D 2.1.1 REPORT

BASELINE VULNERABILITY ASSESSMENT

Report of the NeWater project -
New Approaches to Adaptive Water Management under Uncertainty

www.newater.info

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Preamble

The Newater project has assembled a group of enthusiastic people with different scientific and practical background. In and of itself, the project presents a major challenge and a practical lesson in social learning in order to promote and guide the research process to profit from the diversity of knowledge and experiences. We welcome feedback and suggestions from anyone reading this report since it defines the basic structure of what we intend to do in the project.

All teams involved are grateful for the support of the European Commission in providing funds for this research and to the national organisations contributing to the project.

Claudia Pahl-Wostl

Coordinator of WB1
NeWater project
August 2005

Executive Summary

This report summarises the lessons learned in applying a rapid appraisal of baseline vulnerability in the Newater case studies. Two previous Newater working papers present conceptual and analytical frameworks for understanding vulnerability.

Vulnerability is not the same as an environmental hazard. The relatively similar scores for the Czech portion of the Elbe and the Guadiana indicate that the underlying exposure to stresses and threats may be similar even in quite different conditions of water scarcity and environmental stress. It then follows that it can be difficult to compare vulnerability in complex situations where the stresses, threats, exposure units, dynamic choices and development pathways are all quite different. There is no universal metric of vulnerability that applies to all societies and economies.

Hence, there is a need to understand the root causes of conflicting resource use and to use this knowledge to develop an adequate governance structure to address the unique characteristics of each basin (particularly evident in the transboundary basins). This review of the application of vulnerability in the NeWater case studies reveals the strengths of a vulnerability assessment: by identifying key priorities for consideration in designing an adaptive water management strategy, gaps in existing knowledge are also revealed.

Vulnerability assessments are ultimately subjective. Even if quantitative information is used, the choice of indicators, the priority assigned to different outcomes, the use of weights and thresholds—all are judgements made by experts, stakeholders and/or the vulnerable themselves. There may well be serious differences between stakeholder perceptions and scientific knowledge. There are likely serious differences between stakeholders themselves (and even more so among experts). A formal vulnerability assessment is a way to raise these differences of perceptions and priorities. The methods cannot automatically resolve those differences.

The choice of vulnerability frameworks, ideally, should be left to the stakeholders in the case study basins—what do they already employ in making decisions? Within NeWater, we recommend that:

- The framing of vulnerability from a natural hazards perspective is our starting point, as it is likely to be the most widely used approach among stakeholders.
- Assessments, following up the baseline, develop indicators and profiles of vulnerability that recognise the different exposures of socio-economic groups. Such profiles lead directly to monitoring and evaluating the performance of adaptive systems.
- In constructing scenarios of future stresses and adaptive management, narratives include differential vulnerability as essential sub-plots in the storylines. This requires a bridging of scales between the global drivers of risk and the local nuances of exposure.

Despite a detailed protocol, several presentations to the NeWater analysts and a dedicated, hands-on training session, the NeWater assessments were not done systematically. Actually, this is a common experience in vulnerability assessment (or indeed in any 'top-down' implementation of a protocol where there are different interpretation of the concepts, needs and interpretations). The case study teams are relatively large, with many stakeholders involved, and from a variety of disciplines. Vulnerability assessment is not an end point of the NeWater project—it is only one way to begin thinking about the need for adaptive management.

The most important next step is the link between vulnerability and adaptive management. The identification of exposure units is important—who is exposed to what?--is the precondition for designing adaptive management strategies—who will manage what to achieve which objectives? Indicators of vulnerability relevant to those social exposure units can then be built into understanding adaptation as a process of social learning.

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1 A rapid appraisal of baseline vulnerability

Purpose of the vulnerability protocol

People's vulnerability to changes in water resources depends on a range of social, economic and environmental factors that affect the ability to manage water resources. Within every river basin, those communities and locations which are most vulnerable need to be identified in order to prioritise mitigating action.

The Baseline Rapid Vulnerability Assessment (BRAVA) provides a baseline of exposure and resilience to stresses. For a river basin, it provides a first inventory of questions such as:

- Who and what are the exposure units?
- What hazards and stresses are they exposed to?
- How resilient are the exposure units to current stresses?
- What has been the impact of historical episodes, such as droughts and floods?
- Are the exposure units and stresses changing? In what ways?
- What indicators capture current and future vulnerability?

A structured vulnerability assessment provides a way to compare exposures, stresses and impacts across a range of geographic locations (within and between river basins) and scenarios of future conditions. It lays the baseline for evaluating the outcome of alternative management regimes.

Clearly, many of these questions are common to any baseline for water resource planning; in NeWater the baseline vulnerability assessment links to many of the Workpackages in the project. The baseline vulnerability assessment for all the case studies aims to identify priorities and gaps in existing knowledge. The interdisciplinary dataset for each basin will be useful for subsequent tasks. Building on the baseline, stakeholders and project teams will be able to select which issues they want to pursue further.

The protocol was designed to be implemented without spending too much time working through the nuances and variations in conceptual frameworks, definitions and analytical methodologies.

The specific purposes of the protocol in its basic form are to:

- Identify threats and priorities for improving adaptive management and
- Identify exposure units for analysis of vulnerability (and adaptive management)

A more detailed protocol would also enable one to:

- Identify indicators to use in monitoring the performance of current and future management regimes
- Lay the foundation for exploring more complex models of current vulnerability
    - Aggregation and comparative indices (e.g., a Water Vulnerability Index)
    - Dynamic vulnerability and resilience incorporating behavioural and iterative models
- Lay the foundation for scenarios of future vulnerability and adaptive management

The vulnerability assessment is intended to look across a wide range of threats, hazards and stresses. It is not confined to climate change or climatic hazards (although many of us come from that background). In many cases, the threat of pollution events, regulation and financial constraints are more pressing than coping with droughts or floods, though they are also, of course, closely related.

The protocol for the baseline rapid vulnerability assessment (see the annex) does not assume a specific framework of vulnerability. In the NeWater project, adaptive management is developed and tested with partners in the case study regions. Clearly, it makes sense to use the frameworks that those stakeholders and analysts already employ, rather than seeking to convert them to a new framework. A separate NeWater working paper presents conceptual issues, frameworks and definitions of vulnerability in the context of water resource management (Downing). Section 3 presents a synopsis

of this work, suggesting a choice of the main uses of the vulnerability frameworks. Another NeWater working paper develops an analytical framework for testing hypotheses regarding vulnerability (Ionescu et al. 2005). These two working papers and this report constitute the major deliverable from WP2.1 of NeWater (Deliverable 2.1.1).

Evaluation of the BRAVA

It is difficult to synthesise the results of the BRAVA from all the case studies as it has not been carried out consistently in all cases. A workshop in Leipzig (September 2005) presented the protocol and worked through its application for the Amudarya, Elbe, Rhine and Tisza case studies. NeWater staff based at the University of Cape Town offered to assist the Orange team. Ongoing collaboration with the Guadiana case study team will follow up the issues identified in this report. A water planning model is being implemented in the basin (WEAP, see www.weap2100.org) which will include a training course to establish the baseline vulnerability in the region. The same model is being used in the Amudarya, so it is likely that several case study teams will develop more sophisticated baselines in the coming months.

Where the protocol has been utilised comprehensively it clearly serves to illuminate the key features of the case study situation and this is confirmed by the qualitative information provided in the text of the reports. The analysis has been conducted by someone who was for the most part independent to the design of the BRAVA and as such an evaluation of the ease with which the resulting data can be analysed, can also be usefully conducted here.

It has emerged that the value of tools such as the threats/impacts matrix allows one to quickly understand the vulnerability of the situation under study. Furthermore, the ability to backtrack to individual tables describing threats and further still to the frequency and trends of such stresses is very efficient in enabling a quick understanding of the overall context, particularly in terms of the cross-sectoral scope and extent of the most prevalent impacts as well as the scale at which the most vulnerable exposure units are affected. This aids the identification of areas for further investigation during interviews with stakeholders such as main priorities for improving adaptive management.

In addition all feedback that has been received on the BRAVA from the case study teams will be noted for further development of an extended vulnerability assessment tool, particularly for those case studies where it will be carried out in more depth. The Vulnerability Network (www.VulnerabilityNet.org) provides more information and a manual of vulnerability assessment applied in widely differing contexts (from food security and water to disasters and climate change) is under development, led by the Stockholm Environment Institute (contact oxfordsei@gmail.com for further information).

Common vulnerabilities

Table 1 summarises the main vulnerabilities identified in the NeWater case studies.

Common threats that have emerged in each basin include drought, issues of transboundary governance, pollution and inequitable access and control of resources. Similarly, vulnerable units identified in many of the case studies included the agricultural sector, households in rural, urban and floodplain areas and ecology and nature such as wetland ecosystems. In general terms agriculture is a common exposure unit since water use in agriculture is a common feature in many of the basins and flood risk in many areas is increasingly serious as the trend for more frequent extremes continues. In contrast in some areas a trend of increasing water stress has emerged. Ineffective education on water use and inadequate water information sharing and resulting in poor water management appears to be a common factor.

Case specific problems

Drought is also a regular problem specific to many of the cases, though obviously to differing degrees of severity. Many of the cases are subject to transboundary pollution issues and the associated complicated governance associated with transboundary resources. This results in issues of inequitable access and control of resources in many areas. Poverty and gender inequalities exist though they are more pronounced in particular cases where livelihoods are directly dependent on water resources. Social vulnerability which is age related is also a prominent feature in many of the basins. This issue is more evident than gender inequality in locations where poverty is less widespread. For example, in the Elbe where older people have suffered the effects of past droughts disproportionately compared to the rest of the population. However, it is clear that both social vulnerability and gender inequality are issues which must be considered in those basins in developing countries.

Case study	Common threats	Vulnerable exposure units
Amudarya (Uzbekistan, Turkmenistan, Tajikistan, Afghanistan)	Drought and salinization of soil and water	Households with gardens and those without access to water, agriculture, fisherman and parks.
Tisza (Ukraine, Romania, Slovakia, Hungary, Serbia-Monte-negro)	Floods and droughts within a short time frame, potential industrial accidents, pollution	Agriculture, wetland ecosystems.
Guadiana (Spain, Portugal)	Hydroschizophrenia, lack of education (UGB-Spain)	Environmental conservation groups, government agencies (UGB-Spain).
Elbe (Germany, Czech Republic)	Droughts and water pollution	Urban population in large cities, tourist sector in Spreewald (natural reserve) and the agricultural sector in the floodplain areas. Endangered species are also highly vulnerable to these stresses.
Rhine (Germany, Switzerland, Netherlands, Luxembourg, France, Austria, Belgium, Italy, Liechtenstein)	Climate, floods, droughts, water quality, ecological and agricultural dessication (NB: can be positive in some cases), increasing urbanisation, political change, economic changes, agricultural policies and industrial pollution.	Energy, ecology, agriculture, infrastructure, recreation, drinking water, industry, nature, navigation, housing and people.
Orange (Lesotho, South Africa, Namibia, Botswana)	Drought, storm (resulting in flooding), population growth, HIV/AIDS, poverty, abnormal rainfall, gender-based cultural bias, soil erosion, land and ecosystem degradation, biodiversity loss, inequitable access to water, poor land and water management, conflicting resource use, pollution, siltation, lack of education in sustainable water management practises and poor communication, industrialisation	Urban and peri-urban population, children, women, poor, those living close to the river, agriculture, livestock, industry and business, government and private institutions, shepherds, scholars, general communities.
Nile (Burundi, DR Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda)	Soil erosion and land degradation population growth and poverty, water logging and salinization, pollution (caused by humans and industry), drought, floods, lack of information and education, lack of job opportunities, health hazards from poor water quality, political and economic instability, competition and conflict (resulting in displacement and loss of livelihoods) and a logistically, technically and financially, weak institutional framework.	Agriculture, livestock, fisheries, soils, pastures, deforestation, ecology, biodiversity, pastoralists, small-scale agriculturalists.

Table 1: Summary of vulnerabilities in the NeWater case studies

2 Results

Where similar processes have been followed to carry out the BRAVA, the results have been analysed and compared. From the impact matrices given by each case study below, each threat and exposure unit was scored (i.e. the rows and columns were summed) to assess the most prevalent threats and the most vulnerable exposure units. Back-tracking to earlier tables then allowed a more detailed picture of the basin to emerge and these details were consistently confirmed by the description of the basin in the introductory text to each basin.

Amudarya

The most prevalent threats and priorities identified in the Amudarya basin for improving adaptive management according to this exposure matrix are drought and salinization of soil and water. Private households with gardens as well as those without access to water are the most vulnerable exposure units which must be considered when thinking about adaptive management. However, as in the other basins agriculture is also very vulnerable, particularly as many of the countries in the Amudarya region are reliant on agricultural production. Fisherman and parks are also vulnerable exposure units.

However, the description of the Amudarya also indicates that the transitional phase the region is currently experiencing i.e. the move from centralised control to five newly independent states is a problematic transboundary issue. For example, there are instances in which reservoirs used by one country are based on the territory of another country. This causes tensions between upstream and downstream countries with differing needs at different times of the year.

	Threats					
Exposure Unit	Drought	Flood	Pollution to Surface and Groundwater	Environmental Degredation	Salinization in Water and Soil	Economic Uncertainty from Export Markets
Private Farms	5	2	2	3	4	3
Collective Farks	3	2	2	3	5	4
Private Households (gardens)	5	5	2	4	4	3
Households without water	4	5	5	3	5	1
Private Fishermen	5	B	2	5	4	3
Tourist Industry	2	1	3	3	3	1
Power Plants	2	1	3	1	3	1

Table 2: Exposure matrix for the Amudarya

Tisza

Similarly, in the Tisza floods and droughts are the biggest threats, followed by pollution and these issues should be prioritised when designing successful adaptive management strategies. The ecosystem in general is scored as the most vulnerable. Tied to this agriculture and farmers are at greatest risk, followed by industry. It is important to note the context within which threats and uncertainties exist since this can accentuate or ameliorate them. For example in the case of the Tisza river basin, as in the case of the Amudarya, the additional feature that underlies it is the complicated political framework within which it is situated. This requires transboundary cooperation and

collaboration between the different countries which must take into consideration the EU Water Framework Directive. Additionally, whilst there is a historical legacy of transboundary cooperation this may be hampered by institutional weaknesses which have also been identified in this region. However, while water policy and EU agricultural policy do not score particularly highly as a threat, it still is an important contributing factor and other tables reflecting historical threats and trends in institutional frameworks should reflect this.

Exposure units	Threats and stresses							
	Floods	Droughts	Heat	Pollution	Erosion	Poverty	Water Policy	EU Agricult. Policy
Local people	X(1)	X(1)	X(1)	X(1)		X		
children,	X		X			X		
elderly people								
Households	X(1)						(x)(3)	
Farmer	X(1)	X(1)	(x)	X(2)	X(1)		X(2)	X(1)
Regional authorities	X(2)	X(3)	(x)	X(2)		(x)	(x)	
State	X(3)	X(4)		(x)		(x)		
Local market	X(2)	X(2)						X(2)
Insurances	X(1)	(x)	(x)					
Tourism	X(3)			(x)				
Industry	X(2)	X(3)		X(2)			(x)	
Agriculture	X(1)	X(1)	X(2)	X(2)	X(1)		(x)	X(1)
Fishery	(x)(3)	X(2)		X(1)			X(1)	
Ecosystems	X(1-2)	X(1-2)	X(3)	X(1)	(x)(3)		(x)	(x)
Health	X(1)	X(1)	X(1)	X(1)		X(1)		
Infrastructure	X(1)				(x)			
Households		(x)						
Transport								
Waste water treatment		X(3)		(x)				
Power plants	-	-	-	-	-	-	-	-

Legend:
X = high direct threatened (x) = possible/indirect threat 1 … 5 priorities/degree of threat

Table 3: Exposure matrix for the Tisza

Upper Guadiana

The greatest stresses in the UGB are hydroschizophrenia (where groundwater resources are overlooked at the expense of strong surface water management) and a lack of education. Most vulnerable stakeholders are identified as environmental conservation groups and government agencies. Apparently, this is an assessment of their relatively weak power in adaptive management in the region rather than their direct exposure to threats and stresses.

The relative scoring of common attributes of vulnerability in the UGB illustrates the perceived high vulnerability of actors and institutions along with water usage. In the Guadiana, the context within which threats and uncertainties exist is largely a historical lack of education which is the basis of many of the current conflicts and this was noted in the tables preceding the impact matrix which identified the lack of education at a major threat.

	Threats and stresses						
Exposure units (vulnerable groups)	Hydroschizophrenia	CAP side effects	Aquifer depletion	Aquifer pollution	water transfers	Lack of education	Lack of coordination
Farmers	5	5	2	1	1	5	3
Environmental Conservation Groups	5	5	5	5	3	3	5
Government Agencies	5	3	2	5	5	5	5
Civil society within the basin	2	2	2	3	2	5	3
Civil society outside the basin	5	1	2	3	4	4	3

Sensitivity rated from 1 (lowest) 5 (highest)

Table 4: Exposure matrix for the Upper Guadiana

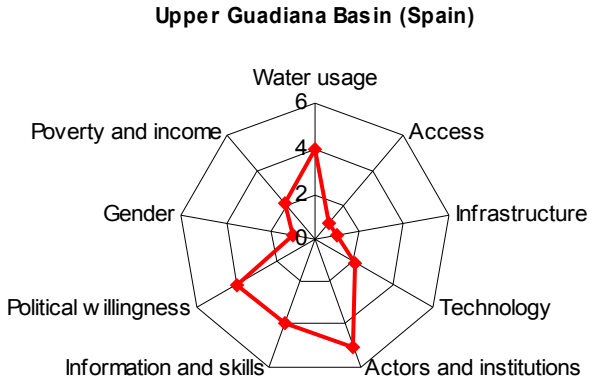


Figure 1: Vulnerability profile for the Upper Guadiana

Attribute	Low	1	2	3	4	5	High	Notes
	Few people affected; few economic impacts			X			Large population affected; economic impacts cause hardship to many people	Water problems affect farmers (and associated industries) as well as the environment very directly, the public at large is generally less vulnerable
Water usage	High water usage, willingness to save water during crises				X		Low water usage; inability to reduce use during times of scarcity	High water use (irrigation), willingness to save water depends a lot on the motivation applied
Access	Piped and metered water use for almost all	X					Large portion of population without piped access	Refers to drinking water only.
Infrastructure	Well developed and integrated water infrastructure	X					Little regulation of water supply	Urban water supply network well-developed. Drinking water is ensured for 100% of the population
Technology	High technological base, strong investment		X				Traditional or out-of-date technology	Supply is enough to suit the daily needs of half a million people
Actors and institutions	Few actors, well integrated management regimes					X	Many actors, fragmented authorities, conflicts over management of resources	Significant conflicts among farmers, the RBA and environmental conservation groups. Conflicts also between regional and central governments. Little control on groundwater withdrawals.
Information and skills	High information base and access, sufficient skill base for wide range of stresses and threats				X		Poor information collection, restricted access, shortage in key skills	Groundwater monitoring network is poor. Irrigation data is generally poor and varies widely depending on the source. Official data is only partial.
Political willingness	High priority for water management, effective political decision making				X		Low awareness and priority, ineffective or restricive decision making	Water is a high political priority in the area, by practical constrains yield many management decissions ineffectual
Gender	Equitable distribution of resources, effective means to promote participation by women	X					Inequitable impacts of hazards, discrimination against women in decision making	Some women play leading roles within stakeholder institutions
Poverty and income	Almost all water users have sufficient income to secure their water needs		X				Large population affected by poverty, inequitable water charges	Small farmers are perhaps the only ones that struggle at times
Others…								

Table 5: Attributes of vulnerability for the Upper Guadiana

Elbe

The most prevalent threats and priorities for adaptive water management, identified in the Elbe basin were droughts and water pollution, with the urban population in large cities most at risk. Other vulnerable groups are elderly people and other vulnerable sectors are the tourist sector in Spreewald (natural reserve) and the agricultural sector in the floodplain areas. Endangered species are also highly vulnerable to these stresses. Floods emerged with a lower score than might be expected given the analysis of stakeholder feedback in the RAP. However, other data provided in the vulnerability assessment confirm **no increase** in the trend of flooding in the summer and a downward trend of winter flooding. The reasons for the disparity between this data and actual stakeholder *perceptions* of flooding events may be interesting to explore further.

Scoring attributes of vulnerability in both the German and Czech Republic parts of the Elbe basin, clearly shows that the German part is least vulnerable in most aspects compared to the Czech Republic part.

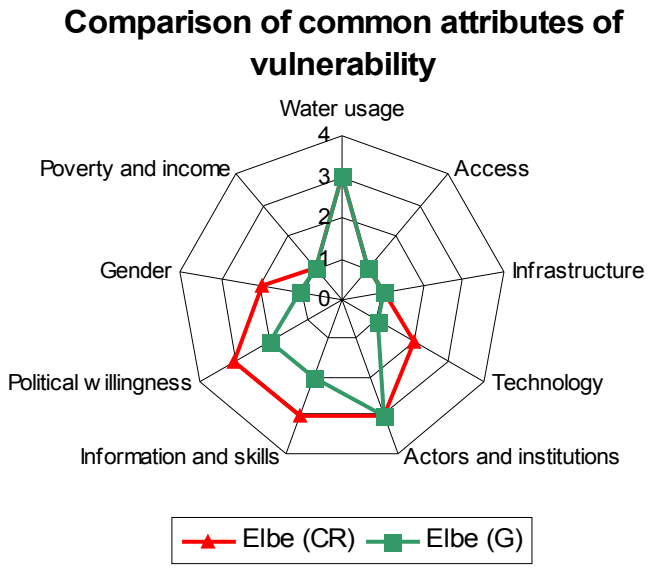
	Threats and stresses							
Exposure units (vulnerable groups)	drought	flood	Warm spell	windstorm	water pollution	higher water price	River training	Acid rains
Water users with a low income	3	3	2	3	3	**5**	2	1
Population living in floodplains	2	**5**	2	2	3	3	2	1
Population in Spreewald (National reserve)	**5**	2	2	2	4	3	2	1
Population in the former mining areas	3	3	2	2	**5**	3	2	1
Urban population in large cities (Berlin, Prague, Hamburg)	**5**	3	2	3	**5**	3	2	1
Old people in the whole basin	**4**	3	**5**	3	2	3	2	1
Agriculture sector in upland areas	**5**	1	2	2	2	**5**	2	1
Agriculture sector in floodplain areas	**4**	**5**	2	2	2	**5**	2	1
Agriculture sector in Saxony Anhalt (loess soils, high concentration of agriculture)	**5**	1	2	2	2	**5**	2	1
Water supply sector in Berlin	**5**	2	1	**1**	**5**	4	**1**	1
Tourist sector in Spreewald	**5**	**4**	3	3	**5**	**1**	**1**	1
Tourist sector in the lake subregions (Havel, NN)	3	3	2	2	**5**	**1**	**1**	1
Navigation in the Elbe	**5**	**4**	1	3	**1**	**1**	2	1
Floodplain forest	**5**	1	3	3	**1**	**1**	**5**	1
Groundwater recharge in the lowland part	**5**	1	3	**1**	**1**	**1**	**1**	1
Mountain areas in CR	2	1	2	3	**1**	**1**	**1**	**5**
Lake ecosystems	**5**	1	3	**1**	**5**	**1**	**1**	2
Endangered species (beaver, white stork, fish species, etc.)	**5**	2	3	**1**	**5**	**1**	**5**	1
Reservoirs	**5**	2	2	**1**	**5**	**1**	**1**	1
Big industrial units (more than 250 employees)	2	2	2	2	2	4	2	2
Public infrastructure	1	**5**	1	**1**	2	2	**1**	1
Sewage treatment plants	1	**4**	1	2	4	**1**	3	1

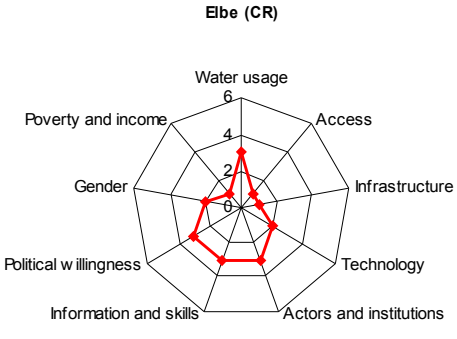
Table 6: Exposure matrix for the Elbe

Attribute	Low	1	2	3	4	5	High	Notes
	Few people affected; few economic impacts						**Large population affected; economic impacts cause hardship to many people**	
Water usage	High water usage		X				Low water usage;	
Water usage	Willingness to save water during crises			X			Inability to reduce use during times of scarcity	
Access	Piped and metered water use for almost all	X					Large portion of population without piped access	
Infrastructure	Well developed and integrated water infrastructure	X					Little regulation of water supply	
Technology	High technological base, strong investment	X G	X CR				Traditional or out-of-date technology	
Actors and institutions	Few actors, well integrated management regimes			X			Many actors, fragmented authorities, conflicts over management of resources	
Information and skills	High information base and access, sufficient skill base for wide range of stresses and threats		X G	X CR			Poor information collection, restricted access, shortage in key skills	
Political willingness	High priority for water management, effective political decision making		X G	X CR			Low awareness and priority, ineffective or restricive decision making	
Gender	Equitable distribution of resources, effective means to promote participation by women	X G	X CR				Inequitable impacts of hazards, discrimination against women in decision making	
Poverty and income	Almost all water users have sufficient income to secure their water needs	X					Large population affected by poverty, inequitable water charges	

Note: these categories combine an assessment from Luis Mata (University of Bonn) and the Water Poverty Index; upon review a revised list of categories may be developed.

Table 7: Attributes of vulnerability for the Elbe





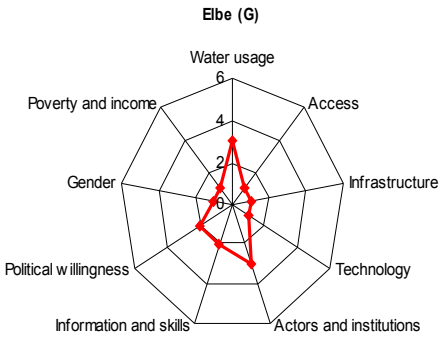


Figure 2: Vulnerability profile for Elbe (Czech, CR, and German, G, sub-basins)

Rhine

The Rhine case study has been divided into sub cases on different scales. That is, the Rhine catchment, the Niederrhein transboundary scale and the local, waterboard level including the Emscher and the Kromme Rijn ("Curved" or "Bending" Rhine). The vulnerability matrix for the Rhine/Niederrhein indicates that climatic stresses such as droughts and floods are a threat to most of the exposure groups, followed by water quality. The exposure units most at risk appear to be nature, navigation and housing and people.

The Emscher case indicates that industrial pollution and floods are the greatest risks. However, as noted in the RAP this does not mean that floods are the biggest threat since water quality is seen as the greatest challenge.

In the Kromme Rijn area the main issues are also water quality and both agricultural and ecological desiccation. However, it is noted that desiccation can have both positive and negative effects depending on the circumstances, hence the notation in the table.

			Climate		Socio Economic		Governance
							Time scale
	Treats	Floods *wp 2.2*	Droughts	Quality	Flow regime	Non integtaion of spatial planning	Shot term politics v.s Long term implemenati on
Exposure units							
Energy			+				
Agriculture		+	+				
Recreation			*wp 2.3* *wp 1.5*	+			
Nature			+	+	+	*wp 1.2* *wp 1.3*	+
Navigation		+	+		+		
Drinking water				+			
Industry	*wp 1.2* *wp 1.3*	+				+	
Housing and People		+				+	+

Source Meeting case study Rhine september 2005 Amersfoort

Table 8: Exposure matrix for the Rhine

	Threats						
Exposure units	Climate Ch Floods	Climate Ch droughts	Pollution Industry	Political change	Demography	Econom change	Agricult Policies (EU+ National)
Industry	-2						
Ecology	-3	-1	-5	-3			-2
Health	-1		-3				
Recreation	-1		-5				
Quality of Life	-1		-5				
Infrastructure	-4			-3		-3	
Personal Possessions	-2						
Political credibility	-2	-1	-5				
Agriculture	-1	-4		-3			
Cult. Heritage	-2						

	Pressures									
Exposure units	Climate change Floods In/extern.		Climate change Droughts In/ extern.		Pollu-tion by Industry	Desic-cation by Agricult.	Pollution by Agric.	Demo-graphy	Environ-mental Policies	Agricul-tural Policies
Industry	-1	-4	-1	-2	0	0	0	3	-3	0
Terrestrial Ecology, dry types	-2	0	+5	0	0	3	-2	-2	2	3
Terrestrial Ecology, wet types	-5/5 ^	0	-5/5 ^	0	-1	-5	-5	-5	5	3
Aquatic Ecology	-4	0	-5	0	-1	-5	-5	-4	5	3
Health	-3	-5	0	-2	-1	0	-3	-3	3	3
Recreation	3	0	-3	0	-1	-1	-1	-4	5	3
Personal Possessions	-3	-5	-1	-1	0	0	0	0	0	0
Agriculture	-2	0	-5	0	0	-3/5#	0	-2	-5	-4/4$
Cult. Heritage	0	-5	-2	-2	0	-1	0	-5	2	2

Table 9: Exposure matrices for the Rhine sub-basins: Emscher (top) and Rijn (bottom)

Orange

Exposure in the Orange basin is strongly related to urbanisation, health and gender issues, as well as climatic events and stresses. Children are seen as the most vulnerable group, with crops and animals also exposed to droughts and water shortages.

Basin: Location:

Historical risk	Year/month	Water system effects	Significance
Population growth - Urbanisation	1970 – 1990s	Insufficient infrastructure over bundering	Very significant
HIV AIDS	1987	Inaccessible to water points	
	1933	Dry rivers and drought	Very nationwide
	1982-1985	Sever drought	Very significant
El Niño	1999 – 2000	Exstream heat low rainfall	Very significant
Al Niña	2001 – 2002	Damaged water infrastructure	Very significant
Abnormal rainfall	2004	Abnormal rainfall (roads damaged)	Significant
Cultural risk (gender based)	Always there	Lack of access to water	significant

Table 10: Risks in the Orange basin

Basin: Location:

Exposure unit	Type of exposure	Location/ scale	Water use (amount)	Water use type	Source of water use	Other notes
Children	Diseases	Nationwide	Very limited	Domestic	Ground water	
Crop	Destroyed	Southern districts most	Very limited	Agricultural	Ground water and surface	
Animal stock	Ill and dead	Eastern highlands	Very limited	Agricultural	surface	

Table 11: Exposure units in the Orange basin

Summary	
Threats	**Exposure units**
Population growth, urbanisation	Children, women, poor
HIV/Aids	Crops and agriculture
Variability in rainfall	Livestock
Cultural risk (gender biased)	Shepherds
Conflicting resource use	Scholars
Poor water governance	General community
Droughts	Farmers
Floods, heavy storms	Industry and business
	Government and private institutions

Table 12: Summary of threats and exposure units in the Orange basin

Nile

The description of vulnerability provided for the Nile identified many threats and stresses which should be priorities for adaptive water management including soil erosion and land degradation, population growth and poverty, water logging and salinization, pollution by both humans and industry, drought, floods, a lack of information, health hazards, competition and conflict and a weak institutional framework overall.

The relative scoring of common attributes of vulnerability in the Nile illustrates the high vulnerability of many aspects of society.

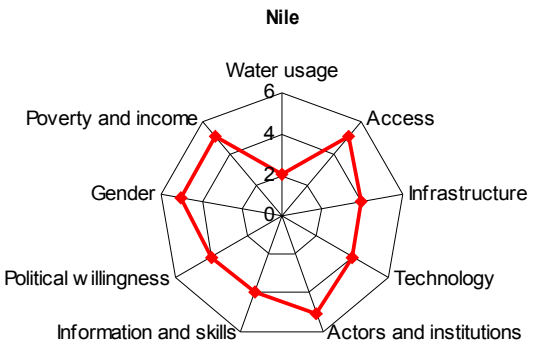


Figure 3 Attributes of vulnerability in the Nile Basin

Attribute	Low	1	2	3	4	5	High	Notes
	Few people affected; few economic impacts					□	Large population affected; economic impacts cause hardship to many people	
Water usage	High water usage, willingness to save water during crises		□				Low water usage; inability to reduce use during times of scarcity	
Access	Piped and metered water use for almost all					□	Large portion of population without piped access	
Infrastructure	Well developed and integrated water infrastructure				□		Little regulation of water supply	
Technology	High technological base, strong investment				□		Traditional or out-of-date technology	
Actors and institutions	Few actors, well integrated management regimes					□	Many actors, fragmented authorities, conflicts over management of resources	
Information and skills	High information base and access, sufficient skill base for wide range of stresses and threats				□		Poor information collection, restricted access, shortage in key skills	
Political willingness	High priority for water management, effective political decision making				□		Low awareness and priority, ineffective or restrictive decision making	
Gender	Equitable distribution of resources, effective means to promote participation by women					□	Inequitable impacts of hazards, discrimination against women in decision making	
Poverty and income	Almost all water users have sufficient income to secure their water needs					□	Large population affected by poverty, inequitable water charges	
Others…								

Table 13: Attributes of vulnerability in the Nile

Comparison of common attributes of vulnerability

The table of common attributes of vulnerability was intended to compare results across the case study regions. The results are available for three basins. The German part of the Elbe basin is less vulnerable in most aspects compared to the Czech Republic part (with lower scores). The Nile has the highest scores for all of the attributes except water usage. It is easy to conclude that it is more vulnerable than the Elbe. The Upper Guadiana is between the Nile and the German part of the Elbe for most scores, but has the highest vulnerability for water usage. Its profile is similar for many scores to the Czech portion of the Elbe.

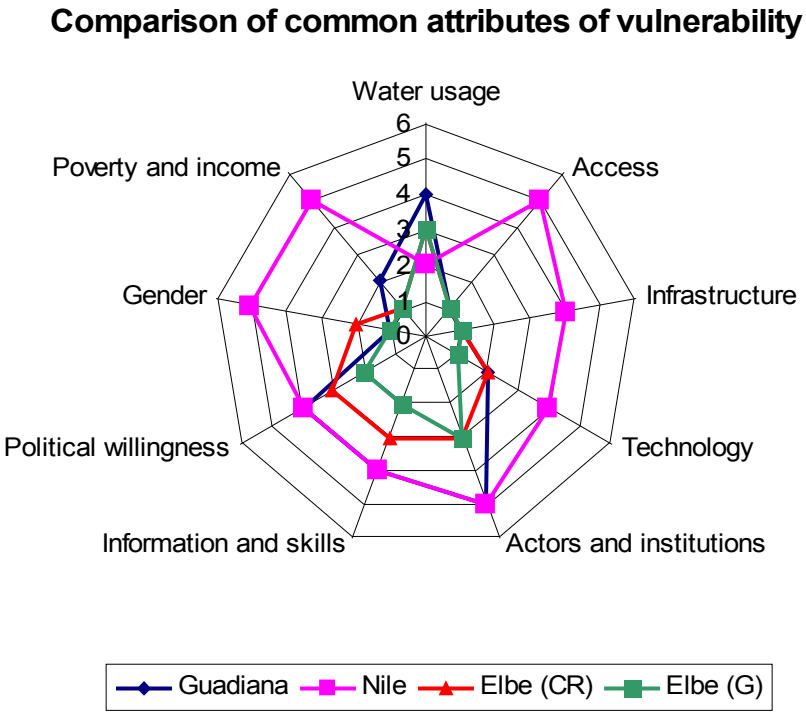


Figure 4 Comparison of attributes of vulnerability in the Elbe, Nile and Guadiana basins.

3 Contribution towards NeWater conceptual frameworks

The BRAVA protocol, as mentioned above, did not adopt an explicit vulnerability framework. However, it was based on an extensive review of vulnerability concepts, definitions and frameworks. The following table depicts the range of definitions of vulnerability that are in common usage (not just in water resource studies and management).

The definitions (or more properly the broad approaches) that are closest to adaptive management are those related to decision making (dynamic choices) and collapse (as the adverse outcome of a lack of system resilience).

However, the most widely used definition comes through the natural hazards literature, where risk is the intersection of vulnerability (exposure and sensitivity) and a hazard (the geophysical probability, duration and magnitude of an event). Two aspects of vulnerability are combined in this approach: the notion that vulnerability differes among exposure units and the use of damage functions to relate the hazard to its consequences.

Vulnerability as a baseline is seen in definitions related to profiles (as shown above) and relative indices, with differential exposure sometimes included. The Intergovernmental Panel on Climate Change (IPCC) promoted a definition of vulnerability as the outcome of a scenario (but this is widely challenged as a confusion between risk and vulnerability). More descriptive uses fall within the category of narratives.

To some extent, each definition implies a specific tradition and perspective. However, many of the attributes noted above cut across the common definitions. For example, a definition based on resilience, where vulnerability is linked to system collapse, could also embrace differential vulnerability, dynamic social networks and multiple stresses as part of the conditions of collapse.

Within NeWater, we recommend that:

- The framing of vulnerability from a natural hazards perspective is our starting point, as it is likely to be the most widely used approach among stakeholders.
- Assessments, following up the baseline, develop indicators and profiles of vulnerability that recognise the different exposures of socio-economic groups. Such profiles lead directly to monitoring and evaluating the performance of adaptive systems.
- In constructing scenarios of future stresses and adaptive management, narratives include differential vulnerability as essential sub-plots in the storylines. This requires a bridging of scales between the global drivers of risk and the local nuances of exposure.

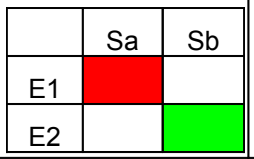
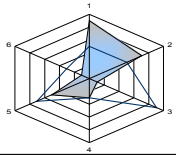
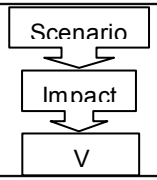
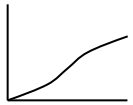
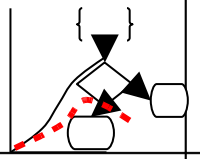
	Differential exposure	Relative index	Multi-attribute profile	Scenario outcome	Damage function	Collapse	Dynamic choices	Narrative
Icon		***V = 0.67***						
Definition	Relative exposure of different groups to different stresses	Aggregate score on selected indicators	Profile of multiple dimensions	Measure of the outcome of a scenario	Equation linking hazard and outcome	Inverse of resilience, collapse of a system	Pathway of choices leading to positive or adverse outcomes	Storylines that depict the structure and nature of vulnerability
Origin	Poverty, development and hazards	Indicators, Human Development Index	Indicators, poverty and development mapping	IPCC	Natural hazards	Resilience, systems models (confusion with sensitivity)	Decision sciences, multi-agent based social simulation	Political ecology, journalism
IWRM	Drought studies	Water Poverty Index	Mata Latin America	Climate impact studies	Flood damage	Aral Sea	Consumer demand for water	Common in scenarios
Socio-ecological systems	Separates hazard and vulnerability, but shows relative linkage	Assumes substitution between attributes	Covers different elements, weak connections	Linear construction of risk-event chains	Separates hazard and vulnerability	System integration but aggregate level attribute	Close coupling of external and internal vulnerability; may not capture system-level properties	Rich content possible
Resilience	Not dynamic, outcomes are often not explicit	Aggregate indices not used	Static baseline, not related to dynamics	Not dynamic	Lower damage, or recovery	Common approach	Dynamic, emergence of system resilience from actions	Can be dynamic, but often not related to formal analytical frameworks
Climate change	NAPA support material, early impact studies	Some examples, rejected as an international planning tool	Common approach, related to livelihoods	Common approach of the 1990s	Implied in climate-impacts, hazard approach is common	Not often explicit	Use of seasonal climate outlooks	Some examples, local scenarios

Table 14: Comparing definitions of vulnerability and their implications for applications

4 Conclusion

This review of the application of vulnerability in the NeWater case studies reveals the strengths of a vulnerability assessment: by identifying key priorities for consideration in designing an adaptive water management strategy, gaps in existing knowledge are also revealed. Other conclusions are:

- Vulnerability assessments are ultimately subjective. Even if quantitative information is used, the choice of indicators, the priority assigned to different outcomes, the use of weights and thresholds —all are judgements made by experts, stakeholders and/or the vulnerable themselves. There may well be serious differences between stakeholder perceptions and scientific knowledge. There are likely serious differences between stakeholders themselves (and even more so among experts). A formal vulnerability assessment is a way to raise these differences of perceptions and priorities. The methods cannot automatically resolve those differences.
- Vulnerability is not the same as an environmental hazard. The relatively similar scores for the Czech portion of the Elbe and the Guadiana indicate that the underlying exposure to stresses and threats may be similar even in quite different conditions of water scarcity and environmental stress. (Or at least the perceptions are similar.)
- It then follows that it can be difficult to compare vulnerability in complex situations where the stresses, threats, exposure units, dynamic choices and development pathways are all quite different. There is no universal metric of vulnerability that applies to all societies and economies.
- Hence, there is a need to understand the root causes of conflicting resource use and to use this knowledge to develop an adequate governance structure to address the unique characteristics of each basin (particularly evident in the transboundary basins).
- Despite a detailed protocol, several presentations to the NeWater analysts and a dedicated, hands-on training session, the NeWater assessments were not done systematically. Actually, this is a common experience in vulnerability assessment (or indeed in any 'top-down' implementation of a protocol where there are different interpretation of the concepts, needs and interpretations). The case study teams are relatively large, with many stakeholders involved, and from a variety of disciplines. Vulnerability assessment is not an end point of the NeWater project—it is only one way to begin thinking about the need for adaptive management.
- The differing notions of vulnerability will be further clarified in the next phase of NeWater as case study teams define the baseline (for vulnerability and adaptive management), using locally relevant concepts and definitions. A synthesis of this experience in 12-18 months is certain to show significant improvement in the understanding of exposure, sensitivity, hazards and risks (in other words, vulnerability).

The most important next step is the link between vulnerability and adaptive management. The identification of exposure units is important—who is exposed to what?--is the precondition for designing adaptive management strategies—who will manage what to achieve which objectives? Indicators of vulnerability relevant to those social exposure units can then be built into understanding adaptation as a process of social learning.

5 List of references

Downing, T.E., Aerts, J., Soussan, J., Barthelemy, O., Bharwani, S., Ionescu, C., Hinkel, J., Klein, R.J.T., Mata, L., Martin, N., Moss, S., Purkey, D. and Ziervogel, G. (2006) Integrating social vulnerability into water management. SEI Working Paper and Newater Working Paper No. 4. Oxford: Stockholm Environment Institute.

Ionescu, C., R.J.T. Klein, J. Hinkel, K.S. Kavi Kumar and R. Klein, 2005: *Towards a Formal Framework of Vulnerability to Climate Change.* NeWater Working Paper 2 and FAVAIA Working Paper 1, Potsdam Institute for Climate Impact Research, Potsdam, Germany, ii+20 pp.

6 Annex I: BRAVA protocol

Source and contributors

This version of the BRAVA protocol was developed following the Oxford meeting of the NeWater WP2.1 and related groups in April 2005. A longer version was judged overly complex for the teams to take on at an early stage. This version was subsequently included in the planning guidance to the case study teams (the so-called RAPs).

The WP2.1 Coordinator is the Stockholm Environment Institute. For further information contact Tom Downing (tom.downing@sei.se) or Sukaina Bharwani (sukaina.bharwani@sei.se). Additional work on water vulnerability indicators is led by Caroline Sullivan at the Centre for Ecology and Hydrology, (caroline.sullivan@ceh.ac.uk). The contributors to the BRAVA protocol are:

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Additional work on vulnerability modelling and links between vulnerability and adaptive management was developed in the Montpellier workshop on social vulnerability (April 2006). Presentations and other material will be collected in the Vulnerability methods and users forum on the Vulnerability Network (www.VulnerabilityNet.org).

Background

The rapid assessment of vulnerability is designed to identify who is exposed to which threats and stresses. This matrix of the sensitivity of exposure units to hazards will help the case study team structure further assessment activities. The issues given high priority should include an indication of their relevance to the most vulnerable groups. For example, in semi-arid basins, groundwater use by larger landowners may be competing with water availability for smaller farmers. A high priority research issue might be related to the allocation of water between these two groups, along with ways to improve governance of groundwater use. Or, the link between climate change and increased flood hazard may be identified as high-priority threats. The case study team might want to focus on the differential impact of floods (for example, households with or without insurance, home owners vs renters) and the balance between ecological uses of the flood plain and flood mitigation (two different exposure units).

Objective 7 of NeWater is: To compile a baseline of present vulnerability and adaptive capacity of river basins that integrates exposure to present socio-institutional, economic and environmental stresses and shocks.

This draft protocol has been developed from the following activities:

- 0-order draft in April, compiled by SEI
- WB meeting in Oxford 19-21 April 2005 reviewed the 0-order draft, recommending substantial changes in the structure and content
- Presentation of the major conclusions from the Oxford WB meeting to the WB3 meeting in Montpellier, 25-28 April 2005 by Caroline Sullivan; the need for the protocol was reinforced although specific recommendations from the case study teams were not received
- Further discussions and elaboration of the methods and linkages with other WBs and projects were developed in early May, including checking the consistency between the attributes of vulnerability

(the major axes of a vulnerability profile) and the WB1 understanding of the dimensions of adaptive management

- The 1st-order draft was circulated among the WB2 partners and some case study coordinators for review, and discussed by the coordinating committee on 9-10 June 2005 in Amsterdam.

Following the Amsterdam PICP meeting:

- The 1st order draft had not been circulated to all of the case study coordinators, and we did not have a lot of time to work through the details. However, it became clear that the full protocol (meant to be rapid in any case) was still far too complicated for all of the case studies to achieve. So it was decided to integrate elements of the protocol into the RAP, which is the WB3 deliverable v.v. a baseline assessment of case study priorities, etc. and to hold a workshop with WB2 experts to help the case study teams achieve the rapid appraisal from the RAP, and begin to identify further efforts that they may wish to achieve v.v. WB2 and specifically WP2.1.

Protocol: Baseline rapid appraisal of vulnerability for adaptation

Introduction and overview of the baseline rapid appraisal of vulnerability for adaptation

A vulnerability assessment (VA) provides a baseline of exposure to stresses. In the Newater project this rapid vulnerability assessment is intended to look across a wide range of threats, hazards and stresses. It is not confined to climate change or climatic hazards. In many cases, the threat of pollution events, regulation and financial constraints are more pressing than coping with droughts or floods.

The output from this task in the RAP includes:

- Identification of the different exposure units. The exposure units, or the elements of the 'water management system', are the basis for subsequent analysis.
- A list of major threats.
- An impact matrix with subjective score relating the exposure units to the major threats.
- A concise summary of current vulnerability. Mostly in qualitative terms, the answers to the key questions will help define priorities for further assessment.
- A subjective profile of vulnerability along common dimensions for use in comparing the case studies (and to help identify priorities for further work)
- A checklist of initial plans for more formal assessment of indicators and future vulnerability. These will be further explored in the General Assembly and throughout the Newater project.

Task 1. Supplementary information on the system description

This task develops basic information on:

1. Geographic location, climatic zones, elevation, etc.
2. Elements of the water resource system: rivers, aquifers, water infrastructure, demand nodes, population
3. Current management and public issues in the basin, such as conflicts over environmental flows, plans to build new reservoirs
4. Case study team: members, skills, links to major stakeholders
5. Additional supporting material and data available (link to WB3)

TASKS	GUIDANCE
1.1 Location	Description of geographic location and resources such as climatic zone, elevation, etc. helps to locate the case study in a larger context; maps are useful
1.2 Water system elements	An inventory and description of the components of the water system, such as the surface and groundwater resources, nodes of abstraction and return, major uses and levels of demand, an overview of the stakeholders responsible for managing the system
1.3 Current issues	A synopsis of management issues in the basin that are recurrent (e.g., periodic regulatory reviews), apparent in public debates (e.g., water metering and pricing), or often mentioned by stakeholders (e.g., in public meetings); these will help identify conflicts and management issues related to different views of vulnerability
1.4 Case study team	Short briefs on the team, indicate who will take the lead in the vulnerability assessment and other WPs in WB2; check with WB3 reporting

Task 2. Scoping of threats and exposure units

The inventory of threats and exposure units involves:

6. Inventory of threats
7. Major impacts of threats, significant historical events
8. Inventory of the exposure units that will be used for subsequent analysis

An inventory of the threats and exposure units found in the case study region is the first requirement of a vulnerability assessment. This is largely qualitative information that can be derived from existing documents, expert judgements and stakeholder knowledge in the region. However, more structured techniques may be desirable in subsequent work.

Inventories of hazards, threats and stresses are fairly common, although they generate considerable discussion as to the relative importance of each threat in reality.

Characterising exposure units is more difficult—that is, it is more of a judgement among the stakeholders and experts as to who or what should be the unit of analysis in a vulnerability assessment. A formal definition of exposure unit is 'an activity, group, region, or resource that is subjected to an external hazard, threat or stress' (in the case of the IPCC this is limited to climatic *stimuli*). Exposure units might be a mixture of:

- Socio-economic classes of people, such as a typology of water users based on income and consumption patterns, relative poverty,
- Demographic classes, such as women, children or the elderly, or ethnic groups
- Environmental components of the catchment, such as groundwater, groundwater recharge zones, wetlands, or endangered habitats
- Public infrastructure, such as bridges, roads, and reservoirs may also be considered as exposure units—in the sense that they are vulnerable to specific hazards

At the same time, assessment teams must decide the geographic scope and resolution of the assessment. It is beyond this protocol to offer specific advice here. However, do not confuse geographic resolution (e.g., a GIS based on 50km pixels) with the notion of an exposure unit—those populations and elements the system that are subject to different hazards, threats and stresses.

Clearly, this rapid appraisal need not cover all of the exposure units in a basin! The case study teams might:

- Adopt a multi-level perspective, with some aspects considered at the basin level and higher resolution case studies of specific exposure units in sub-catchments
- Use a representative exposure unit in this rapid assessment. For example, the range of threats and characteristics of different water users in the lower basin might be compared with those in the upper basin, using aggregated data and typical profiles rather than household or individual data.

TASKS	GUIDANCE
2.1 Identification of threats (historical episodes, present risks)	This is an inventory of the main threats affecting the basin (Table 15). It begins with an inventory of historical epidodes (focus on the event of record or the past 30 years or so), for example: • Climatic hazards such as drought, floods, high temperature events, windstorms • Environmental pollution events • Economic and financial crises • Regulatory and institutional changes These can be drawn from: • Existing documents and reviews: most of the serious risks are likely to have been assessed in some form • Brainstorming sessions with stakeholders (useful as part of a participatory approach, see below) • Expert knowledge among the case study team and consultants This list may be sufficient as background at this point. However, it would also be helpful to provide subsequent information. For example, in Table 16: • Year and month (if the episode was within a year) • Water system effects: description of the major effects on the water system • Significance of the episode in management of water resources and social and institutional responses to risk. For example, the 1995 drought in England was seen as a consequence of the privatisation of the water industry in 1989 and shaped the current regulatory approach. This will be only a qualitative notation, maybe just a rating of High for those events that were most important.
2.1 Identification of threats (participatory)	A supplemental activity is a participatory brainstorming exercise or structured elicitation of threats. This links to WB1 (and could be incorporated in a stakeholder meeting along with other steps in the protocol). The result is further rows in Table 16 (and subsequent tables). A brainstorming exercise is a suitable method: • Assemble a range of participants: if the group is too large, cluster them according to different sectors, levels of stakeholders or thematic risks; if only experts are used, they might be asked to play the role of different stakeholders or populations at-risk • Everyone writes down different threats on cards or post-it notes; different colours can be used for different groups • The cards are posted on a large white board or flip charts • Clusters of similar cards are grouped together, often forming a hierarch of threats, for instance drought might be a general category encompassing winter or summer drought, short term operational losses or multi-year low flows, etc.

2.1 Identification of threats (trends)	Using the same threats as above, fill in Table 16: • Estimates of the likelihood, for example a 1% event is rainfall intensity greater than X mm/hr • Trends in the likelihood: is the event becoming more or less common? • Trends in magnitude: e.g., are storms more intense? • Trend in spatial location: e.g., are droughts covering a larger area, or are new areas affected by storms • Other trends
2.2 Impacts of threats	For each risk, provide as much information on impacts in Table 17 as is readily available (remember, this is a rapid appraisal, further details can be filled in later) • Lives lost: total and as a percentage of the population affected • Population affected: total and as a percentage of the population in the basin at the time • Gender, age or social vulnerability if specific population groups were affected more than others: qualitative notes on whether the impacts affected one group more than another • Economic impacts and costs: quantified if available, otherwise a description of the kinds of impacts and relative severity • Ecosystem and environmental effects: likely to be descriptive unless formal surveys were carried out In the process of collecting information on past and current threats, the teams are likely to uncover a wealth of information about adaptation strategies (or coping strategies). It is worthwhile collating this experience at the same time, although it is somewhat beyond what is essential for a rapid baseline vulnerability appraisal. The SEI (and other Newater partners) can provide assistance on how to evaluate coping strategies.
2.3 Exposure units	This task is an initial inventory of who is exposed to the range of threats identified above. At this stage, the task is simply to list the exposure units and describe their characteristics in general terms (Table 18). If more information is readily available, feel free to provide it, but the minimum inventory might be: • Who is exposed? • What is the nature of their exposure? For example, direct impacts of floods or indirect exposure due to increased water charges • Where are they located, at what scale? • What is their water use (amount and sector)? • What is the source of their water? • Any other useful information

Sample tables

Table 15. Inventory of historical and present threats

Basin: **Location:**

Historical risk	**Year/month**	**Water system effects**	**Significance**

Table 16. Frequency and trends in threats

Basin: **Location:**

Threat	**Likelihood**	**Trend in likelihood**	**Trend in magnitude**	**Trend in location**	**Other trends**	

Table 17. Impacts of threats

Basin: **Location:**

	Impacts					
Historical risk	**Lives lost**	**Population affected**	**Gender, age, social vulnerability**	**Economic impacts**	**Environmental effects**	**Notes**

Table 18 Exposure units

Basin: **Location:**

Exposure unit	Type of exposure	Location/ scale	Water use (amount)	Water use type	Source of water use	Other notes

Task 3. An exposure matrix and narrative

The threats and exposure units are brought together:

9. Matrix of vulnerable groups and their relative exposure to different threats
10. Narrative of vulnerability

The third task brings together information on the social, economic and institutional aspects of vulnerability. It is a description of the structure of vulnerability, which can be further developed with quantitative indicators later in the Newater project.

TASKS	GUIDANCE
3.1 Exposure matrix	The sensitivity of vulnerable groups (or exposure units) identified in the previous step to different threats is collected in a simple impact matrix (Table 19). This is usually done as a guided exercise among experts, but can also be built up from focus groups and interviews with vulnerable populations themselves. The steps are: • List the exposure units as rows in a matrix • List the threats as columns • For each intersection of exposure unit and threat, judge the sensitivity of the exposure unit on a scale of 1 to 5 (other scales can be used, but this is the most convenient) • Review the ratings to see if they make sense: is there consistency for each exposure group across the range of threats? Are the effects of each threat consistent across the range of exposure units? This matrix can be further developed—additional guidance is available from the SEI.
3.2 Narrative & summary	Use the exposure matrix to provide a concise narrative or summary of vulnerability. Common questions are: • Which exposure units are most vulnerable? Does this depend on the nature of their exposure, e.g., loss of life, economic livelihood, property and assets? • Which hazards are most dangerous? • What is the relative stress at present? • Which stresses are likely to become serious in the future? For which exposure units?

Sample tables

Table 19. Exposure matrix

	Threats and stresses						
Exposure units (vulnerable groups)	**Threat 1**	**Threat 2**	**Threat 3**	**Threat 4**	**Threat 5**	**Threat 6**	**Threat …**

The column of exposure units can be separated into different sections:

- Environmental elements of the basin, such as surface water, groundwater, estuary, land cover, etc.
- Infrastructure and economic assets, such as roads, bridges, dams, urban settlements, etc.
- Populations, such as different kinds of water users, those living in flood plains, poor people not served by public water supplies, etc.

Scoring the threats (a scale of 1 to 5 is suggested)

Different symbols can be used to indicate the nature of the exposure:

- Direct impact on property
- Financial effects of increased expenditure or reduced income
- Information flow
- Psychological or social stress
- Others?

Task 4: Subjective profile of vulnerability

The final analysis will help compare the case studies:

11. Comparison of vulnerability for different exposure units and basins

TASKS	GUIDANCE
4.1 Compare vulnerability along common attributes	This task compiles a subjective, relative scoring, on a scale of 1 to 5, for a set of common vulnerabilities (Table 20). The scores will be reviewed among the case studies and used in the project synthesis to compare the relative importance of different factors. The scores are relative, so provide an explanation as to the reasons for the score. This will be an iterative task and we may come back to the case study teams for clarification.

Sample table

Table 20. Relative scoring of common attributes of vulnerability

Attribute	Low	1	2	3	4	5	High	Notes
	Few people affected; few economic impacts						Large population affected; economic impacts cause hardship to many people	
Water usage	High water usage, willingness to save water during crises						Low water usage; inability to reduce use during times of scarcity	
Access	Piped and metered water use for almost all						Large portion of population without piped access	
Infrastructure	Well developed and integrated water infrastructure						Little regulation of water supply	
Technology	High technological base, strong investment						Traditional or out-of-date technology	
Actors and institutions	Few actors, well integrated management regimes						Many actors, fragmented authorities, conflicts over management of resources	
Information and skills	High information base and access, sufficient skill base for wide range of stresses and threats						Poor information collection, restricted access, shortage in key skills	
Political willingness	High priority for water management, effective political decision making						Low awareness and priority, ineffective or restricive decision making	
Gender	Equitable distribution of resources, effective means to promote participation by women						Inequitable impacts of hazards, discrimination against women in decision making	
Poverty and income	Almost all water users have sufficient income to secure their water needs						Large population affected by poverty, inequitable water charges	
Others…								

Note: these categories combine an assessment from Luis Mata (University of Bonn) and the Water Poverty Index; upon review a revised list of categories may be developed.