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Water Working Notes

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PRIVATE PROVIDERS OF CLIMATE CHANGE SERVICES

The Role and Scope for the Private Sector in the Provision of Non-Financial Climate Change-Related Services Relevant to Water Infrastructure

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WATER PARTNERSHIP PROGRAM

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

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TABLE OF CONTENTS

Tables

Boxes

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ABBREVIATIONS AND ACRONYMS

BOD	Biological Oxygen Demand
BOT	Build, Operate, Transfer concession contract
BOOT	Build, Own, Operate & Transfer contract
BRIC	Brazil, Russia, India & China
CC	climate change
CCS	climate change services
COD	chemical oxygen demand
EIB	European Investment Bank
EU	European Union
FRM	flood risk management
GHG	greenhouse gas
GIS	Geographical Information System
IDB	Inter-American Development Bank
IFI	International Financial Institution
IPCC	International Panel on Climate Change
IWRM	Integrated Water Resources Management
MENA	Middle East and North Africa
NAPA	National Adaptation Programme of Action
NFCCS	Non-Financial Climate Change Services
NGO	Non-Governmental Organisation
NOAA	(US) National Oceanic and Atmospheric Administration
NRW	Non-Revenue Water
O&M	Operation and maintenance
PES	Payment for Environmental Services
PP	Private Providers
PPP	Public-Private Partnerships
PPCCS	private providers of climate change services
R&D	research and development
WBCSD	World Business Council on Sustainable Development
WRM	water resource management
WSS	water supply and sanitation
WWTP	wastewater treatment plant

FOREWORD

Man-made climate change is affecting water infrastructure in all regions of the world, affecting large numbers of people in their daily life and the development of their societies. As part of the World Bank Water Anchor's analytical and advisory work on water and climate change, consultants have investigated how private sector services to infrastructure may address the challenges related to climate change while, at the same time, improving development opportunities for people. This report, which is one of the outcomes of the above work, addresses the role of private providers of non-financial climate change-related services with relevance for water infrastructure.

Climate change adds to current climate variability through changes in mean temperatures, in precipitation and in the strength and frequency of extreme climatic events. Many of the results of climate change affect human welfare—both directly and indirectly through infrastructure: For instance, increased likelihood of low flow and drought can lead to water shortages in urban water supply; episodes of heavy rainfall can overload storm drain systems and wastewater treatment facilities and cause floodings; rising sea level can increase the salinity of water drawn from coastal aquifers, thus negatively affecting urban and rural water supply as well as agriculture; lower rainfall and increasing evapotranspiration can increase water demands for irrigation; changing river flows are likely to affect hydropower generation; and increased rainfall intensity can lead to soil erosion and thus affect the sustainability of watersheds or the functioning of reservoirs. Moreover, the water sector can be a driver for climate change itself. For instance, in California and Egypt, a large share of electricity consumption is related to water pumping.

Therefore, water infrastructure will need to cope with greater climatic extremes and uncertainty in the future. On the other hand, the water sector also needs to contribute to mitigate climate change, e.g. through reduced energy consumption. These challenges will pose severe tests on governments and public agencies, whose efforts need to be complemented by those of non-governmental bodies, bringing in additional resources, new perspective and innovative products. However, while the adaptation to climate change may require the development of entirely new services, it will, in particular, require modifications and additions to existing services already dealing with climate variability.

This report investigates to need for additional services with regard to climate change and analyzes the potential for the private sector in providing these services. The analysis focuses on the water sectors likely to be affected by climate change, that is, water resources management, irrigation and drainage, hydropower, coastal protection, flood protection, urban water supply and sanitation as well as water quality. In addition, opportunities for mutual engagement of public and private agencies are analyzed and the perspectives of market development are explored. The central aim of the report is to deepen our understanding of the opportunities for engaging private providers of climate change services in climate change adaptation combined with socioeconomic development opportunities.

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1. THE DEMAND FOR CLIMATE CHANGE SERVICES IN WATER INFRASTRUCTURE

The demand for climate change services (CCS) derives from the measures entailed in CC adaptation and mitigation in water infrastructure and the type of services required to implement them. This chapter contains three sections: 1.1 Orientations—some essential background1.2 Adaptation and mitigation required in water infrastructure1.3 A working typology of CCS

1.1 Orientations — some essential background

Variability and uncertainty

The following extracts from the recent authoritative IPCC report *Climate change and water*[1] summarise the consensus view on this topic:

> "CC affects the function and operation of existing water infrastructure—including hydropower, structural flood defences, drainage and irrigation systems—as well as water management practices…
>
> Current water management practices may not be robust enough to cope with the impacts of CC on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems….As a first step, improved incorporation of information about current climate variability into water-related management would assist adaptation to longer-term CC impacts…
>
> Adaptation procedures and risk management practices that incorporate projected hydrological changes with related uncertainties are being developed in some countries and regions…
>
> Adaptation options designed to ensure water supply during average and drought conditions require integrated demand-side as well as supply-side strategies."

This extract indicates the importance of risk management and demand management in adapting the water sector to CC, and the crucial role of infomatics in mapping the reciprocal impacts of CC and water.

The greater variability of climate around a mean which itself is expected to change under CC is part of the challenge. Whether the mean is changing, and by how much, will only be apparent after several decades. Changes in the mean are more likely to be associated with wider fluctuations about a trend than with steady changes in climatic conditions. For water infrastructure, CC will mainly be experienced through greater variability of temperatures and hydrological conditions. *Adapting to current variability is an important first step in many cases*. As the IPCC have observed:

> "…many actions that facilitate adaptation to climate change are undertaken to deal with current extreme events."[2]

Greater variability around, and changes in, the climatic mean are likely to be compounded by greater *uncertainty*—over the boundaries of variation, the possible appearance of new factors, the significance of past experience, the reliability of climate forecasts, and the presence of thresholds, irreversibilities and tipping points.

Implications for decision making

Greater variability and fundamental uncertainty will have profound implications for decisions about water infrastructure, which typically has a long physical life. These implications are at various levels, and of different kinds:

- the *climate risk* of such infrastructure should be assessed, at a sector and/or project level.[3]
- traditional ways of dealing with risk in *cost-benefit analysis* need to be fully exploited: these methods include

[1] Bates, *et. al.* 2008, Executive Summary, p.4
[2] Quoted in Economics of Climate Adaptation, (2009) p. 27
[3] The ECAWG report (2009) contains cases studies at the regional level. MWH (2009) contains cases studies of multi-purpose water infrastructure projects.

sensitivity analysis, switching values, risk-benefit analysis,[4] etc.

- decision rules should be used that take into account the *risk preferences* of the agency concerned (minimax, maximin, minimum regret,[5] etc).
- these traditional aids to decision making under uncertainty and risk need to be complemented by the use of *scenario building* which constructs multiple imaginary, but plausible, futures which cannot necessarily have been predicted by extrapolation from current trends. (In one such exercise, three contrasting climatic scenarios for 2030 were constructed, and projects and measures which stood up well on each scenario were considered to be *robust*.[6])
- *robust decision making methods* may be utilized. A wide variety of concepts, methods and tools have been developed to address decision challenges that confront a large degree of uncertainty.[7] One specific sub-set called "Robust Decision Making" is a set of quantitative methods and tools designed to support decision making and policy analysis under conditions of deep uncertainty.[8] Researchers associated with the Rand Corporation have been particularly active in this development. The World Bank is currently working this group of researches to test "Robust Decision Making" in relation to different types of water infrastructure.

No regret and climate-justified projects

Project design needs to allow for greater climatic and hydrological variability, and be *resilient* in dealing with events which cannot be foreseen as yet. This may involve postponement of investment decision to achieve better knowledge and/or to incur additional cost of building in resilience (e.g. greater storage, which may not be needed, or forfeiting current economies of scale in favour of greater freedom of manoeuvre in future). If the additional cost is smaller than the benefits even under current climatic conditions, then we may consider this investment as a "no-regret investment". If on the other hand the cost outweigh the benefits under current climatic conditions, it could be regarded as an insurance premium to avoid future losses in the CC scenario. Following tradition, we would call this a "climate-justified" investment.

To be precise, the IPPC$ defined the *no regret* criterion as *a policy that would generate net social and/or economic benefit irrespective of whether anthropogenic climate change occurs.* No-regret policies are also more loosely referred to as *win-win*, or *double dividend* actions. Examples include demand management measures, improvements in the efficiency of water distribution, wastewater recycling, early warning systems for floods, droughts, and other extreme weather events, and risk spreading through insurance schemes. It may also include construction of new supply infrastructure, retro-fitting existing structures, altering operational protocols, developing new water sources, water transfers, etc. The key issue is not whether the project is a hardware or a software project, but whether the positive net benefit stream is dependent on the future climate being different from the climate without anthropogenic climate change.

It may be asked why, if no-regret projects are justified independently of a CC scenario, they are not already being implemented. There may be many reasons why they are not. The projects may not have been adequately formulated and prepared. Because of their scale or nature, capital and credit might not be available. Financial incentives for the sponsors may not be aligned with the positive economic case. Sponsors may have higher subjective discount rates, or different risk appetite, from that assumed by the analysts.

Such factors are familiar in the market for energy-saving policies and devices, where pay-back periods are often very

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[4] Sensitivity analysis measures the impact on the project's rate of return of a change in a specific variable. Switching values are the change in a specific variable required to reduce the rate of return to zero. Risk-benefit analysis compares the risk of action (= its cost) with the benefit of action (= avoided loss).

[5] Minimax = minimising the maximum expected loss; maximin = maximising the minimum likely outcome; minimum regret = minimising the difference between the worst possible outcome and others.

[6] Economics of Climate Adaptation (2009). Another interesting water scenario exercise was carried out by the World Business Council on Sustainable Development, (2006).

[7] An early overview is provided in: Rosenhead, J. (ed). Rational analysis for a problematic world. Problem structuring methods for complexity, uncertainty and conflict. (J. Wiley and Sons).(1989)

[8] See for example: Lempert, Robert, Popper, Steven and Bankes, Steven: Shaping the next one hundred years. New methods for quantitative, long term policy analysis." Rand Corp. (2003)

short, yet projects are not taken up.[9] Similar factors apply to water demand-management programmes, where consumers in both households and industries seem reluctant to take up appliances and technologies that, on paper at least, promise rapid pay-back. No-regret projects may be attractive on paper, but may still need active promotion, and the CC scenario may give them the extra benefits and impetus required to make them happen.

In comparison, projects in the *climate-justified* category would only be justifiable if specific predictions of the climatic and hydrological futures turned out to be accurate. *Climate-justified* policies have to be planned and implemented against the backdrop of an uncertain future. The keynote criteria for these projects are resilience, robustness, flexibility and *intelligence* (ability to provide services or management over a range of possible conditions). Depending on circumstances, these projects may have co-benefits outside a CC scenario. A harder look at co-benefits may lead to projects being considered as "no-regret" rather than climate justified. Climate change is therefore another reason to conduct a thorough review of all project related costs and benefits.

In practical terms, water projects may fall into a spectrum, the opposite ends of which are no-regret projects, and "pure" climate-justified projects, with many in between.[10] The IPCC adopts a pragmatic stance on this issue:

> "..adaptation measures are seldom undertaken in response to climate change alone"[11]

Vulnerability

Certain types of project are especially vulnerable to CC and will in particular benefit from being subjected to risk analysis and management. They include[12]:

- Highly capitalised or unique projects
- Engineering structures with long lifetimes
- Multi-purpose infrastructure systems
- Projects with long-lived streams of benefits and costs
- Systems susceptible to climate anomalies or extreme events
- Rural and urban water supply

Ultimately, there is a limit to how far vulnerable populations can be protected from variability though their water infrastructure. Protection against hazards can never be absolute. In certain circumstances the most feasible form of adaptation may be to ensure that at-risk populations are adequately warned and prepared for hazards, and that social and financial safety-nets exist to compensate and provide for them *ex post facto*. Specifically, *disaster preparedness* and *insurance* should be part of the adaptation tool-kit.

Three categories of markets for climate change services

There are many kinds of CCS as well as a multitude of potential service providers. In order to reduce this complexity to proportions that are manageable for analysis and useful for operational purposes, this section proposes three market categories of CCS:

- ***Reforms to policies, governance and institutions***. This is a broad category of actions concerned with the "rules of the game" under which water infrastructure is managed. In general, these are "soft" actions not involving major investments in hardware, though this does not imply that they are easier to implement than the latter, quite the reverse in fact. Examples include the creation of river basin management bodies, introduction of water demand management policies, setting new regulatory and public safety criteria, creation of stakeholder fora and consultation procedures, implementation of institutional reforms of water utilities, tariff reforms, etc.

  An important "overhead" that can be grouped in this category is the provision of relevant information for water investment and management. Strategy formulation is also included here. Although prime responsibility

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9 A factor stressed in McKinsey, (2009).

10 In terms of the Economic Rate of Return of projects, the no-regret projects will cluster at or above the cut-off rate of return (say 10%), and will be boosted by any extra benefits (including avoided losses) in a CC scenario. In contrast, climate-justified policies would have ERRs well below 10% and could only be contemplated in a CC scenario. The distinction between the two project categories would appear after sensitivity analysis and estimation of switching values.

11 Quoted in Economics of Climate Adaptation (2009) p. 27.

12 Alavian, et.al., 2009.

for initiating and implementing these actions rests with governments and public agencies, private providers (PPs) can offer a full range of advisory services and add value at each stage.

- ***New investment, capacity expansion and major rehabilitation and adaptation*** (e.g. in dams, reservoirs, irrigation systems, levees, new water intakes, wastewater treatment plants). This category includes new technology embodied in investments in new systems and installations.
- ***Changes in the management and operation of existing systems and facilities*** (e.g. greater use of more sophisticated modelling, forecasting, new operating protocols, greater energy efficiency, water loss reduction programmes, conjunctive use of surface and groundwater, water catchment management, etc.)

Capacity building

Water is not a sector known for its dynamism or innovation. In many parts of the world the physical infrastructure of water is deteriorating, its governance and institutions are sclerotic and swollen with political patronage, and its skilled and experienced human resource capital is eroding. This is not the ideal starting point for the rapid and drastic change that water infrastructure and its related services confront over the coming decades.

The hidden assumption underlying much discussion of adaptation and mitigation in this sector is that the public services responsible for policy setting, planning, regulation, monitoring, management, project implementation, operation and other key functions are adequate and sufficiently equipped. In many cases it is clear they are not. PPs can help to remedy this deficiency, either by:

- Performing or supplementing functions currently done inadequately by their public service clients; or,
- Undertaking new services under the control and supervision of the latter.

The first of these roles requires a serious transfer of experience, know-how and technology from the PP to the public client in order to sustain the function in the long term. The second also requires a strengthening of the capacity of the public client to successfully manage the PP and carry forward the latter's work. Anecdotal, but persuasive, evidence is that there is an urgent need for the creation and strengthening of public capacity to plan and manage the adaptation and mitigation efforts outlined in this report. Capacity building is a cross-cutting issue for CCS, common to the three functional categories discussed above, and to all the sub-sectoral categories which follow.

1. 2 Adaptation and mitigation in water infrastructure

This section discusses the needs for NFCCS in seven subcategories of water infrastructure or related services of interest to the Bank, namely: water resources management, hydropower, irrigation and drainage, coastal protection, inland flood protection, urban water supply and sanitation, and finally water quality and environmental protection. The discussion will be in the context of the three market categories of CCS used in section 1.1., allowing for overlaps and commonalities.

Water resources management (WRM)

WRM affects all aspects of water use throughout the water cycle. The main needs stressed in this section relate to the *governance category*, namely, the greater use of coherent and integrated planning methods, including risk-based decision tools, and the generation of better information for such decision making, comprising basic hydrological data collection, analysis and modelling and its use for specific applied purposes. While much of the basic information will rely on systems operated by national public and international agencies, important niches will remain for PPs, especially in the interpretation and application of data for specific economic purposes.

In a CC context, WRM will have to adjust to greater uncertainty, concerning trends, the range of variation around them, tipping points, hazards as yet unknown, and greater risks (the greater probability of more hazardous events). This will call for more use of risk management and methods for taking decisions under uncertainty. The transmission of stresses and shocks through the different parts of the water cycle and among all water users places a premium on coherent and integrated planning methods. These planning needs in turn place greater demands on the generation and interpretation of water data.

Integrated Water Resource Management (IWRM) is a common planning paradigm, aiming to manage surface and groundwater resources for multiple uses in a coherent manner. The production of IWRM plans has made rapid strides recently, thanks partly to countries' commitment to a UN target for the production of these plans, and partly to donor support. The IWRM philosophy is also evident in the spread of river basin management principles and practices in many specific river basins.[13] In EU member states this is due to the requirements of the European Water Framework Directive. Many private consultancies cater to these markets with various types of planning services.

However, discussions of the implications of CC for water infrastructure have exposed the scarcity of data on which planning and adaptation needs to be based. The overriding issue at a global and regional scale is to maintain and enhance the observational networks that can track both climatic and hydrologic data. Unfortunately, in some parts of the World the number of on-active the-ground observation stations has been declining for a several decades.[14]

Much of the observational infrastructure for recording data on a global scale. is owned and operated by the major powers, though with some commercial networks. Setting up and operating large observational networks, including satellite launching and servicing, needs large budgets.[15] Though much of this will remain a public (and international) responsibility, the sheer sums involved leave openings for private satellite operators too.[16]

The use of satellite observations on a national and local scale for applied purposes is making rapid progress, involving both private companies and international public agencies:[17]

- Infoterra is the largest provider of satellite data for the analysis of farmland in France. The firm expects the amount of farmland monitored in this way to increase as a result of CC, since farmers can no longer rely on the past as a guide to the future.
- RapidEye, a German satellite operator, sells data to insurance companies marketing crop-insurance policies to governments in countries at risk of drought and famine. The company has the capability of analysing the productivity of fields down to five-metre square patches.
- The World Agroforestry Centre in Nairobi is cataloguing the radiation signature—giving the agricultural potential—of 100,000 samples of African soils. The data is being passed on to the International Centre for Tropical Agriculture in Colombia to create a database, the Digital Soil Map.
- The National Aeronautics and Space Administration NASA in Washington, and European Space Agency (ESA) in Paris are major providers of public satellite information to a multitude of public and private sector users.

The high-level modelling involved in climate studies is likely to be driven mainly by specialised public (including international) agencies. The same is true of the integration of climatic, meteorological and hydrological models to produce results at a scale useful for international and regional policy-making and national economic planning. This work is a classic international public good[19] requiring collective input to produce optimal results:

[13] E.g. Young & McColl (2008)

[14] For climatic data this is illustrated in Mitchell, Timothy and Jones, Phillip (2005): "An improved method of constructing a database of monthly climate observations and associated high-resolution grids". Printed in International Journal of Climatology. It is known that the number of stations with recording from stream-flow gauges in particular Africa has also declined for some time.

[15] Satelitte imagery can in a number of cases compensate for the lack of ground monitoring. However, it is still far from being an adequate replacement. Observations are much better when satellite imagery can be combined with ground monitoring.

[16] *The Economist*, Oct 17, 2009

[17] These examples are from The Economist, Nov 7, 2009, p. 89

[18] Alavian et al., 2009, Water and Climate Change: Understanding the Risks and Making Climate-Smart Investment Decisions, The World Bank.

[19] Although in theory agencies could deprive others of information about their programmes (e.g. for military or strategic benefit), in the long run results are intended to be of global or regional benefit.

> European meteorologists have recently embarked on an experiment. Flood warnings in Europe were once issued by national bodies and based on a binary system of alerts: they either predicted a flood or did not. National bodies now cooperate to forecast across borders.
>
> Meteorologists have embraced a more complex method of analysis, known as "ensemble" forecasting. It tries to measure flood risks by using dozens of computers that all run simulations of how a river (or a sea) might act, based on slightly different initial inputs. The resulting collection of forecasts is used to create a composite vision of the future, instead of a simple binary result. At Reading, over four dozen computers are used to create this "ensemble", producing a highly nuanced picture of European flood risk.[20]

The market space for private services is likely to be in the refinement of the basic models and their interrogation and interpretation for specific applied purposes. At smaller scales—national, regional and river basin—there is a need for higher degrees of resolution (*granulation)* plus *ground-truthing*, where there is scope for private services, in many cases making their own specific uses of data obtained from the large public networks. There is scope for private services in *rolling out* programmes pioneered by public and international bodies:

> Developments in satellite imagery are being exploited to monitor progress towards the MDGs and to better understand the needs of poor, informal settlements. The Cities Without Slums project of UN-HABITAT in Kisumu, Kenya, led by the local Municipal Council, developed and maintained a digital map of Kisumu based on a high-resolution satellite image. UN-HABITAT has an on-going programme to provide GIS capability to around 1000 cities, with the object of supporting pro-poor urban development programmes.

The importance of producing good hydrological data at a usable scale can be illustrated for West Africa, where since 1970 a decrease of 20 to 40% of rainfall amount for the core of the rainy season in July and August has been observed. The onset of the rainy season has become more variable (a greater *coefficient of variation*). Rainfall variability is clearly observed and reinforced in the discharge time series of many rivers in the sub-region. The decrease of discharge recorded for many of the river basins concerned varies from 40 to 60%. A clear link has been demonstrated between the evolution of ocean sea surface temperature and the evolution of average annual rainfall in the Sahel region.[22]

Bringing the issue literally to the grassroots level, the Mali Agrometeorological project illustrates the practical benefits of climate information for helping farmers to adapt to CC (Box 1).

The above discussion has identified the importance of the following CCSs for WRM, chiefly in the *policy & governance* category:

- Production of IWRM plans;
- River basin planning and management studies;
- Climatic & hydrological data collection, analysis and modelling (informatics, GIS etc);
- Interpretation & presentation of satellite data for applied purposes and specific clients;
- Refinement and interrogation of basic forecasting models for specific purposes and clients.

Hydropower

Any reduction in stream flow and basin yield will diminish the production of hydropower. Conversely, increases compared to the historical pattern may also pose operational problems which impinge on hydro production. Greater variability, within ranges with uncertain boundaries, poses a serious challenge to this sub-sector with implications for both structures and operational procedures. With more intense rainfall periods, storage may have to be enlarged in various possible ways. Changes in flow regimes, exceeding operating safety margins, could also require retrofitting of current structures or the demolition and reconstruction of installations.

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[20] Gillian Tett, *Financial Times*, Nov 10, 2009
[21] UN World Water Development Report 2, p. 110
[22] Further reference and discussion in WWDR3

Box 1. The Mali Agrometeorology Project

Following the severe droughts of the 1970s and the continuing risks posed to rural communities by rainfall variability, the Malian National Meteorological Department (DNM) launched a project in 1982, with external financial help, to provide climate information to rural people, especially farmers. This was the first project in Africa to supply climate-related advice directly to farmers, and to help them measure climate variables themselves, so that they could build climate information into their decision making.

In the words of one farmer:

"If I had to choose between agrometeorological information and fertilizer? Agrometeorological information! For without that, the fertilizer would be useless…"

A number of factors contributed to the success of the project. The drought and famine of the 1970s was prominent in the minds of farmers and their political leaders. Long term financial support was available from the Swiss Development Corporation together with technical support from the World Meteorological Office. The project's farmer-centred approach delivered services relevant to farmers' needs, while good communication channels between all parties and the use of radio (in all the major local languages) helped to disseminate information. Under the project farmers themselves collect much information about rainfall to feed into the information system.

The results of this long term project indicate that the regular provision of agrometeorological information helps farmers to manage the risks entailed by increased climate variability. A framework is in place for gathering, analysing, processing and disseminating information in a form that farmers can use. The project is evidence that farmers can use the information to make better decisions leading to higher yields and incomes. They are able to take more risks by investing with greater confidence in new technologies that can raise incomes and yields further.

Source: Winpenny, 2009, based on Hellmuth, 2007

Climate change adds an extra layer of risk to hydropower projects which tend to be costly and risky in any event. Spending on studies—e.g. modelling different options and permutations of siting, storage, dam structure, etc.—could be a sound investment, given the risks and outlays involved. Since *stationarity* is no longer a sufficient planning basis, and given uncertainty about future events, the use of risk-based decision models to generate scenarios based on Monte Carlo simulations could be warranted.[23, 24]

Policy, governance & institutions

Hydro projects will need to develop (or reinforce existing) agreements and protocols with other river basin stakeholders, to agree coordinated responses to greater variability. This will include the development of new operating protocols for water storage and release. Some revision of the regulatory regime for hydro may be required to address the need of greater safety margins or strategic buffers, etc. This will create a market for technical, economic and financial studies by infrastructure consultancies.

New investment

Brand new projects have greater latitude, allowing adaptation options that are not available in the same extent to existing schemes. One recent analysis (MWH, 2009) examined several actual hydropower schemes from the point of view of their exposure to CC risk. One of these, the Lesotho Highlands Water Project, was planned without explicit consideration of CC. Had this been considered, there might have been different design features in the spillways and intake structures of the dams concerned, and the heights of dams and reservoir storage volumes might have been different. If modifications were to be made now, two of the dams might be raised in height by the addition of parapets.

In another case, the Upper Bhote Koshi Project in Nepal was also planned before CC was a major design consideration.

[23] Milly et al (2008): "Stationarity is dead: Whither Water Management?" Science 319 (5863) p. 573–574

[24] MWH (2009) p. 53

The major new risks posed by CC arise from glacial lake and landslide lake outburst floods, as well as extra sediment load and changes in river flows. Certain project components would probably have been different if the project had been planned now, with CC in view (e.g. greater storage off-site for improved river basin management, different specifications for turbine components to improve resistance to erosion from increased sediment).[25]

Many of the options for *adapting existing multipurpose infrastructure* projects for CC involve *studies and software*. For example, CC risk assessments and corresponding modelling options (especially where several schemes existed along the same river). Also, modifications to the hard fabric of dams and associated infrastructure, either in design (for new projects) or by adapting existing structures, is a routine matter for civil engineering firms and their consultants.[26]

Mitigation is also relevant to this sub-sector. The methane emissions from rotting vegetation in reservoirs, and carbon inflows from catchments, have been identified as potential sources of greenhouse gases (GHG). Work is in progress to determine more accurately the net emission of GHGs from large scale storage, which may lead to a change in the current rules which exclude large hydro schemes with storage from the UNFCCC Clean Development Mechanism.[27] This issue has implications for the choice of location of new hydro schemes, the configuration of the reservoir and the way in which land is prepared prior to flooding.

Changes to the management and operation of existing structures

Expected changes in hydrological conditions will require the design of new operating protocols, revised contractual arrangements with the offtaker, new regulatory frameworks, etc., for which established technical and economic consultancies are available.[28] In the Lesotho Highlands project referred to above, consultants identified a possible need for adjusting the current reservoir operating procedures in order to optimise the yield of the project under CC scenarios. Likewise, for the Upper Bhote Koshi project in Nepal, the modification of the Power Purchase Agreement to give the project greater operational flexibility was identified as a desirable response to CC.

In summary, this section has identified the following need for CCS:

- Technical services for planning, design and construction of new climate-smart infrastructure (incorporating risk-based decision methods);
- studies for the adaptation of existing infrastructure to a CC scenario (forecasting, modelling, , EIAs, etc);
- Similar studies or the reforms needed in the management and operation of existing structures entailed in the above;

Irrigation & drainage

Policies, governance & institutions

The irrigation reform agenda, as recently laid out by the so-called Comprehensive Assessment,[29] is driven by the future food needs of a growing population, competition for water from other use sectors, ecological imperatives, and diminishing groundwater in many regions. CC is an additional driver, but far from being the only one. Implementing this reform agenda will create a market for services in all three of the categories identified earlier.

Countries and regions dependent on agriculture may need to review their entire agricultural and land-use strategy in a CC scenario. *Land-use optimisation modelling* is an option for countries with access to sophisticated data collection and analysis, and the depth of support services needed for implementation:

> The China Tarim Basin II project, supported by the World Bank, has used remote sensing data from Landsat and the US NOAA to map biomass production, maximise consumptive use of water, and reduce non-beneficial evapotranspiration. The combination of remote sensing with socioeconomic data has allowed the assessment of the relationship between site

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2 5 *Ibid*. ch. 7
2 6 *Ibid*, also Alavian *et. al.* (2009) Annex C.
2 7 Bates, *et. al*. 2008, p. 122
2 8 MWH, (2009) Ch.7
2 9 Molden, ed. 2007

> productivity, climate, and project performance. (World Bank, 2005, pp 273–4).

An important potential element of any adaptation strategy in agriculture is insurance for farmers against adverse weather conditions, such as drought or flooding. Many farmers, especially smaller ones, might find conventional insurance unaffordable, in view of the transactions costs involved in investigating individual cases which would have to be reflected in premiums. This is the rationale for *index insurance:*

> "Index insurance is insurance that is linked to an index, such as rainfall, temperature, humidity or crop yields, rather than actual loss. This approach solves some of the problems that limit the application of traditional crop insurance in rural parts of developing countries. One key advantage is that the transactions costs are lower. In theory at least, this makes index insurance financially viable for private-sector insurers and affordable to small farmers. Another important advantage is that index insurance is subject to less adverse selection and moral hazard than traditional insurance."[30]

The key point in the above to stress is that payouts are not directly related to actual losses. Farmers may experience crop loss yet be unable to claim if the overall index does not broach critical levels. Conversely, unaffected farmers may get payouts even if they were not directly affected. Other kinds of *weather derivatives* take account of the individual situations of farms. For example, FIRA, an agency of the Bank of Mexico, links with commercial banks in funding irrigation investments, providing hedging for interest rates to offset the fall of farm incomes due to shortfalls in the delivery of irrigation water.

Major new investment

The growing scarcity of surface water and diminishing aquifers will be major drivers of change in irrigated agriculture. Where rainfed farming becomes too precarious, irrigated land may be brought into cultivation. Elsewhere, there will be a mixture of changes to cultivation practices so as to minimise water use and improve "crop per drop". Greater recourses will be dedicated to non-traditional water sources such as the reuse of municipal wastewater effluent. Some changes in cultivation practices entail sizeable investment, supported by sophisticated technical services, others require modest outlays by farmers themselves, for which microcredit or the farmer's own savings would be adequate.[31]

One such practice is the recycling of wastewater for agricultural use, which is already on a growing trend. At least 20 million hectares of land in 50 countries is estimated to be irrigated with raw or partially diluted sewage, around 10% of all irrigated land. Around half a million hectares are irrigated with treated wastewater. The use of raw or treated wastewater for irrigation is particularly common in and around cities, where many farmers have little choice.[32] Potential recycling projects entail sensitive public health, consumer, technical and environmental issues where specialist expertise is invaluable.

The community of service providers and financiers of irrigation investments have to take great care to fully understand the implications of investments and changes in practices on the water cycle. Many technologies, such as drip irrigation, which reduce abstraction needed for a given crop and thus improve "crop per drop" will at the same time reduce the recharge of acquifers. The "real" water consumption is measured by evapotranspiration (ET) and not by abstraction and ET is very closely linked to agricultural production. There have been many examples of "water saving" irrigation projects which in reality increased water used through a combination of improved "crop per drop" and expanded production. New methodologies to guide decisions based on ET rather than on water abstraction are being piloted, for example in the above mentioned World Bank project in Tarim Basin in China.

Modifying existing practices

Adapting irrigation systems to CC may require heavy investment, as noted above, but others can be achieved through changes in existing farming practices. Certain of these changes in practice rely on new types of seeds and other agronomic products being developed for use in rainfed

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30 Hellmuth et. al. 2009, pp 3–4
31 Section 2.3 contains examples from both ends of this spectrum
32 Bahri, 2009

farming in increasingly dry conditions. In irrigated agriculture there is scope for using small-scale irrigation equipment which makes more efficient use of water. Agronomic advisory and technical services, some of which are offered by equipment suppliers, help to support local farmers and extension workers in making the required changes.

Coastal protection

Many of the world's largest cities are on or near the coast. Half the world's population is now urban, and the majority of urban residents live within 100 km of the sea.[33] Predictions of future rises in the sea level and the more frequent incidence of tropical storms and cyclones are of obvious concern, particularly for small islands and deltaic communities. The World Bank estimates that coastal zone protection represents the largest cost item for CC adaptation.[34]

Policy, governance & institutions

Forecasting extreme events can no longer be based on historical records alone, but needs to incorporate scenarios generated from climatic and hydrological modelling:

New infrastructure

In the World Bank's study *Economics of Adaption to Climate Change* (EACC), coastal erosion and flooding from sea and rivers in coastal areas are two impacts considered, and three adaptation responses are included—beach nourishment, dyke building and upgrading ports—all involving major outlays. Historically, many cities and low-lying agricultural areas adjacent to the sea have had to organise structural defences against sea surges and storm damage, which is a foretaste of the more widespread adaptation to CC that may be necessary.

Changes in management & existing practices

Comprehensive flood risk management requires actions of all types and at all levels. Many of these are *non-structural* and involve changes in behaviour, practices and public responses, which can be highly cost-effective. The flood risk management, and flood preparedness measures appropriate for coastal zones partly overlap with those discussed further below for inland flood protection. This is an often quoted example of a *no regret* policy.

Inland flood protection

The greater hydrological variability and unpredictability expected from a CC scenario places flood risk management (FRM) in the forefront of adaptation. There is substantial overlap between measures required in inland and coastal flood protection and flood risk management. In both domains *disaster risk management* is also highly relevant.

Policies, governance & institutions

The preparation of FRM plans is a stock-in-trade of environmental and civil engineering consultants. The various elements and options in FRM are summarised in Box 2. These options overlap the three categories outlined in section 1.1, and include aspects of planning, regulation, institutional responsibility, stakeholder involvement, and civil actions, as well as investments in infrastructure and management practices.

Improved weather and flood forecasting is crucial to flood risk management, especially in mitigating the impact of floods. Neglecting weather forecasting and hydrometeorological services can have heavy costs; conversely, investment in such services is highly cost-beneficial (Box 3):

New investment

Structural flood risk management measures include the creation of dams, dykes, walls, and embankments, flood-proofing major and vital infrastructure, increasing the flood-resilience of buildings, etc. *Non-structural* measures may also involve sizeable costs, either directly or as *opportunity costs* from foregoing or curtailing an important economic activity (e.g. the creation or restoration of wetlands and other flood storage areas; increasing the area of floodplain around a river; the restoration of natural river systems, all of which could be at the expense of agriculture).

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[33] UN WWAP, Briefing Note, The implications of climate change on water, 2009, p. 6

[34] World Bank, Economics of adaptation to climate change , 2010, p. 10.

Box 2. Strategies and options for flood risk management

Strategy	Options
Reducing flooding	• Dams and reservoirs • Dykes, levees, embankments • High flow diversions • Catchment management • Channel improvements
Reducing susceptibility to damage	• Flood plain regulation • Development policies • Design & location of facilities • Housing and building codes • Flood-proofing • Flood forecasting & warning
Mitigating the impacts of flooding	• Information & education • Disaster preparedness • Post-flood recovery • Flood insurance
Preserving the natural resources of flood plains	• Flood plain zoning & regulation

Source: EIB (2007) p. 4

Changes in current flood risk management practices

The menu of possible measures indicated in Box 3 includes spatial and land-use planning to control development and habitation in flood-prone areas; insurance; and public information and awareness.[35] An effective component is *disaster preparedness*—flood warnings, contingency plans for rescue, evacuation and continuation of vital services, compensation and restitution, etc. These should be the prime responsibilities of public agencies and civil society bodies. Disaster preparedness and emergency management can be highly effective (Box 4):

Urban water supply and sanitation

Policies, governance & institutions

For areas where water is likely to become scarcer (e.g. the lower latitudes, Mediterranean style, semi-arid countries), and population growth and competition for water is high, action will be required both on demand-side and supply-oriented measures. In the realm of demand management, metering, reduction of leakage and wastage from distribution systems, the promotion of water-efficient household appliances and sanitation methods will all be needed. In many cases, tariff reform will be necessary to reflect the true cost of water delivery to the user.

[35] EIB, (2007)

Box 3. Benefits of hydromet services

… the range of the accumulated problems is so great that, without massive modernization, networks in some ECA [Eastern European and Central Asian] countries are on their way to becoming completely dysfunctional. No longer able to count on their own weather services, countries would be forced to depend on low-resolution forecasts prepared by others that often would miss significant local and rapidonset hazards, including floods, frosts, and severe storms. The perils of a weakening forecast capacity have become evident in Russia's system, where the share of hazardous weather phenomena that were not picked up and forecast increased from 6 percent at the beginning of 1990s to 23 percent only ten years later.

Recent research underscores the value of investment in hydromet services. A study in China concluded that expenditures on the meteorological service had a cost/benefit ratio of between 1 to 35 and 1 to 40 (Guocai and Wang 2003). An estimate in Mozambique suggested a cost benefit of 1 to 70 for investment in the meteorological service, which needed to be rebuilt after that country's civil war. Mozambique saw directly the consequences of being uninformed and unprepared: when floods swept the country in 2000, it cost Mozambique nearly half its GDP.

Source: Fay, et. al. (2010)

Box 4. Urban flood risk management in Köln

In December 1993 the centre of Köln in Germany was flooded, resulting in damages estimated at €75 million. This was the first major flood since 1926 and there was little experience with flood management. In 1995 a flood similar in magnitude to the 1993 flood occurred but the damage was only €32 million, 40% of that for the 1993 flood. The reduced flood damage was attributed to:

- improved emergency management;
- extensive emergency measures put in place during the event (the effort was estimated at 125,000 man hours);
- deployment of 1,400 m of demountable flood barriers; and,
- use of 400,000 sand bags for local protection.

Following the 1995 floods the City Council has implemented further measures to reduce flood risk which concentrate on water retention upstream, reduction of potential damage within the city and flood awareness and preparedness of inhabitants.

Source: EIB (2009) p.25

New investment & major rehabilitation

Supply-side measures will include:

- the use of more marginal sources of water (including desalination);
- the development of more effective and energy-efficient treatment of both fresh and used water;
- greater recycling and reuse of wastewater;
- more storage within distribution systems to buffer against irregular flows.

Desalination continues to be the main driver of the global water market, especially in arid regions with limited alternative supplies. The market for desal equipment and plant is very active and competitive, and unit costs continue to fall. However, the heavy energy footprint of this process is a cause of concern. The disposal of concentrated brine as effluent from this process is also an environmental problem, and certain units have also proved vulnerable to algal blooms. There is an active market in services for all parts of the desal project cycle, including Design-build contracts, BOT concession or its variants and management contracts.[36]

Energy efficiency is a crucial mitigation issue for the water sector. Firstly, water is a large, and generally inefficient, consumer of energy. At present 20% of California's power supply goes in the treatment and transportation of water. In China one of the lesser-known side effects of the targeted increase in the proportion of wastewater treated from 40% to 60% would be an increase in energy consumption by the same proportion—50%. In general, the search for more marginal sources of water as it becomes scarcer increases the energy requirement for sourcing and treatment.[37]

Many transmission and distribution systems of water for urban use are highly inefficient in their use of energy. One telling statistic is the high percentage of water put into distribution systems which is lost to physical leaks: this is both a waste of water and a waste of the energy involved in pumping it around. It has been estimated that, in developing countries *physical losses* of water run at an average of 21%, amounting to a total volume of 16.1 billion m^3/a.[38] Energy is a sizeable cost of water delivery, even at the sub-economic prices of electricity that often apply. There is a potentially large market for energy-efficiency audits and action programmes for all urban water supply and sanitation (WSS) systems.

Secondly, wastewater is a major, and rapidly increasing, source of methane. In developing countries, decentralised and "natural" treatment processes can generate large methane emissions. On the other hand, toilet systems with low water use and ecological sanitation methods where nutrients are safely recycled have lower GHG emissions.[39] The potential for methane in WWTPs is both a GHG risk, and an

[36] *Global Water Intelligence* contains a monthly update on the status of current projects

[37] Global Water Intelligence, October 2009, p. 5

[38] Kingdom, et. al. 2006, p. 3

[39] Bates, et. al. 2008, pp. 123–124

opportunity, since the biogas produced can be reused to create heat and energy for operation of the plant itself. Thus, WWTPs can potentially have a zero net carbon footprint and, where such schemes exist, can claim carbon credits for the fossil energy saved. Locally, biogas from human waste is already extensively captured and used for neighbourhood heating in South Asia and elsewhere. This discussion indicates the scale of the potential market for technical advisory services in this area, from consultancy through to design, management and operation.

Recycling of municipal wastewater for agriculture, urban landscaping, industrial cooling, groundwater recharge, restoring environmental flows and wetlands, and for further urban consumption is rapidly growing. Out of 3,300 water reclamation facilities identified recently, most were in developed countries. The MENA region had around 100 sites, Latin America 50 and sub-Saharan Africa 20.[40]

> Tunisia has a high coverage of sanitation, with 96% in urban areas, 65% in rural areas and 87% overall. Industries also have to comply with national standards for the discharge of wastewater into sewers, and are given subsidies for pre-treatment processes. 78% of wastewater collected is treated, mainly to secondary biological standards.
>
> 30–43% of treated wastewater is used for agricultural and landscape irrigation. Reclaimed water is used on 8,100 ha. To irrigate industrial and fodder crops, cereals, vineyards, citrus and other fruit trees. Regulations allow the use of secondary-treated effluent on all crops except vegetables, whether eaten raw or cooked. Golf courses are also irrigated with treated effluent.
>
> Tunisia launched its national water reuse programme in the 1980s. Treatment and reuse needs are combined and considered at the planning stage. Some pilot projects have been launched or are under study for industrial use and groundwater recharge, irrigation of forests and highways and wetlands development. The annual volume of reclaimed water is expected to reach 290 Mm3 in 2020, when it will be equivalent to 18% of groundwater resources and could be used to counter seawater intrusion in coastal aquifers. (*Bahri, 2009)*

The greater variability of natural freshwater supplies and more frequent extreme rainfall under CC scenarios will call for more *storage* within and around freshwater and wastewater distribution systems. This is needed to prevent surcharging as well as shortages of volume, both extremes being damaging to the functioning of freshwater and sewer systems. The re-engineering of existing systems is a potentially large market for technical services from both specialised consultants and experienced water operating companies.

Changes in operating practices in existing infrastructure

Depending on the degree of change and investment required, the reforms discussed above may require major new capital spending, or may be implemented through less costly adjustments to the *modus operandi* of existing plant. Some system improvements readily lend themselves to sub-contracting arrangements with private service providers, such as the reductions in levels of Non-Revenue Water, discussed further in Part Two.

Water quality & ecosystem services

Climate change is likely to lead to poorer water quality in some regions more than others due to forces such as lower dilution of effluent by freshwater, saline intrusion of coastal aquifers, plus periodic events such as flooding and storms, causing damage to WWTPs, mixing of run-off with sewage and stormwater flooding. The projected rise in surface water temperature could lead to a greater frequency and extent of eutrophication[41] and hypoxia.[42] This pollution causes damage to a variety of ecosystem service dependent on good water quality.

Natural freshwater ecosystems will be affected by such changes in water quality, and also by changes in the quantity and timing of water flows associated with climate change and greater variability. Higher temperatures in rivers

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[40] Aquarec, 2006.

[41] the excessive concentration of nutrients in water, leading to dense growth of plant life, such as algal blooms

[42] deficiency of oxygen

and lakes will also have an impact. Other, indirect, impacts of climate change include:

- Disruption of flowering patterns;
- Shifts in vegetative season;
- Species invasion;
- Changes in ecosystem productivity;
- Shifts in nutrient cycles;
- Loss of critical habitat.

Much of the water quality agenda needs to be implemented at source, through action in wastewater treatment and reuse, treatment of industrial effluent, measures to reduce non-point pollution from agriculture, etc. These measures belong to the relevant sub-sectors discussed earlier. This section highlights two additional areas, amongst others, where the market for NFCCS is likely to be boosted by CC—water quality testing, and the development of systems of Payments for Environmental Services. Both are aspects of capacity building in the category of policies, governance and institutions.

Policy, governance & institutions

The market for *water quality testing* is broadly segmented into in-house facilities, small commercial laboratories serving regional clients, and large companies serving national and international clients. Among the major laboratory groups are Inspicio (UK-based, with 8000 staff in 130 countries), ALS (Australia-based, 4000 staff in 30 countries), TestAmerica (US-based, 27000 staff) and SGS (Swiss-based, with 50,000 staff for all its services). It is estimated that the global water testing market as a whole is worth $3.6 billion p.a.[43]

The concept of Payment for Environmental Services (PES) arose in the USA and other OECD countries in the 1980s, principally to reward farmers for adopting practices that are kinder to the local environment. In the 2000s the concept spread to some Latin American countries, mainly in the context of forest conservation. Both kinds of programmes have potential benefits for water quality. The motivation for PES is that private producers (farmers) may be able to provide a public service (protection of ecosystem services) more efficiently than governments, and in doing so they are entitled to a reward to compensate them for any extra costs or loss of production they incur. Globally, there are now hundreds of PES schemes, each designed around detailed investigation of complex local situations, and offering great potential for studies by environmental consultants.[44]

1.3 A working typology of CCS

The 3 generic categories of adaptation/mitigation measures used in section 1.1 can be combined with the seven types of water infrastructure & services discussed in 1.2 to produce a matrix of CCS. This is reproduced in Table 1 with examples of services typical of each case.

[4 3] "Market profile: water testing", *Global Water Intelligence*, June 2009

[4 4] FAO (2007)

Table 1. A typology of CCS

Water infrastructure category	Reforms to water policies, governance & institutions	New investment, capacity expansion & major rehabilitation	Changes to management and operations of existing systems & installations
Water resource management	Preparation of IWRM plans; creation of river basin management systems; crop insurance services	Technical services for planning, design & operation of multi-purpose storage. Increased reliance of robust planning methodologies	Satellite data analysis & modelling;
Hydropower	Agreements on safety margins, risk management & response protocols between upstream and downstream parties	Planning,design, turnkey projects; engineering services for modifications to dams; risk-based decision analysis and modelling for major projects	Forecasting and modelling river regimes; creation of new operating protocols
Irrigation & drainage	Modelling & feasibility studies for optimal land use under future scenarios. Increased integration of service delivery with basin wide WRM considerations	Technical services for new water- and energy-efficient irrigation systems, reliance on new technologies such as ET monitoring; feasibility studies	Improved efficiency in field use of water; adapting cropping pattern and application methods to use of recycled water
Coastal protection	Planning standards and building regulations; design of non-structural measures; preparation of disaster preparedness plans and procedures	Ensemble projections and modelling to support major new works	Tidal flood risk management planning
Inland flood defence	Climate & hydrological modelling to estimate flood risks under non-stationarity scenarios	Digital mapping to identify vulnerable areas and installations for planning flood defences	Forecasting, data collection, analysis and modelling to guide public responses to flooding events; disaster preparedness planning
Urban WSS	Planning, designing & implementing demand management programmes. Increased integration of urban service delivery considerations with WRM considerations	Increased reliance of robust planning methodologies. Feasibility studies & technical services for new plant & systems; design, build & management contracts	Improving energy efficiency of systems and plants; Non-Revenue Water reduction programmes
Water quality & ecosystem protection	Water quality testing; groundwater monitoring; design and implementation of schemes of Payments for Environmental Services	Technical services for major programmes of wastewater collection, treatment and disposal; environmental & ecosystem impact studies of major new infrastructure	Technical studies & advisory services for changes to in-plant industrial processes

2. THE POTENTIAL FOR PRIVATE PROVIDERS OF CLIMATE CHANGE SERVICES

2.1 Status of "private" providers.

"Private Providers" (PPs) will be interpreted broadly and pragmatically to include ***any organisation that markets expertise and products on a commercial basis***.

This definition includes the academic and research community and non-for-profit bodies, where they act in a commercial manner to disseminate their expertise, and develop and market innovations resulting from their core work. Service providers come in a range of institutional forms: academically-based research institutes, international public agencies, national public and publicly-sponsored agencies and research institutes, private not-for-profit, or non-profit distributing companies, private limited liability companies, private consulting partnerships, and social enterprises.

Many "public" research bodies are active in CCS, and operate in the same market as, and in a similar manner to, purely private companies. Many public research bodies have changed their status over time to operate at arms'-length from their government sponsors, have accepted targets to break even financially, and have the freedom to accept sponsorship from private financiers and fee-earning commissions from all types of clientele. Some have passed into full private ownership. There is also substantial private sponsorship of research carried out at predominantly "public" research bodies.

Thus "private" is not a uni-dimensional category—there are many hybrids on the spectrum from purely private to wholly public bodies, and the selection of entities based on their formal legal status would be neither practical nor fruitful.

A growing number of water service operators, as well as equipment suppliers, now exist in South-East and East Asia and the Middle East, and are marketing their services both within and outside their home regions. These companies take a variety of institutional forms and have multiple origins: a number of them are wholly- or majority-owned public corporations, some of which have opened up their capital base to private investors, behave in a fully commercial manner, and compete for operating contracts outside their local domestic base.[45]

2.2 Strengths and limitations of private providers & client constraints

The diversity of providers and the presence of many hybrid forms does not imply that legal, institutional, constitutional or other peculiarities are irrelevant in their selection or in the way they perform. Such factors may limit the scope for their engagement for certain kinds of work, but equally may define their comparative advantage for other tasks..

The same feature may be perceived differently in different contexts. In certain countries, and for certain services, the fact that a provider may have roots in a government institution could be seen either as an advantage or a disadvantage. In some countries major companies, though fully private, have close informal links with their governments and the client may see no clear private-public distinction. Conversely, the client may distrust the ability of a state-owned organisation to give impartial advice or keep information confidential, and may prefer to use a reputable multinational company for these reasons. These considerations are crucial where data is sensitive, e.g. from satellite observations, or hydrological data on shared rivers.

The distinctive contribution of private service providers for the tasks identified above, compared to typical public sector agencies, lies in the following areas, among others:

- Efficiency
- Flexibility
- Speed of response and delivery
- Ability to hire
- Commercial acumen
- Creativity, enterprise & energy
- Independence

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[4] [5] Winpenny (2006).

- Ownership of data bases and proprietory technology
- Connections to other producers
- International contacts

Much R&D is now carried out privately and much expertise provided by the private sector is simply not available to public agencies, and in such cases there is no real choice.

Two recent studies by World Bank staff provide evidence of the scope for using private sector providers for water supply and sanitation services for a specific CC—related task. A comprehensive study of public-private partnership (PPP) in the urban water utilities of developing countries examined, among other performance measures, the impact of PPP on the reduction of water losses.[46] It found that many of these projects did indeed reduce Non-Revenue Water (NRW), though not all were successful in this.

A separate study[47] looked in more detail at the role of private companies in reducing NRW. The following benefits of using private agents were identified:

- access to new technology and the know-how to use it efficiently;
- better incentives for project performance;
- creative solutions for the design and implementation of the programmes;
- qualified staff;
- flexibility over field work (such as working at night); and,
- the ability to bring financial resources for investment, where contractual conditions are conducive to this.

However, the study cautions against treating private companies as the panacea for NRW—much depends for instance on the form of contract employed. Simple technical assistance contracts seem to have been less effective than forms entailing greater risk and reward, depending on performance such as a management contract, lease or concession. This leads the authors to recommend the greater use of performance-based service contracting in this area.

There are offsetting disadvantages of using private service providers. Private agents do not necessarily share the public service ethos prevalent in the best (though by no means all) public agencies. They respond to commercial incentives, and where it is not feasible to introduce these their performance may disappoint. Private companies may in the course of their work develop proprietary software or systems which they do not pass on to the public client (though this could be addressed in their contracts). Conversely, the private provider may impose its own proprietory software or systems on the client, in preference to something else more suitable, or which is in the public domain. In these cases it is important to provide in the service contracts for the *transfer of technology*.

More generally, the expertise which is built up during the course of an assignment may not be retained by the host organisation when the private provider departs, preventing the development of collective memory, or an internal *critical mass* of experience.

The issue can be approached from the converse perspective, the constraints and obstacles faced by public sector institutions in delivering the necessary CCS, which makes them turn to the private service option. The comparative advantages of private suppliers listed above are the inverse of the disadvantages faced by public agencies. However, some constraints of the public sector would also apply to their engagement of private suppliers, such as limited budgets, shortage of skills to manage sub-contracts, political obstacles to delegating tasks to outsider consultants (especially foreign).

Managing and commissioning private agencies itself requires planning and management skills which are, *ex hypothesi*, lacking in many countries, especially in the water sector. In its study of Non-Revenue Water, the World Bank authors[48] pointed out three major constraints on the greater use of private companies in NRW reduction:

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[46] Marin, *et. al*. 2009. The results are presented in terms of Non Revenue Water, which includes both physical and commercial losses, and in many situations it is difficult to disentangle the two. Kingdom et. al. 2006 make a broad estimation that in developing countries NRW consists of 60% physical losses and 40% commercial losses.

[47] Kingdom, *et. al*. 2006

[48] Kingdom, *et. al*. 2006

1. the public utility's lack of capacity to implement a comprehensive programme and coordinate the work of several contractors,
2. the weakness of the local private sector to take on such work, and
3. lack of awareness of the options and of guidance on implementation.

Although this topic is often approached with a *public versus private* mindset, in many contexts it is more fruitful to think in terms of *combinations* or *partnerships* between different kinds of institutions to carry out specific tasks (e.g. the Thames Barrier work cited in section 2.4). In this way, the comparative strengths of both public and private providers can be brought to bear. International networks involving different kinds of institutions can also be useful sources of expertise which transcend the usual categories, e.g. the Delta Alliance, hosted by the Dutch company Deltares:

> The overarching objective of the Delta Alliance is to support the development and dissemination of new and existing knowledge on how river delta regions may respond to the challenges that deltas face, in particular those that come with a changing climate. The Delta Alliance approach includes international research collaboration, multi-stakeholder dialogue and information dissemination in a network of dedicated individuals and organisations.
>
> A growing number of organisations, like research institutes, governments, NGOs and the private sector, all over the world are involved in the Delta Alliance.

2.3 Transfer of technology & expertise from other sectors

The technology and processes developed for the exploration and development of *oil and gas* is particularly appropriate to the tasks required in the water sector. Some tasks are basically similar, e.g. prospection, drilling, pumping and piping of a fluid resource. The Libyan Man Made River project, involving the extraction of deep-lying fossil water and pumping it hundreds of miles to the coast, has many similarities to oil and gas production. CC is raising the level of interest in groundwater aquifers as a source and reservoir of water, which is an area of particular expertise in the oil industry.

Because oil and gas have a relatively high economic value compared to water, it is no coincidence that the technology and expertise involved is much more advanced and infinitely better funded. By the same token, this expertise is available off-the-shelf to solve the future problems confronting water.

> For example, Schlumberger, best known as producers of oil-drilling platforms and other oilfield infrastructure, offers a range of technical services relevant to water, including GIS and data management, aquifer characterisation, aquifer storage and recovery, groundwater monitoring, geologic modelling,[50]

Petroleum consultants have developed proprietory systems for identifying and monitoring underground reserves of oil which could readily be adapted to groundwater purposes:[51]

> As an example, Neftex Petroleum Consultants Ltd (Neftex) is a leading provider of web-based sequence stratigraphic data and interpretations to the hydrocarbon industry. The company provides an online digital Global Earth Model to clients (developed using sequence stratigraphy) including all supporting data. Neftex completed the base modules in all major Regions in 2009, Each Region has eight Modules providing increasing detail in subsurface understanding (Base, Outcrop, Biostratigraphy, Source Rock, Reservoir and Seal, Play Fairways, 3D Exploration and GeoDatabase). The company aims to maintain and update the model for all new public domain data.

Oil companies are often involved in producing water as a by-product of their core operations, or to supply communities adjacent to their projects:

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49 *Deltares website.*

50 www.schlumberger.com.

51 Source: "Financial Times" Supplement on Water & Waste Management, Jan 26, 2010, p. 2 and www.neftex.com.

> Shell's gas-to-liquids Pearl plant in Qatar is designed to produce 140,000 barrels of liquid products per day. It will also produce a large volume of water as a by-product of the chemical reaction when synthesis gas is passed over catalysts. An industrial water processing plant with a daily capacity of 300,000 barrels (of a similar scale to that of a city of one million people) will treat the water to make it usable for cooling, steam, and other uses within the plant. This will enable the plant as a whole to be self-sufficient in water, avoiding any demands on the water supplies of this desert state.[52]

It has been observed that in poor countries technical services developed for the oil or mining sectors (remote sensing, geology, drilling, etc.) are far better equipped and more generously funded than the comparable services available for hydrological purposes. This raises the possibility that water sector might "piggy back" on the use of such services that have been developed for other sectors.[53]

Technologies and processes developed in the *power* sector are also transferable to water. This applies particularly to methods of demand management and customer relations—e.g. "smart" metering, billing, as well as the modelling of systems, risk management, etc. Some systems offer the possibility of common billing for water and power:

In Malta, as part of a Euro 70 million smart grid scheme being implemented by a consortium led by IBM, metering will be integrated into the network, enabling water use as well as energy to be monitored analysis and simulation for optimal water management, systems integration etc. Other products are the production and supply of groundwater monitoring instruments, training, consultancy and software.[54]

In regulation, there is considerable interest in the water sector in transferring experience (so far mainly in the USA) of benchmarking power companies' rewards to their success in *reducing* demand, rather than increasing sales.

In a different realm, the *nuclear industry* has developed expertise in air and water pollution which is now available as policy, advisory and implementation services. AEA Group[55] offers emissions inventory development, environmental data systems, local and mesoscale modelling, assessment and forecasting, instrument calibration, monitoring network construction, operation and calibration, and regulatory policy advice and development.[56]

Finally, an increasing amount of the data needed to monitor CC and plan the adaptation of water infrastructure is obtained from satellite observation. *Space technology* has much to contribute.[57]

2.4 PPCCS in practice.

There is growing evidence, illustrated in this section, of work by PPCCS relevant to water infrastructure.

In the realm of strategy studies for *water resources management,* a private consultancy has developed the *water cost curve* to assist countries facing future water scarcity. This tool systematically assembles all the feasible options for either saving or providing water and arrays them, weighted by the water volumes involved, according to their unit cost. Combined in a single graph, the options describe a rising supply curve, a familiar concept in elementary economics. The concept of the water supply curve is applied to India, China, South Africa and the Sao Paulo region of Brazil to help prioritise measures to mitigate their respective looming water scarcities.[58]

In *irrigation and drainage,* a private company specialising in managing irrigation systems, especially of sugar cane, has implemented a number of projects involving maximising the water-use efficiency of sugar estates. Nakambala in Zambia is predominantly furrow irrigation with laser levelled fields to optimise water use efficiency. Finchaa in Ethiopia uses dragline sprinkers designed to maximise gravity rather than pumped pressure. Simunye in Swaziland uses a combination of systems—furrow, sprinkler, centre pivot and drip. Maple in Peru has a surface drip system to maximise

52 www.shell.com.
53 I credit to Steven Wade for this insight
54 www.schlumberger.com.
55 Part of the former UK Atomic Energy Authority
56 www.aeat.co.uk.
57 The World Bank has a partnership with NASA and NOAA for a project in Morocco
58 McKinsey (2009) ch 3.

Box 5. Low cost irrigation services in India

Global Easy Water Products (GEWP) is a for profit social enterprise in India that focuses on developing and delivering low-cost irrigation solutions to small farmers who are often overlooked by technology advancements. GEWP specializes in affordable micro-irrigation and water storage. Its portfolio contains over 50 different products primarily in drip tape, micro sprinklers, fertilizer tanks and flexible water storage tanks. The first and most successful product is the flexible Krishak Bandhu (KB) drip tape. Different thicknesses of drip tape are produced to correspond with the requirements for short-term (vegetables), medium-term (sugarcane & banana), and long-term crops (mango, sweet lime, pomegranate). The small drip irrigation kits like bucket & drum kits and family nutrition kits are specially designed for women and reduce workload and improve nutrition through kitchen gardening of vegetables. GEWP focuses on affordability and modularity in order to make the products more accessible to their small farmer clients. Its criterion is that products must pay for themselves in one crop season. In addition, farmers must be able to purchase a system small enough to experiment with, and then have the ability to expand their area under drip irrigation as their income grows.

Source: Global Easy Water Products website

the availability of water. At Simunye there has also been conversion and modernisation of an older irrigated area, from sprinkler to sub-surface drip. (www.booker-tate.co.uk.)

At the opposite end of the size spectrum, a commercially-oriented Indian social enterprise is working with small farmers to supply irrigation equipment at an appropriate and affordable scale (Box 5).

Privately-driven networks and partnerships can also play a key role in promoting water efficiency. An example is the *Better Cotton Initiative (BCI)*, sponsored by the major retailing chains IKEA and Marks & Spencer in alliance with the World Wide Fund for Nature (WWF). The BCI works though national farmer associations and peer group pressure and advice to promote water efficiency, amongst other aims, amongst small-scale cotton farmers. (Cotton is a water-intensive crop grown in regions that are often water-scarce).

On a different tack, private insurers are getting involved in the development of index-based flood insurance for farmers in the Mekong Delta of Vietnam (Box 6):

More advanced methods of forecasting are crucial to better *coastal protection,* as seen in work on the Thames Barrier in the UK done by a consortium of organisation. In 2008 the UK Met Office provided advice for the development of a tidal flood risk management plan for the Thames Estuary. The report examined potential future climate-driven changes in extreme water levels in the southern North Sea near the Thames Estuary up to the year 2100. The Met Office Hadley Centre worked in a corsortium including the UK Environment Agency, the Proudman Oceanographic Laboratory and the Centre for Ecology and Hydrology. Climate scientists at the Met Office combined *ensemble* projections, which give a likely range of future extreme water levels, with "H++", described as a "new high-end water level scenario". The scientists developed ten-year climate forecasts to strengthen contingency planning to use alongside the 50- or 100-year time frame projections currently used worldwide. Such decadal models seek to pick up natural variability, such as El Nino and

Box 6. Index-linked flood insurance for farmers in Vietnam

"An index-based flood insurance product has been offered to the Vietnam Bank of Agricultural and Rural Development (VBARD). The product is designed to pay for consequential losses that are suffered by VBARD when flooding creates problems for farmers in repaying loans. The contract is being offered by a Vietnamese insurance company, has support form a global reinsurer, and has been approved by the Vietnam regulatory authority. The prototype index insurance contract is underwritten against recorded water levels at the Tan Chau station. The product is fully priced and loaded by the domestic Bao Minh Insurance Corporation, with reinsurance form the international company Paris Re. No subsidies were involved in the price for underwriting."

Source: Hellmuth et. al. 2009, pp 60–6 fluctuations in the Gulf Stream, as well as man-made climate change. These results are of more direct practical relevance to planners (e.g. for operation of the Thames Barrier) than models with a longer time frame.[59]

Drainage of low-lying coastal areas will become more important in a CC scenario. The experience of existing estates that are particularly at risk from rising sea levels is relevant. The sugar cane industry of Guyana has existed for 300 years and has to cope with two rainy seasons per year, heavy clay soils and a low-lying topography, much of it below sea level. A comprehensive system of canals and drains has been developed to serve the purposes of irrigation, drainage and navigation, while a protective wall has been built along the full length of the Atlantic coastline and along the principal river estuaries. Drainage water is discharged into the sea either through sluices at low tide or through low lift pumps. This infrastructure protects the 8 factories and 43,000 ha of sugar cane operated by the Guyana Sugar Corporation (GSC), which provides around 18% of the country's GDP. Over many years the GSC has received technical, operational and project management services from a private company to meet the abovementioned climatic and environmental challenges.

In localities where tourism is commercially important, *beach nourishment* is becoming a favoured form of coastal protection, along with other methods of restoring natural features. In Barbados this was part of a wider programme involving long term capacity building, supported by an IFI (Box 7).

Flood forecasting is getting more and more attention as a non-structural measure for *flood protection and disaster reduction*. A particular challenge exists in data-poor regions, where hydro-meteorological measurements are missing due to lack of observation systems and procedures. Many break-away republics of the former Soviet Union share the lack of data as a common problem since centralized hydro-meteorological data collection has been abandoned in the wake of national independence in the early 90'. Starting from a pilot project in Georgia, South Caucasus, i the use of (1) local weather prediction models, (2) simple ground observing system, as well as (3) remotely sensed information, has demonstrated that operational flood forecasting is feasible. The study case of Georgia could become an example on how to tackle flood forecasting and disaster reduction

Box 7. Beach nourishment as coastal protection in Barbados

[In Barbados] on a single 1.1 kilometer strip of beach on the southwestern coast, from Rockley to Coconut Grove, shoreline rehabilitation requires the construction of five headlands, one major revetment and five spurs. The revetment requires 30,000 tons of granite boulders imported from Canada, while beach nourishment will absorb 18,000 cubic meters of sand dredged from a Barbados harbor. The procedure is guided by a scientific model developed by an international technology firm in Canada. The project was supported by financial and technical assistance from the IADB involving advice, training and capacity building, as well as funding for investment. The IDB supported the establishment of Integrated Coastal Management from its inception in 1983 by providing financial assistance for technical studies and research, later supplemented by funding for training technicians and for demonstration projects. The Bank financed the drafting of new environmental legislation and aided in the establishment of the Coastal Zone Management Unit and in the drafting of the Coastal Zone Management Plan. An IDB loan of $17 million approved in 2002 financed the rehabilitation and protection of selected, priority beaches, and provided resources for training and strengthening of the Coastal Zone Management Unit.

Source: IDBAmerica, Magazine of the Inter-American Development Bank, Jan 25, 2010

in central Asia. This work has been supported by a large commercially-oriented institution providing hydrological consultancy and technical services (www.deltares.org.)

In certain countries forecasting has been strengthened through public-private partnerships, in which private firms process and disseminate weather data.[60]

Major private insurance companies have unrivalled data bases about natural hazards like flooding, and offer insurance products to mitigate their financial impact. One such company has created a tool for the "geographical underwriting" of natural-hazard risk, based on the company's geocoded portfolio and loss data, which can be used to perform highly

59 UK Met Office website
60 Fay, et. al. 2010

precise spatial and geographic portfolio analysis. The Natural Hazards Assessment Network (NATHAN) has geographically referenced data and display capabilities which enable the user to produce qualitative estimates of the exposure to natural hazards of any of 800,000 locations and urban regions. A "light" version is publicly accessible, and an enhanced version available to clients and subscribers. (*www.munichre.com*.)

In *urban water supply and sanitation* technological developments promise to increase the efficacy and cost of wastewater treatment, compared to conventional processes, and facilitate its reuse. A large number of companies offer technology, much of it innovative , for the treatment of water and wastewater, and many of them offer advisory, technical and operational services associated with the systems they supply. However, in most cases there is still a need for more knowledge and testing and often site specific adaptations.:

Many companies prominent in the *desal market* are also active in that for wastewater treatment and reuse.[61] Reused treated wastewater is likely to encroach on increasingly scarce freshwater as a source of agricultural, industrial, and eventual urban household, water supply. In agriculture, reuse projects often claim to be "win-win" solutions, assuring reliable and nutrient-rich wastewater for farmers whilst releasing the latters' rights to fresh water for the use of cities. However, future reuse projects, with higher levels of wastewater treatment, are increasingly likely to target urban and industrial use.[62] Saudi Arabia's National Water Company (NWC) is discovering a strong demand for treated sewage effluent , mainly among municipalities, district cooling companies and industrial water users, and is forming companies (likely to be mixed public-private ventures) charged with handling all aspects of the distribution and sale of the effluent to end users.[63]

Private operators have long been active in *urban water supply and sanitation services*, working through various kinds of contracts, such as management and operation, asset leasing, concession, and in certain cases, full asset ownership and operation. A recent World Bank review of PPP in urban water utilities concluded that the main contribution of private involvement has been in improving the quality of service and the efficiency of operation, rather than in providing sizeable new funding. The Saudi Arabian NWC is developing management contracts for tendering to private companies for the wastewater treatment projects of Mecca, Taif, Medina, Damman and Al Khobar.[64]

One leading international water operator offers the following management, capacity building and training services (Box 8):

There is also evidence of a burgeoning market in specialised services, such as leak detection and repair. In China innovative technologies are emerging to detect and repair leaks that are offering easier use at lower cost. Services are increasingly being offered to utilities against a share of the savings achieved, rather than against fixed payments. However, the market remains very fragmented and the businesses providing these services are mostly small providers, serving only their immediate local area." (McKinsey et. al. 2009, pp 107–108).

Box 8. Management services from a private water operator

- Management of change
- Organizational and management effectiveness
- Customer Services
- Billing, collection and information systems
- Commercial and financial systems
- Corporate planning and investment
- Development and monitoring of concession contracts
- Operational due diligence for project financing
- Assessment of potential outsourcing opportunities
- Leakage control
- Operational optimisation of plants and systems
- Operations procedures manuals
- Water quality and process monitoring
- Process development and review
- Environmental protection
- Sewerage and sludge disposal studies
- Master planning
- Institutional strengthening
- Asset management

Source: http://severntrentservices.com.

61 The head of GE Water believes that reuse is becoming a better market than desal (*GWI*, Sept 2009, p. 8–9). See also *Municipal Water Reuse Markets 2010*, published by *Global Water Intelligence* and PUB Consultants, 2009.
62 Global Water Intelligence, October 2009, p. 6
63 *GWI* Jan 2010, p. 20
64 *GWI*, Jan 2010, p. 20

3. DEVELOPING THE MARKET FOR PPCCS IN WATER INFRASTRUCTURE

> "The private sector is critical to the transformation of water use in a country…the private sector has at least three important roles to play`: as provider of capital, as water user and as provider of solutions." (McKinsey, 2009, p. 122).

This report is concerned with the third of these roles—PPs as providers of solutions. The topic has both a narrower and a wider aspect. The *narrower* aspect is how PPCCS can be promoted in the operations of the World Bank and similar development agencies. IFIs can promote a market for PPCCS directly through procurement from their lending and technical assistance programmes. In the *wider* sense, IFIs can also be the catalysts of greater PPCCS through the design of country programmes, their policy dialogues, and their capacity building efforts, with the aim of making PPCCS a sustainable part of a country's CC adaptation and mitigation.

This chapter is relevant to both the narrower and wider purposes above. It has four sections:

- An overview of the market for CCS;
- Limitations on demand;
- Supply- side obstacles;
- Developing the market for PPCCS.

Box 9. Categories of CCS

- Strategy studies
- R&D, innovation, design
- Data collection and analysis (including the special case of satellite observations)
- Infomatics, GIS, modelling, software development
- Planning & methodology (e.g. risk assessment)
- Feasibility studies, EIAs, compliance monitoring
- Measuring & monitoring water status
- Training and capacity building
- Advisory and technical services
- Construction and project implementation
- Management and operation

3.1 Overview of the market for CCS

Many types of CCSs are likely to be needed (Box 9):

Information on the size of the *actual* market for CCS for the various parts of water infrastructure is not readily available. Such estimates as there are for the different sub-sectors combine equipment and services and are dominated by the former.[64]

The size of the *potential* market can be appreciated from new comprehensive estimates of the costs of adaptation being developed by the World Bank.[65] Overall, the Bank finds that:

> "the cost between 2010 and 2050 of adapting to an approximately 2 degrees C warmer world by 2050 is in the range of $75 billion to $100 billion a year."[66]

These estimates relate to all types of cost for a broad range of economic and social infrastructure and services and cannot be directly linked to the seven water sub-sectors used in this report. The estimates relate to the cost of constructing, operating and maintaining *new* infrastructure needed. CCS have not been explicitly included in these estimates, though certain services will be wrapped into construction costs.

With these qualifications, it is significant that "coastal zones" and "water supply[68] and flood protection" are two of the three largest cost categories for adaptation, the first accounting for $30 billion, the second for $14–19 billion in the above total ($75–100 billion/year). The Bank's study finds that two-thirds of the adaptation costs in coastal zones will arise in two regions—Latin America & the Caribbean, and

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[6] [5] For instance, the annual size of the market for *municipal and industrial water and wastewater equipment and services* was estimated to be US$ 365 billion by Goldman Sachs in 2005.
[6] [6] Though these omit costs of *mitigation* required in the water sectors.
[6] [7] World Bank, Economics of adaptation to climate change, 2010, p. 1.
[6] [8] Understood to mean bulk water availability.

East Asia and the Pacific. In contrast, for the category "water supply and flood protection" sub-Saharan Africa will incur by far the largest costs of any region.

Strategy studies based on the *water cost curve* for specific countries and regions within them can produce more accurate estimates of both the size and the nature of the market for CCS in tackling impending water deficits. One such exercise[69] concluded that cost-effective adaptation in India would be based overwhelmingly on improving the water productivity of agriculture. In China, by contrast, the strategy should be based on managing the rapidly growing demand from industrial and urban users. In the Sao Paulo region of Brazil the key would be promoting efficiency in industrial, municipal and domestic users. In South Africa the least-cost solution would be a combination of supply-side actions and incentives for industrial water efficiency measures.

In all such situations there is a choice to be made between conventional supply-oriented solutions, and a wide array of demand management measures. The latter are often cheaper, but more difficult because they entail changing water users' behaviour and reforming institutions. Whichever path is chosen will have implications for the type of CCS required.

3.2 Limitations on demand

The constraints on the demand for CCS apply to both public and private service providers, but more particularly the latter, who operate in a market environment. The constraints emphasised here are:

1. National priorities
2. National security concerns
3. Project pipeline
4. Capacity limitations
5. Finance

National priorities

While most developing countries are fully aware of the potential impact of CC on their territories, not all have made the necessary adjustments in their domestic policies. Many countries maintain a distinction between "development" and "climate change adaptation" policies, and give priority to the former.

Although there is growing evidence of the congruence of "developmental" and "climate resilient" policies in the longer term, there is need for further exploration of these issues at national level. What is required is a convincing demonstration to national governments of the potential economic costs of CC- unless countervailing actions are taken:

> "If current development trends continue to 2030, the locations studied[70] will lose between 1 and 12 percent of GDP as a result of existing climate patterns, with low income populations such as small scale farmers in India and Mali losing an even greater proportion of their income." (ECAWG, 2009, p. 11)

It is also important to include in development programmes sufficient *no regret* policies and projects that will deliver economic benefits whatever the future holds. Much of the investment in water infrastructure discussed in this report would have tangible economic and social benefits for the host countries under any CC scenario. Consultants can help to minimise any real or imagined trade-off between development and climate resilience aims through assistance in the process and content of strategy formulation, information gathering, modelling, forecasting, scenario building, etc.[71]

National security concerns

Some adaptation projects and policies trespass on sensitive national security issues (e.g. mapping, satellite monitoring, GIS, international water sharing and management, flood control, modification of major dams, etc). Many governments may prefer such projects to be firmly under their own control. This would not necessarily rule out private sector (including external) involvement, but would have implications for contractual modes. In such cases, national

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69 McKinsey (2009)

70 N&NE China, Maharashtra (India), Mopit (Mali), Georgetown (Guyana), Hull (UK), S. Florida (USA), Samoa & Tanzania.

71 The reports by McKinsey (2009) and ECAWG (2009) are good examples

governments may prefer to keep tight control through the formation of joint ventures to carry out the work, use of a steering group, participation of public officials or agencies in the work, or frequent and detailed reporting.

Project pipeline

The estimates of adaptation needs, typically at regional or national macro and sector level, have not yet been translated into a project pipeline suitable for financing and implementation in the short/medium term. The World Bank[72] observes:

> "…National Adaptation Programs of Action…identify and cost only urgent and immediate adaptation needs, and countries do not typically incorporate adaptation measures into long-term development plans."

The translation of strategies into bankable projects will be specific to each sub-sector. An example of a decision tool for addressing water scarcity is the *water cost curve,*[73] which develops a sequence of measures/projects to conserve or produce water ranked by their unit cost. This is useful for prioritising different kinds of intervention, prior to carrying out full feasibility studies of the projects themselves. Private consultancies are invaluable for assisting the creation of a project pipeline, including sector prioritising, technical, economic and financial feasibility studies, and impact assessments.

The shortage of funding for project preparation in water infrastructure, identified in the Camdessus Report[74] and elsewhere, has still not been overcome. IFIs should ensure that this early stage of the project cycle is adequately funded. One option is to create vehicles (or "platforms", e.g. the EU-Africa Infrastructure Trust Fund) combining grant and loan funding sources, to help project sponsors to draw on "soft" funds for project preparation.

Capacity constraints

Administrations and professional cadres in many developing countries are not geared up to implement the adaptation and mitigation agenda. In many cases they are actually losing capacity as experienced people retire or leave public service. Another aspect of loss of capacity is that for collecting and analysing data crucial for analysis and investment planning.

There are various ways in which PPs can help to create and sustain crucial administrative and technical capacity, e.g. advisory services, training, secondments, peer-group support, twinning, head-hunting, etc.

Finance

Adaptation and mitigation projects implemented by public agencies can draw on a range of development funds, including new adaptation funds created for this specific purpose. However, much of the adaptation/mitigation effort will fall to private companies, farmers and households, as well as sub-sovereign agencies who cannot tap into such funds. For them, commercial financial sources are critical.

Public agencies have access to specialised CC funds, of which there are currently over 20.[75] Leaving aside those funds specialising in forestry or energy, around a dozen funds are available for adaptation or mitigation for water, amongst other sectors. Particularly relevant is the funding provided by the Pilot Program for Climate Resilience (PPCR), sponsored by the World Bank and other major IFIs, described as:

> "The pilot programs and projects implemented under the PPCR are country-led, build on National Adaptation\programs of Action (NAPAs) and other relevant country studies and strategies. They are strategically aligned with other donor-funded activities to provide financing for projects that will produce experience and knowledge useful to designing scale-up adaptation measures." (www.cif/ppcr.org).

Specifically, funding is available through PPCR for technical assistance to enable developing countries to "integrate climate resilience into national and sectoral development plans".

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[72] Economics of adaptation to climate change, 2010, p. 1
[73] Developed by the 2030 Water Resources Group, an international partnership including the IFC, McKinsey & Co, and seven multinational private companies. See McKinsey (2009).
[74] Winpenny (2003)
[75] www.climatefundsupdate.org/listing.

A recent report on these CC funds has warned of the risk of fragmentation and adding to the administrative burdens on recipients who seek access to them (Porter *et. al.* 2008). Such funds can be useful sources of money for pilot projects (e.g. the PPCR), but at a country level, there is a strong case for "mainstreaming" adaptation as much as possible, rather than consigning it to a marginal part of the public investment programme, requiring its own procedures and criteria.

A different kind of finance is required for adaptation/mitigation carried out by commercial entities (including farmers) or other water users. Microfinance is particularly suitable for improving irrigation efficiency among smallplot farmers. Certain forms of contract can also be funded by *quasi-equity*, in which rewards depend on the successful achievement of project aims, e.g. performance-related contracts for water leakage reduction.

3.3 Supply-side obstacles

The defining characteristic of PPs is that they are market-driven. If the CCS market is sufficiently attractive, with long term potential, supply-side obstacles will be overcome. Meanwhile, certain market barriers should be mentioned:

1. Uncertainty about the worth and sustainability of CC services
2. Risks involved in this kind of business
3. Fears about the security of intellectual property

A new, uncertain & marginal market

Many, perhaps the majority, of major PPCCS would count developing countries as a minor part of their total geographical market. The exceptions would be countries producing oil and certain higher value commodities, and the larger emerging markets, which have proven resilient to the current international recession, and which promise strong growth in the longer term. However, this leaves many poorer countries needing CC adaptation which remain unattractive and uncertain markets, except for projects funded by the international donor community. CCS is a recent phenomenon for many companies. One approach to making CCS a less marginal and uncertain source of business could be to offer *framework contracts* to companies or consortia.

The perception of CCS is also coloured by the fee levels for this kind of business, relative to those which it has been possible (up to recently) to earn in core markets. In some OECD countries consultants[76] have been able to earn much higher rewards in their domestic (or regional) markets than from international work. The latter has been seen as basically unprofitable, but worth doing from adding profile and "halo". On-going currency realignments, and strong market growth in certain regions, may alter this view. For the present, service contracts invoiced in local currencies, without the backing of international agencies, may not elicit sufficient interest from PPCCS in some developing country markets.

These perceptions are likely to change with the growth of the market, supported by major funding from IFIs and other agencies, and as CC becomes "mainstreamed". As noted in section 3.1, CC adaptation and mitigation for infrastructure is a multi-billion dollar business. It is also increasingly likely that CCS will be sourced from new regions of expertise, with more competitive fee levels:

> "Singapore is becoming a global "Hydro Hub" through a dual approach of governmental support and mobilisation of private sector investments, and is establishing a research and development base for environment and water solutions. Singapore aims to increase value-added contribution from the water sector by over 300 percent in less than 12 years, generating roughly 11,000 professional and skilled jobs by 2015."[77]

China, India and Brazil, to name only three emerging countries, are registering striking expansion of their scientific infrastructure, which marks them out as major potential sources of CCS in their own and other regions.[78]

[76] This perspective is from the UK. Service suppliers from other countries may have different views on this issue.

[77] McKinsey (2009) p. 124

[78] "In contrast to China, India and Russia, whose research strengths tend to be in the physical sciences, chemistry and engineering, Brazil stands out in health, life sciences , agriculture and environmental research." *Financial Times*, "Big shift in Bric's scientific landscape". Jan 26, 2010. P. 5

The balance of risk and reward

Routine political, credit and foreign exchange risks should not arise for CCS supplied to international agencies and denominated in a currency of choice, though are matters of concern for other business.

Different forms of contract are appropriate for different CCSs. A one-off payment, possibly in instalments, may be suitable for a discrete task such as a study or design, but for a continuing service such as management, operations or advice over some years a performance-based reward may be more suitable. Rewards for the performance of a specific task can be phased over future periods to allow for the longer-term impact of the service to be fully assessed.

Certain types of contract are inherently risky, particularly *concessions* (in which rewards for services, as well as returns on capital, accrue over a lengthy period depending on the performance of the project) and contracts for operation, technical and management services with a *performance-related* element. Problems arise in such cases where the contractors do not have sufficient control over the performance indicator on which their remuneration is based. The solution must lie in the design of contracts that contain an appropriate and realistic share of risk between contractor and client, while maintaining suitable performance incentives for the contractor.

Security risk

Various parts of the world are becoming less secure for operations involving staff of all kinds, particularly those from outside the region concerned (civil unrest, kidnappings, etc). This raises the risk premium, and ultimately the cost, of such involvement. This risk could be reduced, though not eliminated, by maximising inputs from local firms and affiliates, and consulting local governments at all stages of the work.

Intellectual property fears

Companies are increasingly concerned about protecting their proprietory products, systems, and goodwill against pirating and expropriation, especially in the major emerging markets. Some developing countries are demanding free access to relevant intellectual property as a *quid pro quo* for efforts to mitigate CC. Some adaptation projects entail sophisticated high-tech products and expertise, and it is important for sustainability and capacity building that some transfer of technology and experience takes place. To keep a perspective on this issue, it should be recalled that a number of developing and emerging countries are themselves building up scientific and technical capacity in subjects relevant to CC, and share an interest in the profitable use of their intellectual property.

3.4 Conclusion: developing the market

This section selects the main messages from this chapter about the demand- and supply-side obstacles to PPCCS and outlines some proposals for promoting the market for these services.

1. Development of the *methodology of CC strategy* should continue to be strongly supported by IFIs and others, building on impressive advances achieved so far. Its aim should be to demonstrate the long term convergence of "developmental" and "climate change" criteria as the basis for deriving sufficient *no regret* projects and mainstreaming CC resilience. There is now a need for strategy studies at country and sector level, laying the foundation for a credible project pipeline (see below).

2. Nationally, CC adaptation and mitigation strategies in NAPAs and NAMAs should be translated into *project pipelines* in sufficient detail to appeal to potential funders. The current shortage of funding for project preparation in water infrastructure should be overcome by the use of the new dedicated funds for CC piloting, innovation and scaling up, and by the use of blending loan and grant through the various "platforms" now available. There is a good case for setting up, e.g. as a component of IFI country programmes, national funds for PPCCS in the BRICs and other countries with emerging capacity in CCS.

3. Improve *market information* for CCS to assist both purchasers and suppliers. A separate register of PPCCS could be created (e.g. by the World Bank, coordinating systems of other major IFIs) recognising the diverse ori-

gins of PPs in this topic, and also identifying PPs from developing ocountries. A data base on experience with CCS and the outcomes of CCS projects could be created, with "blog" style inputting from all stakeholders. Providing content for this database could be made a condition of the award of contract.

4. *Contractual forms* appropriate to PPCCS will need to be reviewed. Between international agencies such as IFIs and the PP, greater use of framework contracts could encourage the build up and retention of expertise in the latter. Between PPs and the developing country clients contracts need to stipulate an appropriate and realistic division of risk, as well as reflecting the contractor's performance, where this is feasible. In principle, contracts should provide for capacity building and the transfer of knowledge and experience, while safeguarding the supplier's intellectual property.

5. The strategic and security concerns inherent in CCS are likely to entail more *complex partnerships and contractual relationships*. This applies both to suppliers of CCS, where public-private partnerships, international agencies and civil society bodies are increasingly part of the mix, and to the relationships with client authorities, where local public bodies will necessarily wish to be involved. Such partnerships and relationships between dissimilar entities will place greater importance on having a clear line of responsibility for performance and delivery.

ANNEX 1. DEFINITIONS

Risk Management: Any action or portfolio of actions that aim to reduce the probability and magnitude of unwanted consequences, or manage the consequences of realised risks.

Demand Management: The management of a market or economy by manipulating demand so that it reaches a stable relationship with supply.

Resilience: The ability of a system to recover from the effect of an extreme load that may have caused harm.

Robustness: The ability of a system to continue to perform satisfactorily under load.

Scenario: A coherent, internally consistent and plausible description of a possible future state of the world, usually based on specific assumptions.

Uncertainty: A characteristic of a system or decision where the probabilities that certain states or outcomes have occurred or may occur is not precisely known.

Vulnerability: Refers to the magnitude of harm that would result from a particular hazardous event. (Climate vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes)

[1] Source: Demand Management definition from encarta.msn.com. All other definitions from Willows and Connell. (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report, YUKCIP, Oxford.

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