Assessing poverty implications of climate change: impacts on water ecosystems

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1. Executive Summary

Climate change poses serious threats to achieving global targets to reduce poverty. The implications for the poor are of particular concern due to their vulnerability from heightened exposure to increased climate variability and extreme events. Too much or too little water has dramatic and enduring impacts on the poor from immediate and lifecycle impacts of drought or flood to shifts in rainfall patterns. A conceptual framework of the linkages between drivers of environmental change, water ecosystems and poverty is illustrated to assist identification of research gaps and emerging priorities from the recent literature. Seven priority areas emerge, including: water rights, strengthening adaptive capacity, water for food, managing water ecosystems, ecosystems as water infrastructure, investing in water, and water and growth. Three key messages appear of note. First, more coherent policy is required to harness the potential of water as a unifying approach for development, growth and ecosystem integrity. Second, there is a pressing need for sound analysis of what actually works for objective and accountable development policy that responsibly meets the needs of the poor and threatened ecosystems. Third, climate change may offer an unexpected political window for change and renewal across sectors, such as health, education, agriculture, energy, markets and technology. Three themes with associated sub-themes are identified to inform a new research agenda on reducing poverty from climate change impacts on freshwater ecosystems: 1) Strengthening adaptive capacity; 2) Building bridges to the poor; and, 3) Managing water ecosystems.

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2. Introduction

Climate change poses serious threats to achieving global targets to reduce poverty. Global warming impacts on freshwater ecosystems are central to these concerns as water availability will be reduced or disrupted leading to greater physical water stress and human suffering from reduced and unpredictable access to water for welfare, well-being and food needs. The global community is responding by making halting steps to understand the complex pathways, economic costs and distributional impacts of climate change (IPCC, 2007; Stern, 2006). The implications for the poor are of particular concern due to their vulnerability from heightened exposure to increased climate variability and extreme events. Too much or too little water has dramatic and enduring impacts on the poor from immediate and lifecycle impacts of drought or flood to shifts in rainfall patterns. The vulnerability of the poor is largely explained by a more direct and dependent relationship with the environment, their lack of capacity to adapt to or cope with change, and insufficient capacity of institutions and infrastructure to buffer climatic shocks. Recent assessments are gloomy about the prospect to achieving the water-related Millennium Development Goals, particularly in sub-Saharan Africa, but opportunities do exist to counter the impacts of climate change and strengthen the capacity of the poor (UNDP, 2006; WWF, 2005; DFID, 2006a; World Bank, 2006; UNESCO, 2006).

This paper attempts to identify trends, gaps and priorities, which have emerged from the most recent thinking, evidence and analysis in the literature. The review neither claims nor attempts to garner every insight from every source[1]. Instead, it aims to provide a concise summary of the main themes and knowledge gaps within which new research could meaningfully contribute to the challenges faced in Africa and Asia. It should be read in conjunction with two complementary reviews on climate change and freshwater ecosystems (Mayers, 2007) and water governance (Batchelor, 2007). Section 2 discusses the concept of water and poverty, provides a conceptual framework for water ecosystems and poverty relationships, and briefly identifies how climate change will impact on ecosystems and people. Section 3 highlights seven of the key research issues and priority challenges emerging from the literature. Section 4 identifies research priorities and key knowledge gaps from the literature to help inform a future research agenda.

3. Water and poverty

Box 1. Water access
Secure water access depends upon proximity (distance), affordability (price), availability (quantity) and acceptability (quality). UNDP (2006) argues for 50 lcd at less than 1 km from the home, of potable quality and at cost no more than 3% of household income. The Government of the Republic of South Africa (RSA) has guaranteed a Free Basic Water Provision of up to 6,000 litres per household per month for each and every citizen (RSA, 1998). Often there are difficulties with water access proxies. For example, seasonal variations in sources often limit or confuse proximity comparisons. Cairncross (2003) suggests if a round-trip to collect water is greater than ½ hour, people typically carry insufficient water for basic needs. Acceptability is another elusive concept in practice not least because hygiene awareness and education are so important. Such issues plague objective understanding of progress in meeting and understanding impacts of improved

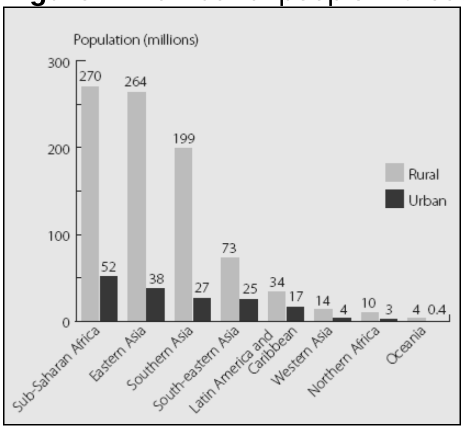
3.1 What is water poverty?

Poverty is multi-dimensional state of deprivation, of which lack of access to adequate water of safe quality is a key characteristic. It is widely agreed that increased access to improved water for the 1.1 billion people, who do not have access to improved water to meet basic needs, is a global humanitarian and developmental priority (Box 1). However, progress to meet global targets has been stymied by institutional, financial and socio-demographic factors. For example, between 1990

[1] Sanitation and hygiene education are not directly addressed in this paper, though its important interactions with water and health are acknowledged in various sections.

and 2004 1.1 billion people gained access to improved water but, due to population growth, this translated into an absolute gain of 118 million people (WHO, 2004). Inequalities to improved water access are illustrated not only by the exclusion of the income poor to water but also by a growing urban-rural divide as 84% of the water insecure living in rural areas while 85% of spending is on urban areas (Figure 1) (IDC, 2007; WHO, 2006). Geographical inequalities highlight that sub-Saharan Africa lags far behind the rest of the world as 23% more people do not have improved water access in 2004 than in 1990. There is also the enduring problem of gender inequality as women and girls bear the brunt of water poverty as it is they who commonly fetch water in often harsh physical and dangerous environments with immediate health costs and future opportunities spurned as their education deficit constrains their own and society's development progress. As such, improved access to water can act as an important catalyst in building the capabilities and choices of people, particularly for women and children, who may otherwise be constrained by ill-health, hunger or income poverty, which in turn can spur sustainable development in society at large.

Figure 1. Number of people without improved water access in 2004 (source: WHO, 2006)

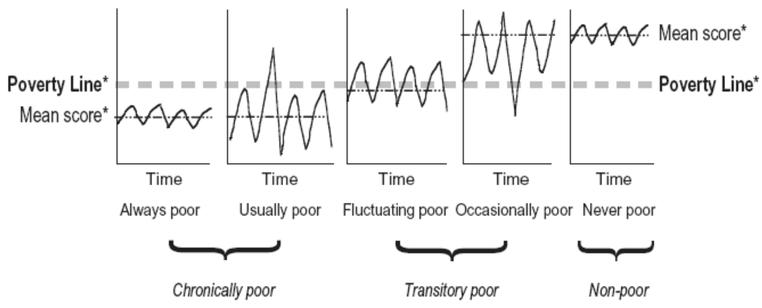


Linkages between water and health suggest that improved access could reduce the human toll from lack of water and sanitation, which claims an estimated 1.8 million lives of children under five every year (WHO, 2006). The association between unclean water and sickness is strong (UNDP, 2006) but causal pathways are more complex as national census analysis from India highlight that without improvements in parental education and hygiene practices the impact of access to improved water access may by-pass the poor (Jalan and Ravallion, 2003). Imputed gains from reduced water collection times for women and girls in income, education, dignity and equity terms clearly offer significant development benefits. Yet, simple arithmetic disguises the complexity of water poverty. For example, a global aggregate estimate of benefits from improved water and sanitation access indicates that convenience savings dominate economic calculations so that "the real economic benefits accruing to the population may not be financial in nature, nor will they be immediate (Hutton and Haller, 2004: 39). It is thus not clear if more water will reduce poverty, in a wider sense, unless complementary initiatives in health, education, infrastructure and employment are not also in place. This point is important as the calls to increase investment in water to US$15-20 billion per year to provide a higher level of service whilst maintaining existing services (Section 3.6) may be unsuccessful unless a coherent and iterative sequencing of interventions is successfully introduced. History provides many lessons of how well-meaning water initiatives fell short due to the scale and complexity of providing sustainable water access (Therkildsen, 1988; Thompson et al., 2001).

Water poverty is not limited to access to water for basic needs alone. Improved access to productive uses of water is also a key determinant in lifting the poor out of poverty. Water availability introduces the temporal and spatial dimensions of water poverty. For example, a person can remain permanently below a stylised poverty line and be 'chronically poor' (Figure 2). Alternatively, she can be 'transitorily poor' and step out of poverty following a good harvest or reduced disease burden but fall back into poverty the following year. The transitorily poor may cause additional development policy concern to the enduring problems of 'chronic poverty' as this group may have increased exposure climate change. Evidence from Ethiopia following the mid-

1980s drought revealed how the terms of trade between livestock and food collapsed pulling thousands of the ‘transitorily poor’ into destitution, forcing migration and social dislocation and famine; women bore the brunt of impacts, with many people still having failed to recover asset levels a decade later (Dercon, 2002). Covariance between assets and income when there are significant and widespread climate shocks reduces the ability of rural communities and individuals to manage risk before the event or cope effectively after the impact. With few livelihood options, the poor adopt a range of low-risk, low-return activities or informal insurance networks that may reduce their risk from minor perturbations but leaves them exposed for the next major climate event (Dercon, 2004).

Figure 2. Temporal dimensions of poverty (source: CPRC, 2004)



*Depending on data availability, poverty could be assessed in terms of household expenditure, income, consumption, a poverty index or scale, nutritional status, or an assessment of assets.

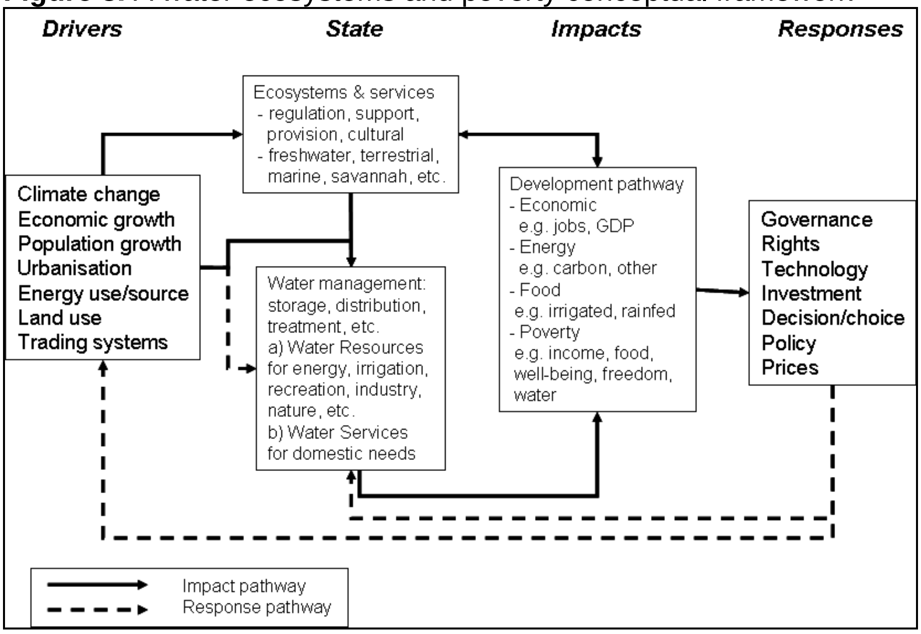
Agriculture lies at the fault-line of water resources, poverty and ecosystem sustainability debates as increasing water variability from climate change with growing water competition has put allocations to agriculture under greater scrutiny than ever before (Molden, 2007). With 70% of freshwater withdrawals allocated to agriculture and food production systems, improved productivity and equity in water access is pivotal to meeting the world’s growing food demands whilst protecting ecosystems globally (MA, 2005). The escalating nature of the challenge inevitably requires trade-offs to be made and difficult decisions to be negotiated; to date, freshwater ecosystems have been the loser as society has failed to understand or protect their vital role in providing, regulating and provisioning a myriad water goods and services to society (MA, 2005). Reducing distributional inequalities in food access is equally important as some 850 million people suffer a food deficit globally. Opportunities do exist for sustainable agriculture but significant re-thinking and re-casting of the relationship between water, development and nature is urgently needed (Section 3.3).

Measuring the complexity of water poverty is thus a complex task due to the multiple pathways and dynamic interactions indicated above and illustrated in the thematic areas below. Given the increased challenges posed by climate change and billions of US dollars called for to finance water-related development targets (Camdessus, 2003; Troubkiss, 2006), objective and rigorous measurement of progress, impacts on the poor is essential (Baker, 2000). An expanding literature illustrates the emergence of indicators and composite indexes to guide policy, compare situations and measure performance on water poverty (Sullivan, 2002) and, more recently, on water vulnerability under climate change (Sullivan and Meigh, 2005). However, there are significant methodological and data difficulties in combining multidimensional components of water access and availability, which can result in unsatisfactory associations emerging at different scales (Molle and Molinga, 2003). Indicators do provide useful information for water decision-making but their role and effectiveness must be balanced by their inherent reductionism, often under incomplete information, and dangers of political (de-)legitimisation in uncritical shifts from measuring what we value to valuing what we measure (Hoon et al., 1997)

3.2 A water ecosystems and poverty conceptual framework

Given the complexity in water and poverty relationships, a Drivers-State-Impacts-Response (DSIR) framework provides a conceptual understanding of some of the linkages between drivers of change, water ecosystems and poverty (Figure 3). The framework illustrates the role of change in water ecosystems and how this has direct impacts on development pathways, including water poverty, and a range of responses available to society. Drivers of change on water ecosystems include climate change, economic growth, population growth, urbanisation, energy use, land use change or trading systems. Drivers can work independently or in combination to alter the state of water ecosystems. Combined drivers might occur when economic growth leads to higher incomes, increased energy demands, urbanisation and changes in dietary requirements, e.g. from low-water use (e.g. cereals) to high water use (e.g. dairy, meat). The state of water ecosystems will have water management implications in terms of water availability for allocation for domestic, industrial, agricultural or energy uses. The timing, allocation and access to water have implications for development pathways across economic, energy, food systems and poverty sectors. In turn, these sectors may have direct impacts on water ecosystems in terms of abstraction, pollution or system modification (e.g. draining wetlands). Society has an array of responses at its disposal to alter drivers of change, subject to its political, economic, institutional and environmental situation. Responses available to global, national or local actors and institutions to mitigate, adapt or cope with climate-related changes to water ecosystems include improvements in governance, rights-based approaches, technological innovations, investment allocations, individual or collective decision-making, policy shifts or economic instruments, such as water pricing. The framework is illustrative of the complexity of the dynamic and multiple interactions. It implicitly rejects any linear or simplified articulation of water poverty as we will explore in the thematic areas below.

Figure 3. A water ecosystems and poverty conceptual framework



3.3 Implications of climate change

PCC (2007) reports on the current scientific understanding of impacts of climate change on natural and managed ecosystem, and the vulnerability and capacity of social systems to adapt to predicted climate change (Figure 4). The overall message is that the resilience of many ecosystems will be exceeded this century, with increases in frequency of flood and drought events. Poor communities are considered to be particularly vulnerable in high risk regions, such as the tropics and coastal zones. This is because poor people have limited adaptive capacities and are vulnerable to changes in climate-sensitive resources, such as local water and food supplies[2]. In Africa, which largely depends on rain-fed agriculture, there will be decreases in the area suitable for agriculture, the length of the growing seasons and yield potential, particularly along the margins of semi-arid and arid areas. An estimated 600,000 km^2 of arable land could be lost in Africa with between 75 million and 250 million of the 800 million people sub-Saharan Africa facing physical water scarcity. Rising sea levels poses threats to Gambia around to the Gulf of Guinea (Figure 5). A predicted band of dessication will wrap around the Congo Basin from the Gambia to Angola, as a massive area and millions of people face increased livelihood risk (Figure 5). In Asia, there are an expanded set of challenges, including increased flooding due to glacier retreat in the Himalayas, which will result in decreased dry-season river flows over the next 20-30 years resulting in significant implications for the tens of millions of people living in the Indo-Gangetic plains and depending on the seasonal flow of waters.

Figure 4. Climate change impacts on ecosystems (source: IPCC, 2007)

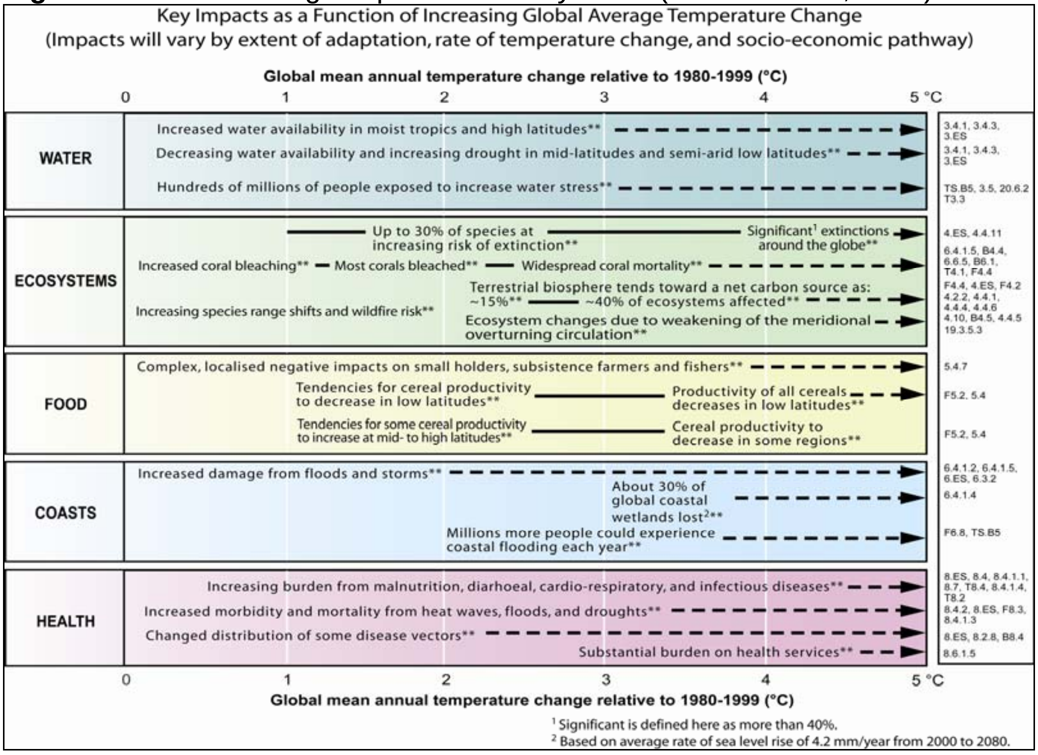
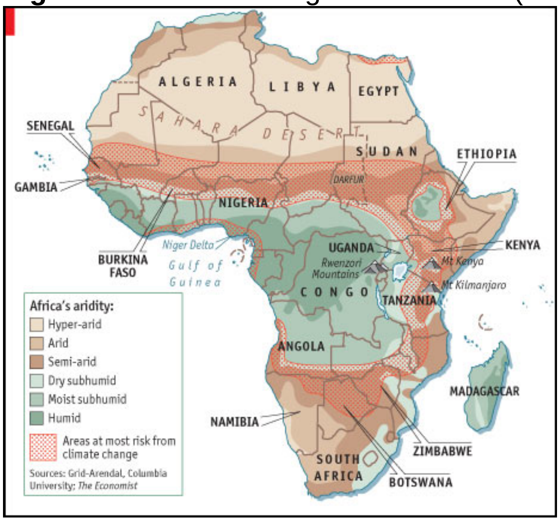


Figure 5. Climate change risk in Africa (source: The Economist, 2007)



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[2] This does not discount the real problems faced by the non-poor, who face equal, and ,in some instances, greater problems adapting to change.

4. State of knowledge by thematic areas

The following seven sections attempt to provide a brief review of the some of the key research issues and priority challenges emerging from the literature.

4.1 Water rights

In 2002, the United Nations recognised water as a human right in a legally non-binding normative framework, which has been supported by DFID and other bilateral donors (UNDP, 2006; DFID, 2006b). The right to water provides a tool for citizens, excluded water access on income, ethnic, location or religious grounds, to increase access by making governments accountable (WaterAid, 2006). Water as a human right emerges as a unifying principle in the literature to empower and mobilize poor people to claim a basic needs requirement for life and well-being (UNDP, 2006; IDC, 2007; DFID, 2006b; UN, 2002). The moral case is complemented by economic and political arguments to foster national prosperity and stability. Benefits of improved water access accrue in terms of productivity, education, health, dignity and social equality and, over time, as lifecycle barriers to development from sickness, lack of education and income poverty are diminished, releasing the next generation of poor from a legacy of deprivation. What is less clear is how such desirable outcomes can be achieved effectively and sustainably given past water policy failures (Thompson et al., 2001; Biswas, 2003). Fore example, will making water a 'right' tip the balance in the favour of the poor or paralyse embattled governments and service providers? Anand's (2006) analysis of changes in water (and sanitation) access between 1990 and 2004 suggests legacy matters along with an uncertain combination of growth and social sector spending. The case of Tanzania is also instructive as a litany of re-written water policy between 1968 and 2000 has been insufficient to deliver sustainable water access (Therkilsden, 1988; Thompson et al., 2001).

A rights-based approach explicitly puts people at the centre of development in terms of transparency, accountability and choice. It calls for an inversion of the water planning process (Camdessus, 2003; UNDP, 2006) and acknowledges that prescribed water technology solutions to meet coverage targets and investment goals are not sufficient conditions for sustainable water delivery unless interventions respond to the needs of people's water use needs (Thompson et al., 2001; Hope, 2006a). The current gap between water policy and practice often results in water decision-making processes that are disjointed with failures to 'close the circle' between policy responsibility and effective action that results in an accountability gap to the poor (WaterAid, 2006). As Thompson and colleagues (2001: 103) note: "classifying a good or service as a 'basic need' does not imply that there need be state provision of a homogeneous good to all households. The good itself is merely an instrument through which the basic need is met. Rather than providing the good, the state can be guarantor of its provision." This commentary elegantly captures the kernel of rights-based arguments and illustrates useful pathways for public policy articulation.

It is unclear of the conditions under which water as a human right can work as a catalyst to reduce poverty. There remains the unanswered question of whether water as a human right will strengthen the perception of water as a free (public) good and undermine cost recovery and sustainable delivery. Who can best act as independent guarantor of 'water rights' to foster flexible and context-specific delivery that matches local demand? In areas of legal pluralities, how will customary water rights sit with a formal human right to water at the local level? Climate change will have implications for water rights in terms of long-term water planning, investment and management due to increased rainfall variability affecting storage provision and extreme events affecting risk of damage to infrastructure. This suggest research may needs to more effectively combine back-casting to data points in the past with forward-casting through narrative scenarios that recognise risk and uncertainty to better evaluate societal demands and preferences, ecosystem integrity and the financial sustainability of delivering water as a human right.

4.2 Strengthening adaptive capacity

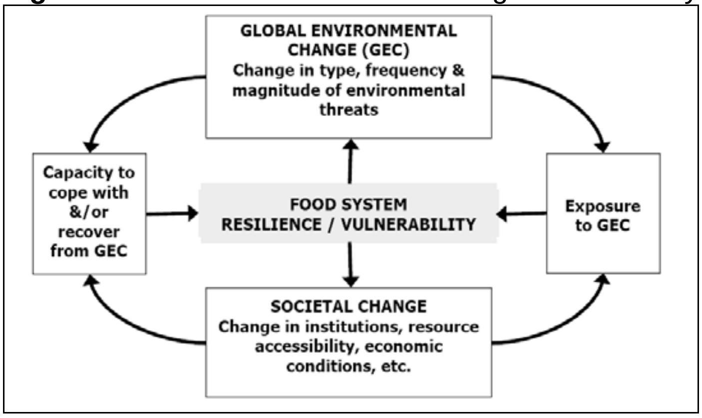
The vulnerability of the poor is a dynamic condition influenced by a combination of inherent capabilities and entitlements, and exposure and sensitivity to climate variability and extreme events. Some impacts of climate variability in semi-arid regions, such as southern Africa, appear to be within the 'head-room' of affected communities' adaptive capacity (Thomas et al., 2005). However, there is only partial understanding of the limits to resilience and adaptive capacity, particularly among the poor, because effective adaptation varies by context and the associated institutional, political and financial capacity. A wide range of adaptive responses is available to society from technological change (e.g. improved crop varieties) to behavioural (e.g. dietary choices, energy consumption), and from managerial (e.g. altered farm practices) to policy (e.g. land use, energy, transport) (IPCC, 2007; Mortimore and Anvell, 2006). Modelling analysis suggests that levels of population growth and economic development will strongly influence the ability to cope with the risks and impacts from environmental change, with significant implications for developing regions at higher levels of global warming. For example, scenario analysis of impacts of climate change on food systems and water scarcity indicate that differences in the number of people affected is explained more by income and population levels (e.g. development pathway) than climate change (IPCC, 2007). This is consistent with a systems approach to climate change that advocates building on and enhancing adaptive capacity in favour of vulnerability analysis (Mortimore and Anvell, 2006).

Research is called for to evaluate how effective current adaptive strategies are in reducing food and water security risk for vulnerable groups in developing regions at higher temperatures (IPCC, 2007) and higher agricultural commodity prices related to cropland conversion to biofuel production. Technological innovations for natural resource use under climate variability can also play a role in poverty reduction (Mortimore and Anvell, 2006), particularly when strengthening existing adaptive capacity among poor people. Wider concerns exist in terms of how the political economy of climate change influences development policy priorities between meeting immediate needs in favour of laying down effective plans for the future. It is recognised that there are 'policy silos' at different planning level but effective approaches to connect silos are few. Climate change may perversely offer a political window where public support drives institutional change in exploiting synergies between Poverty Reduction Strategy Papers, National Adaptation Programmes of Action and water policy. What is less certain are the complex but inter-connected pathways that climate change will have on society and critically how effective public health provision, infrastructure and economic resilience will be in shaping the capacity of peoples and institutions to manage and cope with impacts (IPCC, 2007).

4.3 Water for food

Since 1950 there have been remarkable developments in how we grow food. Food production has outpaced a global population that has grown from 2.5 billion to 6.5 million and food prices have fallen to near historic lows as irrigated areas have doubled and water withdrawals have tripled. Water infrastructure, improved crop varieties and fertilizers have been critical to these successes. Yet, agricultural progress has been uneven with significant damage to ecosystems and hardship for the 850 million people who are food insecure (MA, 2005). For the poor, unequal entitlements to food results in limited access to aggregate production geographical inequalities concentrating the food insecure in South Asia and sub-Saharan Africa (Molden, 2007). Climate change presents significant and new challenges to agriculture as higher temperatures will increase rainfall variability, trigger glacial retreat and extreme events (IPCC, 2007). Linkages between climate change on global food systems are related to levels of exposure, capacity to cope and mechanisms of societal change (Figure 5).

Figure 5. Global Environmental Change and Food Systems (source: Ingram and Brklacich, 2002)



Increasing the productivity and equity of agriculture within the ecological capacity of ecosystems are key requirements to achieve sustainable agricultural systems (Molden, 2007). The poor are identified as a particularly vulnerable group to ecosystem change as their livelihoods are heavily dependent on provisioning, supporting, regulating and cultural services from functioning and healthy ecosystems (MA, 2005). An integrated approach is recommended that manages land and water resources and ecosystems in a multiple function framework which balances food production and ecosystem resilience. New approaches are called for to make better decisions on trade-offs under uncertain conditions based on adaptive management, scenario planning and rigorous monitoring (Falkenmark et al., 2007). The case of biofuel production is illustrative of how market forces are driving ecosystem change as prices for oil have risen and global demand for alternative energy has soared. Increasing farmer returns, higher foreign exchange earnings, reduced fossil fuel imports and investment in rural areas are some of the positive outcomes. The flip-side is that impacts on ecosystems are unknown but likely to be negative from rapid processes of agricultural intensification or expansion. For example, increased water demand for biofuel production has significant water resource implications, it is estimated that under a scenario of heavy reliance on biofuels by 2050 total water demand for biofuel production will be equivalent to today's total agricultural water demand (Molden, 2007).

As populations and incomes grow, demand for agricultural water will rise. For example, by 2050 food demand is expected to double. Falkenmark and colleagues (2007) identify three main ways in which increased water demand can be met: 1) through intensified water use on existing land, 2) through expansion of agricultural land, or 3) from increased agricultural productivity. Rockstrom (2007) argues that "investments in rainfed agriculture have large payoffs in yield improvements and poverty alleviation through income generation and environmental sustainability." The challenge is tackle rainfall variability rather than an absolute lack of water. The problem is rain is often available at the wrong time, causing dry spells and crop losses, but this may be overcome by investments in water management with complementary initiatives in soil, crop and farm management. Given that over 90% of farmed land in sub-Saharan Africa is rainfed and is home to many of the world's poor, progress here seems particularly important though significant efforts have been to this end. While the 'latent potential' of rainfed agriculture is one of the key messages of the Comprehensive Assessment on Water Management in Agriculture, rainfed innovations also require complementary investments in infrastructure, market access, credit, farm diversification and building adaptive capacity for productivity gains to be sustainable in reducing poverty. What is less clear is if farmers are able and willing to adopt rainfed innovations, who will bear the costs, what will be the role of prices on agricultural productivity and land use[3], and how local improvements in rainwater harvesting may impact on interdependent water users.

Unlike water and food systems, interactions between livestock systems, water and ecosystems are less well understood. Water requirements for livestock are estimated at 500 billion m^3 per year for maintenance based on a total 1.2 billion tropical livestock units (converted at 250 kilograms per live

[3] Changes in crop prices has been demonstrated to be a particularly important driver of increasing/decreasing land area being brought into rainfed production, subject to falling/rising prices, *inter alia* (Berkoff, 2003).

animal weight) in developing regions (Peden, 2007). Significantly, drinking water use is less than 2% of that required for feed production. Drinking water is essential for livestock survival and strategic placement of adequate drinking water enables livestock to graze in otherwise inaccessible areas with food, income and asset-protection benefits. Droughts and land degradation are intimately related to climate and development interactions. For example, panel data for Ethiopia reports that ten years after the mid 1980s drought cattle holding were only two thirds of the level before the shock; terms of trade between livestock and food also collapsed resulting in food prices tripling resulting in a reduction of purchasing power of two thirds (Dercon, 2004). During this drought coping strategies are found to be of limited value with transfers of three per cent of total losses for the poorest households (Reardon, 1988). Poverty impacts are felt in terms of declines in current consumption and income and over time through deficits in nutrition, health and education across and within households, particularly for women (Dercon, 2002). Efforts to integrate livestock management with environmental protection and social equity, particularly gender equity, are considered to offer significant benefits but investments and integration are low. Changing preferences and demand for meat and dairy products place new pressures on rangelands ecosystems and agricultural water resources, but opportunities for increased incomes for livestock owners are emerging though remain linked to managing and coping with the impacts of climate change.

While agriculture lies at the fault-line between ecosystems, poverty and climate change, identifying practical and acceptable approaches is far from straight-forward. Significant knowledge gaps remain in determining under what conditions agricultural systems enhance ecosystem services for poverty reduction. While advances are being made to improve weather forecasting in order to communicate early warnings/opportunities to rainfed farmers in Africa (Brew and Washington, 2004), how significant and usable this information will be is difficult to predict. Equally, the actual benefits of innovative financial mechanisms such as monsoon-indexing and climate reinsurance in semi-arid North Africa and India are uncertain, though they may provide farmers with more choices and reduce risk in the face of increasing climate variability (Hess, 2003). Technology is playing an important role in preparing farmers for climate change with improved crop varieties, though greater understanding is required of farmers' engagement, adoption and use of these advances (Mortimore and Manvell, 2006; Perret and Stevens, 2006). Equally, wider initiatives are being called for in social marketing to change dietary attitudes and preferences to reduce agricultural water demand and fuller understanding of 'virtual water' trading approaches (Molden, 2007).

4.4 Managing water ecosystems

Society depends on the integrity of ecosystems to provide goods and services for consumption and production. Land use decisions are pivotal to these interactions as they effectively act as a water resource decision by partitioning rainfall between vapour flow (green water) and liquid flow (blue water). This understanding has been recognised in South Africa where Stream Flow Reduction Activity (SFRA) policy taxes land uses that have an incremental impact on water resources above a baseline natural condition (RSA, 1998). For example, commercial forestry is taxed by area on non-native (exotic species) forest species based on reductions in runoff. With increased physical water scarcity under climate change, improved understanding of forest-water interactions can generate useful information for water managers to more completely assess appropriate land planning decisions against development policy goals (FRP, 2005). It requires a fine balance to understand in different contexts the type and extent of forests which meet societal needs and environmental requirements. Simplified and banal statements of 'forests are bad/good' are unhelpful given the complexity of system interactions and the limited extent of adequate biophysical data, environmental evaluation or societal assessment (ETFRN, 2005).

The Working for Water (WfW) programme is one example of how land use externalities have been combined with poverty reduction goals. The programme pays local poor people to remove alien invasive plants to generate local employment and income benefits, increase water availability, reduce risk of forest fire damage and reduce biodiversity loss (Hope, 2006b). The WfW programme shares many characteristics of a new breed of market-based approaches often called Payments for Environmental Services (PES) (Landell-Mills and Porras, 2002; van Noodwijk et al., 2004; Wunder, 2005). The logic of payments schemes is to create missing markets by linking the costs and benefits of different ecosystem regimes through more explicit valuation, which permits interdependent user groups to recognise and negotiate improved outcomes. This requires several important obstacles to be overcome to reach a satisfactory and sustainable outcome. Emerging evidence identifies transaction costs, behavioural change, compliance, institutional development, economic valuation, and resource evaluation and monitoring as some of the key obstacles (IUCN, 2006). Schemes acknowledge the implicit inequality in expecting poor people to sustainably manage ecosystems, whose goods and services benefit remote, un-paying or future generations. To date, there is ambiguous evidence whether PES, like traditional integrated conservation and development programmes, can successfully achieve environmental improvements and poverty reduction (McCauley, 2006; Wunder, 2005; WWF, 2003). Imposing strict poverty reduction criteria may, in some cases, be counter-productive as a broader definition of rural development may mean the approach can be more widely applied to explore innovative interventions while not making the poor worse off. For example, research in Latin America and India suggests that transitional payments to assist farmers move from degrading land management practices to more benign practices can be self-funding over time, can reverse ecological decline, and are socially acceptable, if there is adequate compensation and support during the costly transition process (Bassi, 2002; Pagiola et al., 2004; Hope et al., 2006). Outcomes may not therefore be directly 'pro-poor' but could provide important environmental benefits, subject to the specific context.

4.5 Ecosystems as water infrastructure

Environmental flows maintain freshwater ecosystems, whose services provide critical contributions to surface and groundwater availability and quality, economic development and poverty reduction (IUCN, 2003). As might be anticipated, the South African's have legislated for such an Environmental Reserve in the National Water Act (RSA, 1998) and Europe has attempted to follow suit with the Water Framework Directive requirement for 'good ecological status'. The devil, as always, is in the detail and difficulties arise in defining, measuring and valuing environmental flows against societal preferences and governance capacity. WWF (2003) provide global lessons from ten river basins, which suggest an adaptive mix of governance across spatial levels with long term and participatory visioning, in association with effective partnerships and knowledge, plus predictable and sufficient investment are key ingredients for success. WWF (2005) illustrates several successful initiatives, including the restoration of Lake Dongting wetland systems in China and how the approach is being up-scaled to wetland management nationally. Other case studies reveal how the hydraulic mission continues to beguile national water planning, such as Spain's (rejected) National Hydrological Plan that took little note of economics or the environment, or China's planned north-south water transfer that is informed by similar grandiose policy goals but weak engagement with society or implications for ecosystem integrity.

Valuing ecosystems as water infrastructure is one approach that acknowledges the considerable economic benefits the world's ecosystems generate (IUCN, 2004). For example, it is estimated global wetlands generate in the region of US$70 billion per year (WWF, 2004). Climate shocks can result in such values being depreciated rapidly by strategies of desperation as people employ more labour-intensive resource harvesting activities in a destructive, short-term logic. High but unredeemable environmental values, in this context, are meaningless as the poor have no choice but to liquidate all available assets, including natural resources to buffer losses from other assets (Dercon, 2002; Pearce, 2003). Policy responses here need to recognise that vulnerable groups have no effective insurance mechanism from large negative climate shocks and reducing vulnerability needs to develop more accessible and effective savings schemes for vulnerable groups that are insulated against climate risk (Hess, 2003; Dercon, 2004; IPCC, 2007).

4.6 Investing in water

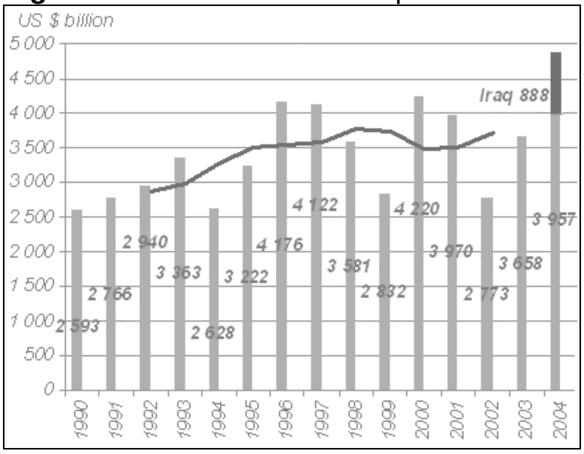
The Camdessus Report (2003) estimates that more than US$13 billion per year is required to meet drinking water provision targets in developing countries. Investment depends crucially on the type and level of service provided[4]. Water investment costs are for new infrastructure and do not cover recurring expenditure on administrative overheads, operations, maintenance, routine repairs and periodic replacements. These figures compare with other water infrastructure investment requirements of US$100 billion for municipal and industrial wastewater treatment, US$40 billion for agriculture and US$10 billion for environmental protection. Troubkisss (2006) compares more recent studies of water investment estimates and concludes: "if the results are analysed on comparable bases, they appear quite similar: approximately US$10 billion per year would be required to supply low-cost water and sanitation services to people who are not currently supplied, a further US$15 to 20 billion a year to provide them with a higher level of service and to maintain current levels of service to people who are already supplied. A much larger figure, up to US$80 billion is projected solely for collecting and treating household wastewater and for preserving the global environment through integrated water resources management (IWRM) and ecological methods". UNDP (2006) estimates that there is currently a significant investment funding gap which cannot be met by government or (poor) users alone. Investments of such magnitude are only likely to be effective and avoid the mistakes of the past with improved water governance structures (Batchelor, 2007).

Policy has a major bearing on investment. For example, in a review of Poverty Reduction Strategy Papers (PRSPs) in Africa, Meera Mehta and colleagues (WSP, 2003) found that despite the high priority of water and sanitation in participatory poverty assessments, the sectors received minimal or no attention in the PRSPs. One aspect of this problem is that donors tend to be un-coordinated, unpredictable and focus on countries with strong sectoral planning (UNDP, 2006). This contributes to 20 countries receiving three quarters of total water aid and results in mismatches in financing needs and aid flows as illustrated by a Ghanaian without improved water access receiving US$88 in aid and a Mozambican receiving US$2 (UNDP, 2006: 69). Uganda's integrated review and monitoring framework represents a welcome exception to progress in water access in Africa, and partly explains its higher aid flows compared to other African countries (Box 2). How progress on water reform translates into benefits for Uganda's water users will provide important lessons for other nations and donors.

Doubling of current investment in water services is viewed as an "investment in humanity" but will not achieve poverty reduction without "a participatory form of managing society, where women take their rightful place" (Camdessus, 2003). What is unclear is how wide-spread demand for water services backed-up by users' willingness-to-pay for improved services fits with calls for water as a human right. For example, UNDP (2006) tempers 'water as a human right' with a threshold pricing limit of up to 3% of household income. Why 3% instead of 6% or 9% is not clear. Nevertheless, the point is that a right to water is not seen as being consistent with free water. This may be problematic but is not discussed. In many cultures, water is considered a free good. The question for sustainable financing is when you capture, store, treat, transport, distribute and treat the wastewater, how much should (poor) users pay for those services? One of the key reasons that the public sector, which delivers 97% of water services globally, struggles is financial sustainability. It is uncertain whether water as a human right will lead to improved coverage and access without bankrupting service providers. Understanding how rights interact with the social impacts of water as an economic good may allow insights into the consequences of legislating water as a right. Related issues concerns (for cost recovery) might consider not whether the poor can pay for water but whether can they save.

[4] This is particularly germane to sanitation and wastewater treatment investments.

Figure 6. International Development Aid flows to water (US$ billion)

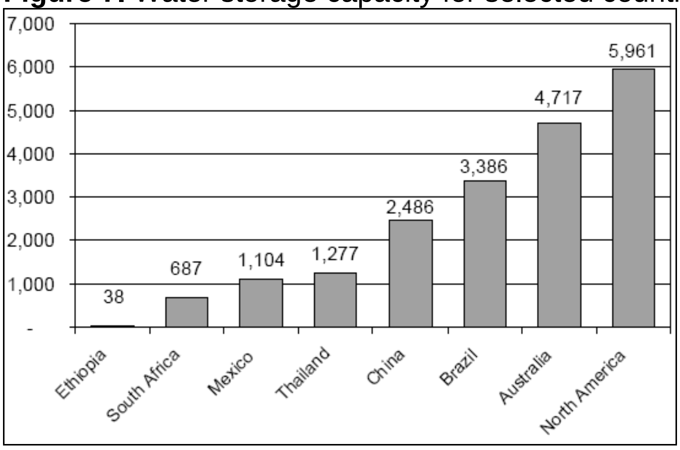


> **Box 2. Exceptional Uganda**
> Uganda illustrates one African country that has made progress in water sector reform based on an integrated review framework. Poverty diagnostics justify enhanced sector-wide water and sanitation allocations with action plans, policy reform, capacity-building, and public finance and management. Progress is effectively monitored in national systems of on-going evaluation. Aid flows have proved pivotal in improved water and sanitation access and to propel water to be a priority issue alongside health and education. (Source: WSP, 2002; UNDP, 2006)

4.7 Water and growth

Almost all developed nations have followed a path of extensive investment in water resources infrastructure and institutions to develop and manage water resources for growth (Grey and Sadoff, 2006). Country comparisons provide stark contrasts: the Colorado River in the USA has 1,400 days of storage, while the Indus has 30 days; Ethiopia with higher rainfall variability than North America has less than one per cent of North America's storage capacity (Figure 7). A path of 'responsible growth' recognises water resources development and management are prerequisites for growth, mitigating risk and poverty reduction, particularly under climate change, and implies significant investments in water infrastructure by developing countries for poverty reduction and growth, based on building on the lessons of the past (WCD, 2000; Grey and Sadoff, 2006). UNDP (2006: 159) acknowledges the legacy of past dam failures but concludes that "(M)ost developing countries do not need more of one and less of the other (*i.e. big or small water infrastructure*): they need more of both." Environmental organisations recognise the role of water infrastructure for growth and advocate several approaches to modify existing water infrastructure (IUCN, 2003).

Figure 7. Water storage capacity for selected countries in 2003 (m^3 per person)



(source: Grey and Sadoff, 2006)

The Stern Review (2006) estimates the economic costs of climate change to be between 5% and 20% of global GDP. Costs of adaptation are in the range of tens of billions of dollars in developing countries, which need to accelerate investments in technology, infrastructure and information. In countries where growth is strongly associated with rainfall, growth becomes 'hostage to hydrology' (Grey and Sadoff, 2006). Calls for increased water infrastructure for growth and development goals, needs to balance the sequence of infrastructure and institutions in order to avoid poor investment choices. The case of unsustainable groundwater abstraction in India provides an example of how technological development without appropriate institutional checks and balances has led to significant resource depletion, which is associated with socially-distributed outcomes. Where donors or clients emphasize infrastructure investments over institutions, or vice versa, the returns on investment are likely to be low, ecosystems may be damaged and the poor may not benefit. Transparent and effective decision-making processes are thus central to facing the inevitable trade-offs and avoiding a costly 'status quo' paralysis by pragmatic and accountable application of social and environmental safeguards to harness the potential of water for responsible growth (WCD, 2000; Grey and Sadoff, 2006).

5. Conclusion and priority research themes

The Commission for Africa (2005) argues for a "coherent package for Africa" that increases growth for poverty reduction. This review would argue that this position holds true in all developing countries and that water is a unique and unifying theme that can harness or hold people hostage to responsible growth and poverty reduction (Grey and Sadoff, 2006). However, incoherent policy can derail other positive interventions by a failure to understand complex and dynamic interactions as water passes through natural and man-made landscapes (WWF, 2003; IUCN, 2003). For example, limited investment in wastewater treatment is associated with significant and growing urban environmental problems and associated public health concerns, but municipal and industrial wastewater treatment requires three times more investment than water and sanitation (Camdessus, 2003), but is often low on the funding and policy radar compared to improved domestic water access, which undermines potential health gains and increases ecosystem degradation. Alternatively, increasing calls for more irrigation in Africa and Asia needs to be balanced with hydrological realities and supplemental irrigation that includes rainfed investments, learns from past failures and addresses current inequalities (Molden, 2007). A second key message from The Commission for Africa report that resonates with the wider literature is its advocacy of a "new kind of development … rooted in sound analysis of what actually works." This review would echo those words as there is a worrying lack of objective understanding of basic water and poverty relationships in the literature and a plethora of unsubstantiated and recycled assumptions driven by advocacy research (Banerjee et al., 2006). Development agencies must recognise that there is surprising little known of the direct impacts of development aid on poverty, largely due to a lack of rigorous impact evaluation (Baker, 2000). A third key message is that climate change presents an unexpected political window for change and renewal in areas where there are immediate and on-going poverty gains by addressing issues of public health provision, education, agriculture, energy, markets and technology that strengthens the capacities of the poor for the uncertain threats posed by climate change to ecosystems (IPCC, 2007; MA, 2005; Stern, 2006; UNDP, 2006).

As DFID re-engages with the water sector after "taking its eye off the ball" in recent years (IDC, 2007), it must think carefully about its own capacity, comparative advantage and stomach for the long and unromantic haul of addressing water and poverty challenges from an integrated and evidence-based platform. Climate change presents significant and uncertain threats to freshwater ecosystems and society. Three key research themes emerge from the literature, which appear of importance in reducing poverty from climate change impacts on freshwater ecosystems[5]:

[5] Water governance is a central and unifying theme, therefore all recommendations are made with an implicit 'plus improved governance' stamp (see Batchelor, 2007).

Thematic Area 1: Strengthening adaptive capacity

- Technology – improved crop varieties and indigenous soil and water conservation in farming systems; reliable hydrological data that permits more effective planning at farm, catchment and national levels.
- Infrastructure – matching choices of water service technology against effective demand; appropriate levels of water infrastructure for responsible growth and poverty reduction.
- Reducing risk – informal or formal risk-reducing and knowledge-sharing institutions and approaches for poor people to reduce livelihood vulnerability from climate change events that trigger significant degradation to regions of high ecosystem value.

Thematic Area 2: Building bridges to the poor

- Policy and practice – improved methods, tools and approaches that build bridges and understanding between what the poor want and effective policy to deliver services in a transparent, accountable and financially sustainable manner.
- Rights and responsibilities – investigation of water as a human right to drive sustainable delivery of water services to the poor.
- Impact evaluation – longitudinal data that can provide objective assessment of the causal relationships between development interventions and poverty reduction.

Thematic Area 3: Managing water ecosystems

- Decisions under climate change-related uncertainty – methods and tools that improve water allocation decision-making under conditions of limited data and uncertainty.
- Political economy of water management – empirical and theoretical understanding of the socio-political process of water decision-making from competing interest groups, sources of knowledge and power domains across community, catchment and transboundary levels.
- Productivity-equity nexus – investigation of water allocation to agriculture and ecosystems under conditions of scarcity against competing criteria of productivity (food, income) and of equity (nature, generational) across formal and customary legal systems; impacts of widespread and unplanned expansion of biofuel production.
- Market-based mechanisms – the limits and potential of market-based logic for more effective environmental governance and poverty reduction.

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