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Adapting to Climate Change in Europe and Central Asia

Background Paper on Water Supply and Sanitation

May, 2008

Barbara Evans and Michael Webster

Sustainable Development Department
Europe and Central Asia Region
World Bank

Adapting to Climate Change in Europe and Central Asia
Background Paper on Water Supply and Sanitation[1]

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TABLE OF CONTENTS

[1] This paper is one of a number of sector-specific background papers written for the ECA flagship study on adaptation to climate change (led by Marianne Fay). The paper was written by Barbara Evans (Consultant, UK) and Michael Webster (World Bank, ECCSD) with contributions from Andy Peal, Ron Hoffer and Marianne Fay.

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

LIST OF ABBREVIATIONS

AMWA	Association of Metropolitan Water Authorities
AWWA	American Water Works Association
ECA	Europe and Central Asia
EU	European Union
EUR	Euro
DWD	Drinking Water Directive
GEF	Global Environment Facility
IPCC	International Panel on Climate Change
IWRM	Integrated Water Resources Management
lpcd	Liters per capita per day
MDG	Millennium Development Goals
NRW	Non revenue Water
OECD	Organization of Economic Cooperation and Development
UK	United Kingdom
US	United States (of America)
USD	United States Dollars
UWWD	Urban Wastewater Directive
WFD	Water Framework Directive

EXECUTIVE SUMMARY

i. In general the Europe and Central Asia Region (ECA) is predicted to become wetter and warmer as a result of climate change, with more frequent weather extremes (drought, floods, heatwaves, and winter squalls).

ii. Climate change will impact the ability of water utilities in ECA to deliver water supply, wastewater and flood protection services in a number of ways. For example, water demand will increase as temperatures rise creating an increased stress on utilities struggling to meet their existing demand; increased variability of precipitation will require greater storage volumes (such as dams) and flood protection measures.

iii. Climate-change 'hotspots' in the region include:

- **Southeast and central European areas and Baltic states** with high reliance on fragile groundwater sources or surface water sources already under stress and transboundary surface water. These areas are likely to experience hotter and drier average conditions coupled with an increased risk of high intensity flood and runoff events.
- **Eastern Russia** – significant warming, shift of permafrost line northwards.
- **Central Asia** – significant warming and variations in precipitation putting strain on already stressed surface water sources and transboundary waters. Increased risk of catastrophic flooding due to lake and glacial outbreaks.

iv. In the rest of the region climate change impacts will certainly be felt but may in general be less severe although localized effects may be significant:

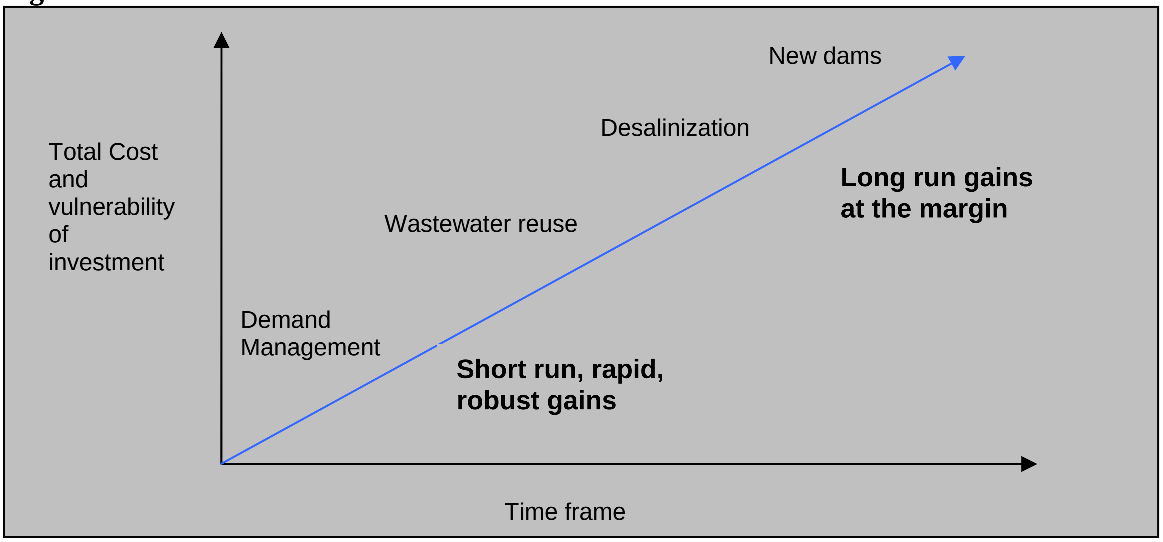
- **Caucasus, Kazakhstan, Moldova and Belarus –** areas showing a significant warming trend and possibility of increased precipitation and runoff.
- **Western Russia –** warming and increased precipitation in parts – likely exacerbating of current flood impacts

v. Climate change will impact utilities in different ways but will have most impact in utilities already under stress**.** In ECA a significant percentage of utilities face a massive investment backlog and **the costs of climate change adaptation may be dwarfed by the costs of meeting maintenance and rehabilitation backlogs and raising access and service levels to acceptable standards.** In other words climate change may have an impact 'at the boundary' but for many utilities in ECA it is not yet the most critical factor driving investment requirements.

vi. In the absence of reliable long term climate data sophisticated and flexible planning is needed to identify likely future scenarios. **A serious shortfall in planning capability coupled with weak performance incentives is probably a more serious problem for most ECA utilities, than the lack of highly sophisticated climate-change responsive modeling tools.**

vii. Adaptation strategies can be divided into short run rapid gain strategies (mostly related to supply side management), through medium term strategies for flood mitigation and infrastructure adaptation, to longer run adaptations that are required when climate change affects a utility's ability to function at the 'margin' (for example where additional storage capacity or new water production is required) (**Figure S1**). **Short run performance improvements are likely to have the greatest impact on both resilience to climate shocks and operating costs and can be prioritized by utility managers even in the absence of reliable climate data.**

Figure S1: Time and Cost Trade-offs



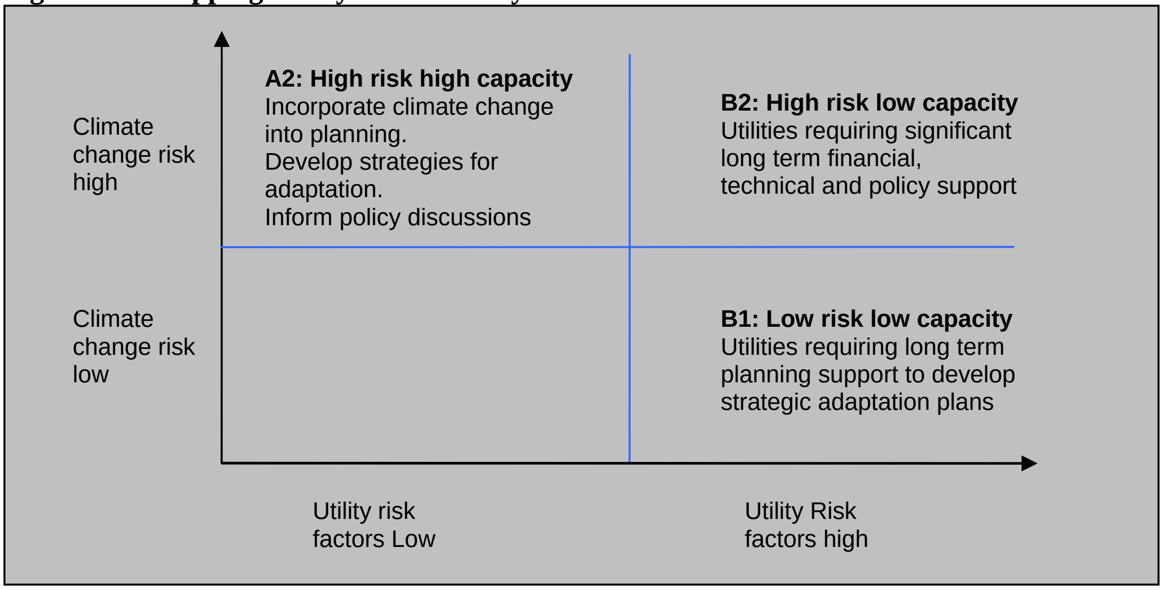
viii. At the policy level new and more sophisticated responses are needed **to develop appropriate financial and policy instruments that will promote good practice and responsible stewardship of resources while maintaining and increasing access to basic services**.

ix. The challenges faced by ECA utilities as a whole are so large that it is important to identify those places where climate change can be expected to make a significant impact at the margin thus meriting specific attention in the short term. Identifying this set of utilities is a function both of the level of risk of climate-change-induced stress and the degree to which the utility has the capacity to respond. The set of 'B2' utilities which face the highest risk climate-change-induced stress and have the lowest capacity to respond are the most critical –there is an urgent need to identify this set of utilities and begin to develop strategies for their long-term support (**Figure S2**).

x. The capacity of any utility to meet the challenges of climate change can be assessed by considering four sets of 'risk' factors, namely:

- **Economic risk factors**: relating to the macro economic environment within which utilities must operate;
- **Utility endowment risk factors:** relating to the condition of the utility's baseline endowment of infrastructure;
- **Utility operations risk factors:** utilities with poor operational conditions are likely to be in a weaker position to adapt than those with better operational conditions;
- **Utility baseline resource risk factors:** which can be divided into two elements. Firstly the robustness of the resource (utilities who rely on multiple sources of water with high potential for further development and exploitation are likely to be in a stronger position than those with a heavy reliance on single and/or fragile water sources) and secondly the relative position of the utility within the water market .

Figure S2: Mapping Utility Vulnerability



xi. Those utilities with the highest combination of risks are most vulnerable and will fall into the 'B' group for whom support is most urgently required. The identification of these utilities and within the group those most at risk (the B2 utilities) is a priority.

xii. While more work is needed to classify every major utility in the region against climate change risks so that the most urgent cases can be identified and support strategies designed **the overall prospect is rather bleak with a significant majority of utilities poorly placed to meet the coming challenges** (located in the upper or lower right-hand quadrants of **Figure S2**)..

xiii. For these utilities external support is certainly needed to:

- Build capacity and skills;
- Provide a bridge to the growing body of experience and knowledge on adaptation around the world;
- Develop appropriate policy and financial options;
- Provide a needed injection of financial support; and
- Support the generation of credible data and empirical analysis at the local level.

Adapting to Climate Change in Europe and Central Asia
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1. INTRODUCTION

1. In general the Europe and Central Asia Region (ECA) is predicted to become wetter and warmer as a result of climate change, with more frequent weather extremes (drought, floods, heatwaves, and winter squalls). While in general precipitation in the region is low, around 40% is converted to runoff – higher than in any other region. Changes in runoff patterns are likely to be significant across much of the region, with increases in much of the Russian Federation and decreases in most other subregions. Overall the outlook for the region is one of increasing uncertainty and extremes in weather events with northern areas becoming wetter and warmer and southern areas drier.

2. Water supply and sanitation in the region is largely delivered by public utilities with joint responsibility for both water supply and sanitation. In general these utilities are characterized by aging infrastructure, high operating costs, low responsiveness to customers and poor access to capital markets. Most are in the midst of a difficult transition from being highly subsidized central-government-funded departments towards becoming autonomous and self-financing municipal companies. The 10 ECA countries already in the EU, as well as the 7 ECA countries with a strong chance of joining the EU in future also face the challenge of meeting the EU environmental directives[2]. Coverage is officially high, but the data mask severe problems, particularly in terms of access to services in many rural areas, and in terms of quality of services in urban areas. Many consumers face intermittent supplies of poor quality water.

3. At the same time, the region faces strong shifts in economic and demographic patterns. The economies of some central European countries, Southeastern Europe, parts of the Caucasus and central Asia are under economic strain, characterized by declining industrial output and increasing poverty. The shift from command to market economies in the countries of the former Soviet Union has created numerous challenges. Multiple uses of water resources and transnational boundary issues in river basins add further complexity.

4. Thus ECA faces significant challenges; climate change exposes under performing utilities faced with a dynamic and increasingly uncertain planning horizon, and increased risk of exposure to climate extremes in an environment of scarce resources and limited capacity.

5. This paper is written from the perspective of the utility manager or municipal/ government planner. It examines the increasing risk and uncertainty facing utilities in the ECA region and explores some of the potential responses and resources available. It is based on a short literature review which draws on three broad bodies of literature:

- the first deals with climate change and adaptation in general and provides useful information about likely impacts in the ECA region and generalized policy responses;
- the second deals with adaptation in water utilities. This literature tends to have little explicit analysis pertaining to the ECA region; and
- the third examines the performance and operating options of utilities in the ECA region but which tends to have little explicit analysis on the impacts of climate change.

[2] EU environmental directives are required to met by all countries joining the EU as part of the *acquis communitaire.* The most important directives impacting the water supply and sanitation sector are the Drinking Water Directive, Urban Wastewater Directive, and Water Framework Directive. These require a level of service much higher than currently exists in ECA.

2. CLIMATE CHANGE PREDICTIONS AND THEIR IMPACT ON WATER SUPPLY AND SANITATION

General Trends

6. While climate modeling is notoriously uncertain several general trends are predicted for the region with a fair degree of confidence:

- Higher temperatures throughout ECA will raise water demand and evaporation in surface water bodies;
- Decreased precipitation in the south will impact surface and groundwater resources, already constrained in some parts of the region.
- Groundwater depletion will lead to declining water quality and saline intrusion – likely to be a particular problem in Southeastern Europe and the Baltic states where reliance on groundwater is high;
- Increased and more intense precipitation in the north will have an impact on river and reservoir management, and surface drainage as well as putting infrastructure assets at risk
- Greater precipitation variability throughout ECA may require greater storage capacity and certainly more sophisticated storage management
- Higher sea levels in the Adriatic, Baltic, Black and Caspian Seas may result in coastal erosion and flooding
- Declining levels in inland water bodies such as the Aral Sea and lake Baikal will result in severe damage to ecosystems, declining water quality and reduced availability of water.
- In Russia, shifting of the permafrost line to the north may threaten infrastructure assets (affecting the stability of water and sewerage pipes, water production facilities, storage and wastewater treatment plants)
- Increased extreme weather events throughout the region will result in increased demand for flood management and emergency-response capacities (water services to those cut off for example).

7. The risk of these impacts varies across the region and at a micro-level. **Table 1** shows the general distribution of predicted trends across the region.

Extreme Weather Events

8. While there is a consensus that uncertainly in predicting weather patterns will increase, there is also agreement that extreme weather events will become more common. In ECA the main issues will be:

9. **Floods** – Floods are already the most "common natural disaster" in ECA (EEA 2007). Flooding has several implications for utility managers – not only in terms of management of stormwater drainage systems but also in terms of management of reservoir storage (to balance maintaining supplies against retaining capacity to dampen the effects of flooding through storage). Flooding also puts water supply and sewerage assets as well as lives at risk.

Table 1: General climate trends in sub-regions of ECA

Sub- region	Current trends and weather related events	Projected Temperature Rise by 2050	Mean annual Precipitation	Runoff	Rainfall intensity & variability	Interval between wet days	Heatwaves
Baltic Russia	Flood and landslide damage is significant in some parts.	1.9ºC, decrease in frost days	Increasing (6%) Winter and spring will be wetter	Increase (13%)	Increase		Increase
Baltics	Warming trend over the past century. Flood damage significant.	1.6ºC, warmer winters, decrease in frost days	Unclear	South: decrease; north increase	Increase		Increase
Central Asia	Warming trend over the past century. Droughts and landslides in some parts	2.0ºC, decrease in frost days.	Unclear	Decrease	Increase		Increase
Caucasus	Warming trend accelerating in past 20 years. Droughts and landslides in parts.	1.7ºC, warmer summers, decrease in frost days.	Unclear	Decrease	Increase and more variable	Increase	Increase
Central Europe	Warming in the last 20 years but no trends in precipitation	1.7ºC, decrease in frost days	Unclear	Decrease (median 13%)	Increase and more variable	Increase	Increase
Central and Volga (Russia)	No trends, flooding significant	1.9ºC, warmer winters, decrease in frost days	Winter and spring will be wetter	Increase (7%)	Increase.		Increase
Kazakhstan	Warming over past century	2.0ºC	Increasing (4-9%)	Slight increase	Increase	Unclear	Increase
North Caucasus (Russia)	Increasingly wet over the past century	1.6ºC, decrease in frost days	Unclear	Decrease 12%	Increase and more variable	Decrease	Increase
Siberia and Far-eastern Russia	Significant warming and wetting in the past century.	2.4ºC, decrease in frost days.	Increase (11%), particularly in winter (17%)	Increase (22%)	Increase	Decrease	Increase
Southeastern Europe	No trends, but vulnerable to floods and drought.	1.8 – 2.1ºC, decrease in frost days.	Decrease except summer.	Decrease (25%)	Increase	Increase	Increase
South Siberia (Russia)	Warming and wetting trend over the past century. Floods and landslides.	2.1ºC	Increasing (8%)	Increase	Increase	Decrease	Unclear
Urals and W. Siberia	Significant wetting in past century. Floods and landslides.	2.2ºC, decrease in frost days.	Increase (9%), winter (15%).	Increase (10%)	Increase	Unclear	Increase

Source: derived from climate summary tables (Westphal, 2008)

10. Many major river basins and most countries in the ECA region already experience significant flood events many of which cause serious economic and human damage (**Box 1**). The intensity and hence the potential impact of such events is likely to increase particularly in those regions where precipitation events are predicted to become more intense (Central Europe, Southeast Europe, Belarus, Moldova and Ukraine) and where rates of runoff are predicted to rise (most of Russia). The impacts are also likely to be felt in countries where there is limited surface water storage in the form of reservoirs and flood mitigation infrastructure (Armenia, Georgia). In Central Asia there is rising concern about the potentially devastating impacts of flooding from lake and glacial outbreaks – particularly as temperatures rise and glaciers retreat.

Box 1: Flooding in Central and Southeastern Europe

The Czech Republic, Poland, Slovak Republic, Slovenia, and Hungary have experienced several floods of historical severity in the last decade. The most devastating event was the flood of summer 1997 in the Oder basin, killing 55 people and causing damage estimated at USD3.4 billion in Poland alone.

In the case of Romania, floods have occurred in half of the last 100 years. During the past decade, floods were recorded almost every year. In the period 1991-2002, floods resulted in material losses estimated in total at over USD1 billion and killed more than 200 people. Serbia has also experienced regular and occasionally catastrophic flooding during recent years. The most damaging one was the 1999 flood, which affected several basins in central Serbia. The damage was estimated at USD150 million.

In August 2002 a 100-year flood caused by over a week of continuous heavy rains caused damage of billions of euros in the Czech Republic, Austria, Germany, Slovakia, Poland, Hungary, Romania and Croatia. Several villages in Northern Bohemia, Thuringia and Saxony were more or less destroyed by rivers changing their courses.

Source: http://greenhorizon.rec.org/bulletin/Bull102/floodening.html, World Bank 2003a

11. **Droughts** - Summer heatwaves have been increasingly common during the 20th century in the ECA region (see **Box 2**), but the impact of climate change on heatwaves and warm periods out of the summer season is inconclusive(IPCC 2007, EEA 2007). Heatwaves would have a serious impact on utility managers simultaneously increasing demand and suppressing supplies.

Box 2: Heatwaves and Droughts

Bulgaria has experienced several summer droughts since mid-1984. The summer drought of 1993 affected the agriculture sector, and crop losses were estimated at 2% of GDP. Romania has also observed eight years with droughts during the period 1982-2000, affecting the river basins in the southern part of the country. The runoff of these basins was about 50% of the monthly annual average, while in the plain areas; the runoff was only 30%. Droughts caused severe damage to the agriculture and energy sectors as well as to a shortage of the drinking water supply.

Nearby Spain is currently suffering its worst drought in more than four decades. There has been 40 per cent less rain than usual since October 2007 across the nation as a whole and the situation has become so serious that the city of Barcelona has begun to import freshwater by sea; the first delivery of nearly 23m liters arrived on May 13, 2008.

Source: World Bank 2003a, Times Newspaper, April 8, 2008; Guardian Newspaper, May 14, 2008

12. Droughts are of particular concern to those utilities that are dependent on seasonal surface water sources and those who rely on sensitive groundwater sources, such as Karst water for a proportion of their supply (see **Box 3**).

Box 3: Karst Water
Many parts of Southeastern Europe including Croatia, Montenegro, parts of Bosnia and the city of Vienna are dependent on groundwater from so-called *karst* formations. Karst are limestone deposits characterized by irregularity, sinks, underground streams and caverns. Karst deposits tend to be rich but unreliable sources of groundwater. The hydrogeology is much more complex than that of other fractured rock deposits. Supplies may become periodically saline or dry up during the summer months. Over exploitation can lead to unpredictable outcomes and the risk of contamination for example where wastewater is discharged onto karst formations. In the US it is standard practice to disinfect wastewater outflows into karst.
Source: http://www.karstwaters.org, World Bank 2003a

13. Droughts not only place an overall strain on the resources of the utility, but increasing uncertainty in weather forecasting makes it difficult for utility managers and other users to plan ahead and ensure sufficient contingency supplies are available. Even in Western Europe this is a growing challenge; Spain for example has resorted to severe rationing and importing freshwater to cope with recent prolonged periods of drought while other developed nations are turning to water imports to meet growing supply-side deficits (see **Box 4**).

Box 4: Who Exports Water?
Hydrologists expect the demand for water will continue to increase with the world's growing population. Some predict that by 2025, 3.5 billion people will be living in water-scarce countries, compared with 500 million in 2002. In response several countries have begun to export fresh water including Turkey (which is exporting to Israel, Syria, Jordan and Greece) and France (which sends tankers to Algeria). Canada, Russia, New Zealand, Scotland, and Norway have all developed plans for exporting fresh water.
Source: Times Newspaper, April 8, 2008; Guardian Newspaper, May 14, 2008

14. **Water Quality:** Both extreme precipitation and drought can impact negatively on water quality. Floods increase the risk of contamination from wastewater overflows and excess agricultural and industrial runoff. Increased sediment loading may also arise particularly in areas which are also experiencing deforestation (see **Box 5** for example). Where lake and stream flows decline (for example under drought conditions) increasing concentrations of nutrients and pollutants will result. As temperatures rise surface evaporation could lead to salinization. Warmer water temperatures could also have an impact on fresh water fish stocks.

Box 5: Flooding and Turbidity in Supplies for New York City
Flooding caused by Hurricane Floyd (1999), Hurricane Ivan (2004) and heavy spring rains in 2005 resulted in turbidity levels rising to levels 1000 times higher than acceptable limits at some upstream reservoirs supplying New York City. These spikes in turbidity result not only in increased treatment costs, but also place a great strain on the water quality surveillance system.
Source: AMWA (2007)

15. **Table 2** summarizes the likely direct impacts of predicted climate changes in the region.

Table 2: **Expected Impacts of Climate Change on Utility Service Provision**

Dimensions	Indicators	Expected Impacts
Ambient Temperature	Increase	Increased evaporation and evapotranspiration leading to reduced water availability (supply). Salinization, eutrophication of surface water resources. Lower groundwater tables. Increased demand
Surface water temperature	Increase	Reductions in dissolved oxygen content, mixing patterns and self-purification capacity. Deterioration in water quality including algal blooms that impair color, odor, taste and purity of water supplies.
Precipitation	Increase	Increased average runoff leading to decreased water quality, including microbial and chemical pollutants to water resources, increase in incidence of cryptosporidium (and other enteric pathogens resistant to chlorination).
	Decrease	Reduced water availability (supply)
	Greater variability and extreme events	Flooding and drought Increase in difficulty of flood control and reservoir utilization during the flooding season Contaminant and turbidity spikes.
Permafrost	Increased rate of melting	Unstable ground conditions reduced bearing capacity, risk of subsidence, unseasonal or early flooding.
Sea Level	Rise	Erosion, coastal flooding, inundation of low lying coastal areas and rivers, saline intrusion into groundwater aquifers.

Source: Adapted from IPCC 2008

16. Evidence of these effects has already been seen around the world, providing a sobering reminder of what the ECA region is facing. The mid-western United States for example is already experiencing severe water stress due to a combination of reduced snow-pack, falling river levels and population growth (New York Times, 2007). Severe flooding is on the increase in many parts of Europe – 2007 saw devastating floods in many parts of the UK which are predicted to worsen in the coming years. Many countries in Europe note an increase in planned investments for flood defense and management and in coastal defenses (EEA, 2007). In parts of the UK again, long-standing coastal flood defenses have been lowered to allow for periodic inundation of coastal wetlands in recognition that simply increasing the height of the flood defenses is deferring a major disaster as sea levels rise.

17. In ECA itself the potential devastating impacts of climate change are presaged by the recent spate of catastrophic floods in central and southeastern Europe, the growing challenge of managing water quality in the Baltic Sea and the crisis in the Aral Sea Basin (see **Box 6**). While falling levels in the Aral Sea can be explained though increased upstream abstractions, such stresses are likely to become more severe, and spread to other basins, as water availability declines and precipitation becomes more variable. Climate change poses a series of complex and

interconnected challenges, which must be addressed alongside longer term trends in demographics and changes in economic patterns.

18. In the countries of former Yugoslavia and those of the former soviet union, the impacts of climate change must be assessed alongside changing patters of water use and the pressing need to rebuild infrastructure damaged either during the years of conflict or during years of neglect. This complex situation offers both a challenge and an opportunity to begin planning for a future of changing climatic conditions.

Box 6: Conflict and Cooperation – the Aral and Baltic Seas

Once the world's fourth largest body of inland water, the Aral Sea has now shrunk to just 15% of its former volume. Its salinity has risen by almost 600% and all native fish are gone from its waters. Over 40,000 km^2 of the former sea bed is now exposed - an area equivalent in size to six million football pitches. Trawlers lie stranded and commercial fishing activities have long since ground to a halt.

While the damage to the Aral Sea's ecosystems began in the Soviet era, the situation has deteriorated substantially under the Karimov administration. Indeed, between 1990 and 2000 the sea's total volume decreased by almost 50%. The decline in the Aral Sea is closely linked to Uzbekistan's highly inefficient cotton irrigation systems which draw water from the region's two major rivers, the Amu Darya and the Syr Darya.

The crisis is now being addressed through the Aral Sea Basin Program but there is widespread agreement that the Aral Sea cannot now be returned to its former state.

By contrast the clean up of the **Baltic Sea** is widely hailed as a success of international collaboration and has become a cornerstone of the environmental strategy of the Baltic riparian countries. Estonia, Latvia, Lithuania, Poland, and the Russian Federation have joined their wealthier western European neighbors to collaborate through a series of linked water supply, sanitation, coastal management, agricultural and pollution control projects.
Source: http://www.ejfoundation.org and World Bank 2003 a

3. THE STATUS OF WATER UTILITIES IN THE REGION

19. Water utilities in the ECA region face a number of specific challenges which hamper their efforts to meet the challenge of climate change. These are discussed briefly below.

Lower than expected coverage– particularly in rural areas

20. International data suggest that the ECA region as a whole is performing relatively well when compared with other regions in terms of overall access to improved water sources and sanitation (see for example WHO, UNICEF (2006)). Notwithstanding this relatively good performance the Joint Monitoring program itself observes that 'almost 27 million people in the former soviet union and the Baltic states do not have access to improved water supply' (WHO, UNICEF 2004). Further examination of the data however puts even this bleak picture in doubt. OECD observes that data sets for the Eastern Europe, Caucasus and Central Asia region are generally unreliable. The main methodological problems relate to:

- lack of baseline data (few countries have reliable data for the 'MDG Baseline year of 1990);
- a focus on technological definitions of access (connection to a water network) which mask performance failures which are significant in the ECA region; and
- lack of and poor quality household survey data for current estimates. A lack of a review of the disaggregated data suggests there are some areas of particular concern.

21. Key country figures cited by OECD in a recent review of water services for the region make sobering reading. Access to improved water sources hovers around 70-75% of the overall population in some countries, with particularly poor performance in rural areas in certain parts of the region. The situation with respect to sanitation is even worse (**Table 3**).

Table 3: Selected coverage data for ECA countries

	Access (% of population)				
	Improved water source	Connection to Centralized water supply		Improved sanitation (Urban)	Connection to centralized sewerage
		Urban	Rural		
Armenia	96	68	32	92	67-89
Azerbaijan	73	95-83	11	77	78
Belarus	..	94	53	100	68
Georgia	96	95	35	76	60
Kazakhstan	87	93	26	86	
Kyrgyz republic	75		70	76	
Moldova	86	73		92	56
Russian federation	93	84		96	70
Tajikistan	71			58	
Turkmenistan	77	80	28	71	61
Ukraine	100	83	26	98	53
Uzbekistan	73	65	64	89	

Source: Based on World Bank (2002 and 2003), OECD (2003)

22. The situation is therefore one of mixed performance. OECD goes on to observe that "Almost all trends in the water supply and sanitation sector point in the direction of further deterioration of water services." This is against a baseline situation of 'moderate water stress' even prior to the impact of human-related climate change, particularly in the south of the region (WWAP 2003)

Low levels of revenue and high investment needs

23. ECA countries have a poor track record of cost-recovery. In most countries water utility revenues are estimated to cover only around 60 percent of operational costs - for example Russia (61%) and Ukraine (64%). (OECD 2005). Many utilities report that user fees represent 45-85% of income with the rest coming from implicit operating subsidies (OECD 2003). This is a result of an unwillingness to raise tariffs coupled with the fact that many of the systems that were constructed during the soviet era were significantly over designed and expensive to run. The resulting low revenue base results in a predictable cycle of underinvestment, poor maintenance, deterioration of infrastructure and rising costs. Resources for rehabilitation and major investment are scarce and the poor revenue record makes borrowing difficult.

24. An estimated USD 15-34 per capita per year of additional finance is needed simply to maintain and renew infrastructure at its current levels. If MDG targets are also to be met an estimated investment of around EUR 7 billion per year is needed - and this may be an underestimate given the doubts that arise over the baseline coverage data that is in use (OECD, 2005).

Highly inefficient systems

25. The legacy of soviet-era centralized planning is also seen in the highly labor intensive and inefficient utility systems of the region. Non revenue water rates are high (for example reported data suggests rates of physical losses alone in excess of 40% in eight countries of the region; Poland, Moldova, Georgia, Albania, Estonia, Kyrgyz Republic, Bulgaria and Armenia with Armenia reporting rates in excess of 70%). Labor costs are high (most utilities report 3-5 staff per thousand connections, which can be compared with the UK average of 0.3-1.0 staff per thousand) (World Bank, 2005).

26. Overall performance is poor- statistics collected by the World Bank suggest that in the capital cities less than 65% of households with a connection enjoy 24 hour supply, and this falls below 50% in smaller towns and cities. Some countries, in particular Albania, Armenia, Azerbaijan and Moldova report very low hours of service.

Transition from centralized economies to municipal government

27. In addition to the legacy of centralized planning, the transition towards a market economy which has characterized the region since the early 1990s has also probably resulted in some level of underinvestment. Most countries in the region (with the exception of Slovakia and parts of Bulgaria) have undergone a rapid and almost complete decentralization to municipal level. This has placed severe strains on local government capacity and finance. A slow process of re-aggregation of utilities has been underway since around 2004 in some parts of the region (World Bank, 2005).

28. This series of institutional 'shocks' in the system has certainly resulted in underinvestment but this in turn may have had a knock-on impact on technical skills and capacity within utilities.

Resistance to reform and lack of alternative delivery mechanisms

29. "Slow progress in reform at the municipal level is arguably the single biggest obstacle to improved provision of urban water supply and sanitation." This is the conclusion of a background paper prepared for the follow up conference to the Almaty conference held in October 2000[3]. Almaty recognized the need for root and branch reform of utilities and municipalities in the ECA region in order to equip them to cope with the challenges of the 21st century. Conference documents note that many utility and municipal service providers had simply failed to respond to the changing political, social and economic circumstances of a post 1989 world. Five years on while there are a number of positive examples where municipalities have "adopted plans with clear objectives and identified the means for achieving them (e.g. Surgat and Yaroslavl in Russia and Yerevan in Armenia)" progress is painfully slow.

30. In addition to a lack of political will to make the needed change on the part of national and local government, the private sector has shown little appetite to invest in the region outside selected capitals and big cities. The international private sector now seems more willing to enter into management contracts, possibly as a 'first step' but more ambitious contractual arrangements with greater transfer of risk have proved unpopular. The exception seems to be Russia and Kazakhstan. In the latter there is significant domestic private sector participation; nearly 40% of the small and medium sized towns are served by private utility operators. In Russia domestic companies have established contacts in over 20 cities covering about eleven per cent of the population.

Rapid population changes and increase in informality

31. Since 1989 countries with transitional economies (as defined by UN Habitat) have 'witnessed dramatic increase in population movements, due to social changes that occurred with the collapse of their political systems." (UN Habitat 2004). The Russian Federation, Ukraine, Kazakhstan, Poland and Uzbekistan are the countries with the largest number of international migrants, while Belarus, Ukraine, Kazakhstan, Latvia and Estonia have the highest percentage of international migrants within their populations. International migration tends to be concentrated spatially and over time, so for example, in 2000 more than a quarter of Estonia's population comprised international migrants.

32. General trends around the region can be summarized as follows:

- **Russia** – the most important destination country in Eastern Europe and Central Asia (with more than 13 million immigrants in 2000 (UN Habitat 2004)
- **Baltic Republics** – have the highest percentage of migrants within their populations
- **Tran Caucasus countries** – characterized by high levels of out-migration
- **Eastern Europe**, particularly capital cities – high and increasing rates of migration associated with the move to join the EU

33. Eastern European cities are also transit points for illegal immigration towards Western Europe with an estimated 15,000 illegal migrants passing through Poland for example every year.

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[3] At a conference in Almaty, Kazakhstan, 16-17 October 2000, ECA Ministers of Finance/Economy and Environment with Ministers from several OECD countries endorsed a set of Guiding Principles for Reform of the Urban Water Sector in EECCA to help reverse this preoccupying situation. Five years later, on 17th and 18th of November 2005, in Yerevan, Armenia, Ministers met again to review progress in the implementation of the Guiding Principles adopted in Almaty and to discuss further action.

While the numbers of illegal migrants in transit is relatively small it has an impact on both the housing and labor market and increases uncertainty still further for utility managers.

34. High and fluctuating rates of migration have an impact for utility managers who are faced with fluctuating demand and the challenge of identifying and legally connecting consumers who may have very specific reasons to remain outside the formal system of service provision. The impact is likely to be seen in increased demand, and increased non-revenue water through theft. A recent study of the World Bank also pointed to the need to adapt supply strategies to the realities of the declining quality of the housing stock (World Bank 2005).

Transboundary Issues and the Water Market

35. For some parts of ECA cooperation between riparian states is of particular importance. Ninety percent of the area of South-eastern European countries falls within trans-boundary river basins and more than half of these basins are shared by three or more riparian states. Ninety-two percent of the land area of central Europe and the Baltic states and much of Central Asia and the Caucasus also falls within such trans-boundary basins and in the catchments of the regional seas (Aral, Caspian and Baltic) (see **Box 7**).

Box 7: Transboundary Issues in the Caucasus

In the Caucasus countries, problems have already emerged in the Kura/Araks River basin (which covers Armenia, Azerbaijan, Georgia, Turkey and Iran), over allocation of water to millions of users for agriculture, domestic and industrial, power generation and recreational use. Increasing conflicts are forecast if predicted declines in runoff materialize. The construction of a dam by Turkey on the Chorokhi River has led to erosion of Georgia's coastline due to decreased sediment flow in the river.

Source: World Bank (2003a)

36. Cooperation between competing users, even where river water is not shared between states remains challenging. The integrated management of the resource is likely to become increasingly challenging as demand from competing users rises and shifts at the same time as uncertainty relating to climate change (see **Box 8**).

Box 8: Changing Patterns of Irrigated Agriculture in Central Asia

In Central Asia it was estimated that at the end of the 1990s at least 90% of water abstractions were for irrigation, mostly of cotton. However a 2003 report from the World Bank pointed out that up to 70% of this water was wasted due to poor water management and deteriorating infrastructure, resulting not only in un-necessary losses but also in increasing salinity and water logging (World Bank, 2003a). Looking forward, predicting the likely water requirements for irrigated agriculture seems at least as uncertain as predicting changing precipitation and runoff due to climate change.

4. ADAPTATION STRATEGIES

Adaptation Options

37. "At the present time, only some water utilities in a few countries…. have begun to consider the implication of climate change in the context of flood control and water supply management". This is the conclusion of a recent report on climate change and water from the IPCC. Climate change can have both a negative and positive impact on water services, but one thing is clear, utilities need to plan for change if they are to cope with it.

38. As a region ECA appears to be rather ill-equipped to cope with such change. Utilities that are already somewhat water stressed, with aging and deteriorating infrastructure, and ill-trained workforces now have to face up to unexpected increases in investment needs and greater uncertainly in their future planning.

39. The challenge is to identify the extent to which climate change impacts will be small enough to be managed within the existing system, and those situations where changes 'at the margin' are likely to require more significant changes in infrastructure (for example where reduced rainfall might result in the need for additional reservoir capacity). These changes 'at the margin' are more likely in utilities which have a history of persistent under-investment (as is typically the case in ECA). For example, where investments in new source development have been deferred for many years, these may be urgently required as demand climbs. On the other hand the inbuilt inefficiencies of the soviet-era distribution systems may provide needed extra capacity to cope with future fluctuations in demand as a result of climate change. The degree to which climate change will result in the need for major new investment over and above what is already required to make good decades of neglect is thus not easy to predict.

40. Water utility mangers universally face a trade-off between supply-side adaptive options (more sources, increased storage) and demand-side options (loss reduction, pricing, metering, demand management). With increased uncertainty about water supply, demand management measures will become more attractive. On the positive side water and wastewater systems in the ECA region are generally over-designed. This excess capacity may prove useful in mitigating the impacts of climate change, but could also further stress inefficient dilapidated infrastructure.

Planning for Change at the Utility Level

41. The biggest challenge in adaptation relates to uncertainty in climate change: how can utility managers adapt to climate change given that the magnitude – or possibly even the direction – of change is not known. Conventionally, utility managers assume the future resource base will be constant over the design life of the asset, or that past yield data will apply in the future. This reliance on historical data in particular becomes redundant in the face of growing uncertainty about future changes (AMWA, 2007).

42. A typical response might be to build assumptions about climate change into future demand and supply scenarios which can then be used by managers to make decisions. The problem with this 'top-down' approach is that most climate models, while generating fairly consistent global predictions on temperature rise tend to generate less consistent predictions of precipitation, and become less useful at the regional and sub regional level. This is particularly an issue in the modeling of precipitation and runoff which are heavily influenced by localized geomorphology[4].

[4] When considering towns and cities located in river valleys, or utilities dependent on complex rivereine systems and reservoir cascades for their supply where localized effects may cause flash floods or sudden changes in water quality and turbidity that could not be predicted by more generalized models.

In the absence of credible and consistent scientific data 'top-down' analysis can become bogged down in uncertainty; unpalatable investment options can then more easily be rejected by managers short of capital. The end result may be stasis. The best strategy therefore is to avoid reliance on such models where ever possible.

43. One way around this is to plan on the basis of a set of credible macro-scenarios based on data from across the range of results available. This was the approach for example adopted by the city of Boulder in Colorado which evaluated 12 potential water supply/ demand 'futures' for the city. The intention was to evaluate the long-term adequacy of the city's water system[5].

44. An alternative approach is to start from the bottom-up. Using existing water resource planning models, utilities can analyses the vulnerability of their existing and planned systems to changes that appear likely from the range of climate modeling data available (for example the changes in temperature, precipitation, runoff and water quality described in Tables 1 and 2). This approach enables the 'robustness' of current plans to 'likely' changes in key climate variables to be assessed (APWA 2007). The probability of the most critical events can then be tested against data generated from all the available climate models.

45. This approach is probably a more practical way to 'address and solve the vulnerability in the face of the climatic uncertainty.' (IPCC 2008)

46. In addition to both top-down and bottom up systems planning, the challenges of climate change increase the urgency for utilities to plan their long term future strategies within the context of whole-basin management, in other words within an Integrated Water Resource Management (IWRM) framework. Increasing water resource stress and/or variability will exacerbate existing tensions between competing users of scarce resources, particularly agriculture and the energy sector. Perhaps more than any other region, ECA is faced with severe challenges to manage surface water resources in a way that secures energy supplies, agriculture and water supply. All these users will be facing similar challenges to the water sector in the future, and adaptation options need to be planned in an integrated manner.

47. In either case, new skills and capacities are likely to be needed in utilities that have failed to demonstrate strong capacities to plan and adapt in a pre-climate change world. **A serious shortfall in planning capability coupled with weak performance incentives is probably a more serious problem for most ECA utilities, than the lack of highly sophisticated climate-change responsive modeling tools**.

48. This lack of capacity in planning could be addressed in a number of ways including twinning or technical assistance from utilities with a demonstrated track record of adaptive planning, or technical assistance from other sectors which have demonstrated more effective decision making under uncertainty.

Demand management

49. Modifications to the supply-side infrastructure are costly and difficult to plan for. EEA notes that in many regions of Europe '[c]onventional strategies to increase water supply….are unable to cope with the uncertainty arising from increased climate variability and climate change.' (EEA 2007). Sustained efforts are therefore needed to reduce water demand. Even where supply-side options exist reducing demand is likely to increase the robustness of the system and its ability to

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[5] Another response is to assume that more and more detailed climate modelling is needed. While this may have merit in itself it is not necessarily required for planners at utility level. The Association of Metropolitan Water Authorities in the US observe that 'the general findings of climate research are sufficient to trigger concerns for water supply plans on the 20-50 year horizon' and questions whether more detail is really needed. (AMWA 2007).

cope with future stresses by reducing dependence on scarce water resources. There is tremendous scope to improve demand-side operations in ECA through a combination of reduction in physical losses, and increased control and accountability by the end user through improved metering and billing and better tariff setting.

50. Unfortunately the omens are not good. The OECD noted that responses to the Almaty conference in 2000 which called for many of these changes had been poor (OECD 2007). What is also of concern is that some utilities are small players in the water market (as we have already seen). This means that changes on the demand side in municipal water systems will have limited impact on the system as a whole. Nonetheless even marginal improvements can reduce the vulnerability of the utility to external shock and since they also have merit for financial reasons are probably justified in most cases. Central Europe and the Baltic states are leading the way and show that demand reductions across all consumption sectors are achievable (see **Box 9**).

Box 9: Withdrawal reductions in Central Europe and the Baltics

Over the past decade, there has been a 20% reduction in water withdrawal across the sub-region and in all water-using sectors partly as a result of the decline in economic activity and partly following the introduction of economic instruments in water pricing. For the sub-region as a whole, there has not been a major shift of water allocation among sectors during the 1990s. About 71% of the water withdrawn is used for industrial purposes, 20% for domestic purposes, and 9% for agriculture. Higher water prices and introduction of metering has caused a drastic decline in water consumption in some urban areas, reaching in some cases up to 40%. For example, between 1990 and 2001, domestic water consumption in the Czech Republic decreased from 174 liters per capita per day (lpcd) to 104 lpcd, while water prices increased from 6 US cents per cubic meter to 42 US cents. Similar reduction was also observed in Budapest. Agricultural water use is at the same levels as the 1980s. A considerable reduction in industrial water use intensity has been observed during the 1990s, particularly in the Baltic countries as a result of the restructuring of the industrial sector in favor of industries that consume less water. Some industries have also adopted water-saving technologies.

Source: World Bank (2003a)

51. There remains huge potential to improve demand side management elsewhere. For example there is widespread scope to increase the rate of **metering**. A number of countries have extremely low rates of metering. (Armenia, Azerbaijan, Kyrgyzstan, and Tajikistan all report rates between 0-10% of total connections and even Russia shows only around 20% connection are metered in 2003 (OECD: EAP Task force on Water Utility Performance – Indicator Database).

52. At the same time overall **consumption** of water per capita is extremely high across the region Georgia, Kazakhstan, Moldova, Russia, Tajikistan and Ukraine all report consumption rates well above the UK median of 200 liters per capita per day (lpcd). Non-revenue water (NRW) is similarly well above international best practice, with eight out of nine reporting countries showing NRW in 2003 over the US median in 1996. (The city of Yerevan in Armenia in 2003 reported NRW just below 75% although other country data shows rates more commonly falling in the range of 30-60%).

53. **Tariffs** too present opportunities to improve demand side management. As already noted, tariffs are generally low compared to costs. The challenge in restructuring tariffs may be in terms of affordability although the data from the utility data base shows for nine city or national utilities that water bill is well below 4% of average household income. Increasing tariffs may present more of a problem in smaller towns and cities and rural areas served by utilities.

54. Unfortunately the poor performance of many utilities makes such demand-side interventions challenging. Consumers are usually slow to support weak utilities if they try to limit

consumption, raise tariffs or increase collection rates. Furthermore consumers in many states have long enjoyed ‘free’ or highly subsidized water and the shift towards cost-recovery tariffs, metering and demand management may prove politically challenging, particularly given many utilities’ limited experience of customer-engagement (World Bank, 2001).Nonetheless demand-side interventions are clearly a big part of the future for most of these utilities in the face of predicted climate changes.

Supply-side Adaptation Options

55. In addition to demand-side interventions there may be a need for supply side adaptation as well. Table 4 summarizes some of the typical interventions that may need to be considered. Some of the specific issues arising from these are discussed below:

56. **Reservoirs and Dams**: Declining water supplies and increased seasonal variability in river flows will naturally lead to a discussion of the need for increased storage. Storage provides a dampening effect against variability which can have important advantages both to secure supplies during drought and to dampen the effects of extreme flood events. The problem is that these two objectives, coupled with competing demands for water for agriculture and power generation are often in conflict. Should reservoirs be kept full against drought, or empty against floods?

57. Dams are costly to build, and the economics are difficult to calculate given the extreme uncertainty of the climate predictions upon which their design must in future be based. Nonetheless, improved management of existing reservoirs, and further development of existing and new facilities is certainly an important ‘long run’ option for many utilities. New construction and management techniques will be needed to protect costly dams against extreme flood events. In 1985 for example an unexpected flood surge from a glacial lake outburst destroyed the almost-complete Namche Small Hydro Project in Nepal – at a cost of US$1 million (Stern Review, 2008).

58. **Flood Protection**: Investments in flood protection will also become increasingly important, not only for run-of-the river-assets such as dams which lie in the direct line of flood surges but also for treatment plants, and distribution systems.

59. **Flood Management Planning**: Management of flood risks will be critical for many utilities as the frequency and intensity of flood events is likely to increase across much of the ECA area. Of particular concern is the risk of catastrophic flooding mostly in Central Asia due to lake and glacial outbreaks.

60. Flood management is challenging, particularly where competing users place strains on the requirements for use of storage capacity. It is also challenging for countries with limited resources to invest in costly infrastructure (dams) and where rivers are already fully developed. Hungary and Romania provide interesting examples of how flood preparedness can be built into national plans (see **Box 10** and **Box 11**).

Box 10: Hungary – Vasarhelyi Flood Mitigation Plan

Between 1998 and 2001, four extraordinary floods occurred in the Tisza River Basin. Considering the magnitude of the endangered areas, the populations threatened, and the goods damaged, these floods broke every record in the upper and middle Tisza areas. Evaluation of the repeat floods made it clear that the method of heightening and strengthening dams to protect the country against floods should be reconsidered.

The ‘Improvement of the Vasarhelyi Plan’ (IVP) project has been developed, aiming to provide flood safety by storing excess water in reservoirs. The overall objective of the program is to increase the discharge capacity of the flood bed together with the ecological revitalization of the floodplain.

Preparatory studies have looked at ways to facilitate an increase in the discharge capacity of the flood bed through alteration of land use, and have identified around 30 sites which might be able to store excess water as reservoirs. Between 10 and 12 sites have been selected which have the total storage capacity of around 1,500 million cubic meters. According to preliminary calculations, this capacity is enough to decrease the peak levels of extreme floods by one meter all along the Hungarian section of the Tisza.

Prompted by the results of these extensive preparatory studies, the Hungarian government adopted a decision on the first stage of the IVP in 2003. During this first stage of the plan, six reservoirs (Cigand-Tiszakarád, Szamos-Kraszna-közi, Nagykunsági, Hanyi-Tiszsülyi, Tiszaroffi reservoirs and part of the Nagykunsági reservoir) will be built. In addition, the discharge capacity of the flood bed will be improved.

The IVP also aims to establish new landscape management in the territory of the reservoirs as well as regional, rural, and infrastructure development – which will result in a healthier Tisza River Basin.

Source: International Commission for the Protection of the Danube River at http://www.icpdr.org/icpdr-pages/dw0602_p_11.htm

Box 11: Hazard Risk Mitigation and Emergency Preparedness Project, Romania

Romania is severely exposed to a range of natural disasters, especially earthquakes, floods, and landslides, which have caused large economic and human losses across the country. A Hazard Risk Mitigation and Emergency Preparedness Project with support from the World Bank aims to implement risk reduction measures and raise institutional and technical capacity for disaster management and emergency response. Among the project components, there are two specifically aimed to reduce flood risks and to protect the Black Sea and Danube. The flood risk reduction sub-component aims at reducing flood risks and vulnerability of flood-prone areas in Romania through structural and non-structural measures and to improve the safety and effectiveness of large and small dams. The component on risk reduction of mine-induced pollution to the Danube and Black Sea basins will improve the management of tailings dam facilities located in the Tisza Basin.

Source: World Bank (2003a).

61. **Other Strategies to Increase Water Production: Table** 4 provides a brief overview of physical adaptation options. In addition to dams, some utilities will ultimately turn to new sources to secure long-run supplies. One option may be desalinization. The economics of desalinization have until recently kept it out of reach of most utilizes, but the increasing costs of alternative supplies, and improvements in technologies may make it increasingly attractive in the future (Global Water Intelligence, 2006). Other options will include promoting more recycling and re-use of wastewater (a strategy that is currently being rolled out in the Midwestern US for example).

62. **Reducing energy reliance:** In an effort to reduce their operating costs, and carbon footprint, many utilities globally are focusing on changing their operating strategies to reduce energy use. A recent study in Germany, Austria and Switzerland suggested that energy costs of operating conventional wastewater treatment plants could generally be reduced by 30%-50% simply be improving operational procedures (Wett et al, 2007). In ECA the World Bank is already

supporting utility energy audits (for example in Ukraine and Moldova) that highlight areas where small operational changes can reap big rewards. Reducing energy reliance has the advantage not only of reducing costs but also reducing the vulnerability of the utility to shocks in the energy network caused by climate effects.

Table 4: **Options for Physical adaptation**

	Water supply	**Wastewater and sewerage**	**Stormwater drainage**
Decrease in water availability	Increased production from alternative sources: new sources, new storage capacity, desalination Demand management: reduce physical losses, increase metering, improve billing and collection, and restructure tariffs.	Increase recycling of wastewater for appropriate uses Invest in decentralized wastewater systems; increase the use of on-site and dry systems where appropriate.	Invest in collection, groundwater recharge and recycling of stormwater. Recycling and re-use of wastewater, dual-use systems to reduce reliance on potable water for toilet flushing and other non-potable uses.
Lower water quality	Improve and change water treatment processes Shift to alternative sources Invest in protecting key water sources	Provide appropriate additional treatment as required.	Invest in collection, groundwater recharge and recycling of stormwater
Saline intrusion	New sources, desalination, recycling of treated wastewater for selected users and uses. Demand management to reduce reliance on groundwater.		Invest in collection, groundwater recharge and recycling of stormwater
Increase in runoff variability	Increased or modified storage capacity. Demand management to increase robustness of the system to supply-side shocks. Reduce energy reliance.	Provide for bypass facilities to prevent overloading or washout of key facilities. Invest in flood protection at key facilities. Separate wastewater and stormwater drainage.	Increase capacity of key facilities. Invest in more flexible non-pipe options (greenways and street-as-drain systems). Invest in collection, groundwater recharge and recycling of stormwater.

Source: Author's summary

Costs of Adaptation

63. The Stern review estimated that the total additional costs of making new infrastructures resilient to climate change in OECD countries could range from USD 15-150 billion per year ((0.05-0.5% of GDP). There is little detailed information in the literature on which to base detailed cost estimates for climate change adaptation and this is an area where more work is needed; although also one where utility-specific analysis is likely to be of more use than generalized region-wide data.

64. **One thing is clear however, that the costs of adapting to climate change may be dwarfed by the ongoing needs of existing systems in the region** (the figures in the paragraph above can be compared to the estimates of USD 15-34 per capita required to bring maintain and renew infrastructure in ECA utilities at the current level already cited). An earlier analysis by Boland (1997) cited by AMWA showed that 'the estimated effects of climate change on municipal demand in Washington, D.C.… is "small" relative to economic development and the effect of different water conservation policies' (AMWA 2007**). In other words climate change may have an impact 'at the boundary' but for many utilities in ECA it is not yet the most critical factor driving investment requirements**.

Linkages and Tradeoffs

65. There is no doubt however that climate change brings additional uncertainty and complexity to the planning environment. The interlinkages of the water cycle mean that most decisions will impact on other aspects of water and sanitation service provision or will interact with other sectors particularly energy and agriculture (see **Box 12**).

66. Utility managers will inevitably have to make judgments about cost-tradeoffs. Short run investments with immediate impact on the operational viability of the utility (demand management for example) need to be set against long-run investments that may provide protection against future climate-related shocks but will have only a negative impact on operating margins in the short run (a new dam for example). Investments in desalinization may secure supplies but will increase the dependence of the utility on increasingly-insecure energy supplies (see **Figure 1**).

67. Short run performance improvements are likely to have the greatest impact on both resilience to climate shocks and operating costs and can be prioritized by utility managers even in the absence of reliable climate change data for the coming decades. The challenge is to identify where the 'margin' of viability lies and generate sufficient information to judge when it is appropriate to 'step-up' to the next band of investment requirements. The American Water Works Association suggest that "the general findings of climate research are sufficient to trigger concerns for water supply plans on the 20-50 year planning horizon" (AWWA, 2007) – a horizon that is likely to encompass new reservoir developments, and other more capital intensive developments even before taking the likely impact of climate change into account.

68. **Fundamentally, climate change demands new and sophisticated planning skills which are lacking in many utilities in the region. Support for capacity building is urgently required**.

Box 12: Interlinkages between different adaptation strategies

Increased storage – while increased storage can help mitigate against drought it is a high cost option and can have damaging negative effects on groundwater recharge and river management downstream. Its management is challenging – winter releases for energy generation must be balanced against summer releases for irrigation; summer storage against potential drought must be set against emptying reservoirs to cope with potential food events.

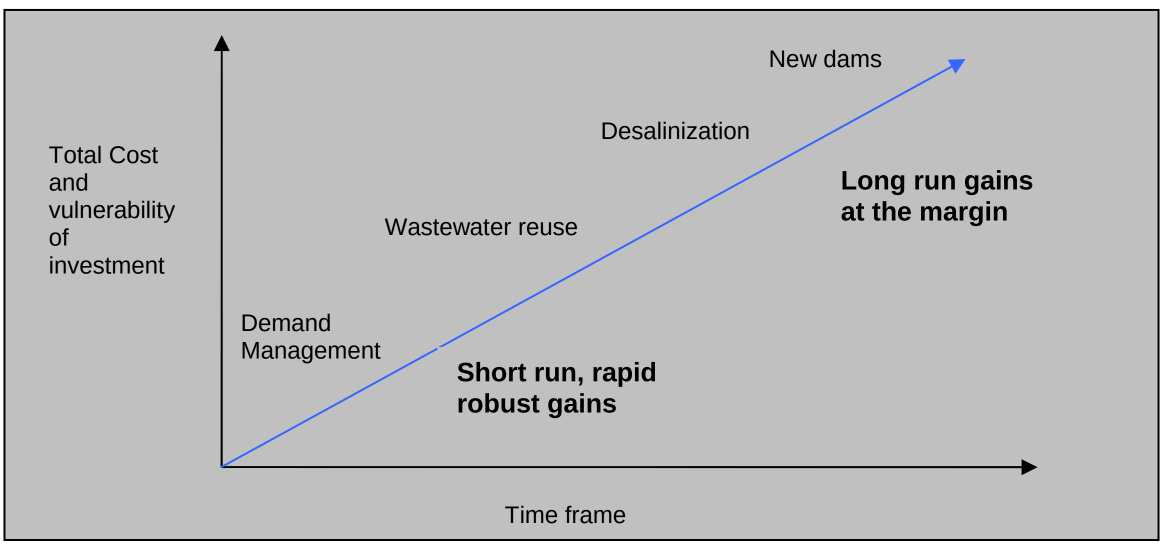
Improved Stormwater drainage capacity – while more efficient and higher capacity stormwater drainage may help to prevent flood damage it may reduce infiltration rates with detrimental impacts on groundwater.

Coastal and river flood protection – raising embankments and levees in flood risk areas may provide short term protection but can increase the risk of long term catastrophic flooding as water levels are allowed to rise to higher and higher levels. Saline intrusion may also result in some coastal areas, whereas in upstream catchments there may be a negative impact on groundwater recharge and agricultural practices if historic seasonal flooding events are interrupted.

Desalinization – while desalinization is increasingly economic attractive in some locations it is highly energy intensive – perhaps placing additional burdens on the need to use upstream storage for electricity generation. It can also have a devastating effect on coastal ecosystems.

Wastewater re-use – while re-use is attractive particularly where separated systems are constructed, the recharge of rivers and groundwater downstream may be negatively impacted.

Figure 1: **Time and Cost Trade-offs**



5. IDENTIFYING THE KEY CHALLENGES

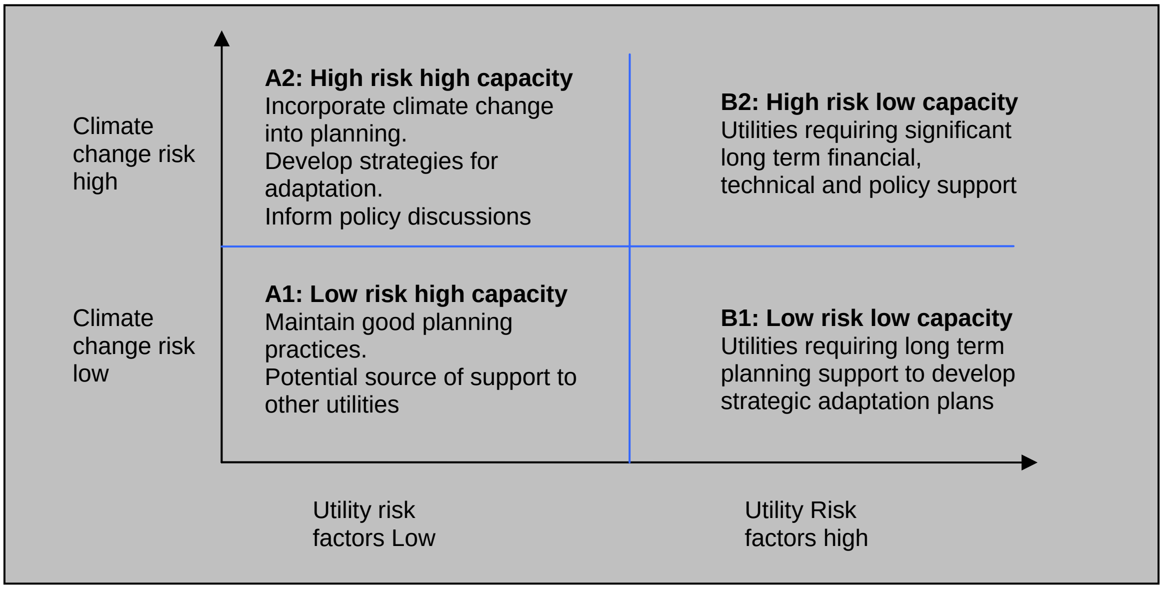
A generalized model to assess vulnerability

69. The picture which emerges in ECA is complex and rather daunting when it comes to assessing vulnerability of water utilities to climate change. Not only are the problems large but there are significant variations across the region, both in terms of the magnitude of the changes that are expected and the ability of utilities to respond. A blanket approach will not work; the benefit-cost of adaptation options will depend on local circumstances. As a region we cannot assume that there is a single optimum response, rather that there are thresholds for every utility in every water stressed country which will determine when the best balance between different potential responses. The concept of a 'threshold' limit helps to identify key vulnerabilities in the system. In many cases other issues (for example restoring systems to their design capacity, reducing non-revenue water or negotiating new abstraction rights in response to changing agricultural patterns) may remain a priority well ahead of adaptation to climate changes.

70. As we begin to overlay utility-specific analysis of capacity and water stress / utility risk factors with the potential impacts of climate change a picture begins to emerge; utilities are likely to fall into four broad categories or sets (see **Figure 2**):

- The first set of utilities (**A1 in Figure 2**) is those which face low climate change risks and have good capacity to respond. This set of utilities have little to do but to maintain good planning practices and perhaps represent a potential pool of support to more highly stressed utilities elsewhere in the region. This is probably a rather small set of utilities likely to be concentrated in a few countries.
- The second set of utilities (**A2 in Figure 2**) face much higher climate change risks but also have good capacity to respond. Here it is important that likely climate change impacts be rapidly brought into the planning horizon and suitable strategies for short to long term responses are planned. In addition this set of utilities can provide useful insights into appropriate policy responses for government; their own response will provide guidance for similarly-located but weaker utilities.
- The third set of utilities (**B1 in Figure 2**) face low climate change risks (as for the A1 group) but have much weaker capacity. Although the likely impacts of climate change are small they may still have an effect at the margin. This is a set of utilities that already requires significant support to improve operational and investment performance and for them, climate change should be built into strategies for capacity building and enhanced planning.
- The final set of utilities (**B2 in Figure 2**) is the group who give cause for greatest concern. These are utilities with very weak capacity facing significant risks from climate change. Here significant financial, technical and policy support may be urgently needed to equip these utilities to face the challenges of both improved operation and climate change. The impacts of climate change must urgently be built into all plans for rehabilitation, improvement and extension of these systems and an analysis is needed to identify those instances where climate change is likely to result in the need for major new investments. Identifying this group is perhaps one of the most pressing tasks.

Figure 2: Mapping Utility Vulnerability



71. In the following sections we discuss briefly how such a map of vulnerability could be built up for the utilities of the ECA region.

Mapping Climate Change Risk

72. The first step in the analysis is to identify **climatological 'hot spots'** or areas where the effects of climate change themselves are likely to be greatest. From Section Two we have seen that these can be broadly grouped as follows:

- Southeast and central European areas and Baltic states with high reliance on fragile groundwater sources or surface water sources already under stress and transboundary surface water. These areas are likely to experience hotter and drier average conditions coupled with an increased risk of high intensity flood and runoff events.
- Eastern Russia – significant warming, shift of permafrost line northwards.
- Central Asia – significant warming and variations in precipitation putting strain on already stressed surface water sources and transboundary waters. Increased risk of catastrophic flooding due to lake and glacial outbreaks.

73. In the rest of the region climate change impacts will certainly be felt but may in general be less severe although localized effects may be significant:

- Caucasus, Kazakhstan, Moldova and Belarus – areas showing a significant warming trend and possibility of increased precipitation and runoff.
- Western Russia – warming and increased precipitation in parts – likely exacerbating of current flood impacts

74. In every case, as we have already seen, the analysis needs to be further refined to reflect local conditions but this initial analysis gives us an idea of where to focus the analysis and in what parts of the region are the most climate-change-affected utilities likely to be found.

Mapping Adaptation Capacity

75. The second step is to map the **capacity of these utilities to respond and adapt**. We would propose to do this through a process of identifying specific risk factors which will hamper efforts to adapt to climate change challenges. Risk factors can be generally divided into the following broad sets:

- **Economic risk factors**: The set of economic risk factors relate to the macro economic environment within which utilities must operate. Economic factors that might mitigate against effective responses from utilities include: a recent shift from command to market economy; a declining industrial base resulting in rapidly changing demand and supply environment and unstable economy; and high and/or increasing levels of poverty. By contrast utilities operating in a more stable growing economy (possible in the larger cities of Western Russia for example) may be in a stronger position.
- **Utility endowment risk factors**: The condition of the utility's baseline endowment of infrastructure will also determine how robust a response is possible to climate-change-induced stresses. Several factors may weaken utility response including: poor condition of existing utility infrastructure; historically under- or over-designed systems; poor quality or inappropriate mix of services (for example over or under investment in wastewater treatment facilities); and a large backlog of maintenance requirements.
- **Utility operations risk factors:** Risk factors relating to operational conditions have already been discussed in Section 3. In summary, utilities with poor operational conditions are likely to be in a weaker position to adapt than those with better operational conditions. Thus high levels of non-revenue water, low operational cost recovery, and poor operations and maintenance practices are all likely to result in suppressed ability to adapt.
- **Utility baseline resource risk factors**: which can be divided into two elements. Firstly the robustness of the resource and secondly the relative position of the utility within the water market .
    - Robustness of the resource: Utilities who rely on multiple sources of water with high potential for further development and exploitation are likely to be in a stronger position than those with a heavy reliance on single and/or fragile water sources - for example Karst water and river sources which have little potential for further development. Armenia and Georgia for example have extremely limited storage capacity while competition between users is increasing. In Latvia it is noted that utilities are highly reliant on groundwater which is falling rapidly (15-18m in recent years). These cases could be contrasted with, say, Hungary, which has a reliable and under-exploited source at its disposal (see **Box 13**).
    - Water Market risk factors: A final set of risk factors relate to the ability of the utility to influence significantly the supply-side water market. In basins where domestic and industrial or municipal water constitutes only a small fraction of abstractions it may be relatively more difficult for utilities to influence the long term viability of the resource through new development or changed operational procedures. In such cases changes are needed at a higher 'policy' level. This would be particularly a challenge in basins where agriculture dominates water use. For example in Armenia 80% of crop production is irrigated while in central Asia up to 75% of agricultural land is irrigated.

Box 13: The Use of Bank Filtered Water in Hungary

Hungary relies on bank filtered water to meet one third of public water demand. All of the drinking water supply of Budapest for example derives from bank-filtered water of the Danube. The abstracted amount is only limited by the filtration capacity of the bank and since the discharge of the river is an order of magnitude greater than the abstracted amount there is practically no limitation from the resource side. The supply is therefore extremely secure especially when contrasted to the sensitivity to climate change of other groundwater resources.

The advantage compared to the direct abstraction of surface water is the reduced treatment requirements of the water. The natural filtration capacities of the exploited river sections are very efficient, no micro-pollutants have been found in the abstracted water. This advantage is valuable for users requiring high quality drinking water for public supply and some industrial use, but not for irrigation. Well fields exploiting bank filtered water are mostly along the Danube, only two can be found on other rivers (one in the south-western part of the country, and one in the northern part). The actual use is 0.9 Mm^3/day (75% for public purposes), the further potential capacity is approximately 4 Mm^3/d, out of that 300 000 m^3/d capacity is protected as designated future water resources.

Source: UNESCO IHP (2005)

76. By combining these risk factors we can build up a picture of vulnerability and ability to adapt for individual utilities.

77. In **Figure 3** we have shown how risk in utilities could be mapped. To illustrate the approach we have taken two contrasting ECA utility situations; Yerevan in Armenia, and Budapest in Hungary and mapped them against what might be considered as a stylized or ‘ideal’ utility in Western Europe.

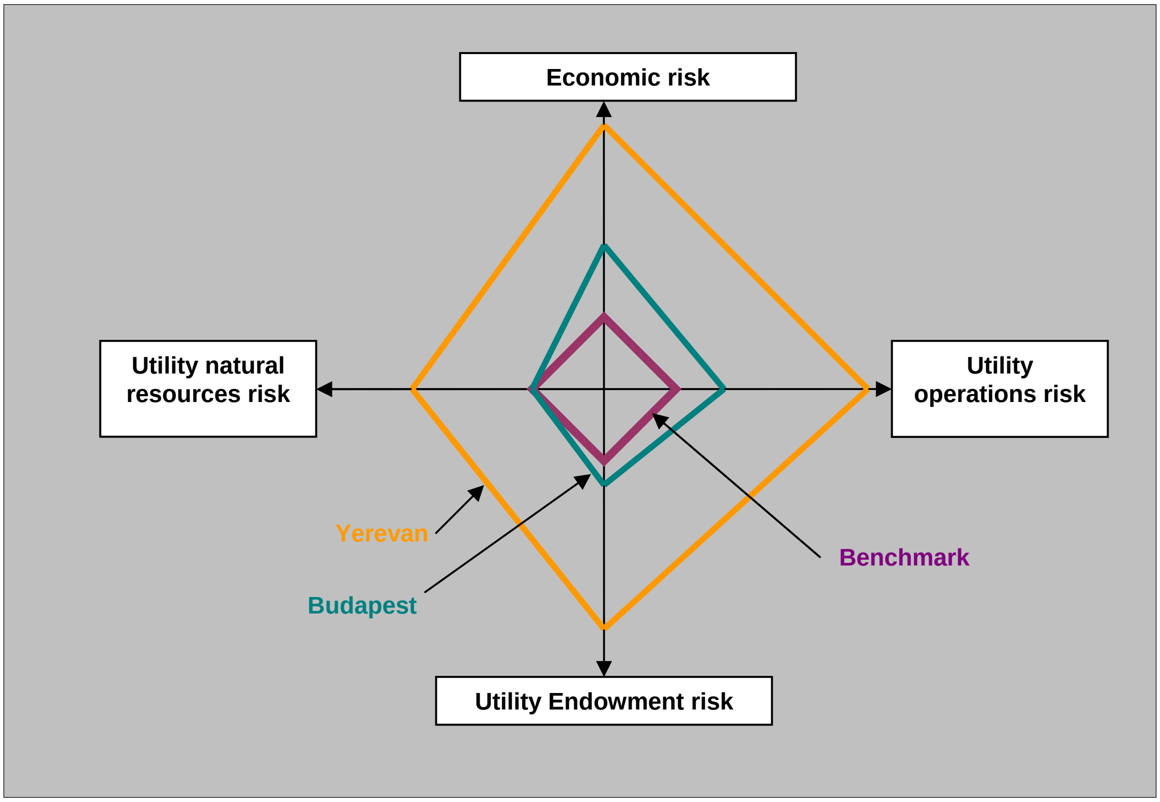
78. Yerevan is in a state of change with slow improvements being made from a very low operational and performance base. Unaccounted for water is high (over 70%), metering low, and hours of service very low (around 5 hours per day) but revenue is approaching operational cost recovery. The utility operates within the very weak economic conditions prevalent in Armenia, with high levels of poverty and low financial resources. The natural resource endowment is rather fragile.

79. In contrast the city of Budapest is located in the stronger economic framework of Hungary, with lower levels of poverty in the city. It has a robust natural resource base. Recent tariff increases and other demand management interventions have seen both domestic and industrial consumption decline. While it is challenged by the need to meet the requirements of various European directives since Hungary’s accession to the EU the city has been able to invest in new wastewater treatment capacity in recent years.

80. When mapped, broadly, against the risk factors listed above we can see immediately that the city of Budapest is in a stronger position to respond to the challenges of climate change but that both are at higher risk than an idealized or ‘average’ western European utility.

81. Returning to **Figure 2** we can see that while Budapest and Yerevan are likely to be exposed to similar climate change risks (including more frequent and more severe flooding, possibly necessitating significant investments to protect existing infrastructure and prevent contamination of water sources due to wastewater overflows, and increased risk of drought) their capacity to respond is different. Budapest probably falls in the ‘A2’ set of utilities (high risk, high capacity) but Yerevan falls in the ‘B2’ set (high risk, low capacity). The risk of catastrophic impacts is higher for Yerevan and its ability to adapt may be much more constrained than that of Budapest.

Figure 3: Risk Mapping for Climate-change Adaptation in Utilities



82. Other utilities may do better or worse along some of the axes of analysis of **Figure 2**. The point here is to show that the baseline situation of the utility may be at least as important as the level of exposure to climate-change-related stresses in determining how well a utility can respond.

83. In conclusion it is clear that the ability of ECA utilities to respond to climate change risk will vary enormously. In this section we have laid out one possible analytical approach to analyzing the interactions between climate change risk and utility capacity. This is a nascent conceptual framework that can be further developed and used to identify a set of appropriate responses for differently-stressed utilities in the region.

6. POLICY RESPONSES

Constraints and Opportunities

84. Most utilities in the ECA region are already facing a massive bill to clear a backlog of delayed maintenance and rehabilitation of existing infrastructure. On top of this there remain outstanding challenges in some countries just to reach unserved populations, and to raise levels of service to standards required for the maintenance of basic health. When the costs of adapting to climate change are added the situation appears extremely bleak.

85. Utilities face three types of constraints to meet the challenge thrown up by climate change action:

- firstly financial (a lack of available capital, and appropriate financial instruments)
- secondly institutional (a lack of appropriate incentives, legal instruments, capacity and skill); and
- finally in the wider environment (the politics and political economy of wider decision making).

86. There are also important opportunities which can be useful for countries in ECA. These include additional and new financing structures: EU grants for adaptation, funds from the United Nations Environment Program and the Global Environment Facility; and the growing body of knowledge and experience of adaptation, particularly in Europe.

87. Governments both at the national and regional level clearly have a role to play in addressing all three sets of constraints and exploiting the available opportunities.

Finance

88. The challenge of accessing new sources of finance cannot be entirely separated from the institutional situation of these utilities (after all, lenders remain reluctant to finance utilities with weak cost recovery and decaying assets). Governments may be able to assist both by working with international financing agencies to design appropriate financial instruments, by structuring internal financial incentives to increase the flow of funds to utilities that demonstrate a commitment to improving performance, by ensuring that water utilities are eligible to apply for funds associated with climate change adaptation, and by channeling technical assistance towards utilities with credible plans and programs.

89. Governments can also help to protect utilities from financial shock by structuring insurance-type strategies - financial instruments that protect the utility from external risks while maintaining performance incentives for good operation of the system - and by diversifying the financial base of public utility companies[6] (Willows and Connell, 2003).

90. Another way to protect utilities from shock is to establish their permanent right over certain abstractions. This is usually done by purchase of rights from farmers and is only a viable option where the value of water for domestic and industrial supply outstrips its value as an input to the agricultural sector (Miller and Yates, 2005). It is also dependent on the existence and formalization of water rights in a river basin, which is not always the case in ECA (For an

[6] In other words to ensure that a utility can continue to function even under situations of extreme shock the institutional structure of the sector can be modified to provide additional sources of finance to the utility operator.

interesting discussion on the advantages and potential pitfalls of various water rights regimes and their implications for climate change adaptation see Levina and Adams 2006).

Institutional Incentives

91. The current institutional environment in many ECA countries does not always promote better performance (OECD 2005). The general literature on water utilities provides many examples of the ways in which performance incentives for utilities can be improved in general and these are equally applicable to improving performance with regard to climate change. Several areas however merit particular attention, in particular shifting incentives and financing so as to encourage improved and more responsive long term planning – a key strategy for climate change adaptation.

Links with the wider environment

92. We have already seen that interventions to address climate change in water supply and sanitation are both affected by and will affect all other uses of water within the water basin. Potential conflicts between, for example, water supply to the capital city and irrigation water for agriculture are matters of public policy and therefore call for a response from government.

93. Governments can take action at three levels. Firstly by committing at the national level to addressing climate change head-on across all sectors. Secondly by strengthening regional linkages and thereby improve the potential for basin –wide Integrated Water Resources Management. Finally by embedding water utility planning solidly within a generalisable Environmental framework (that is by providing a planning framework that links the needs of the utility to the needs of other sectors).

94. The use of comprehensive **Drought Plans** has proved important in drought prone areas of the US, Western Europe and Australia for example (see **Boxes 14** and **15**)

Box 14: Drought Planning in Colorado USA

There has been a drought situation in Colorado which started in 1999, peaked in 2001-03 and has eased in recent years. Inflow into some of the reservoirs was 25% of the long term average in 2002. As a state that is very sensitive to water issues, Colorado has launched a number of initiatives to address potential droughts.

Colorado has a Drought Mitigation and Response Plan which was first created in 1981 (when it was one of only three drought plans in the US), and last revised in 2002. The Department of Local Affairs, the Division of Local Government, the Office of Emergency Management and the Department for Natural Resources were all involved. It was partially funded by the Federal Emergency Management Agency (FEMA). It involves four stages monitoring, assessment, mitigation and response and has been activated fully or partially several times over the last 25 years.

To address long term water shortages, the State wide Water Supply Initiative (SWSI) was carried out in Colorado, the conclusions of which were published in 2005. This was a long-term drought plan that aimed to explore, at a basin level, existing water supplies, projected demands up to the year 2030 and the ways in which supplies could be met. For each basin the ways in which water supplies could be met were researched and listed. This kind of long term water supply plans will be more helpful in adapting to climate change and reducing vulnerability in the long-term. However, climate change was not included as a variable which will affect water supply.

Also in 2005, as a result of the State wide Water Supply Initiative, the "Colorado Water for the 21st Century Act" (House Bill 1177) was passed into law. The act seeks to initiate a state wide discussion on how water may be managed and shared among river basins to meet future water demands (Formisano, 2005). This House Bill also guarantees that the current system of allocating water rights will not be 'superseded, abrogated, or otherwise impaired'.

Source: Levina and Adams (2006)

Box 15: Drought management in Australia

Australia has developed a sophisticated and wide ranging policy response to the increasing risk and growing impact of droughts on the country. This includes both technical responses to modify both supply and demand of water and institutional responses to better enable the country to cope with the impact of droughts in the future.

Technical adaptations include:

- Increased monitoring of water use in terms of production and climate rather than area
- Development of probabilistic forecasts of likely water allocation changes
- Development of tools that enhance crop choice (maximize efficiency and profit per unit water)
- Building of climate change into integrated catchment management strategies and new infrastructure development
- Incorporation of climate change into long-term water sharing agreements between states and users
- Development of a better understanding of sustainable yield and environmental flows taking climate change into account
- Minimization of water loss from storages, canals and irrigation systems
- Recycling of waste water.

Steps are also increasingly being taken to better design human environments to cope with potential health stresses resulting from climate change. These measures include:

- Air conditioning and other measures to reduce exposure to heat.
- Limiting exposure to disease vectors by measures such as use of screens on doors and windows and restriction of vector habitats (especially near waterways and urban wetlands).

Land-use planning is now also geared to minimizing ecological factors that increase vulnerability to potential climate changes, such as deforestation (which increases runoff and the risk of flood related injury and contamination of water supplies), animal stock pressures on water catchments, and settlement of marginal or hazardous areas such as semi-tropical coastal areas that are prone to storms and close to good vector breeding sites.

Source: Pittock, B. 2003

95. In general in ECA water utility planning is only weakly linked to the overall management requirements for water resources as a whole (World bank 2003a) although there have been notable successes in the Baltic Sea states and slow progress is being made in the Aral Sea basin. Changes are clearly needed both to create stronger incentives in the water supply sector, create stronger linkages into the arena of water resources management and to stimulate an improved flow of capital towards cash-starved utilities with serious investment needs.

96. In terms of building stronger linkages with water resources management a possible model for the future is the Water Framework Directive (WFD) of the EU. The WFD is a key instrument in climate adaptation policies in the water sector in member and accession states in the EU (EEA 2007) because it requires member states to:

- undertake comprehensive stocktaking of environmental pressures including additional climate change pressures;
- apply a river basin (catchment areas) approach (across administrative boundaries)
- aim for long-term ecosystem management
- monitor relevant environmental (climate change and related other) impacts
- define clear (environmental quality) targets
- devise and implement management plans with concrete measures to achieve these targets; and
- review management plans regularly to take account of recent data and information.

97. Importantly the WFD applies to all member states and thus creates a common platform for riparian states sharing river basins. Most European countries have taken steps to implement both the letter and the spirit of the WFD (see **Box 16**). Similarly robust structures are needed in ECA to balance the interests of users of increasingly stressed water resources in transboundary river basins.

Box 16: Adaptation in Policy in Western Europe

Western Europe has adopted the Water Framework Directive of the EU as its standard for responsible stewardship of water resources and many countries have made specific changes to the way water is managed. For example:

Greece has launched collective land reclamation projects which combine surface run-off collection, improvements in irrigation networks and the use of underground and pond aquifers.

In the **Netherlands** climate change is integrated into the water policy agenda. The spatial and urban planning implications of climate change have been considered along with the balance of risks from flooding and drought. The government's rural policy also includes provision for increased safety and flood prevention and measures such as improving water quality and combating falling water-tables.

In **Denmark** several areas are at risk of both coastal inundation and increased runoff from land-based drainage systems. Immediate technical solutions such as raising flood embankments will have a limited impact in the long run, to measures to address and change land use patterns further upstream in the river basins are being considered.

Finland has a program of dam safety improvements, **France** and the **UK** are both improving flood risk assessments and management. **Malta** has instituted water conservation and water saving projects, while **Ireland** is investing in interbasin water transfers.

Source: adapted from EEA 2007

98. Levina and Adams (2005) note that despite the adoption of the WFD, national frameworks in member states could all be 'enhanced to promote adaptation to climate change' and this is likely to be even more the case in ECA countries. Levina and Adams go on to note that a suitable national framework would comprise the following elements:

- A system of laws (legal frameworks) that stipulate rights and responsibilities of different levels of government and private entities. These may include, for example, a system of water rights and abstraction permits;
- A variety of national, regional and sub-national institutions that are responsible for developing policies and overseeing their implementation;

- A set of policies that guide the implementation of national, state and provincial laws;
- Clearly defined roles for the key players, including government ministries, departments, water suppliers, regulators and other local authorities;
- Physical water infrastructure, that is dams, levees, reservoirs and sewerage systems that are capable of managing the flow and distribution of water;
- A set of water management plans (long-term strategic plans, drought plans and flood plans) with flexibility to anticipate and respond to climate changes; and
- A system to share current and projected climatic information.

8. OUTLOOK

Future Prospects

99. ECA is a region facing severe challenges because of climate change. Current relatively high access data for water and sanitation service mask a deteriorating situation with aging infrastructure and serious operational challenges. Capacity to adapt to climate change appears to be rather limited. Utilities are in poor financial shape and seem to be relatively ill-prepared to face increasing uncertainty in the future.

100. The region as a whole faces serious challenges to balance the water demands of several critical sectors (domestic water supply, agriculture, energy and industry) in the context of growing climate variability. While the southern part of the region is facing increasing overall scarcity, the region as a whole is also facing up to increasing extreme weather events – both of which will create specific challenges for management of reservoirs. Particular challenges are likely to arise in the short to medium term in:

- the Mediterranean region where water will become increasingly scarce;
- countries of former Yugoslavia and in the basins of large regional seas (the Aral Sea and Caspian for example) where transboundary issues will be exacerbated;
- in central Asia where there will be reduced supply due to glacial snow melt and increasing risk of catastrophic floods from lake and glacial outbreaks; and
- in the countries of the former Soviet Union in Central Asia where capacity is extremely low and the transition to a market-based municipal model of service provision has left many utilities severely under-capacitated.

Support to be Provided

101. Efficient adaptation to climate change in the water sector requires effort in 5 areas:

- Improving incentives, institutional structures, financial arrangements to improve the overall operational capacities of utilities and specifically to build their capacity for strategic and effective long term planning;
- Building international structures for transboundary negotiation and cooperation;
- Building domestic structures for improved integrated water resources planning;
- Improving systems of data collection and analysis so as to build the best possible basis for future planning and adaptation; and
- Supporting and implementing priority actions and investments.

102. Crucially there is a serious lack of capacity to plan and manage utility services in the region. Efforts are needed urgently to build technical capacity to address the growing challenges. Catalytic support could immediately improve the linkages between struggling utilities and those with rather better track records of performance within the region and in Western Europe. Stronger linkages to available source of expertise and funding such as the EU, UNEP etc would also have a significant impact.

103. A specific need is for support in improving operational and management practices at critical reservoirs so as to balance the requirements of water supply, flood control, energy generation and irrigation as effectively as possible.

104. **This would be critical even in the absence of climate change given the fact that the backlog of rehabilitation and investment requirements for many ECA utilities dwarfs the investment requirements triggered by climate change.**

Research Needs

105. The need for generalized and highly technical research is perhaps less than the need to develop credible data and empirical analysis at the local level. The absence of reliable information severely hampers the planning efforts of utility managers and policy makers alike and points to the need for tailored support to utilities on a case by case basis to equip them to face an increasingly uncertain future.

106. Further there is a need to create linkages for utility managers with the growing body of knowledge and information on effective strategies for flood and drought management, demand-side management and supply-side adaptation. Best practices and industry standards exist but are perhaps too little known in the ECA region.

Role of the Bank

107. The Bank clearly has a role of play in four main areas:

- To support a region-wide analysis that can broadly identify the utilities in most critical need for support due to a combination of high climate-change-related risk and low capacity;
- to support high quality localized analytical work that can be used to equip those utility managers and policy makers to improve both policy and planning;
- to provide targeted investments to those utilities with the most critical need; and
- to play a convening role, linking ECA institutions to the wider professional and policy making community within Europe.

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