United Nations
Framework Convention on
Climate Change

TEC Brief #5

Technology Executive Committee

Technologies for Adaptation in the Water Sector

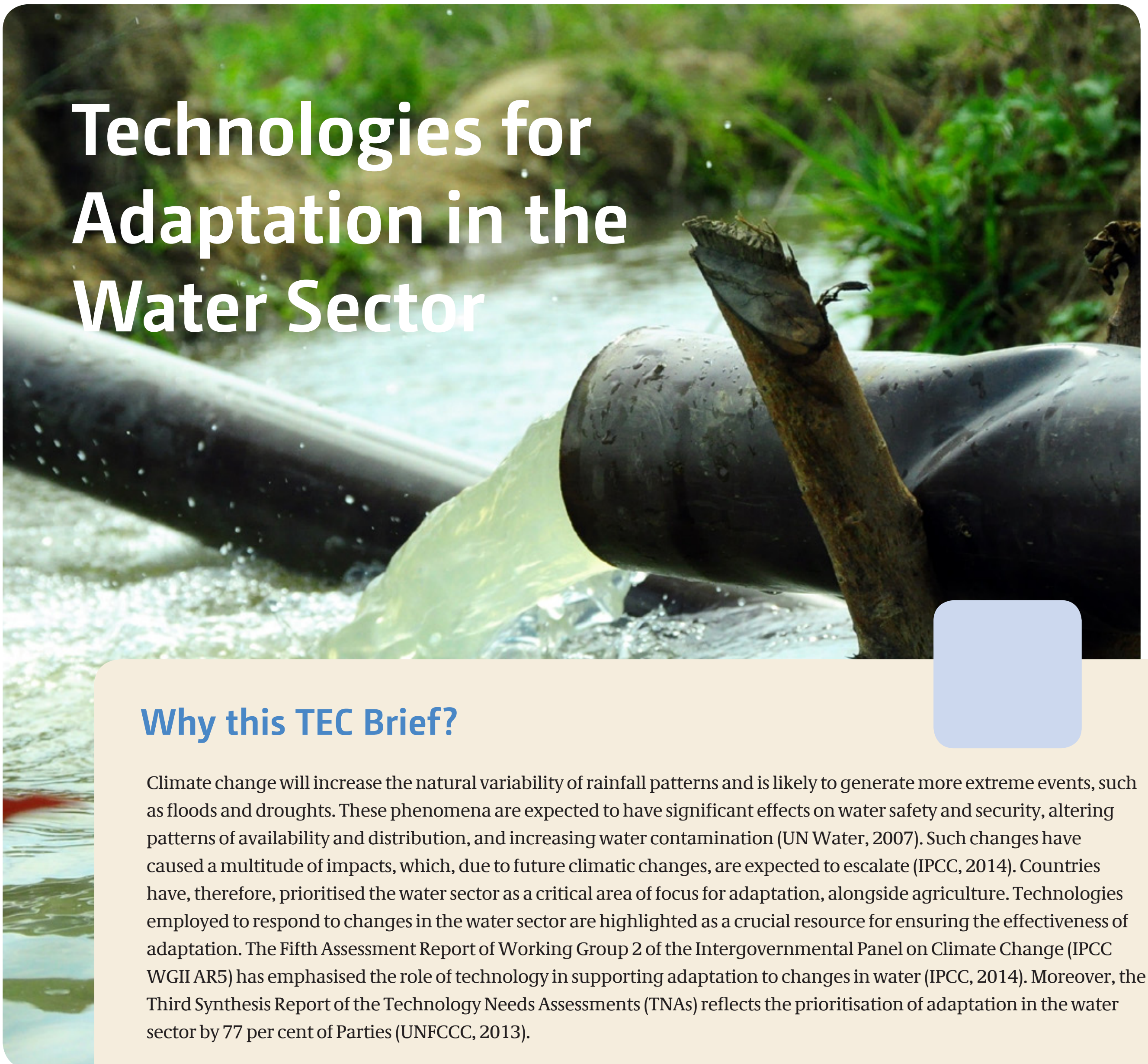


Photo: P. Casier (CGIAR) - Lawra Village Ghana.

Why this TEC Brief?

Climate change will increase the natural variability of rainfall patterns and is likely to generate more extreme events, such as floods and droughts. These phenomena are expected to have significant effects on water safety and security, altering patterns of availability and distribution, and increasing water contamination (UN Water, 2007). Such changes have caused a multitude of impacts, which, due to future climatic changes, are expected to escalate (IPCC, 2014). Countries have, therefore, prioritised the water sector as a critical area of focus for adaptation, alongside agriculture. Technologies employed to respond to changes in the water sector are highlighted as a crucial resource for ensuring the effectiveness of adaptation. The Fifth Assessment Report of Working Group 2 of the Intergovernmental Panel on Climate Change (IPCC WGII AR5) has emphasised the role of technology in supporting adaptation to changes in water (IPCC, 2014). Moreover, the Third Synthesis Report of the Technology Needs Assessments (TNAs) reflects the prioritisation of adaptation in the water sector by 77 per cent of Parties (UNFCCC, 2013).

The Technology Executive Committee (TEC) recognises the need for appropriate policies to support countries in employing technologies for adaptation, in order to meet the objectives of the United Nations Framework Convention on Climate Change (UNFCCC).

This policy brief has been developed for policy makers in national and local levels of government. In so doing, it has drawn upon existing examples of water technologies to highlight lessons learned and provide recommendations for policy, while bearing in mind the principles for effective adaptation (outlined in Section C-1 of the Technical Summary of the IPCC WGII AR5).

Technologies employed to support adaptation in the water sector may address issues of drought and scarcity, floods and over-abundance, water quality degradation, ecosystem impacts and service demand and use. To focus the scope of the discussion, this brief only covers technologies employed for addressing decreases in water availability (drought and scarcity), particularly in rural and developing country contexts. Nevertheless, the Brief will touch upon other issues aforementioned above, whenever relevant. Finally, a separate policy brief for agriculture can be referred to for an understanding of symmetries, co-benefits and integration between both sectors.

Executive Summary

- This policy brief offers recommendations for policy formulation by policy makers within national and local level governments.
- The brief addresses the application of adaptation technologies in the context of water scarcity, highlighting lessons learned, identifying examples of technologies, along with their suitability, enablers and barriers, and outlining the role of stakeholders.
- There is a high demand for adaptation technologies within the water sector, and experience to date shows their potential in contributing to sustainable adaptation and achieving co-benefits with mitigation.
- In order to avoid unsustainable adaptation and maladaptation of a technology, experience has highlighted the need for caution in applying technologies for adaptation in the water sector, making apparent the need to consider the users of the technology and the specific geological and political context in which the technology is applied.
- Collaboration between stakeholders in planning, implementing, managing and formulating related policy will strengthen the success of water technologies.
- Effective policy development in this area can contribute to an efficient and meaningful approach to applying water technologies, improve sanitation and sustainable growth and development and ultimately promote better health and human survival.

1 Technologies for Adaptation

The use of adaptation technologies has been broadly defined as "the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change" (UNFCCC, 2005). In the water sector, site-specific solutions need to be considered within the broader context of integrated water management approaches. A lack of regard for particular contexts, alongside poor planning, as well as overemphasis on short-term outcomes, or failure to account for possible climatic consequences and adaptation limits, can result in maladaptation or "an adaptation that does not succeed in reducing vulnerability but increases it instead" (IPCC, 2001: 378).

Water represents a particularly complex sector, due to the intrinsic linkage between freshwater resources and other sectors and ecosystems (UNFCCC, 2012). Technologies can only be deployed if certain requirements are fulfilled: there is no guarantee that a technology that works well in one country will deliver as expected in a different country. For instance, dam and water diversions in one location can have an impact on the water balance and micro-climate in a different part of an ecosystem. In addition, with mitigation, there are significant synergies, trade-offs and co-benefits to be considered. Trade-offs are particularly significant in the water sector, where there is a conflict between the security potential of large-scale projects and the energy costs that such projects demand. Therefore, climate change poses a major challenge to water managers, users and policymakers at different levels, who must examine all potential and probable impact scenarios and interrelated issues, both within and amongst regions and sectors throughout planning and implementation processes.

In least developed countries, technological application is supported by various processes and institutional arrangements. Support on technology include Technology Needs Assessments (TNAs), which identify, prioritise and highlight technology needs, and Technology Action Plans (TAPs), which are developed

Photo: Practical Action - Drip irrigation System Nepal.

on the basis of TNAs to address specific barriers, and identify targets, budgets and responsible stakeholders for prioritised technologies (UNFCCC, 2014a). TAPs specifically relevant to the water sector have been created by many countries. For example, Cambodia has addressed the transfer and diffusion of small dams, reservoirs, and micro catchments, whilst Lebanon specifically focuses on the Water Users' Association, and Zambia seeks to enable the implementation of boreholes and tube wells. Resources for such plans and processes can be accessed from the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), which prioritise the water sector, allocating it 14 per cent and 23 per cent of their budgets, respectively (UNFCCC, 2014a). These processes and arrangements are strengthened through the work of the UNFCCC's Adaptation Committee, Technology Mechanism (including the TEC and the Climate Technology Centre and Network) and other relevant bodies under the Convention.

Box 1. Complementarity of hard-, soft-, and org- ware

Technologies are often classified into three types: hardware, software, and orgware. In considering adaptation, it is important to understand the differences between these technology types, as well as their synergies and complementarities. Hard technologies, or hardware, refer to physical tools; soft technologies, or software, refer to the processes, knowledge and skills required in using the technology; and organisational technologies, or orgware, refer to the ownership and institutional arrangements pertaining to a technology (Christiansen et al., 2011, UNFCCC, 2014b). In the water sector, hard technologies refer to structures such as ponds, wells, reservoirs and rainwater harvesting equipment, whereas 'soft' technologies are those applied to improve water use efficiency through, for example, water recycling techniques. Institutional mechanisms, such as water-user associations and water-pricing specifications, are examples of orgware. The Highland Water Forum in Jordan, for instance, shows how the employment of software and orgware can support the appropriate adoption of hardware. The forum brought together multiple stakeholders to assist farmers in securing the technical, financial and institutional resources necessary to switch to more sustainable irrigation methods (Haddadin et al., 2006; Glatzel, 2013). This formed a basis for the planned adoption of hardware in the form of sustainable irrigation technologies. Though all types of technology are necessary, there is a concern that hard technologies are often applied in isolation, their perceived impact being prioritised over soft- and org-wares (Christiansen et al., 2011; UNFCCC, 2014b). Countries require encouragement and assistance in implementing all three technology types in a mutually supportive manner, in order to ensure sustainable and effective application of technologies for adaptation in the water sector.

2 Lessons Learned

Key lessons have emerged from experiences in employing technologies in support of adaptation in the water sector. Consideration of the complexity of water-related issues and the diversity of impacts must be central to the application of any technologies for adaptation.

THE USE OF WATER TECHNOLOGIES FOR ADAPTATION MUST BE ASSESSED IN CONSIDERATION OF COMPLEX SYSTEMS THAT ENCOMPASS INTERRELATED ISSUES.

These include issues resulting from the direct and indirect impacts of climate change. Direct impacts include fluctuating weather patterns that can lead to both drought and floods in one area. Indirect issues include the impacts of climate change on freshwater resources, which, in turn, has an effect on not only ecosystems and biodiversity, but also on agriculture and food security, land use and forestry, water supply and sanitation, health, urban settlements and infrastructure, and energy supply, including electricity generation (UNFCCC, 2012). Compounding factors such as population, and economic growth and decline, have significant impacts on water availability. Integrated Water Resource Management (IWRM) approaches broadly encompass comprehensive management strategies devised to address such complexity. The International Union for Conservation of Nature is involved in an ecosystem-based strategy designed to reduce the vulnerability of those affected by rain and floods in the trans-boundary Sixaola river basin (UNFCCC, 2012). Sustainable river basin management can strengthen climate resilience, whilst also contributing towards economic development, food security and environmental protection (de Madrid, 2012). However, an analysis of this initiative has highlighted the need for consideration of the dynamics between institutional structures and approaches, and local socio-cultural contexts (Blanco and Durán, 2014). Stakeholder co-operation in such trans-boundary contexts is crucial in addressing interrelated issues and limiting the vulnerability of water resources.

THE ANTICIPATED BENEFITS OF WATER TECHNOLOGIES MUST BE CONSIDERED IN ACCORDANCE WITH THE SPECIFIC LOCATION OF ITS APPLICATION.

A lack of consideration for local geology, climatic conditions and precipitation of minerals can lead to a lack of effectiveness or even maladaptation. For example, preliminary base-line monitoring for the introduction of rainwater catchment management in the Andes has highlighted differentiation in its effectiveness across different locations in the same area (UNFCCC, 2014a). Moreover, in the case of water extraction technologies, such as boreholes, implementation in an unsuitable location can lead to over-extraction of groundwater resources. For that reason, land use and spatial planning require special attention (UNFCCC, 2012). The utilisation and enhancement of existing infrastructure as adaptation technologies can help ensure contextual suitability. For example, the Multiple Use Water Systems implemented by the NGO International Development Enterprises in Nepal and India have built upon existing effective infrastructure to ensure locational compatibility. Additionally, this approach has proven to reduce implementation costs and access disagreements and enhance the efficiency of water use (Mikhial and Yoder, 2008). Sensitivity to

Photo: International Rivers - Rain water harvesting in Ethiopia.

location and comprehension of interrelated issues can also be enhanced through Community-Based Adaptation approaches (see Box 2).

CITIZEN ENGAGEMENT WITH A NEW TECHNOLOGY CAN BE ENCOURAGED THROUGH APPROPRIATE MARKETING AND INCENTIVISING STRATEGIES.

Marketing approaches adapted to the context of the introduction of a technology, alongside a comprehensive understanding of indigenous knowledge systems and appropriate and effective information sharing and communications, is crucial, in order to encourage users to incorporate new technologies into their existing adaptation strategies (UNFCCC, 2014a). Market incentives, including pricing structures, can provide encouragement for citizens to engage in the process. To increase water supplies, it is necessary to change business models that reward water providers for the volume pumped out, rather than the amount that reaches consumers. On the demand-reduction side, ensuring that end users are conserving water requires individual metering and billing, and market incentives are necessary to encourage consumer investment in water saving technologies, such as low-flow toilets or rain barrels. Non-market incentives, such as information provision, have also proven to be successful in encouraging the adoption of technology. The introduction of the California Irrigation Management Information System (CIMIS) by the California Department of Water Resources, in 1982, actually resulted in farmers paying into public weather information provision and, as a result, new irrigation technologies, due to the value of such information for water saving strategies (Osgood, 2011). Such past examples can be transferred to the current context to inform incentivising strategies for the adoption of new technologies.

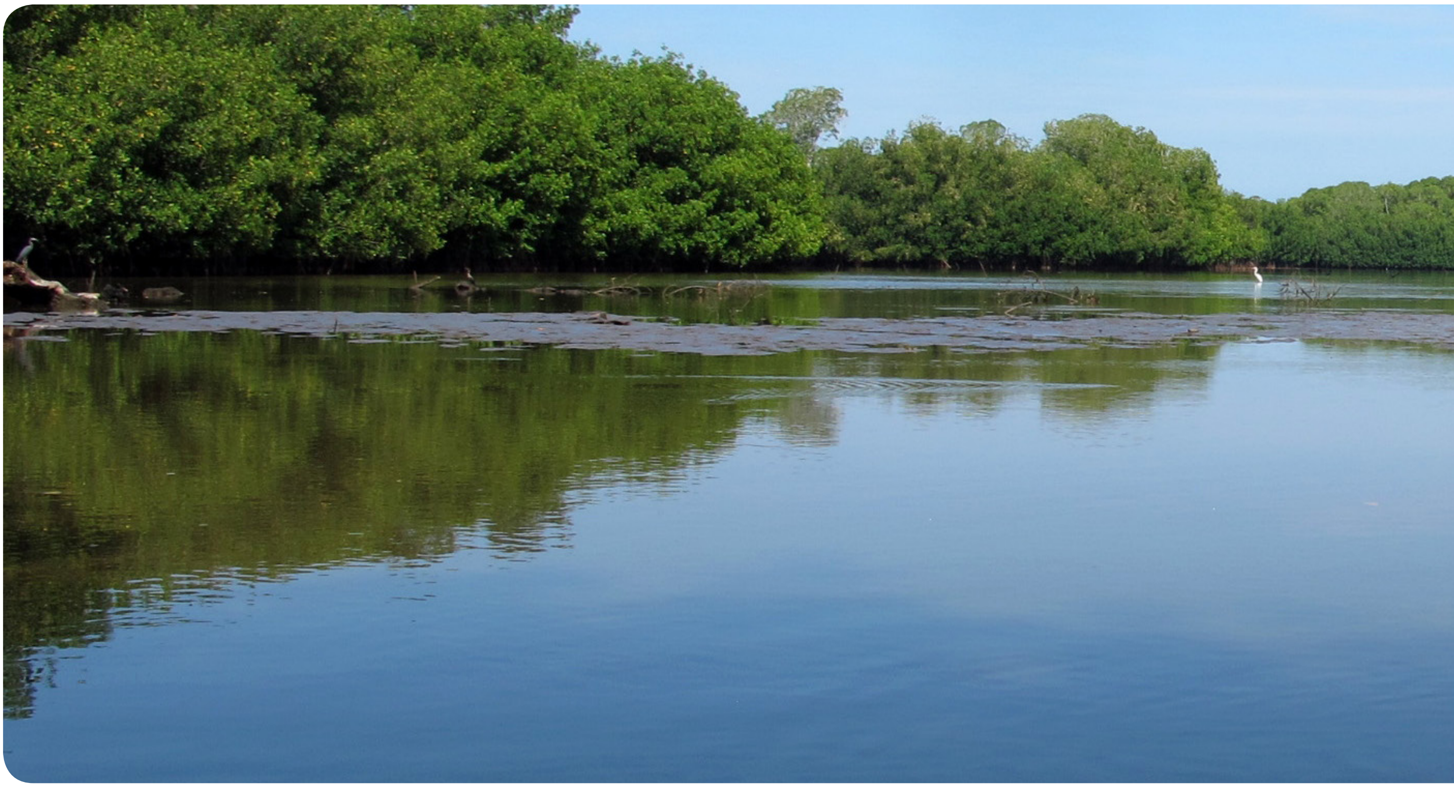


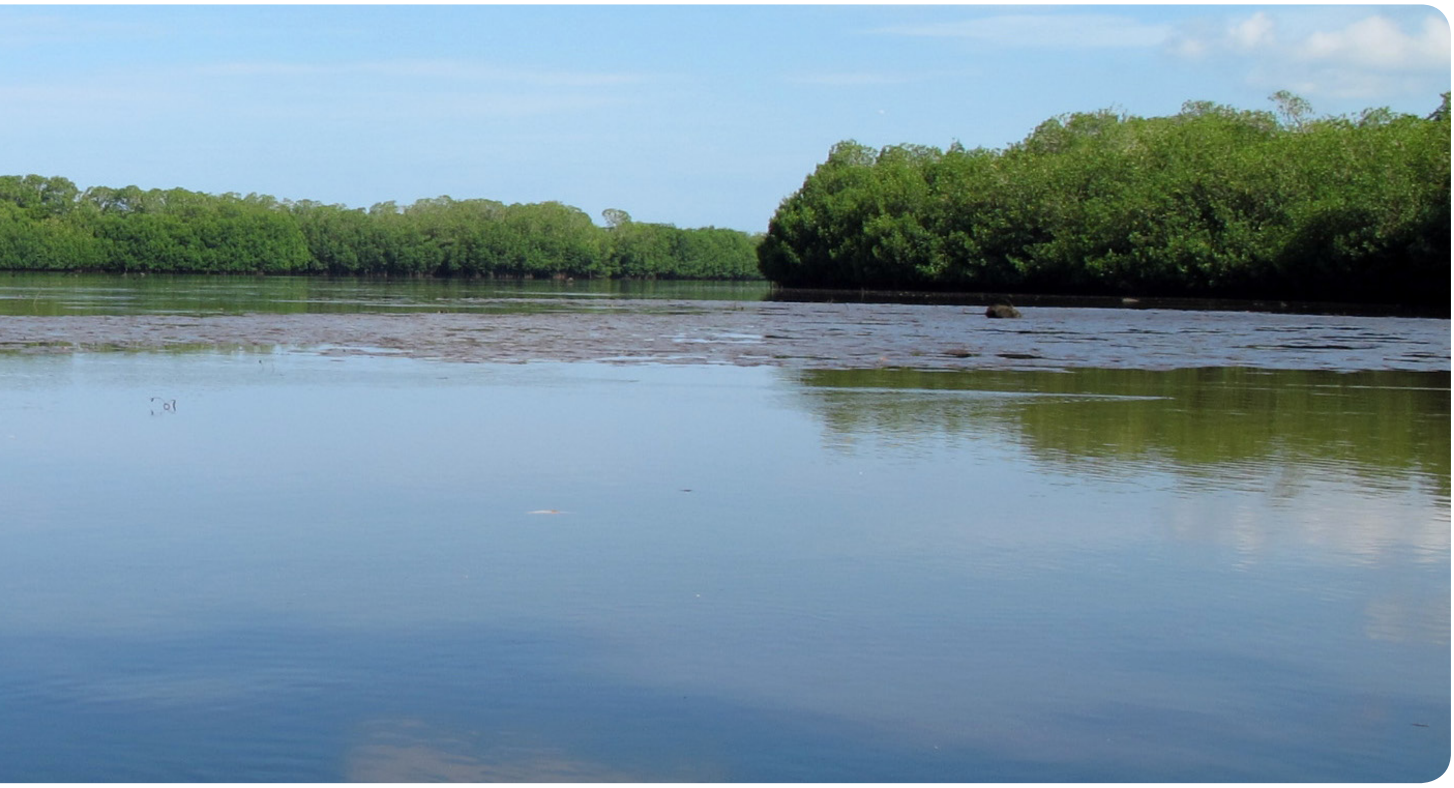
Photo: Marta Pérez de Madrid -IUCN Mesoamérica - Mangrove in the Gancho Murillo Reserve.

THE COST AND TIME EFFICIENCY OF TECHNOLOGIES MUST BE COMPREHENSIVELY CALCULATED TO ENSURE EMPLOYMENT AND SUSTAINABILITY OF A TECHNOLOGY AFTER ITS INTRODUCTION.

Experience has shown that efficiency can be secured through the rehabilitation and repair of existing strategic water sources, such as wells and boreholes. This is in contrast to large-scale methods, such as water trucking and water desalination, which have often proved to be unsustainable. The Torrevieja desalination plant in Spain exemplifies the need to address cost-efficiency from the preliminary stages, in order to ensure that a technology is engaged with by targeted users (Palomar and Losada, 2010; Cala, 2013). Here, the costs of completing the plant's construction and running the infrastructure outweigh the prices consumers are willing to pay for purified water outputs. Moreover, it has been estimated that the plant's operational equipment will require major refurbishment and maintenance work within the next two decades, exacerbating the imbalance between costs and profits. (Nicol, 2012). This represents a significant oversight in planning processes by water planners and can be drawn upon in advising future large-scale projects. Cost-benefit analyses for technologies for adaptation in the water sector are therefore useful, provided they include consideration of the variation in the range of costs for each technology, which are determined by the diverse locations and political, economic and social contexts of their application.

COMPREHENSIVE KNOWLEDGE MANAGEMENT IS CRITICAL TO THE DEVELOPMENT, TRANSFER AND DIFFUSION OF TECHNOLOGIES FOR ADAPTATION.

Due to the complexity of addressing adaptation in the water sector, it is important that water and climate work, running in parallel, is consolidated through comprehensive knowledge sharing. Some institutions, such as the World Water Forum (www.worldwaterforum7.org), the Global Water Partnership (www.gwp.org), and the International Water Association (www.iwahq.org) seek to do just this. Knowledge and know-how related to the South-South transfer of technologies is particularly important (UNFCCC, 2014b). Reflecting this need, international networks often have a regional focus. The Asian Cities Climate Resilience Network (www.acccrn.org) is an urban knowledge platform for Asia, and it prioritises water as a major theme, sharing research, expertise and suggestions on how to ensure resilience in the urban water sector. Yet barriers to South-South knowledge transfer still are observed in areas such as data availability, information sharing, and communication, encompassing a lack of quality documentation and information sharing platforms, alongside political barriers between countries.



Appropriate knowledge management is also critical at the micro-scale, where knowledge networks are also employed. (An example of this is the Highland Water Forum in Jordan – see Box 1). Here, communication barriers, such as literacy levels and language differences, must also be addressed, as well as equal access to information, which is often determined by cultural, social and political structures.

Box 2. Community-Based Adaptation

Community-Based Adaptation (CBA) aims to achieve climate change adaptation in tandem with development goals, through employing bottom-up processes to enhance community capacity, while also ensuring contextual suitability and local acceptance of projects instigated. Such practices aim to identify local-level knowledge, including technological innovations, and strengthen and replicate this knowledge to promote effective adaptation. Spreading local innovations requires coordination and collaboration between multiple stakeholders, including governments, farmer groups, non-governmental organisations (NGOs) and local leaders. In many cases, financial, cultural, natural and institutional barriers, or a lack of information, hamper wider adoption of innovative approaches. As a long-term, adaptive and reflective process, CBA allows such barriers to be addressed taking into consideration the specific contexts within which they are experienced. CBA is an ever-evolving process and whilst many projects have now been established, particularly in Asia and Africa, comprehensive monitoring and evaluation processes now need to be developed and applied in order to assess the effectiveness and sustainability of the approaches taken. A positive experience comes from the Suid Bokkeveld tea farmers in Northern Cape Province, South Africa. Here, NGOs have been providing training and mentoring to farmers to encourage expansion and diversification in small-scale local practices in response to fluctuations in rainfall patterns, which have resulted in drought. Farmers diversified their practices through employing roof water harvesting and storage in big tanks, the sinking of boreholes, the construction of concrete water dams for expanded water storage, and the sharing of implements to clean fountains (Owuor, 2010). However, in the context of adaptation in response to water scarcity, CBA might soon come to its limit, and instead, large scale solutions might be a more viable option, provided that there is a strong basis for broad cooperation.

Photo: G-lish Foundation - Borehole Bolgatanga Ghana.

Technologies for Adaptation in Water Sector

A range of technologies has been developed for adaptation in the water sector. Some are very sophisticated, such as remote sensing, water-smart metering, hydraulic sea walls and water-reuse systems. Some are simpler, such as land trenching for ground water replenishment, flood management for wetlands and water filtration. The suitability, enablers and barriers of a few selected technologies are highlighted below, and examples of each are provided.

Table 1: **Enablers, barriers and examples of water adaptation technologies**

Adaptation Technology	Boreholes and tube wells	Rainwater harvesting	Desalination	Water management fora
Suitability of Technology	For extracting water from subsurface and groundwater levels to provide access to safe drinking water and enhance water efficiency	For collecting rainwater from rooftops and other catchments to supplement domestic and institutional water supply and increase water efficiency	For purifying saline water through the removal of sodium chloride and other dissolved constituents	For bringing multiple stakeholders together, to discuss options and develop comprehensive plans
Enablers	Cost and time efficiency; institutional support; reuse of resources through rehabilitation	User land/property tenure; links to climate forecasts; storage options	Appropriate planning; political and financial support; comprehensive environmental assessments	Cost efficiency; training provision; institutional and individual enthusiasm for collaboration
Barriers	Inappropriate governance approach; differentiated stakeholder access; lack of geological assessment; inadequate energy supplies; technical barriers	Lack of rainwater; lack of initial investment capital; lack of technical knowledge and resources	Cost and energy requirements; negative ecosystem effects; lack of disposal options for removed minerals; political opposition	Diverse objectives of stakeholders; governance needs; poverty; cultural traditions; lack of technical and financial resources to access identified needs
Examples	UNICEF's rehabilitation and reparation of boreholes in Somalia: www.unicef.org	World Agroforestry Centre's rainwater harvesting projects in Africa: www.worldagroforestry centre.org/	Reverse Osmosis Desalination Plant in Egypt: www.citeseerx.is t.psu.edu/viewdoc/summary?doi =10.1.1.302.2597	GIZ-JOHUD 'Water Wise Women' initiative in Jordan: http://www.gender-in-german-development.net/jordan.html

3 Stakeholder Involvement and Collaboration

Adaptation planning and implementation can be improved through complementary actions across and between levels, from individuals to governments. Similarly, the successful application of adaptation technologies demands the engagement of multiple stakeholders. One example of effective collaboration comes from the PACC project in Ecuador, where alternative water management approaches aiming to reduce vulnerability to climate change are being applied by alliances of communities, NGOs, sub-national governments and research centres (UNFCCC, 2014a). It has been found that the close involvement of the community, or user group, is integral to ensuring effective collaboration amongst stakeholders. The diverse roles assumed by different stakeholders are broadly indicated here:

- **Communities deploy technologies**, having contextual interaction with hard-, soft- and org-wares;
- **The research community devises and tests new technologies.** While this has often been in isolation, efforts are now being made to ensure testing in-situ;
- The **local government supports users and assists scaling-up** of small-scale or community-led technologies;
- The **national-level government is responsible for devising necessary policies.** They must also be aware of maladaptation and how to curb this. An enabling environment for effective adaptation across multiple levels of intervention implies responsive, accessible, inclusive and equitable institutional capacity, especially in the context of governance, where change can be promoted at the local, provincial, national and regional levels and beyond;
- **NGOs play a combinative role in researching, implementing, facilitating, monitoring, evaluating and financing technologies for adaptation.** They tend to have close links with multiple stakeholders, acting as vehicles for communication from and to the local level and promoting appropriate technologies;
- **Private sector stakeholders can assist by securing financial and non-financial resources.** Consistency in legislation to regulate the water sector can enable the positive engagement of the private sector. Insurance schemes for protection against losses incurred from flood or drought also represent a clear entry point for private companies. The MCII hosted at the United Nations University Institute for Environment and Human Security, has had success in securing private sector support in developing and implementing insurance-based tools to manage climate risks. Besides traditional insurance, instruments such as catastrophe bonds provide a new and alternative way to both access private financing for adaptation and transfer risks posed by high-impact, low-frequency disasters to global capital markets.
- **International stakeholders can support adaptation technologies for the water sector by providing financial resources and increasing connections.** Multilateral banks can play a role in financing adaptation technologies. For example, the African Development Bank Group (AfDB) has established the Multi Donor Water Partnership Programme together with the Government of the Netherlands. The programme seeks to provide support to multi-national, regional and sub-regional institutions in strengthening IWRM, knowledge management and the sharing of best practices and experiences to support adaptation in the water sector (AfDB, 2011). UN Water and the Global Water Partnership also advocate for countries to develop both IWRM and Water Efficiency Plans, tailored to the individual circumstances of subject countries and regions, to support the comprehensive management and efficient use of water resources (UNEP, 2012).

Photo: Robert Burns - Dropping aquifer low pump pressure.

4 Policy Formulation

Experience has highlighted that the legitimacy of water policies can be strengthened through ensuring effective multi-stakeholder participation in their development. Wide-reaching involvement can ensure multiple perspectives are considered, identifying previously unseen issues by providing stakeholders with the opportunity to raise concerns or make suggestions. Such participatory decision-making can elicit widespread support for resulting policies and actions. These recommendations draw upon the discussions within this brief, and seek to guide policies development for the support of water technologies for adaptation:

- The **integration of hard-, soft-, org-ware** can be supported by appropriate policies to reduce barriers to technological application
- Policies can encourage **iterative risk management approaches** to aid in decision making and address uncertainty (IPCC, 2014). The flood risk management plan for the Thames Barrier approaches this through recommending actions to be taken respectively for the short, medium and long-term, that are flexible to updates from the latest climate change projections, in order to reduce flood risks (Radunsky, 2012)
- Policies need to **address contrasting and complex socio-political inter-relations**, such as complex land tenure dynamics that can otherwise render technology use and management inappropriate and **incentivise the use of appropriate technologies** that are suitable for the context within which they are introduced
- Stakeholders can be brought together through a **comprehensive participatory framework** that also enhances **effective knowledge management** across scales. Such a framework should be defined and communicated from the initial stages, in consultation with all involved, from farmers, farmer groups, and NGOs, to governments, government services (such as agricultural extension networks) and private sector organisations
- Policies are needed to **strengthen collaborative Research and Development**, including the piloting of water technologies in-situ
- **Monitoring and Evaluation** of technologies in context is needed to provide an ongoing assessment of introduced technologies after their initial implementation
- Policies addressing **political will and capacity barriers for financing technologies** can enhance the scaling-up of adaptation technologies. Consistency and continuity in policies lowers the risks of private investment, making it a feasible option for financing technologies
- Policies can support **appropriate planning for national-level adaptive processes**, such as IWRM, and serve to **mainstream and integrate** the use of appropriate technologies in national development planning, through addressing challenges in water distribution and safety and advancing the scaling-up of successful responses through social safety networks, disaster risk reduction approaches or extension services
- Cross-cutting policies can enable **international and regional co-operation to help overcome legal barriers** that hinder the application of successful water technologies. International cooperation is particularly required on trans-boundary water management issues.

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Acknowledgements: The Technology Executive Committee extends its appreciation for expertise and inputs provided by members of the Adaptation Committee and representative of observer organisations in the development of this TEC Brief.

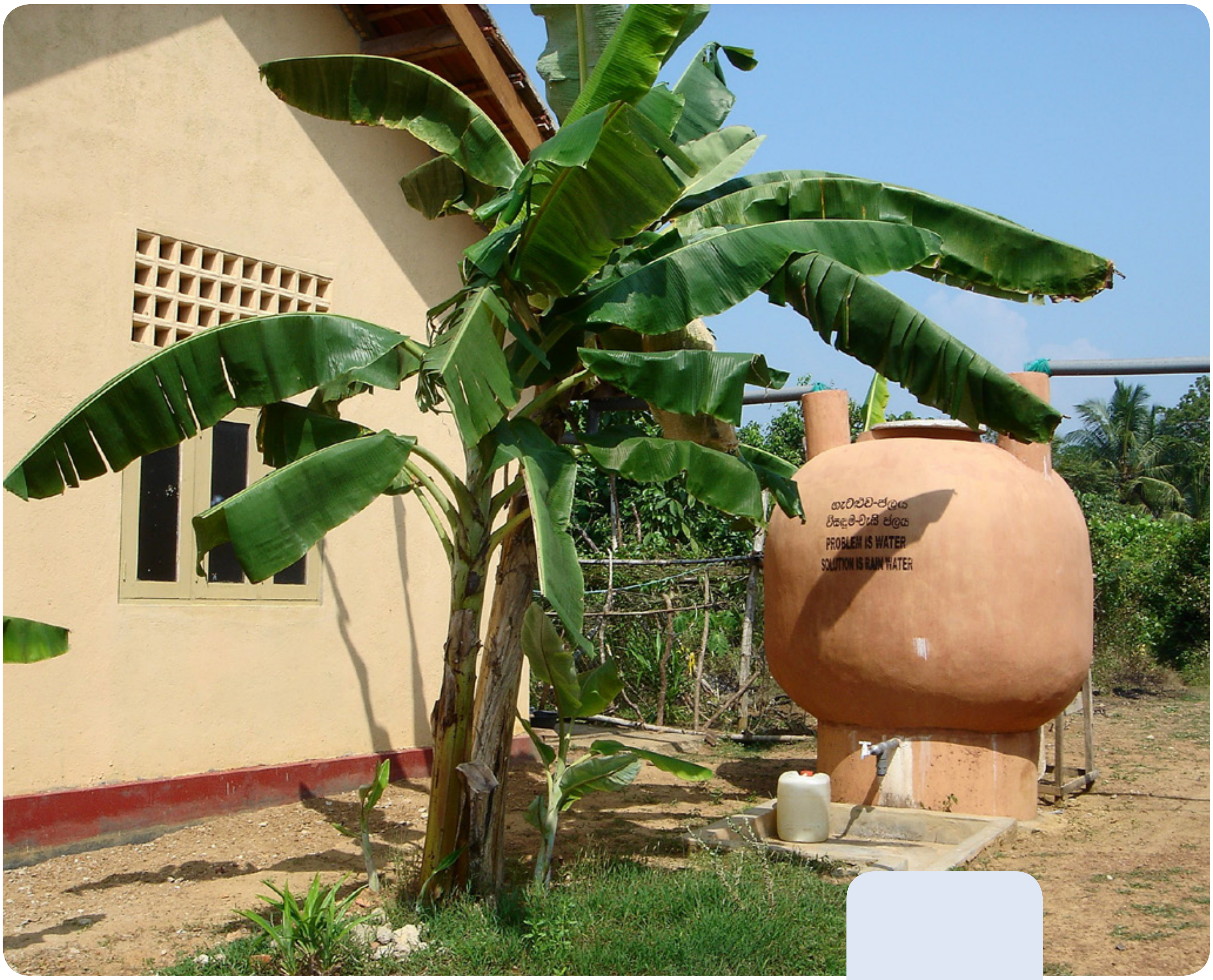

Photo: Worldwatch Institute - Rainwater harvesting in Sri Lanka.

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About The Technology Executive Committee

The Technology Executive Committee (TEC) is the policy component of the Technology Mechanism established by the Conference of the Parties (COP) in 2010 by decision 1/CP.16 to facilitate the implementation of enhanced action on technology development and transfer to support action on mitigation and adaptation. Along with the other component of the Technology Mechanism, the Climate Technology Centre and Network, the TEC is mandated to facilitate the effective implementation of the Technology Mechanism.