SECTOR KEYSHEETS:

Water Resources Management and Supply

Raymond Colley

October 2015

This report has been produced for Evidence on Demand with the assistance of the UK Department for International Development (DFID) contracted through the Climate, Environment, Infrastructure and Livelihoods Professional Evidence and Applied Knowledge Services (CEIL PEAKS) programme, jointly managed by DAI (which incorporates HTSPE Limited) and IMC Worldwide Limited.

The views expressed in the report are entirely those of the author and do not necessarily represent DFID's own views or policies, or those of Evidence on Demand. Comments and discussion on items related to content and opinion should be addressed to the author, via enquiries@evidenceondemand.org

Your feedback helps us ensure the quality and usefulness of all knowledge products. Please email enquiries@evidenceondemand.org and let us know whether or not you have found this material useful; in what ways it has helped build your knowledge base and informed your work; or how it could be improved.

DOI: http://dx.doi.org/10.12774/eod_hd.october2015

First published October 2015

EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

Contents

List of Tables

List of Case Studies

Sector Definition

Providing clean water and sanitation in developing countries involves more than clean water supply, and wastewater disposal, it may best be seen as part of the move towards water security: building resilience to 'water related hazards' and ensuring there is sufficient water of sufficient quality for productive sectors as well as ecosystems. The appropriate interventions may include large or small-scale infrastructure; policy, legislation and institutional restructuring; and, behavioural change through support for awareness raising and education initiatives. The delivery mechanism may be through direct support, through intermediaries or through partnerships with the private sector.

Environment and climate risks vary with the nature scale and location of the intervention but those most commonly associated with the sector include the following:

- Quantitative changes in availability of water for competing beneficial uses, such as "environmental water" (availability of water to wildlife and plants), fisheries, recreation and tourism, potable water supply, irrigation and industrial use;
- Large energy requirement for pumping and treatment leading to strain on the electricity grid and production of GHGs. Conversely insufficient water is a key risk to energy infrastructure (most obviously for hydropower but also for thermal power generation);
- Changes to hydrogeology and groundwater flows, leading to damage to groundwater resources including salt-water intrusion, depletion and chemical or bacteriological contamination;
- Sensitivity to climate variability and climate hazards (changed sustainability of the water resources, water flows, flooding, spread of bacteriological contamination) and drought;
- Disposals of contaminated solid wastes and wastewater;
- Land use changes with effects on tenure, agriculture, cultural resources, public safety, access, wildlife and leisure;
- Other risks might include impact of poor water quality/quantity on health and sanitation and the transboundary impact of water related infrastructure (reduced or increased flow following placement of dams for hydropower or irrigation).

Data show that dramatic climate changes, heat, and weather extremes are already impacting people, damaging crops and coastlines, and putting food, water, and energy security at risk. There is growing evidence that even with very ambitious mitigation action, warming close to 1.5°C above pre-industrial levels by mid-century is already locked into the Earth's atmospheric system, and climate change impacts such as extreme heat events may now be unavoidable.[1]

Current warming is at 0.8°C above pre-industrial levels. CO_2 emissions are now 60 percent higher than in 1990, growing on average over this period at about 2.5 percent per year. If emissions continue at this rate, atmospheric CO_2 concentrations in line with a likely chance of limiting warming to 2°C would be exceeded within just three decades.

[1] World Bank Group. 2014. Turn Down the Heat: Confronting the New Climate Normal.

Structure and Content of this Keysheet

This keysheet provides a summary of the activities, typical environmental and climate risks and potential mitigation and management measures relating to the development of water sector interventions, including construction and operation of supply and disposal facilities and the impacts of policies to manage and secure water resources.

This keysheet should be used specifically to help with drafting ToRs for the assessment of environment and climate risks associated with different stages in the sector programming cycle. It can also help in reviewing the assessment documentation.

The keysheet is organised under the following headings:

- Sector components and activities;
- Sources of impact and receptors/resources;
- Mitigation and management options.

The phases of the programming cycle considered are: identification and strategic design; detailed design and planning; construction; operation and maintenance; and where appropriate, decommissioning (closure).

Sector Components and Activities

Water security is emerging as a significant global risk in terms of development impact. Water challenges cut across economic sectors. The global population is growing fast and estimates show that with current practices, the world will face a 40 percent shortfall between forecasted demand and available supply of water by 2030. Today, 70 percent of global water withdrawals are for agriculture. Feeding nine billion people by 2050, will require a 60 percent increase in agricultural production and a 15 percent increase in water withdrawals.

The effects of climate change are expected to add to water security challenges. Currently, 1.6 billion people live in countries and regions with absolute water scarcity and the number is expected to rise to 2.8 billion people by 2025. For poor countries that have always faced hydrologic variability, climate change will make water security even more difficult and costly to achieve. Climate change may also cause water security challenges in countries that have traditionally enjoyed reliable water supplies and few, if any, water shocks. Coastal zones, water supply, infrastructure and agriculture will all be affected. The effects on natural systems will be widespread: from accelerated glacier melt, altered precipitation, runoff, and groundwater recharge patterns, to extreme droughts and floods, water quality changes, saltwater intrusion in coastal aquifers and changes in water use.[2]

These changes have an upward linkage to the economy. Indirect and second order impacts can also be significant in water storage lakes and reservoirs; agricultural production; navigation; and the increased vulnerability of ecosystems. Many developing countries are particularly vulnerable to the impacts of hydrologic variability and climate change given weak institutions and institutional capacity, high levels of poverty, insufficient stock of water management and services infrastructure, dependence on climate sensitive sectors such as agriculture, forestry and fisheries. The estimated one billion people living in monsoonal basins and the 500 million people living in deltas are especially vulnerable[3].

[2] World Bank 2009 Water and Climate Change: Understanding the Risks and Making Climate-Smart Investment Decisions

[3] World Bank 2015. Global Development Topics: Water

The water sector interventions with most potential to give rise to risks[4] and opportunities[5] for the bio-physical environment include the following:

Water Supply

- Water collection/resource abstraction and diversion of surface water;
- Water storage (Impoundments, reservoirs, tanks);
- Water treatment (primary – filtration, and/or secondary –disinfection);
- Installation or rehabilitation of pipe networks;
- Pumping water up from wells or through distribution networks.

Wastewater Collection, Treatment and Disposal

- Wastewater collection through sewers or household systems;
- Waste disposal (sludges);
- Wastewater treatment;
- Wastewater discharge.

Resource Management

- Erosion control measures, including afforestation;
- Land use controls and changes;
- Abstraction controls and groundwater recharge;
- Demand management and water pricing strategies;
- Promotion of alternative livelihood strategies with associated waste and effluent streams.

Sources of Impact, Receptors and Resources

Programme Cycle Stage	Sources of Risk/Opportunity
Identification and Selection of Intervention	
Strategic planning and initial design will include options analysis, selection of modality and partners, determination of the nature of interventions and regions in which activities will be located. For major development affecting policy and planning over the entire sector or multiple jurisdictions across a (sub-national) region, a strategic environmental assessment (SEA) should be conducted.	Factors relevant to environmental and climate risk or opportunity that should be considered at the strategic planning level include the following: • Major constraints and strategic alternatives (including different approaches to achieve the same strategic outcomes such as demand management, approaches to ownership and service delivery, variable levels of service and quality objectives). • Water source and major infrastructure or conveyance corridor locations and design procedures such that environmental considerations are given consideration alongside engineering and financial ones.

[4] Where a risk is anything that i) is likely to change the way people use the environment ii) can as a result of a climate/environmental shock threaten sustainability; iii) increases communities' exposure to threats; or, iv) harms the environment.

[5] Includes activities that address ongoing environmental degradation as well as activities that achieve water sector aims while restoring degraded resources or contribute to low-carbon development through use of renewables or waste-to-fuel initiatives

Programme Cycle Stage	Sources of Risk/Opportunity
	• Land tenure changes, energy sector reform, agricultural policy, the role of River Basin Organisations or Water User Associations, around the collection of data for spatial planning (e.g. LiDAR) etc.) land tenure changes, energy sector reform, agricultural policy, the role of River Basin Organisations or Water User Associations, around the collection of data for spatial planning (e.g. LiDAR) etc.) • Technologies such as drip fed irrigation, grey water reuse/recycling, rain water harvesting, green as opposed to grey infrastructure could all be included at the micro level. At the macro level, spatial planning, SEAs etc. should present opportunities. • Opportunities for mobilisation of funds for climate adaptation and/or mitigation (through e.g. the International Climate Fund) and joint-working opportunities across HMG, particularly with FCO, DECC and DEFRA • Any obvious additional actions that could be considered to achieve a desired climate/ environment outcome, eg: by adopting energy-efficient or low-carbon technologies, strengthening local environmental management capacity, improving environmental quality, protecting or enhancing biological habitat. • Stakeholder engagement/consultation with all effected water users (through Water User Associations or River Basin Organisations) to ensure an equitable use of the scarce resource • Climate Change Risk Assessments (CCRAs) to help define possible site selection • Consideration of trade-offs (both between sectors and also between countries)
Detailed Design and location specific planning	
Detailed design and location specific planning, will be able to investigate the above issues in more detail and take account of geographical factors (terrain, topography, land use, regional and international boundaries of the water basin) and local environmental sensitivities in consultation with affected communities. Instruments to assess impacts and propose mitigation include the following: Initial Environmental Assessment (smaller projects)	Key issues may include the following: • Construction issues such as, noise, dust, traffic, restricted movement of people and wildlife. These are of particular concern if the development involves long linear structures that disrupt lateral movement of people and wildlife (eg surface or buried water conveyances) • Impacts associated with changing surface flows (flash floods, erosion, scarcity) • Interference with or change of land use (occupation of land, or control of land-use rights, and restriction of access, waterlogging,

Programme Cycle Stage	Sources of Risk/Opportunity
Environmental Impact Assessment (larger projects) Environmental Management Plan (EMP)	inundation,) • Creation and disposal of polluting solid wastes • Loss of cultural property (through excavation or inundation) • Destruction, fragmentation of biological habitats • Pollution or contamination of land, water resources and coastal water by waste water or sludge and consequent public health impacts • Hazards associated with water storage and conveyance in seismically active areas • Vulnerability of intervention to floods and droughts • Water efficient design, demand side management, water harvesting, and grey water recycling/reuse.
Construction	
Construction activities may include: Establishing temporary access routes, work sites and labour camps; taking land for surface or sub-surface construction; installation of water abstraction or collection infrastructure (river intakes, wells, pipelines and pumping stations and conveyances). Where temporary facilities such as access roads, quarries, worker accommodation and laydown areas are developed during construction, they should be decommissioned and rehabilitated in accordance with a site-specific closure plan Instruments to ensure that the EMP is followed and that unexpected impacts are detected and addressed include: Monitoring of EMP performance Monitoring of compliance with loan covenants Monitoring of sub-contractor contract provisions Monitoring of public consultation plan	Key issues may include the following: • Inadequate implementation of the EMP leading to unacceptable construction impacts • Delays and poor management of construction leading to disturbance over an extended period
Operation and Maintenance	
During operation impacts may result from breaks or blockages in the system leading to leakage of fresh and contaminated water. In addition contaminating sludge and waste water will be generated from wastewater collection and disposal. The sludge can be used to generate energy under the right market conditions. *Instruments to ensure that operation is*	Key issues may include the following: • Water-logging, mosquito breeding areas from fresh water leakage • Pollution through (wastewater) leakage • Contamination of wastewater receiving bodies • Hazardous waste (sludge) especially where

Programme Cycle Stage	Sources of Risk/Opportunity
responsible and that unexpected impacts are detected and addressed include: *Operations Manuals* *Compliance Monitoring* *Environmental Monitoring*	there is no adequate waste management system that can be utilised • Disturbance/damage to biota and habitats
Completion, closure or phase-out	
When temporary facilities are established they should be decommissioned and the closure process should include site clearance, removal of all equipment, and appropriate disposal of waste materials. Most water sector projects are long-term developments. Closure planning should be carried out only when the end of useful life can be foreseen.	Key issues may include the following: *Land degradation/dereliction due to abandoned equipment, materials, structures, borrow-pits and waste dumps.*

Table 1 Sources of Risk/Opportunity and Assessment Tools

Case Studies 1 DFID Malawi's WASH Programme

DFID is providing up to £20m over a three year period (2012-15) to support the delivery of rural water, sanitation and hygiene services in Malawi. Expected results include 850,000 gaining access to improved water and sanitation facilities and one million people adopting key hygiene practices. The major stresses and threats to WASH services appear to arise from: rapid population growth; increasing demands for water; rising production of faecal and solid waste; and the degradation of the natural environment, with knock-on effects on hydrology and water quality. In the latter case, there is evidence that runoff is becoming more flashy and that sediment loads are increasing.

A Programme-level risk assessment identified the following key opportunities to strengthen environmental performance and/or adapt to climate change.

Water resources management

- Catchment protection/management to a) protect gravity flow systems catchments; and b) encourage groundwater recharge to point sources.
- Strengthen hydro-meteorological monitoring data quality and availability

Water supply

- Undertake a transition from hand-dug well construction to manual drilling
- Adopt an alternative deep-well hand pump in addition to the Afridev (and drill deeper)
- Transition from individual water point committees to multiple-point water source management.
- Protect gravity flow systems and pumped water intakes / adapt to lower water levels
- Transition from pumped groundwater to spring protection

Risks/Opportunities and Mitigation/Optimisation

Table 2 summarises the main risks to the environment which may arise during the programming cycle for water sector interventions, the receptors and resources they affect, and the main options for mitigation or opportunities to improve the environmental performance. It considers impacts on the bio-physical environment, including climate, and

the need for resilience to climate change. The mitigation measures described assume that higher level design and network planning measures, as described in Table 1, have already been implemented.

The guidance on impacts and options for their mitigation can be used to help discussions with the beneficiaries, borrowers or client and improve their understanding of DFID's requirements. They should also be used to assist preparation of ToRs for an EIA so that they are tailored to the particular circumstances of the development under consideration.

Case Studies 2 DFID DFID Sierra Leone's WASH Portfolio[6]

DFID is implementing a major £50 million programme over the period 2010 to 2016 with the Ministry of Water Resources (MoWR) and the Ministry of Health and Sanitation (MoHS). A large component of this project is focused on improving the way in which water resources are managed and includes establishing water resources management (WRM) institutions, and addressing associated environmental monitoring activities. Environmental degradation is considered a significant and widespread problem .For example deforestation around Freetown is a major concern, and mining and agro-industry are increasing rapidly with little regulation, the latter potentially leading to increased extraction of water resources and pollution. Meanwhile, population is projected to grow by a factor of 1.79 between 2010 and 2050.

A Programme-level risk assessment identified the following key opportunities to strengthen environmental performance and/or adapt to climate change.

Water resources management and disaster preparedness

- Flood risk mapping and flood control through dams and canals
- Strengthening government emergency preparedness and response
- Development of early warning systems and community emergency preparedness
- Improvement of data collection and management (ground water, surface water and rainfall)
- Catchment protection activities
- Avoid shallow wells and use sealed boreholes instead
- Rainwater harvesting

Sanitation

- Literature review and dissemination of guidance note on latrine technologies for high water table areas
- Environmental sanitation policy review
- New lagoon outside Freetown for faecal sludge
- Storm water drainage infrastructure
- Smaller above-ground chamber toilets to allow regular de-sludging
- Mapping urban drainage systems

6 http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8859.pdf

	Risks/Opportunities	Mitigation
PHYSICAL	*Geology/Hydrogeology* • Changes to hydrogeology and groundwater flows allowing lowering of the water table, land subsidence, decreased water quality, and saltwater intrusion into aquifers • Potential for seismic events to cause breakage of conduits, spills and contamination of land and water.	• Detailed site selection to take account of local groundwater conditions, e.g. by avoiding areas with springs or where the water abstraction is likely to exceed recharge • Limit sealed or compacted areas as much as possible, to maintain natural recharge of the water table. • Maintain sufficient flow in watercourses to prevent salt-water intrusion. • Install systems to control leakage and ensure adequate drainage • Detailed site selection to take account of geological conditions, avoiding unsuitable areas or, undertaking risk analysis and contingency planning. • Green infrastructure as an alternative to grey infrastructure
	Erosion, Hydrology and Flooding • Loss of soil / sediments (including landslides) and pollution of watercourses, and interruption of drainage patterns • Reduced surface flow leading to saltwater intrusion into surface waters • Flooding or overtopping of structures during extreme weather events, causing physical hazards and pollution	• Minimisation of cleared areas and soil disturbance, with replanting as soon as feasible, with native species. • Avoidance of areas liable to flooding, slope instability, and water crossings where possible. • Restrictions on work and other activities around waterbodies (e.g. vehicle washing), and minimisation measures around water crossings where this not possible. • Limit unnecessary movements of heavy machinery. • Avoid areas sensitive to erosion, where possible. • Implement integrated watershed management in order to control soil erosion. • Stabilise the soils in order to reduce potential erosion. • Careful design: e.g. minimal diversion of watercourses, timing of works (overall duration and seasonality).
	Pollution of Soils and Water and Effects on Public Health • Discharge of construction site/camp sewage effluent that may pollute watercourses. • Eutrophication algal blooms, proliferation of aquatic weeds • Release of hazardous substances during construction (e.g. vehicle or vessel spills) leading to soil, surface water, marine or groundwater contamination. • Release of untreated and treated waste water into the environment	• Installation of sewage treatment to meet required standards and assurance that receiving water quality will be acceptable even in periods of low flow. • Materials handling and control procedures. • Control of construction vehicle movements and prohibition of vehicle washing in watercourses, and similar practices. • Emergency response plans during construction (contractors and local authorities) and operation (local authorities).
	Disturbance and Nuisances associated with Construction(Air Quality, Noise and Vibration Solid Wastes, Visual Impacts, Movement of People and Animals)	• Detailed construction EMP with responsibilities clearly assigned to institutions with resources and capacities in place • EMP included in sub-contractor conditions and payment triggers • Modern equipment and vehicles meeting appropriate emissions standards, and regular preventative maintenance. • Phasing of works to minimise time and areas of disturbance
	Solid and Hazardous Wastes • Solid waste produced, including potentially hazardous wastes, during	• Prepare Waste Management Plans including handling of excavated materials • Ensure that adequate waste handling and reception facilities are available at locations close to the generation sites

	Risks/Opportunities	Mitigation
	excavation and replacement of pipe networks. • Highly polluting wastes generated from sewage collection and treatment.	
	Energy and Climate • Large energy demand overstrains local electricity supply especially at peak demand • Significant increase in fossil fuels burning to meet energy demands	• Assess energy availability, manage pumping times to reduce costs and reduce peak demand • Use energy efficient technology where available and cost effective • Investigate renewable and low carbon sources of energy • Investigate waste to energy potential, particularly from sewage sludge
	Natural Resources • Demand for construction materials causes over-exploitation of local resources	• Require contractors to identify sources of supply and certify sustainability
	Destruction of habitat caused by changes to surface water flows, as a result of diversion, abstraction or impoundment of water.	• Environmental flow assessment, to avoid significantly altering flow regimes and ensure that water flows are sufficient to maintain downstream ecosystems.
BIOLOGICAL	• *Loss, fragmentation and degradation of habitat, and severance of animal migration routes and pathways caused by landtake for infrastructure and* construction impacts on habitats and species (e.g. from changes in drainage, soil erosion, pollution of water, soils or air, introduction of invasive species, noise and general human disturbance).	• Careful siting and minimisation of area impacted, clear demarcation of remaining intact areas of habitat, and prohibition of activity in those areas; maintenance of wildlife corridors between fragmented areas wherever possible. • Buffer zones around locations identified as ecologically sensitive and avoid or minimise activity within these zones. • Maintain migration corridors through linear sites and phase work to avoid the most sensitive times for the animals affected. • Habitat rehabilitation and ecosystem restoration of areas no longer required after construction, as soon as possible. • If loss of Critical Habitat is inevitable, development/implementation of an Offsets Programme.
	Direct Impacts on Terrestrial and Marine Flora and Fauna • Clearance or flooding of vegetation may lead to loss of plant species and habitat of conservation interest, and displacement of fauna.	• Careful site selection, with advice from biodiversity authorities/wildlife specialists. • Careful planning of phasing and timing of construction activities. • Demarcation and avoidance of areas of conservation interest (high value species, feeding or breeding sites, migration routes, etc.) where possible. • Consider translocation of both flora and fauna before the reservoir floods, if appropriate, under expert supervision.
	• Adverse impact on fisheries due to changes in water flow and limnology, disruption of fish migrations, and degradation of water quality.	• Minimise sedimentation in spawning grounds downstream. • Maintain a minimum water flow for fish • Identify and where possible conserve spawning grounds.

Table 2 Summary of Risks/Opportunities and options for Mitigation/Optimisation