Living with climate :
Can the water sector lead in building resilient societies ?

Mike Muller
Graduate School of Public and Development Management
Wits University
South Africa

Introduction

At the World Bank's Annual Conference on Development Economics in Tokyo a few weeks ago, Professor Michael Grubb of the UK Carbon Trust complained that scientists and economists are talking past each other about the challenges of climate change.

"To date, this debate on impacts between economists quantifying specific, potentially measurable and monetiseable impacts, and scientists focused on risk indices and scenarios, has been largely a dialogue of the deaf."
Climate change impacts, energy, and development, Professor Michael Grubb,
Annual World Bank Conference on Development Economics, Tokyo, 30 May 2006

And, although we work together all the time, the same could be said about the engagement in the climate discussions of the community of water management practitioners, particularly the engineers who conceive, design, build and operate the infrastructure that sustains our societies but also the other professionals who, together with the engineers, manage our water resources.

While some debate has occurred in the developed world, it is not as well developed in poorer countries despite the efforts of the climate community. This is in part a consequence of the focus which is still primarily on mitigating the effects of climate change rather than adapting to it. It also reflects the nature of the climate change community, which still focuses on its view of the future rather than starting from the perspective of sectoral practitioners.

Yet , it is important to break the mould. As Professor Grubb said, the infrastructure we build today locks us in to patterns of behaviour for many years in the future.

"'Leapfrogging' in infrastructure, by trying to make choices at the leading edge for the long term, is … a huge opportunity in the course of development."

Grubb was talking primarily about energy and development but the point is even more valid in the water sector where, unlike energy, the useful life of infrastructure is often measured in hundreds of years and where investments that are being made today will be operating under the new climates of the next century.

So I will focus on the implications of the current debate about climate variability and change for the water resource sector from the perspective of a practitioner rather than an economist or climatologist and ask what should be done differently? what could be done better? if appropriate information and instruments were available.

To recognise the linkages between different issues and gaps in our understanding and to identify areas in which we would do well to act now to make the future a better place is an obvious priority. But we must go beyond that to address strategies for action and within that , the roles and responsibilities of the different actors and agencies.

So I will also consider some of the policy issues in the climate debate that affect water resource management. And without apology, I will draw most of my examples from Southern and subSaharan Africa more generally, because it is one of the regions where the challenges and threats are greatest and the resources and ability to respond most limited.

Managing variability, reducing vulnerability, building resilience

Managing climate variability is the day to day business of water managers, whether in planning for extremes or optimizing long term resource utilization.

Much of the simplest traditional water infrastructure, the rain water cistern in the rural homestead, the "tank" in the Indian town, enables households and communities to manage the variability of the water resources on which they depend, which in turn, reflects their local climate. The same is true for the simple river training and flood wall structures and flood diversion canals that protect many of the world's towns and cities.

Over time, climate information and assumptions have been embedded more formally in the design of this essential infrastructure, as well as the water distribution and waste collection networks, roads and storm water drains and human settlements more generally.

The most obvious formal mechanisms for addressing the impact of climate's variability on water resources remain those which perform the function of capturing peak river flows when they exceed users' requirements and releasing them at times when low flows are not sufficient to meet their needs. (In this presentation it will become obvious that I speak from a perspective of water scarcity which I should balance by recognizing that, in situations of excess, the considerations are inverted and it is the peak flows that are stored to be released when flows are low, to avoid damage).

Dams also store water as a form of potential energy to generate electricity in peak consumption periods. Other important water works include the canals, tunnels and pipelines that serve not just to supply demand but, less obviously, to create linked systems which, by virtue of multiple sources, suffer less variability and therefore offer enhanced supply security. All these structures reflect formal assumptions about the likely variations in rainfall and streamflow as well as likely storm intensities and maximum flood sizes.

But the armory of the water manager to address variability is not restricted to infrastructural means. As important as storage are the institutional mechanisms that, again more or less formally, help to deal with climate variability and to achieve goals such as water supply for people, industries and farms, to protect communities from flooding while sustaining ecosystems.

An obvious example are rules on water allocation that prioritise different uses of water, at different times. As in many countries, South African water law had categories such as "winter water" and "surplus flow". From this perspective, drought restrictions in countries like Australia or the UK should not be seen as supply failures but rather as institutional mechanisms to manage variability by prioritizing different uses during times of supply stress.

Beyond direct water management, instruments such as land use planning can make a substantial difference to the vulnerability of societies to water based natural disasters. And this, it should be understood, is the reason that water managers seek to manage variability for the flip side of vulnerability is resilience. Resilient societies, which are less vulnerable to sudden shocks climatic or otherwise, are more likely to be sustainable in the long term.

The example of land use planning demonstrates that resilience can be achieved by building infrastructure such as flood walls, designed to manage variability or societies can be designed to be resilient by planning, for instance by not building settlements in vulnerable areas. And alternative approaches to building resilience can be taken further; resilience to drought can often best and most cost effectively be achieved by storing food and money rather than storing water.

Recognition that there are multiple pathways to resilience has seen the emergence of the philosophy and methodology of Integrated Water Resources Management (IWRM), which encourages the engagement of communities and sectors impacted upon by water into its management. Their involvement ensures both that optimal (indirect) mechanisms are recognized but also, more important, that understanding of water constraints and challenges is diffused into the society.

And the importance of an IWRM approach to the achievement of sustainable development was emphasised by world leaders at the 2002 World Summit on Sustainable Development where the leaders agreed that all countries should establish water management plans by 2005 (a target that has proved to be aspirational and motivational rather than practical but no less important for that).

Variability : the development context and constraints

It would seem obvious that the threat of climate change should see societies paying greater attention to building their capacity to manage the impacts of climate variability on water resources. This is not (yet) to say that that specific action is required by water managers to address climate change, although the case is strong. But just the uncertainty would suggest that more explicit attention needs to be given to mechanisms that help to manage variability; from there it is a small step to recognise that the bounds of that variability may be changing.

Is this happening ? The answer is not straightforward. Precisely because water resources management is already about dealing with variability, some practitioners in the better resourced countries believe that business as usual will be good enough; that given the relatively slow onset of climate change, its impacts can be managed adequately using current approaches.

Meanwhile, many of the poorer countries are not even able to manage their current variability, not because the overall strategies needed are unclear but because the means to implement them are lacking. They may reasonably ask why they should address tomorrow's climate change if they cannot afford to manage today's drought?

The challenges of agriculture in sub-Saharan Africa illustrate the point. More storage, properly placed, could help many agricultural communities to manage their rainfall variability better than they do presently. The problem is the cost. And often it is the poorer countries, which face the greatest variability, that have the most limited storage capacities –indeed, there are sound reasons to suggest that climate variability and its economic impact prevent many of them from escaping their poverty traps. The maps certainly show an association between the incidence of under-nutrition and the absence of irrigation while the economists show graphically the link between rainfall and GDP.

But for communities to take advantage of the resilience that increased storage can offer, there must be production systems, with the infrastructure to support them, that allow stored water to be used. In many cases, these are not in place either. This is certainly the situation in much of sub-Saharan Africa where rainfall variability is high but the extent of irrigation is extremely small.

According to the FAO, only about 10% of agricultural production in sub-Saharan Africa came from irrigated land; in Africa as a whole, only 8.5% of cultivated land was irrigated. According to the World Water Development Report, in sub-Saharan Africa only 15% of irrigation potential was being used at the turn of the century, expected to grow to 20% by 2030.

In this context, sequencing is important and the sense that climate change is not the big issue is understandable – it is just one more reason to do something that has already been identified as a priority. And indeed the promotion of irrigated agriculture has been prioritized by both NEPAD (from the African side) and the World Bank (from the donors side).

NEPAD's Comprehensive Africa Agriculture Development Programme has the ambitious aim of doubling sub-Saharan Africa's 12.6 million ha under irrigation in 1998 by 2015 –the "business as usual" rate of progress would see only 2 million additional hectares by then. The programme foresees a combination of small- and large-scale schemes as well as the rehabilitation of major schemes where some areas have fallen into disuse.

There are similar challenges for urban communities and industry. In developing countries generally and sub Saharan Africa in particular, both are growing and will need more water. The nature of urban living and modern industry requires those sources to be reliable in the short term and assured over longer time periods.

At first sight, Africa's challenge is not so great. 255 of the 295 million urban residents in Africa already have "improved" water supplies. Assuming that the volumes consumed remain the same, it would need only a manageable 15% increase in supplies to reach 100%. However predicted urban growth of at least 50% to 2015 will see an additional 150 million people moving to urban areas, requiring a 60% increase.

The challenge – and the opportunity – is whether these needs can be met in a manner that "leapfrogs" the current approaches and puts the countries in a situation that allows them not just to meet these new needs but to do so in a manner that leaves them more resilient to the potential impact of climate change.

How can this be done ? Investing in more efficient irrigation rather than more storage is one obvious example. Designing cities with denser housing rather than larger gardens will reduce water use although domestic food security may suffer.

But whatever strategy is chosen, substantial investments will be required and happily, there are indications that these will be forthcoming. Indeed, investment for Africa will again have been on the agenda at the G8 meeting just across the Baltic. The question for this conference is what impact climate change could have on the costs of achieving Africa's goals and those of other poor countries?

The challenges of climate change for water resource management

In the water sector, the answer is straightforward - we don't really know. The general picture of global warming is reasonably clear and agreement about its regional dynamics and scale may be growing. However, from there to reliable predictions of rainfall is already a big leap. I will not venture into the science of rainfall predictions under new climate scenarios, save to say that my understanding of the current consensus is that they should be considered to be indicative rather than definitive. More important, they are at this stage relatively general and of limited use save perhaps for indicating the type of strategic challenges that may arise.

Similar caveats apply to the other key dimension of climate variability that impacts on water resources and their management, namely the suggestion that there may be more extreme weather: more powerful storms and longer, more intense droughts. This would again be consistent with the energy implications of global warming and are important for water managers for whom extremes are bread and butter.

Will these variations be significant in the context of the extensive natural variability that we already have to manage? The typical design parameter for a water supply project is to ensure reliable supply for a given probability, anything from three in five years (60% reliability) for annual crop agriculture to 99 in 100 years (99% reliability);

similar considerations apply to flood protection although, when we design a bridge, we are loath to consider a major failure more often than once in a 1000 years and for a dam spillway, the one in 10 000 year event is considered.

It should thus be clear that anything that extends the tails of our distributions of extreme events will impact on how we manage risk and uncertainty in the water sector. But whether we are yet in a position to make strong predictions rather than indicative suggestions is something that the climate community needs to assist us on.

And these are still the easy questions. Turning to the more difficult ones, how much useful information can the climate community give today to water resource managers as they go about their work? Can you tell them enough about how climate change may (or may not) impact on water resources to lead them to do things differently?

The immediate practical challenge is to go beyond predictions of change in rainfall to understand how these will impact on water availability. Specifically, we need better to predict average stream flows (to determine water availability and storage requirements) as well as extreme flows (to design infrastructure to withstand them).

The effect of climate change on available water (as opposed to rainfall) is far less certain because a number of effects combine. Crudely:-

- If it is hotter, there will be more evaporation from the soil and plants and less water will flow into rivers or seep into the aquifers underground

but

- If rainfall is more intense, a larger proportion of water will flow off the ground as floods or infiltrate through the soil into the deeper groundwater

Changes in CO2 concentrations, temperature and rainfall will impact on plant cover and land use which will, in turn, substantially affect the behaviour of water when it falls as rain. And there are still more anthropogenic impacts to be considered - changes in land use (cropping systems, for instance) will also impact on the availability of water and add a further layer of complexity to the uncertainty about the “natural” processes.

So the idea that we can predict stream flows under climate change scenarios is ambitious (although SA is quite advanced in this).

In all this, uncertainty is the one constant. So we need to emphasise two messages:

First, that changes in temperature and rainfall will usually be amplified in the response of water resource systems;

Second, that as we try to derive water resources predictions from climate forecasts, the uncertainty grows as we extrapolate from the climate models to the temperature predictions, from there to rainfall predictions and finally, the last big step, to predictions of what is really important in water resource management : the streamflow consequences.

Only if we make progress in this area can we move from the current situation in which we use design procedures based on past data rather than future forecasts.

Two practical examples illustrate the implications:-

- calculation of the likely yield of a dam
- establishment of a framework for the allocation of water between users

In order to determine the likely yield of a dam, the traditional approach is either

- to use a historic record of the flows in relevant streams and rivers to determine how much water can reliably be made available or
- To use rainfall and runoff data from a similar area and "synthesise" a record.

In both cases, parameters derived from historic information will be used to generate a series of predictions of possible streamflow sequences against which the performance of the structure will be evaluated. The details of these approaches are not important for the purposes of this presentation save to say that both are dependent on local or related records of streamflow and rainfall and, as important, the ability to use the data and translate it into useful information.

In a few years, South Africa will have to decide on the source of the next major increment of supply to its industrial heartland. There are two main options:

The first is to expand the existing Lesotho Highlands Water Project, taking more water from the Orange river system which rises in the mountains of Lesotho and flows to the Atlantic Ocean on the border with Namibia.

The second is to capture water from the other side of the divide, from the Thukela and other shorter, smaller rivers that flow to the Indian Ocean on the East Coast.

Either way, this will be an expensive project, costing a couple of billion dollars and will take up to a decade to plan and build, so decisions cannot lightly be taken. The comparative costs of the alternatives are not dissimilar; detailed cost comparison is also dangerous given the fragility of the underlying hydrology since a 5% difference in unit costs may be meaningless if the level of reliability of the hydrological forecasts is greater than that.

There are operating cost differences since the one solution would require less pumping than the other. And there are political dimensions too, since the existing Treaty between Lesotho and South Africa provides for further phasing of existing transfers and a further phase would bring a substantial cash injection to Lesotho.

What information can climate science add to help in making this decision? It is currently suggested that, for South Africa, in terms of rainfall:

- the West and south western parts will get drier
- the east of the country will stay the same and may even get wetter.

In this case, climate predictions would suggest that it might be less risky to opt for an eastern river source which is predicted to be less affected by climate change (less risky) and would have the advantage of maintaining a balance between different sources – a more resilient system.

But how much weight should be given to these criteria ? Will firmer numbers be available when the decisions have to be made and known differences – in, say, project cost – traded off against what are presently far less precise climate parameters?

A less obvious example is the challenge of establishing a framework to allocate water between users. Traditionally, available water resources would be identified and allocations quantified and made. What happens if the amount of water available is less than provided for ?

South Africa has recently completed a national water resource strategy that seeks to reconcile supply and demand up to 2025. Our available physical and financial resources should keep us ahead. There are already catchments which depend on imported water. Communities where that cost cannot be supported are already having to choose between different uses and to use what they have more efficiently to make way for new water-use activities. If our institutions are up to the challenge, new laws on water allocation will allow allocations to change to reflect changing conditions.

This illustrates the challenge – the law must be drafted to recognise that a robust water allocation system does not provide fixed and predictable allocations but rather applies fixed and predictable rules to make allocations. So basic human needs take precedence over annual crops and golf courses, for instance. This should be able to accommodate seasonal variability as well as longer term trends.

But the kinds of long term changes that are predicted will increase pressure on stressed areas. Investments to increase water availability will have to be accelerated. We can cope if we have to, although it will be painful. But there are limits. If long term availability falls to 20% or 30% below current long term averages, which is entirely within the bounds of current predictions, the predictability of the rules becomes less useful as certain users will find themselves squeezed right out of the system. Once perennial crops, citrus orchards or vineyards for instance, are deprived of water for a season, it may take six years before they can be brought back into production – if ever.

It is examples like these that explain why, given the challenges of managing today's variability, many practitioners argue that climate change is a secondary priority for water managers in developing countries. Yet the logic remains: water investments should be designed to perform under future climate regimes. The present challenge is thus to improve our descriptions of those possible regimes by reducing the uncertainties that multiply at each step of the hydrological cycle, from temperature predictions to estimates of rainfall, evaporation, infiltration and runoff. If we can predict them, we can manage them.

And we should remember why we are doing this. If the rainfall changes are within the range that is currently predicted, if the forecast increased variability and event intensity actually occur, this will impose substantial costs on poor countries. Perhaps an indication of the magnitude of those costs would help to focus efforts on addressing them.

Adaptation to climate change : the added burden of water resource costs

There is no clear boundary between managing "normal" climatic variability and managing the impacts of climate change. What proportion of a dam helps to manage "normal" variability and what proportion the variability "created" by climate change? This is not a trivial question since, if we accept that climate change is driven by the activities of richer countries, and we are guided by the "polluter pays" principle, there could be a substantial financial liability at the end of that particular rainbow.

Bouwer and Aerts in their paper on Financing Climate Change Adaptation, have recently reviewed the challenges of funding the costs of adapting to climate change. Specifically, they asked whether the costs should be funded through the 1992 UNFCCC (Framework Convention on Climate Change) or through other channels and conclude that a twin track approach would be appropriate.

The present approach of the UNFCCC, which tends to separate climate adaptation from the "normal" development and management activities has been questioned. The result, say Bouwer and Aerts, is that "most of the proposed funding is limited to capacity building (such as joint research and knowledge exchange) and does not include the provision of funds for the implementation of adaptation."

I have made some preliminary order of magnitude estimates of the additional costs that may be imposed in sub-Saharan Africa, a useful exercise if only to identify some of the underlying issues. For a start, it is necessary to distinguish between the cost of adapting today's activities from the more serious burden that climate change might place on future development.

The first focus is on the cities where changes in rainfall patterns and streamflow will have a direct impact. Some of the effects are very obvious

- Water supply is costly and, if availability of water is reduced by climate change, larger conurbations will have to change their consumption patterns or go further afield to meet their water needs

- any climate change that brings increased intensity of rainfall and therefore flooding will increase the cost of roads and stormwater drainage.

- Standards for wastewater treatment typically depends on the extent to which effluents can be diluted when they are discharged, so if streamflows are reduced, treatment must be intensified. Since treatment costs increase exponentially with the degree of purification required, this will substantially increase costs (and wastewater collection and treatment is the already most costly element of infrastructure required to meet MDGs for health, water and environmental protection.)

But there are also less direct effects

- Floods impact on the quantum of land available for settlement as well as the cost of protecting vulnerable land from flooding (and this presentation will not address the challenge of sea-level rise).

- Bringing water from further afield not only increases the cost of water but also the the area affected by competition with cities for water. This will have economic impacts on the cities themselves, whether through higher prices for rural products or the aggravation of rural unemployment leading to urban migration.

Cities, as engineered environments can be designed to accommodate climate change – but at what cost ? As a first crude estimation of the direct cost implications, we can say that

- if everything else is equal, the reliable yield from dams may reduce at the same rate as stream flow. Since the storage costs of water are determined by the yield of those dams – for 30% less yield, the unit cost of water goes up by over 40%;

- where we dispose of waste into a stream, we determine a limit on the acceptable concentration of the pollutant in that stream. If there is less water, we can dump less waste. If the streamflow is reduced by 50%, the concentration of the discharged waste must be reduced by 50%. The overall cost of waste water treatment may then more than double.

Just to give an order of magnitude, very crude estimates of the costs of adapting *existing* urban water infrastructure in Africa are

Water storage	US$500 – US$1500 million
Waste water treatment	US$100 - US$200 million *annually*

Outside South Africa, many cities are heavily dependent on hydropower for their electricity. It is estimated that the additional costs that may be imposed on these existing users by a reduction in stream flows could be between US$900 and US$2300 million *annually.*

These costs are high but remain fundable, given current ODA flows to SSA and promises that they will doubled over the next few years. But the further bad news is that the costs of new development are also likely to be at least 10 – 20% higher than they would have been in a pre-climate change scenario. This implies that a substantial proportion of increased ODA will simply go to maintaining the status quo.

Costs of irrigation related impacts in SSA

The impact of climate change on the cost of future irrigation developments can be estimated using similar methodologies. Thus, taking the NEPAD/FAO proposals for an expansion of irrigation in SSA, assuming that

- storage costs will be increased by 20% (although additional costs could also be incurred in more efficient reticulation infrastructure to reduce total demand),

- that transmission costs may increase 10% (due to extra distances from source to site),

the additional costs will be approximately US$4.2 billion of an estimated US$37 billion investment programme

As in the urban case, these additional costs can be met. They do however demonstrate the potential impact of climate change on water resource management in developing countries – it adds to their cost of doing business and potentially impacts on their ability to compete in an increasingly globalised agricultural market.

There are many other costs that will be imposed by new climate extremes, in the construction of roads and storm drainage, setting aside land threatened by floods. The costs of these and other indirect effects is less easy to quantify, particularly the effect of rural economic impacts on cities. However, urban migration is a management challenge for all South African cities. And a decline in rural production will certainly have second order impacts on city economies.

Finally, the issue of flooding highlights the fact that climate change may not always be negative. Thus the availability of land for urban settlement may be positively affected by any reduction in rainfall – the periphery of Cape Town may provide examples. However, if the frequency and intensity of extreme storms rises, these will counter any possible expansion of habitable area. All these effects bear quantification as we seek to deal not just with current variability but with changes in its nature.

Paradoxically, the economies of rich countries may even benefit from extreme events, this is unlikely to be the case in poor ones. The performance of the Mozambican economy after the floods of 2000 showed that, contrary to the belief that aid compensated for much of the disaster's impact, it set back development efforts by some years.

A final practical challenge

A first practical challenge is to provide the climate and hydrological information needed to design new water management infrastructure. A natural consequence of the drought in water investments over the past few decades is that less priority has been attached to collecting and processing the hydrological data that is used to support them. There has been a marked decline in hydrological networks over recent years, exacerbated perhaps by the fact that remote systems have made such powerful contributions in other dimensions of observation, reducing dependence on terrestrial networks. Hydrological observation has yet to benefit.

Many poorer countries thus have limited information to support the planning, development and management of water. This situation cannot be reversed overnight since, to be most useful, hydrology requires long, relatively complete records. We need to emphasise the importance of this information; otherwise, when the investment tide turns, we will not be available to guide the new funding flows.

This is surely an area in which we should be aiming to "leapfrog" into the future, by developing and applying new technologies. But, while remote monitoring of stream flow is creeping onto the global climate agenda, it is difficult to detect any great urgency about the matter, perhaps a reflection that the promised investments have yet to create the demand.

Conclusion – can water resource management be a lead sector in adaptation ?

Over the past decade, energy has rightly and necessarily taken centre stage in the climate change debates with their focus on mitigation. The stakes are high; climate policy affects the very structure of the world's energy and industrial economies which is why they are focusing on it, again, across the Baltic.

But while mitigation has correctly been the primary focus, because prevention is always better than cure, attention will have to turn to adaptation as yesterday's predictions become today's realities. And, in the process of adaptation, water rather than energy could become a lead sector.

The needs are great and there are quick wins to be had and opportunities to leapfrog into the future. The stakes are high but, as illustrated by the costings presented, not nearly as high as those required to meet the energy challenges.

For these reasons, water resource management may provide practical opportunities, at a realistic scale, to begin to make progress towards the goals of adaptation while the debates about the restructuring of the world energy and industrial technology platform continue. And it is good development sense to make poor communities, countries and continents more resilient, another reason why it should be an early focus for adaptation efforts.

Building resilience into water management systems will be critical if Millennium Development Goals are to be achieved by 2015. Climate change may well impose additional costs, both to "retrofit" existing infrastructure and to build climate compliant new infrastructure. But the earlier we start, the easier it should be to accommodate adaptation into "normal" development.

In a world where rules were just and fair, a substantial proportion of the incremental costs would be supported by those whose actions have imposed them, in terms of the "polluter pays" principle. Conventional public finance approaches, if applied globally, would invest in adaptation now to avoid later crisis spending.

Effective action has not yet begun but the opportunities are there for the taking. And we should count our blessings. Climate change is a slow onset disaster that is giving us time to adapt. In this, the water cycle offers its own natural learning opportunities; it can be a patient teacher, if we are willing to learn.