping to better estimate impacts of climate change.

Scaling up and Sustaining Rural Sanitation Outcomes (SA/IND/56)

This WSP project involves the promotion of 'total sanitation' (including safe disposal of excreta and solid and liquid waste management) with a focus on achieving and sustaining open defecation free communities through behavior change. The risks posed by climate change to the sustainability of rural sanitation are potentially significant. The major threats are rising temperatures, increased droughts, increased flooding, and a more variable monsoon. These changes could impact rural sanitation in several ways.

Flooding

The main threat from flooding arises from the possible inundation of domestic and public toilets, especially in low-lying areas. This would create many problems with damage to infrastructure and additional public health problems that may arise. The roll out of sanitation services in rural areas could be affected if enhanced protection is required and it will not be easy to deal with devastating floods as the damage could be severe. It is, however, possible to mitigate the effects of most floods by reviewing the infrastructure. Climate change will require greater emphasis on protecting toilet facilities and districts and states should provide advice on the location and design of toilet blocks to protect against flooding. Likewise, improved drainage and solid waste management are critical, especially with urbanization of rural communities.

Water Quality and Waterborne Diseases

The WSP approach towards 'safe water and sanitation for all' addresses quality aspects of water to make it safe and also an inclusive approach to address the poor. The climate change challenge will require a higher order of capacity of service providers and a greater level of responsible behavior and hygiene adaptation at the household level. Water Safety Planning frameworks in WSP areas are the starting points to work towards addressing water quality issues. One reason for decline in water quality is the increase in run-off and precipitation that carries with it higher levels of nutrients, pathogens, and pollutants, especially in cases where there are sanitation problems. Another significant source of water degradation results from an increase in water temperature as bacterial growth is enhanced in warmer conditions. The great advantage of installing sanitation is the resultant reduced pollution and hence the reduced likelihood of diseases being spread in rural areas. For example, enhanced contamination of wells and water supplies following flooding is restricted significantly by rural sanitation.

Droughts and Extended Breaks in the Monsoon

The expected increase in droughts and the likely extended breaks in the monsoon rains will create problems for sanitation in rural areas, where water is required for flushing of public toilets. Climate change also raises the question of the reuse of sewage effluent for irrigation, as this may be possible where there are water shortages. Again, states should decide on policy in relation to water source situations and advise gram panchayats accordingly.

Policy and Education

Policy and education are also key aspects of the WSP project and these have a big role to play in combating the effects of climate change. There may be a need to reevaluate the design of public toilets and sanitation systems, but this is a task for state and national governments. Increased focus on solid and liquid waste management is critical and has already been made a priority by the national government.

Task Action Plan

The adaptation measures and opportunities highlighted earlier for rural sanitation could give rise to a significant set of tasks and potential actions, including:
- Providing support to state and national governments for the improved design of toilets and sanitation systems to ensure these

The density and size of populations in urban areas mean that climate change problems are magnified. Associated with reliability of water supply are improved leakage control, policy on nonrevenue water, improved controls on drinking water quality derived from water safety plans, and public education programs.

are not damaged by floods and remain effective in droughts. However, care must be taken to ensure that the costs of improved codes do not become counter-productive to the acceptance of sanitation behavior change.

- Supporting integrated approaches for water supply and sanitation planning that anticipate urbanization and water scarcity, through initiatives for solid and liquid waste management, water safety planning, and ensuring adequate quantity of water for domestic needs.
- Supporting educational systems to inform local people and also providing the expertise and research needed to undertake the above tasks.

Improving Urban Water Service Delivery in India (SA/IND/57)

In many ways, the risks posed by climate change to the urban water service are similar to the rural water supply but operate at a larger scale. The density and size of populations in urban areas mean that climate change problems are magnified. Demand controls are vital, especially with a growing population. It has now been shown in India that 24x7 supply systems actually reduce overall water demand, so an important policy decision is the timetable for its achievement across all cities. The reliability of supply provides for public confidence and a greater willingness to pay for a sustainable service. Associated with 24x7 supply is a policy on nonrevenue water including improved leakage control. Performance indicators and benchmarking are already being introduced by national and state governments to drive the implementation of operational improvement programs. Also, city and public education programs are essential for demand management. As intermittent supplies are one of the greatest risks to drinking water safety, 24x7 supply also provides for safer water. Policy should include the requirement for improved controls on risks to drinking water quality derived from water safety plans. Moreover, operational matters are for the cities, whether or not they contract out the management of the services. How they meet the required system capacity and performance targets should be a matter for them. States should check that city plans are appropriate to achieve and sustain those service requirements.

The major threats as a result of climate change are rising temperatures, increased droughts, increased flooding, and a more variable monsoon with the unpredictable intermittent breaks in the monsoon. These changes will impact urban water service delivery in many ways.

Flooding

The flooding problems are likely to be severe in urban areas as the impermeable surfaces (for example, car parks, roads, and so on) retain no water and provide a rapid overland route for the water. Houses, buildings, and factories intensify flooding as roof drains are overwhelmed and rapid flow occurs. Moreover, drains and streets focus the water flows through low-lying urban areas, especially where culverts and drains have not been adequately designed to take the extra flow volumes. These extra flow rates and the force of the water are quite likely to damage infrastructure such as drains, culverts, and water supply pipelines. In general, urban areas have larger external storage capacity, in the form of reservoirs or dams, for supplying the larger city populations than rural areas. In theory, such extra capacity should provide greater supply reliability. However, groundwater, direct river abstraction or dam systems supplying urban centers may be themselves vulnerable to excessive floods. Floods can overwhelm reservoirs or dams, especially if the flow volumes exceed the dam design criteria, which are based on past rainfall and flow regimes. Also, groundwater and river water can be contaminated by flood water, so there are clearly several issues here that need addressing. WSP can support national and state governments in checking current design criteria and ensuring that the water infrastructure can cope with increased rainfall and floods. Also, it is necessary to ensure that water treatment plants have sufficient capacity to handle the extra volumes of contaminated water.

There is also the possibility that water treatment plants and pumping stations will be located in low-lying areas and they will be vulnerable to flooding. For example, recent floods in the United Kingdom caught water supply authorities by surprise as water treatment plants were put out of action for up to three weeks (Severn Trent Gloucester area in summer 2008).

The severe threat to human populations by floods in low-lying areas can be limited by a flood warning system and by the prevention of building in low-lying areas. Models of catchment hydrology can also be used to give advance warning of floods provided data is available from rainfall gauge networks or weather radar systems. These are outside the remit of the WSP projects but WSP can provide support for such initiatives.

Droughts and Extended Breaks in the Monsoon

In urban areas, the expected increase in droughts and the likely extended breaks in the monsoon rains will create problems for water supply but these may not be as immediate as for rural areas because of the larger capacity backup storage available in urban areas. However, groundwater levels will fall as continued abstraction depletes the resources, and reservoirs and rivers will dry up if a drought persists. This will obviously create problems for public water supply. Measures to improve the water sources are costly in urban areas because of the large scale infrastructure required to supply the larger populations. This can only be addressed with major funding and planning. There is also a need to refine the estimated effects of climate change in urban centers, use the best information to redesign the water supply systems, and put in place long term plans. However, as in the case of the rural situation, the climate change issue provides an opportunity to improve the sustainability of urban water supplies.

Water Quality and Waterborne Diseases

Waterborne disease will also be an issue for urban areas, especially if flood water contaminates the public water supply system or droughts cause people to drink untreated water because of the lack of supply. Again, the only adaptations possible to this are educational, to warn people of the dangers, and to increase the basic water treatment infrastructure to minimize the contamination or the loss of supplies.

Policy and Education

Policy and education are also key aspects of urban water services and these have a big role to play in combating the effects of climate change. Urban populations can be assisted by flood warning systems and also warnings about water contamination. WSP can support the review and updating of design codes for water infrastructure but this is a policy issue for national, state, and local levels.

Task Action Plan

The adaptation measures and opportunities highlighted earlier for urban water services could give rise to a significant set of tasks and potential actions, including:

- Improving data collection and providing reliable information to help policy makers make better decisions.
- Supporting national and state governments to assess engineering codes for street drains, culverts, roof drains, water treatment plants, water pipeline and supply systems, local reservoirs, dams, and groundwater resources.
- Supporting improved flood forecasting measures based on measure precipitation gauges or weather radar systems, linked to catchment models for urban low-lying areas.
- Supporting educational systems to inform local people and also providing the expertise and research needed to undertake the above tasks.
- Taking a community-centered approach, since adaptation is necessarily local and would be best tackled by putting the affected community at the heart of the process.
- Integrating adaptation into development plans to develop climate proof infrastructures in urban areas.

Improving Urban Sanitation and Municipal SWM Services (SA/IND/58)

The risks posed by climate change to the sustainability of urban sanitation are also significant. The major threats are rising temperatures, increased droughts, increased flooding and a more variable monsoon. These changes could impact urban sanitation in several ways.

Water Reuse and Solid Waste Management

Sanitation is an integral part of the water cycle and water reuse in urban areas is a possibility. Thus improved sanitation will increase the water availability in towns and, if treated, this wastewater can be recycled to meet industrial and agricultural water needs. Moreover, the nutrients in the wastewater can partially offset the need for fertilizers. This will also produce considerable savings in energy as fewer fertilizers have to be manufactured, which will contribute to lower green house gas emissions.

Climate change will also have a substantial impact on solid waste management practices, underlining the need for urgent action on these. The major threat of rising temperatures will be to augment the rate of decay of solid waste that is dumped on land without treatment and safe disposal. This will lead to increased emissions of methane gas,

which is 21 times more powerful than carbon dioxide in terms of its impact on climate change. It is thus critical to step up attempts to ensure timely treatment and disposal of solid wastes, especially in urban areas, which are major generators.

Flooding

The main threat from flooding arises from the possible inundation of domestic and public toilets, especially in low-lying areas. This would create many problems with damage to infrastructure and additional public health problems that may arise. The roll out of sanitation services in urban areas could be affected if enhanced protection is required and it will not be easy to deal with devastating floods as the damage could be severe. However, it is possible to mitigate the effects of most floods by reviewing the infrastructure and improving engineering codes for toilet systems. Also, increased flooding in areas where untreated waste has been dumped carries the risk of groundwater contamination, and the spread of infection. Treatment of wastes and land-filling of inert pollutants and waste can mitigate this risk.

Water Quality and Waterborne Diseases

Water quality is affected by the increase in run-off in urban areas that carries with it higher levels of nutrients, pathogens, and pollutants. In addition, increased water temperatures enhance the pathogens in water. The WSP approach towards 'safe water and sanitation for all' addresses quality aspects of water to ensure potable water for poor people. The climate change challenge will require a higher order of capacity of service providers and a greater level of responsible behavior and hygiene adaptation at the household level. Water Safety Planning frameworks in WSP countries are the starting points towards addressing water quality issues.

Where sewerage systems take both sewage and street run-off (that is, combined systems), cities need to consider how to improve flow capacity to avoid contaminated flood water. Attention should be given to means of slowing down and reducing run-off through porous paving, installation of vortex devices in gullies, and local network storage. Where there are separate storm water drainage systems, these should be kept clean and cleared of garbage. Sewage treatment works should be protected from river flooding.

The great advantage of installing sanitation is the reduced pollution and, hence, the reduced likelihood of diseases being spread in urban areas. For example, enhanced contamination of wells and water supplies following flooding will be restricted significantly by urban sanitation.

Policy and Education

Policy and education are also key aspects of the WSP project and these have a big role to play in combating the effects of climate change. There may be a need to reevaluate the design of public toilets and sanitation systems. The expected increase in droughts and the likely extended breaks in the monsoon rains will create problems for sanitation in urban areas, where water is required for flushing of public toilets.

Task Action Plan

The adaptation measures and opportunities highlighted earlier for urban sanitation could give rise to a significant set of tasks and potential actions, including:

- Supporting a review of design codes for toilets and sanitation systems to cope with floods and droughts.
- Increasing focus on water reuse and treatment and disposal of solid waste.
- Adopting Water Safety Plans to focus investments towards health-based outcomes.
- Redefining policies at national, state, and local levels to encourage the authorities to expand the use of sanitation systems as quickly as possible.
- Supporting educational systems to inform local people and also providing the expertise and research needed to undertake the above tasks.

Conclusions

This review of climate change risks as they affect urban and rural water supplies and sanitation has indicated that there is considerable risk to these programs by climate change. However, adaptation is possible and, in many ways, the threats can be used as an opportunity to further refine the programs and help many more poor people in rural and urban India.

Inevitably, in a general overview of this nature, it is not possible to go into great detail on every program. However, a series of tasks have been identified which can be pursued to climate proof the WSP programs. Whilst these are not all tasks that WSP can fulfill directly, they are tasks that WSP can support so that the program officers have the necessary information.

A crucial point to consider is that of separating extreme events which are difficult to manage but can be planned for in advance, and ongoing challenges that can be managed but may have some costs. In practice both will have costs because there is a cost/uncertainty (risk) trade-off and, critically, there is a need to consider planning time horizons.

Another key point is that climate change factors are 'merely' items to be included in a risk assessment alongside other risks to the sustainability of water and sanitation services. There has always been uncertainty about rainfall both in the provision of water resources and in intensity of rainfall whether on monsoon yields or local storms in regard to flooding. The difference now appears to be the extent (range) of change and the frequency of extreme events. A bigger risk may be the ongoing rapid population growth or migration. In parts of India this has resulted in the gross over-abstraction of groundwater to the point where there is no alternative but to develop surface water sources and promote aquifer recharge through rainwater harvesting and reuse.

Broad issues where WSP can participate in sector dialog include:

- Additional climate change research for a fine scale regional climate change model for India to provide much greater detail of the specific threats in different regions of India. This can be linked to local water use patterns to better estimate impacts of climate change. Funding such a program is beyond the scope of WSP, but the information from such research will be valuable for WSP projects.
- Advocacy for government to support detailed studies on climate change impacts on water resources and water quality in specific catchments, with results being fed to authorities and aid agencies.
- Identify coastal aquifers that could be affected by saline intrusion from rising sea levels, and areas affected by wastage of the region's snow and ice stores.
- Provide flood forecasting measures based on measure precipitation gauges or weather radar systems, linked to catchment models to warn local people in rural and urban areas.

Issues which WSP can take up directly are:

- For policy and design, it is necessary to develop a module or materials for sensitization of policy makers and designers on safeguards for future infrastructure assets or refurbishment of existing assets based on review of engineering design standards and building codes.
- To flag the need for counterpart ministries of rural and urban development to engage with the ministry of health to undertake research on the likely impacts of climate change on disease response and identify measures to combat such disease outbreaks.
- Support improved use of data collection and provision of reliable information to help policy makers make better decisions in areas relating to climate change impacts including integrating adaptation into development plans to develop climate proof infrastructures.
- Develop simple communications strategy and associated guidance materials for informing local communities, and a check list of safeguards to consider when designing new infrastructure or refurbishing existing assets.
- Support educational systems and community-centered approaches to inform local people and provide the expertise and research needed to undertake local safeguards.
- Flag the use of rainwater harvesting, groundwater recharge, and water reuse, and improved solid waste management.

This 10-point plan (outlined above) will require major investment but will strike at the heart of the problem and, over time, radically improve the water supply and sanitation systems in rural and urban India.

ABOUT THE SERIES:

WSP Field Notes describe and analyze projects and activities in water and sanitation that provide lessons for sector leaders, administrators, and individuals tackling the water and sanitation challenges in urban and rural areas. The criteria for selection of stories included in this series are large-scale impact, demonstrable sustainability, good cost recovery, replicable conditions, and leadership.

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