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DRIVING FORCES AND FUTURE DEVELOPMENT PATHS OF CENTRAL NORTHERN NAMIBIA

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INTRODUCTION

The challenges of water scarcity and climate change require those countries located in arid regions to adapt and develop long-term solutions. This is certainly the case for Namibia, which is the most arid African country south of the Sahara. The majority (60-70%) of Namibia's population depends on subsistence agriculture, practised on non-freehold or communal land under conditions of low and highly variable (spatially, temporally) annual rainfall. Increasing population and unemployment combine to create a strong direct dependency on natural resources and a related increasing demand for land and access to water (Werner, 2007). This is occurring under prevailing conditions of overgrazing and declining water tables, which require policy and management interventions (MET, 2005) that are also robust in terms of responding to the uncertainties of climate change.

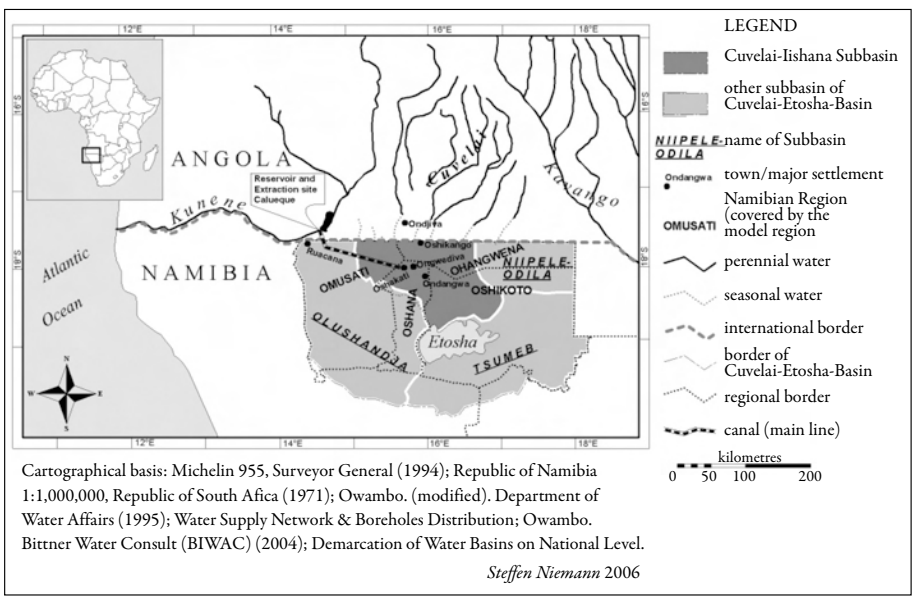
The situation just described is most pronounced in the densely populated central parts of northern Namibia, which is the geographical focus of this study (see Figure 1). The region[1] covers four administrative areas – Omusati, Oshana, Ohangwena and Oshikoto – and is inhabited by almost half of the Namibian population. It is characterized by unreliable rainfall, mostly brackish or saline groundwater and an absence of perennial rivers. Presently, most drinking water is abstracted from the Calueque Dam – near Ruacana on the Kunene River – which is shared between

Exploring Sustainability Science • A Southern African Perspective, 433-469.
Burns & Weaver (eds.)

Angola and Namibia. The water is transported to end users through an open canal (150 km) supplying a system of pipelines measuring some 2 000 km. The raw water is treated for drinking water purposes, but is also supplied for other purposes such as stock-watering (Niemann, 2000).

Growing demands for water in both Angola and Namibia have increased the pressure and dependency on water infrastructure, making the region especially vulnerable. This is aggravated by the fact that alternative sources of surface water tend to be polluted due to non-existent or inadequate waste water disposal and treatment systems – a situation that is particularly prevalent in and close to urban areas. In rural settings, limited quantities of potable water are sourced from traditional boreholes and hand-dug wells; however, few settlements have access to such supplies in sufficient quantity. As a consequence, water consumed by many people does not meet standards for potable water according to WHO (2004).

Livestock in central northern Namibia is a major consumer of water and their numbers exceed the rangeland carrying capacity. This results in extensive degradation and soil erosion such that current pattern of livestock farming cannot be sustained in the long-term (Werner, 2007). Further, it is in question if water demand of livestock can be accommodated in future.



Cartographical basis: Michelin 955, Surveyor General (1994); Republic of Namibia 1:1,000,000, Republic of South Afica (1971); Owambo. (modified). Department of Water Affairs (1995); Water Supply Network & Boreholes Distribution; Owambo. Bittner Water Consult (BIWAC) (2004); Demarcation of Water Basins on National Level.

Steffen Niemann 2006

FIGURE 1: Map of central northern Namibia – focusing on the Cuvelai basin, which is shared between Namibia and Angola.

In summary, the prevailing situation of central northern Namibia is characterised by a scarcity of natural resources, high vulnerability to influences originating from outside the region and a high internal dynamic with regard to demographics

and the economy. This results in difficult framing conditions for the sustainable provision of both water supply and sanitation facilities. Different environmental, social and economic issues are closely interwoven and integrated responses to the challenges that they pose are, therefore, essential. This is recognised in the Namibian Government's Second National Development Plan, which states that natural resources have to be used in a way that does not compromise the ability of future generations to make use of them (NPC, 2001). There is a clear need to manage water and other resources at the appropriate scale (e.g. the scale of the river basin) and a requirement to form resilient institutions to enable this – as identified in the Namibian Water Resource Management Act (GRN, 2004). Against this background, important foundations for Integrated Water Resources Management (IWRM) are established in Namibian legislation.

An adapted IWRM concept that integrates specific social-ecological situations in particular areas with the potential of technology is crucial in mitigating water supply and sanitation problems. It is obvious that the challenges associated with such problems cannot be solved permanently on the basis of the existing infrastructure system (Kluge *et al*., 2008). The reasons for this are threefold: Most important, is the high level of uncertainty regarding future availability and reliability of water sources and the limited supply options. Secondly, a system of water supply infrastructure that extends into sparsely inhabited areas is increasingly exposed to the problem of disproportionate increases of fixed costs and efficiency constraints. Thirdly, there is a certain momentum to the expansion of water supply infrastructure that cannot easily be constrained, which will intensify the water demand/supply problem rather than resolve it.

Current planning initiatives within the region include aspects that address the improvement of water use efficiency and the diversification of sustainable water supply from local, or endogenous, resources[2]. This is being strongly promoted through the project, CuveWaters[3] (of which this study is part), which focuses on the improvement of the livelihoods of people through innovative and adapted water technologies. CuveWaters promotes the development and implementation of an IWRM concept that: is harmonised with existing processes; allows participation of all relevant stakeholders; and, is adapted to the specific conditions of the region. The fulfilment of these requirements is recognised by all parties as a decisive step that will enable successful attainment of the project's objectives.

An important element in the development of local opportunities is technology that can open up alternative water resources. Through technology, it is intended to promote water use efficiency, for example, by targeting different sources – with different quality attributes allocated for different purposes. Technology alternatives that have been investigated include rainwater harvesting techniques, solar-coupled groundwater desalination, artificial enrichment of underground freshwater lenses and decentralised wastewater disposal based on water-saving interventions. In order

to establish the viability of these alternatives it is necessary to gauge their degree of harmonisation with both the present situation, relating to social and cultural habits and norms, and with possible future development perspectives.

The study that is presented in this chapter provides an important basis for this technology assessment. It recognises the crucial role of individual perspectives in informing policy decisions. It is, therefore, based on a consultation process involving a range of relevant stakeholders in Namibia, in order to establish their views regarding water demand/supply and possible future development paths – within the constraints imposed by the environment. It employs a systems analysis approach to establish the major driving forces between environmental provisioning services (specifically water) and human wellbeing, dependencies and relationships, and the most important factors of uncertainty as perceived by different stakeholders. This provides the basis for a better understanding of regional development challenges from a social-ecological system perspective. The formulation of two plausible scenarios on possible future development paths responds to the need to incorporate uncertainty within the analytical process. The concept of system resilience is also incorporated into the analysis as an aid to direct the evolution of the defined social-ecological system on a sustainable trajectory – i.e. capable of responding to surprise (e.g. related to climate change). A transdisciplinary approach is also adopted to deal with the complexity of issues that the system faces – *inter alia*, sustainable water management, regional economic development and poverty reduction – and the fundamental role of societal actors in finding sustainable solutions.

RESEARCH APPROACH

TRANSDISCIPLINARY APPROACH TO SOCIAL-ECOLOGICAL SYSTEM RESEARCH

The theoretical framing for this study is grounded in both social-ecological systems research and transdisciplinarity. Social-ecological research aims to find solutions to problems of sustainability through an integrated perspective on social, ecological and economic issues. Research with this goal requires disciplinary collaboration (bridging of disciplinary divisions), with a focus on resolving societal problems – such that environmental capacity to enable this is accounted for. A transdisciplinary approach requires the involvement of different societal actors throughout the process – which integrates science, technology and other knowledge systems of society. In particular, the integration of the societal dimension into the process differentiates it, for example, from interdisciplinary science-based research. This form of integration demands an adaptation of science and technology to the specific societal needs and potentials. Also, it demands a reflection of how the development of societal options for action is influenced by the availability and limits of scientific knowledge and

technological alternatives. du Plessis (Chapter 3, this volume) and van Breda and Reyers *et al*. (chapters 4 and 5, this volume) elaborate on the concepts of social-ecological systems research and transdisciplinary processes respectively.

A crucial component of this type of research process is that integration must occur from the very beginning. The creation of an agreed outcomes-based research focus is the first integrative task of the research process. The second step consists of specific investigative tasks that exploit disciplinary and other knowledge forms to greatest effect. Key in this regard is the involvement and contribution that is made by different societal actor groups. The application of the resultant integrated knowledge to problem-solving is the final research component. Solution options that might emerge could include changes in norms, values and behaviour as well as science and technology-based interventions. The concept of ongoing refinement and adaptation is implicit in the outcomes that are achieved (Jahn, 2005; Jahn and Keil, 2006). This chapter focuses on the second step of the process – with an emphasis on stakeholder engagement, in the Namibian case study outlined in the introductory section.

SOURCES OF INFORMATION AND METHODOLOGY

This study is based on a series of interviews with different stakeholders and the analysis of official documents produced by the Namibian Government and scientific research reports considered relevant to the case study.

The interviewed stakeholders belong to the segments of society that are involved in/affected by water management and shaping future development perspectives in central northern Namibia. The affiliation of stakeholders can be grouped into administrative institutions at national, regional and local levels, traditional authorities, water suppliers and specific water-related committees, water users, institutions of public and non-public research, non-governmental institutions, consultants and agencies of international development cooperation. The surveyed population included 30 representatives of stakeholder groups, as indicated in Table 1.

The interviews had a dual focus: first, to enable a critical reflection of the current water supply and sanitation infrastructure; and, secondly, to inform a view on the major drivers shaping the future development of the region, accounting for opportunities, constraints and risks. The variety of backgrounds of the stakeholders made a fixed procedure of a guided questionnaire unsuitable for use in interviews. Instead, the interviews were adapted to the specific institutional and individual expertise and experience of the interview partner. The interviews were documented by sound recording in almost all cases and the compilation of minutes for each interview. All interviews were conducted in English with the assistance of a translator in the case of the traditional authorities.

TABLE 1: Overview of the composition of the different stakeholder groups interviewed over the period August to October 2007. The majority of interviews were conducted by the author in cooperation with Martin Zimmermann (IWAR). Some interviews were arranged via a separate process: (i) with the author focusing on major factors, hindrances and risks shaping the future development; and, (ii) interviews reflecting on the current infrastructure, undertaken by Martin Zimmermann.

Stakeholder Group	Total of interview partners	Separate interviews Liehr / Zimmermann (total of interviews)
State administration (ministries)	6	– / 3 (6)
Regional administration	3	– / – (3)
Town administration	2	– / – (2)
Traditional authorities	1	– / – (1)
Specific committees	2	– / – (2)
Water suppliers	2	– / 1 (2)
Water users	1	– / – (1)
Public research	4	– / 4 (4)
Non-governmental institutions (research)	4	4 / 2 (6)
Non-governmental institutions (non-research)	1	– / – (1)
Consultants	2	– / 2 (2)
International development cooperation	2	– / 1 (2)

A stakeholder group that appears to be missing from the list in Table 1 is the representation of the private economic sector, which is clearly a very important group in terms of sustainable water demand and supply issues. The views of these stakeholders are not incorporated into this study, but are the focus of a separate process of interview and analysis, which will be documented elsewhere. However, the main findings on private sector economic aspects are considered here as far as they play an important role in our understanding of the social-ecological system functioning and its evolution along a sustainable development trajectory.

A second and decisive stakeholder group that is also not listed in Table 1 includes the range of water users. The views of this group, for example regarding patterns of water use technology options, were captured in a social-empirical field survey conducted through a series of participatory workshops – the outcome of which is documented by the CuveWaters Project (2007). However, the results of this survey that are deemed relevant to the analysis comprising this chapter are taken into account.

The process of identifying driving forces and the formulation of two possible future development paths consisted of several steps of qualitative analysis and synthesis. Important in this regard was the interpretation of existing official Namibian documents and scientific studies. Added to this was the analytical task of clustering

the results of the interview statements, for example, with regard to system drivers, relationships and dependencies. In this way, the comparison of statements and the identification of points of consensus and dissent provided an indication as to the importance and strength of a factor and also to possible uncertainty and aspects of dispute. The process also included the synthesis of two contrasting and consistent possible future development paths or scenarios for the region, based on the analytical findings. These paths or scenarios are based on assumptions regarding the future, considering different system characteristics, linking relationships and responses to change. Together, they cover the range of what might be considered plausible, albeit inexact, possible system futures.

DRIVING FORCES

The future development of a region such as central northern Namibia is influenced by a wide variety of factors. These factors have different origins such as the economy, policy and politics, institutions, social conditions, finance, technologies and the environment. Not all of these factors are expected to have the same level of importance in determining the future development of the region. However, for some factors, it can be assumed that they will indeed play a dominant role in this regard due to their strong and widespread influences. These so-called 'driving forces' were defined through the stakeholder engagement process and document analysis and are discussed below.

WATER

Water is central for sustaining human life and is regarded by the stakeholders as a driving force of utmost importance. MET (2002) identifies the lack of water as a key limitation to Namibia's development and the water sector as most vulnerable to climate change. Water conservation and demand management are key priorities defined in the country's Water Resources Management Act 2004 (GRN, 2004).

Since its sustainable management is a basis for improvements in the region's future economic and social conditions, the availability of reliable supplies of water could provide an economic impulse – and could lead to the organisation of profitable economic cycles, with new services and products creating income opportunities and support for livelihoods. Positive effects are also expected for the ecosystem, in particular with regard to the reduced degradation of rangelands. The management of water resources usually includes water supply and sanitation, the provision of impoundment and/or reticulation infrastructure as well as socially acceptable water allocation and pricing. The specific conditions in central northern Namibia give rise to two aspects that exert strong influences on current and future developments: water supply over long-distance via pipeline and alternative water sources and technologies.

The stakeholders have no doubt that the long-distance pipeline grid, which supplies water abstracted from the Kunene River, will remain the major source of water in future for central northern Namibia. Further extensions of the pipeline grid are expected to lead to new continuous and stationary water sources, especially in remote rural areas, which will reduce seasonal movements of the people. Subsequent developments that may be linked to the pipeline and its extensions are concentration processes along the grid infrastructure (the so-called "magnetic" effect), with an increase of overgrazing problems caused by an intensification of land use in areas close to available water. The supply limitations of traditional hand-dug wells have minimised the problem of overgrazing in the past (Marsh and Seely, 1992); however, this situation will change in response to the "magnetic" effect of the pipeline as it is extended to meet the requirements of a growing population and to reduce pressures on the existing grid in certain areas. Account also needs to be taken of the dynamic through which a proportion of the rural population is moving to new places of economic opportunity away from the grid, which reduces the value of the infrastructure.

The functionality of the infrastructure system and the acceptability of the water that it supplies are two issues of high priority and concern to stakeholders. Building functionality depends on the availability of human, physical, financial and environmental resources. Different stakeholders are concerned about a lack of knowledge and inadequate capabilities of the people managing and/or using the water infrastructure. Future national and regional initiatives concerning education and capacity building are considered to be decisive for an improvement of the situation. Financially, a path towards cost recovery should be pursued; however, this is compromised by problems relating to a willingness to pay, vandalism and misuse.

This gives rise to the issue of acceptability. The acceptability of water from the pipeline grid depends strongly on a fair tariff system that avoids discrimination of different social groups. Historically, in the times before independence, water supply was free. A different situation now prevails and ongoing communication and information campaigns are considered to be very important in terms of making people aware about the value of water and water supply infrastructure – in order to not only increase the willingness to pay but also to clarify the role and responsibility of every individual for securing the infrastructure against vandalism and misuse (Klintenberg *et al*., 2007).

The future potential of, and risks associated with, the long-distance water supply from the Kunene River are closely connected to each other. Heyns (2003) indicates that the river's mean runoff is about 5.500 Mm^3/yr and the Third Water Use Agreement of 1969 between Namibia and Angola specifies that the abstraction limit for water from the Kunene River is 6 m^3/s (about 190 Mm^3/yr). Namibia can, at present, divert 3.2 m^3/s from the Kunene River which means that there is a high potential for expansion and extension of the water supply, for example to be used

for irrigation and production within the agricultural and other economic sectors. Realising this potential in abstraction volumes would require a massive increase in water conveyance infrastructure – the viability of which needs to be considered in the context of the implications of a binding dependency on the Kunene River and accounting for the development of upstream water uses in Angola. This option, therefore, carries a high level of perceived risk and uncertainty.

Besides the long-distance water supply alternative, the general concept of developing decentralised water sources and technologies is endorsed by different stakeholders. The importance of the latter is expected to increase in response to water scarcity and a desire to reduce the risk of dependency on a single major source of water. Clearly, the development of alternative water sources, to complement the pipeline grid, offers the benefits of diversified supply. Such options reduce the risk to communities of water shortages and the pressure on the pipeline supply and also offer possibilities for supplies of high quality water. The latter, in particular, is an important consideration since alternative supply sources offer a variety in terms of water quality for different end uses – e.g. potable pipeline water for human domestic use vs. rainwater capture for livestock and irrigation.

Having access to alternative water sources in the case of communities residing far from the pipeline is important both in terms of opportunities for livestock watering and for domestic use. As dispersed (vs concentrated) points of water supply, they reduce the pressure on the rangelands in close proximity to the pipeline network, which are in a state of deterioration. Viability obviously depends on the availability of alternative water sources, the finances and technology needed to exploit these resources, quality considerations affecting fitness for use, and the technical and administrative capacity to develop and manage them.

ECONOMY

The fact that central northern Namibia is inhabited by almost half of the country's population (CBS, 2003) and that traditional rural lifestyles are compromised by strong urbanisation and development processes reveals the role of economic dynamics for the future development of the region (Mendelsohn *et al*., 2000). Stakeholder understanding of the economy is characterised by a high degree of uncertainty – with confidence therein varying between visions of decline, stagnancy and growth. However, there is agreement regarding the current and future importance of farming and trade – insofar as this relates to food security and food self-sufficiency in Namibia and within the SADC region (Bird *et al*., 2003; Mano *et al*., 2003; Rosegrant *et al*., 2005; Love *et al*., 2006).

Some stakeholders expect that strong economic prospects are determined by commercialisation and trade activities associated with service providers and business. There is also a view that the economy in the central northern region is currently

sustained by a cash flow from the south due to migration of the work force out of the region to other parts of Namibia. Despite the economically stimulating role of such cash flow, the trend of out-migration implies that expertise and decision-making capabilities leave the region with impacts on institutional capacities as well as household and community lifestyles and values (see Cundill and Fabricius, Chapter 16, this volume, who describe a similar situation for the Eastern Cape in South Africa).

Historically and today, livestock and crop farming (mainly cattle and mahangu, or pearl millet) form the basis of the subsistence-oriented economy (Mendelsohn *et al*., 2000). This situation persists despite ongoing urbanisation processes, since migration to urban areas does not terminate people's connection with their traditional rural roots. Many migrants continue to hold some form of title to land and livestock in the rural areas they leave. This is evident from a comparison of sources of income at the level of households. As indicated in Table 2, between 48 and 80% of income is generated through subsistence farming in central northern Namibia, compared to the countrywide average of 29% (CBS, 2006).

There is agreement between stakeholders that in both the short- and medium-term, farming will remain important in terms of sustaining the economy. Consequently, livestock numbers might be expected to diminish only over the long-term as sustainability constraints set in, despite the trend in urbanisation. These constraints will manifest through either the exceedance of ecological thresholds and severely diminished rangeland carrying capacity or the emergence of socially acceptable policies for limiting livestock numbers. Either of these constraints carries with it a high potential for conflict because livestock is traditionally not only considered as an economic good but as a cultural part of wealth. Policies affecting this integral part of societal living need to be formulated and applied with caution and a sense of commensurability. The strong dependency on cattle and the importance of subsistence can thus be seen from a two-sided perspective: as a hindrance for other developments; and, as a societal protection or buffer in times of need.

The trend in commercial farming is one characterised by fewer and larger farms, with land-owners residing elsewhere in Namibia. This results in improved and more sustainable range management practices leading to an increase in livestock productivity. Irrigation schemes serve to secure crop harvests against the natural variability of rainfall pattern and allow the cultivation of profitable crops such as vegetables and mahangu. Under the commercial scheme referred to here, cattle change from a cultural good with long-term value (including a form of insurance – point made earlier) to a marketable and traded commodity.

TABLE 2: Data on demographic and economic factors for the four regions in central northern Namibia (compared with Namibian national-level statistics). Values for central northern Namibia are weighted mean values accounting for the population distribution.

	Administrative region				Central northern Namibia	Namibia
	Ohang-wena	Omusati	Oshana	Oshi-koto		
Population[(1)] [inh.]	228.384	228.842	161.916	161.007	780.149	1.830.330
Fraction of Namibian population[(1)]	12%	13%	9%	9%	43%	100%
Area[(1)] [km²]	10.703	26.573	8.653	38.653	84.582	824.116
Population density[(1)] [inh./km²]	21,3	8,6	18,7	4,2	9,2	2,2
Fertility[(1)] [chil-dren/woman]	5,3	4,0	3,7	4,6	4,4	4,1
Annual population growth rate (1991-2001) [(1)]	2,4%	1,5%	1,8%	2,2%	2,0%	2,6%
Urban population[(1)]	1%	1%	31%	9%	8%	33%
Rural population[(1)]	99%	99%	69%	91%	92%	67%
Population born outside the region[(1)]	8%	7%	23%	24%	16%	---
Subsistence farming as the main source of household income[(2)]	58%	80%	48%	50%	60%	29%
HIV prevalence[(3)]	18,2%	21,7%*	25,2%	19,0%**	20,4%	19,7%

[(1)] 2001 Population and Housing Census (CBS, 2003); [(2)] Namibia Household Income & Expenditure Survey 2003/2004 (CBS, 2006); [(3)] 2004 National HIV Sentinel Survey (MOHSS, 2005). * average of sites Oshikuku (26,7%) and Outapi (16,7%); ** average of sites Onandjokwe (22,1%) and Tsumeb (15,9%).

The commercialisation of livestock farming is much more exposed to restrictions and regulations than crop farming. As a result, its future depends on improvements in facilities for veterinary quarantine, transport, auctions, veterinary services and market transparency. A focal point is the veterinary fence, which aims to prevent the transmission of diseases (in particular foot and mouth disease), but also affects the perceived profitability of livestock farming through its constraint on expansion. Although the future of the fence and its possible displacement northwards to the Angolan border is under discussion, this is regarded as a long-term issue with high levels of uncertainty regarding when/if it might happen.

In addition to livestock and crop farming, manufacturing and trade are potential fields for further and far-reaching economic impact and contribution to a broadened

base of the country's economy. The adoption of the Export Processing Zone (EPZ) Act in 1995 and the establishment in 1998 of an EPZ point in Oshikango, on the border with Angola, offers positive regional economic opportunities. In addition, the new railway extension that connects Oshakati and Oshikango with Tsumeb and other parts of Namibia is likely to enhance the economic links with Angola and to stimulate the local and regional economy through new investments in business, service providers and manufacture. Trade is regarded as a leading field of economic activity, linking other parts of Namibia and Southern Africa with the growing economy of Angola. The potential for expansion will largely depend on improvements in the institutional and administrative framing conditions necessary to create an environment for entrepreneurship. If successful, this would trigger knock-on effects in the form of job opportunities, income generation and an increase of wealth and living standard of the region's population. Currently, significant limiting factors include the educational background of the local population, loss of human capacity from the region due to urban migration, water availability and financial conditions such as lack of access to credit facilities.

Expectations concerning additional economic possibilities differ among stakeholders, but with generally high levels of uncertainty. In general, small scale irrigation and aquaculture have a high potential to improve food security in the region and indeed the country as a whole (Nantanga *et al*., 2007). Aquaculture (on a limited scale), in particular, seems to have potential as a new economic source since the demand for fish in the region is high and the local population would seem to have a cultural interest in this type of activity. A Green Scheme Programme (MAWRD, 2003; Odendaal, 2006) was initiated by the Namibian Government in order to enhance socio-economic development and to uplift rural communities. In this context, irrigation projects are perceived as offering economic opportunities and there are possibilities for new schemes to be established in the central northern part of Namibia. There is some potential for small-scale urban gardening, although the expense associated with reticulated irrigation water is prohibitive and insect pests are a problem. Tourism offers important possibilities for Namibia as a whole (especially in the central north), although specific attractions and tourist centre infrastructure are lacking. Industrial development is a highly unlikely option for the region.

URBANISATION AND CONCENTRATION

The concentration of population occurs in central northern Namibia due to the movement of parts of the rural population to locations close to water points. In time, these settlements grow to become villages with the need for further services and infrastructure. These villages represent a first step for many people to break away from their traditional roots and habits as they move towards large urban centres. Such nodes of initial concentration of the population may also either serve

as relief areas for growing urban centres or develop to form the nuclei of possible future towns. Thus, these small agglomerations play a significant role regarding the urbanisation process as a whole (Seckelmann, 2001). Quite a pronounced phenomenon is the development of small towns in proximity to business centres. This drives urbanisation through a positive feedback cycle, since living closer to services and infrastructure leads to the perception of residing in remote areas as being disadvantageous – with the growing disparity of economic status of rural and urban communities already representing a problem in this region. The dominance of young people within the migration process leaves a deficit in the workforce capacity in the rural areas that they leave. Cundill and Fabricius (Chapter 16, this volume) draw similar conclusions for the rural areas they study in South Africa.

The urban environment, which is the target of the migrations process, reflects the classical pattern of urbanisation under the conditions that have been described. People migrating from the rural areas first live in informal settlements within and surrounding towns like Oshakati and Ondangwa. These informal settlements have no, or only poorly developed, services and infrastructure. Many migrants stagnate in this situation, with a smaller proportion moving into formal settlements; alternatively, some formalisation of the informal settlements takes place. The latter process is confronted with hindrances entailing the need to restructure the settlements in order to build formal infrastructure and to implement basic services.

Rural areas that suffer the effects of out-migration lose not only the young sector of the population, but also land to the expanding towns. This latter effect generates conflict along the dynamic border between urban and rural areas. Financial compensation to affected rural areas is possible, but the limited financial resources of urban administrations and doubt whether this measure ultimately addresses the greater problems facing rural communities are obstacles that hinder resolutions. The loss of land to urbanization implies losses for both livestock and crop farming, and without the possibility of investments in new land, the livelihood base of affected rural communities is threatened.

A further aspect of urbanisation is the already-mentioned phenomenon that urban migrants retain some form of title to their rural homestead, from which a sub-optimal form of livestock farming persists. Urbanisation does not, therefore, introduce some benefit in the form of lowered pressure on overstocked rangelands.

A final aspect of concern regarding migration pattern is that it is often the least degraded areas near the expanding towns and the pipeline infrastructure that are targeted – which rapidly triggers an *in situ* process of land degradation. Stakeholders also regard related trends that interfere with traditional patterns of transhumance in dry seasons (Marsh and Seely, 1992) as having the potential to cause interregional conflict.

CLIMATE CHANGE AND EXTREMES

Few scientific studies address the effects of global climate change with regard to its specific consequences for Namibia, and in particular the central northern region. Some specific reference to Namibia is made by Tarr (1998), Hulme *et al*. (2001), Beyer and Jacobeit (2002) and Reid *et al*. (2007). Also, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) presents some information that is of very broad regional relevance (IPCC, 2007). Recent studies confirm that up to 30% of the country's GDP is reliant on the environment (Lange, 2003) and that between 1 and 6% of annual losses to the economy could result from impacts of climate change (Reid *et al*., 2007). Reasons for the country's high degree of vulnerability include its very direct dependency on basic ecosystem services, limited economic opportunities and, therefore, limited adaptive capacity (MET, 2002; Boko *et al*., 2007).

Scientific studies report a rise of temperatures in Namibia that are three times the global mean increase reported for the 20th century, and predict future increase in temperature ranging from 2 to 6°C until 2100 (Reid *et al*., 2007). The rainfall pattern is expected to become more variable and a higher probability of extreme events including drought and floods is expected. Predictions under conditions of enhanced greenhouse warming, based on statistical down-scaling procedures of large-scale circulation models and regional climate, indicate a shortened but intensified rainy season in central northern Namibia (Beyer and Jacobeit, 2002). Other investigations predict, with high levels of confidence, that the African semi-arid areas like Namibia will experience a decrease in water resources, accompanied by shifts in rainfall distribution and intensity (IPCC, 2007).

The direct effect of the predicted changes in rainfall pattern and higher evaporation rates, due to the predicted temperature increases, will be a reduction of water availability (MET, 2002). Set against projected increases in water demand, this will adversely affect livelihoods and exacerbate prevailing water-related development constraints (see Ashton *et al*., Chapter 9, this volume, who describe equivalent implications associated with diminished water supply options in areas of South Africa). The most severe economic consequences are predicted, with medium to high levels of confidence, for traditional subsistence agriculture. Low to medium levels of confidence are attached to predictions of decreasing commercial production of cereals, other crops and livestock. This raises serious questions regarding access to food and the situation of food security for the country's population. Associated social impacts can be foreseen relating to health problems, unemployment and increased poverty – affecting the poorest sector of Namibian society. As a consequence, there will be an intensification of the urbanisation process and new challenges will arise in terms of policies for sustainable development and their implementation, under conditions demanding adaptation (Boko *et al*., 2007).

On the part of the government, climate change is considered as one of the most serious threats to the wellbeing of Namibia's population in terms of implications for human health, the economy and the capacity of the environment to provide essential ecosystem services (MET, 2002). Close social-ecological system links are very apparent in the subsistence economy that relies on crop and livestock farming – an economy that is currently sustained by scarce natural resources and constrained by limited financial resources, technologies and skills.

Namibia acceded to the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and has launched a National Climate Change Program (NCCP). Actions under this program include the establishment of the Namibia Climate Change Committee (NCCC) in 2001 – a multi-stakeholder committee that advises government on policies and strategies aimed at preparing the country for the effects of climate change. An important development is the preparation of the Initial National Communication on the status of climate change (MET, 2002) as well as proposals for corrective actions to reduce the predicted effects of climate change. This communication was delivered to the UNFCCC in 2002. In future, the NCCP will be integrated into the national planning and development processes of the government, leading to a national strategy and action plan for climate change. The issues of institutional adaptation and adaptive management capacities are important components of this process – in which all actors will need to engage to devise appropriate interventions and solutions to promote sustainable development under highly dynamic conditions of climate change (MET, 2006).

Against this scientific and political background, the interviews with stakeholders revealed that the issue of global climate change is highly pertinent. However, there is no agreement on specific impacts anticipated for the central northern region. In this regard, opinions range from climate change having little effect on the region, to having already induced impacts of the kind previously described in this chapter. Despite this lack of consensus, perceived effects of climate change were widely acknowledged and afforded importance by a majority of stakeholders consulted in the interviews. Concrete examples mentioned include an expected decrease in availability of water during the rainy season and the termination of surface water flow into the Etosha Pan, with consequences for the landscape and ecosystem of the oshanas (shallow depressions, seasonally inundated by flood-waters – efundja). The intensification of flooding is expected to affect the expanding urban centres and conditions for safe habitation – a phenomenon that had dramatic consequences within the region in February and March 2008. Such shocks caused by extreme events (both flooding and drought) are regarded as major risks for the region.

Generally, development of the region is seen to be at risk due to climate change and, therefore, this requires particular attention in planning processes.

POLICIES, INSTITUTIONS AND FINANCE

A comprehensive policy framework exists in Namibia and a variety of institutions have been established since independence to manage the different natural resources, economic and development sectors, and to facilitate related public participation in decision-making. Despite the fact, that 'integration' is accepted as a major issue for the sustainable management of natural resources, this is not embedded consistently and throughout all policies. For example, the integration of water and land is not addressed in the National Land Policy, beyond a very general commitment to sustainable development. On the other hand, the National Water Policy exhibits a more holistic view about balancing different resources such as land and water, but omits the Ministry of Lands and Resettlement (MLR) as an important stakeholder for inter-sectoral cooperation and coordination with other ministries (Werner, 2007).

New insight exists within government regarding the necessity of integrated policy reform within the water and land sectors. Tentative initiatives in this regard include the Environmental Assessment Policy, adopted in 1994, and the Environmental Management Act, which has been approved but not instituted thus far. These examples of policy/legislation are based on the concept of integrated, coordinated and sustainable management of the country's natural resources (Tarr and Figueira, 1999; GTZ, 2007).

In practice, informational and structural linkages between the water and land management sectors are being established. For instance, members of the Communal Land Boards receive training to build understanding of the linkage between land use and access to water. With this insight it is envisaged, for example, that the availability of water will determine certain conditions included in land leasehold contracts – such that where circumstances demand, land may not be developed for irrigation. It is thus clear that strong political support exists for the establishment of appropriate institutional structures, capacity building and integrated planning at national and regional levels of government.

Beside the issue of policy integration, Namibia is shifting towards decentralisation of decision-making processes. The adoption of the Water Resources Management Act 2004 (GRN, 2004) provided direction for this process in the form of its directives for the establishment of regional-level Basin Management Committees and additional structures at the communal level. Similar developments are taking place within the land and environmental management sectors.

There is some way to go in terms of bridging the expression of political will, regarding the above, and implementation – effected through the promulgation of administrative acts. Currently, there is a backlog in this process, with regulations and by-laws lagging policies. Further challenges to implementation include capacity limitations at different administrative levels and the need for institutional

structural change and development. Despite these problems, there is widespread institutional awareness on the integrated relationships, for example, between water, land and other environmental aspects. Decentralisation supports this development since it enables the integration process in practice at the regional and local levels, especially pressing issues.

Interviews concerning economic development within the region revealed the dual structure of policy objectives relating to food security and economic growth. This is also evident, for example, in the National Water Policy White Paper (MAWRD, 2000), National Development Plan (NPC, 2001) and Vision 2030 (Office of the President Windhoek, 2004). The practical implementation of these policies requires the creation of incentives for long-term integrated engagements at the local level. Such incentives include adequate financial and institutional structures for supporting initial investment – for example, to promote small local-scale economic growth centred on water supply. However, the immediate feasibility of this is questionable since the necessary coordination of activities within and between various ministries is currently a significant challenge. To illustrate this, reference can be made to the development of marketing structures for local producers and distributors, which have taken decades to realise and with limited success (Price Waterhouse Coopers, 2005). However, this issue is being addressed by the "Namibian Market Share Promotion", devised by the Namibian Agronomic Board, and some progress is being made – for example, through the requirement that importers must procure a certain percentage of their products in Namibia. In response, import substitution has increased from 7 to 30% between 2002 and 2007 (Brock, 2007).

EDUCATION AND CAPACITY BUILDING

There is consensus amongst the interviewed stakeholders on the importance of education and capacity building. It is acknowledged that both general and specialist knowledge is required in political and administrative decision-making processes – to the same extent that this is required in all societal sectors. Decisions, for example, relating to technologies and institutional changes are likely to fail if they are not based on appropriate knowledge. In this sense, education and capacity building are important cross-sectoral requirements necessary for the sustainable management of water sources and the introduction of technology alternatives, changes in water use practice, etc. Expressed in the words of stakeholders – developing the capacities of the people is a crucial factor for avoiding mismanagement and for dealing with constraints and risk (see FIRM, 2003).

Education in schools should increase awareness amongst the younger sector of the population of the value of water, its scarcity and basic principles of water supply, sanitation and wastewater treatment. Everyday practices relating to water-conservation measures and simple options such as water collection from roofs can be learned. This holds equally for both the rural and urban populations. Education

can also condition people for adaptation to water-related impacts of climate change and to anticipate livelihood responses necessary to sustain the country's economy.

An important principle for enhancing the effectiveness of formalised capacity building initiatives is the multiplier effect; i.e. the potential of capacitated individuals to propagate their knowledge and skills through the institutional positions they hold, their capabilities, etc. Identifying this group of candidates for training and establishing suitable structures for knowledge dissemination will be important for building capacity in an effective and efficient way.

Specific target groups for capacity building in the sphere of water management include the members of Local Water Committees (LWC), Water Point Committees (WPC) and the Iishana Basin Management Committee (IBMC). These institutions play a central role in the water management structure of the region and their capacity to do this effectively is of concern to stakeholders. It is felt that, currently, LWC members are not adequately trained to do their jobs – a situation that extends to new appointees who are neither sufficiently educated (in the field of water management) nor adequately mentored by senior committee members. In some instances failures also relate to deficiencies in the selection process for appointing candidates. Considerable effort has been invested in capacity building within the IBMC, which was officially inaugurated in October 2005 by the MAWF; however, this has not focused on the actual management of the sub-basin (Klintenberg *et al*., 2007). These observations do not relate to the capabilities and potential of the people appointed to committee positions, but to failures in the systems for building competency and realising capabilities and potential. An urgent response to the challenges of capacity building is necessary if the management of water and other environmental priorities is to be effective in terms of responding adaptively to current problems and the exacerbation of these under the uncertain conditions of climate change.

Stakeholders see the urgency of capacity building as extending beyond water governance structures to include, in particular, the farming and business sectors. All farmers are implicated in the sustainability of agriculture and rangeland management – with strong influences and dependencies on water. The land reform process appears to be problematic in this respect because land is assigned to people without the provision of appropriate training. Profitability of farming, competitiveness and marketability are critical challenges that new farmers are increasingly confronted with. There are concerns about adverse environmental, economical and social consequences if capacity building is not afforded higher priority than at present.

Also, business and entrepreneurship are important areas for capacity building and strengthening competencies. At a very practical level capacity needs to be developed in the services sector relating to the production, marketing, installation, operation and maintenance of water-related technologies – which can support the regional

economy as well as water management in general within the country (Roland-Holst, 2006).

DEMOGRAPHY AND HEALTH

The Population and Housing Census of 2001 (CBS, 2003) indicates a Namibian population of 1.83 million people, with an average annual growth rate of 2.6%. Table 2 shows that the four administrative regions of central northern Namibia are inhabited by almost half of the Namibian population, with each region having a population density above the country's average. The regions of Ohangwena and Oshana have exceptionally high densities of some ten times the national average. Patterns of interregional migration are particularly pronounced for the Oshana and Oshikoto regions, with both having a higher proportion of urban to rural population than in any other regions. The annual growth rate in population of central northern Namibia is about 2.8%, which is slightly above the Namibian average; however, this is expected drop to 2% due to a decrease in fertility and the dual effects of migration and HIV/AIDS (Mendelsohn *et al*., 2000).

Stakeholders acknowledge that the population density within the region exceeds the capacity of the environmental resource base to sustain a desirable level in the quality of human life. This situation has prevailed since before the installation of the long-distance pipeline grid, but has been exacerbated by it through the attraction it has exerted for the establishment of other infrastructure and facilities (e.g. schools), which have accelerated the process of in-migration. Illustrative in this regard, is the town of Oshakati, which has a population of about 45 000 people – two thirds of which live in informal settlements, where households each comprise about 15 persons. These numbers increase significantly during holiday seasons, especially in December, when the town supports a population of about 150 000 people. Throughout the year, this situation results in a demand for water and sanitation services that is proving difficult to respond to.

It is appreciated by stakeholders that the region must prepare for population growth and an increase in water demand under very restricted financial conditions. The risk of an exclusive dependency for water supply from NamWater, and a history of water shortages has sensitised stakeholders to seek alternative technologies for supplementing the existing water supply infrastructure.

The health of the region's population is regarded by stakeholders as a crucial determinant of sustainable development. Responding to the HIV/AIDS crisis, which is the primary cause of hospitalization and death in Namibia, is regarded as a top priority. With an overall HIV prevalence of 19.7%, Namibia is one of the countries in the world most affected by the pandemic (MOHSS, 2005). As indicated in Table 2, the most urbanised region of Oshana has the highest prevalence of this disease, well above the country average.

Stakeholders do not believe that mortalities attributed to HIV/AIDS will significantly reduce the region's population or retard rates of increase in the long-term. It is believed that infection prevention measures, future treatment possibilities and the availability of drugs will be effective in reducing mortalities. However, given the uncertain time horizon of medicinal and pharmaceutical developments, the disease does pose a significant societal threat to the region's population, at least in the short- and medium-term (i.e. the next few decades).

One of the many problematic aspects of HIV/AIDS is that it impedes continuity in the building of competences within a range of institutional structures. Where tacit knowledge relating to water management is held by sick individuals, and this is lost through early mortality, the transfer of this knowledge is compromised. This demands creative responses, for example, ensuring overlapping responsibilities within institutions to ensure the retention of essential competency and knowledge. Obviously, such an intervention attracts costs in terms of efficiency – however, these are unlikely to outweigh the cost of lost capacity. The retention of social capital and social memory is critical for the maintenance of resilience and adaptive capacity within functioning social systems (Folke *et al*., 2005; Cundill and Fabricius, Chaper 16, this volume).

HIV/AIDS is certainly not the only threat to social resilience within the region. A very strong relationship exists between human health and water quality associated with surface water sources. The canal water, and also water delivered through the pipeline reticulation system (where there is damage to the system), carry high risks of malaria, bilharzia and other water-borne diseases. Risks from other pathogens exist in situations where both water for domestic and livestock watering purposes is sourced from polluted lakes (oshanas) and from the canal. Illegal fishing is also practised in sewage oxidation ponds and this is clearly highly hazardous to human health.

FUTURE DEVELOPMENT PATHS

Given the driving forces that have been described, finding sustainable solutions for future water supply and sanitation is a considerable challenge. Complexity, uncertainties and varying expectations, for example, of impacts associated with climate change indicate that it is necessary to have recourse to extra-ordinary approaches to strategy formulation and implementation as well as technologies. Central in this regard are adaptive approaches, both in terms of management structures and technologies – in particular, relating to water and more broadly encompassing natural resource management.

The conceptual basis of social-ecological system research, and related approaches to resilience analysis, require a comprehensive understanding of integrated *whole systems*, characterised by complex interactions between society and nature (Jahn and

Keil, 2005; Burns and Weaver, Chapter 1, this volume). For the case study discussed in this chapter, this is taken into account in Figure 2, which illustrates the strongly interwoven social-ecological system structure, driving forces, causal dependencies and feedback loops that characterise the situation in central northern Namibia. However, prior to developing integrated models such as this, differentiation is required to establish the important relationships between the societal and natural system components that sustain either system stability or adaptability and functioning. This is represented in Figure 2, which focuses on the integrating role of water management and different types of technologies.

Understanding the main components and determinants of dynamic social-ecological systems, and allowing for uncertainty and surprise, facilitates system analysis and the projection of management strategies and intervention planning into the future. This approach requires a level of bounding (what is considered plausible), within which the capacity of a system to adapt to and shape change can be fostered (Folke, 2006). Such enabling of adaptive capacity relates to both societal and ecological system components due to their high levels of interconnectedness.

Critical thresholds, beyond which undesirable change can be expected, must be avoided. Rather, social-ecological systems must be managed towards increased adaptability – an ability to change, but within a range that is both socially desirable and sustainable. Implementing adaptive governance structures is one important approach towards strengthening the adaptive capacity of social-ecological systems to cope with future uncertainties. In the context of water resource management, such adaptiveness must include experimentation with a range of land use (including urban) planning approaches and water supply and demand management technologies.

A well-established approach for analysing and preparing for uncertain futures is the development of scenarios (Alcamo, 1998; IPCC, 2000). The alternative term 'future development paths' is used in this chapter due to the preferred linguistic notion in the regional project context and the focus on general perspectives without specification of timescales. Future development paths describe contrasting and consistent developments that are characterised by different combinations of driving forces and their subordinated aspects. As Figure 3 illustrates, two possible future development paths can be constructed for the central northern region of Namibia on the basis of the preceding analysis of driving forces and the model of causal dependencies illustrated in Figure 2. Both paths can serve as a background for identifying and assessing concrete options for water management technologies, and for planning important aspects of governance within the water and other related/interconnected sector.

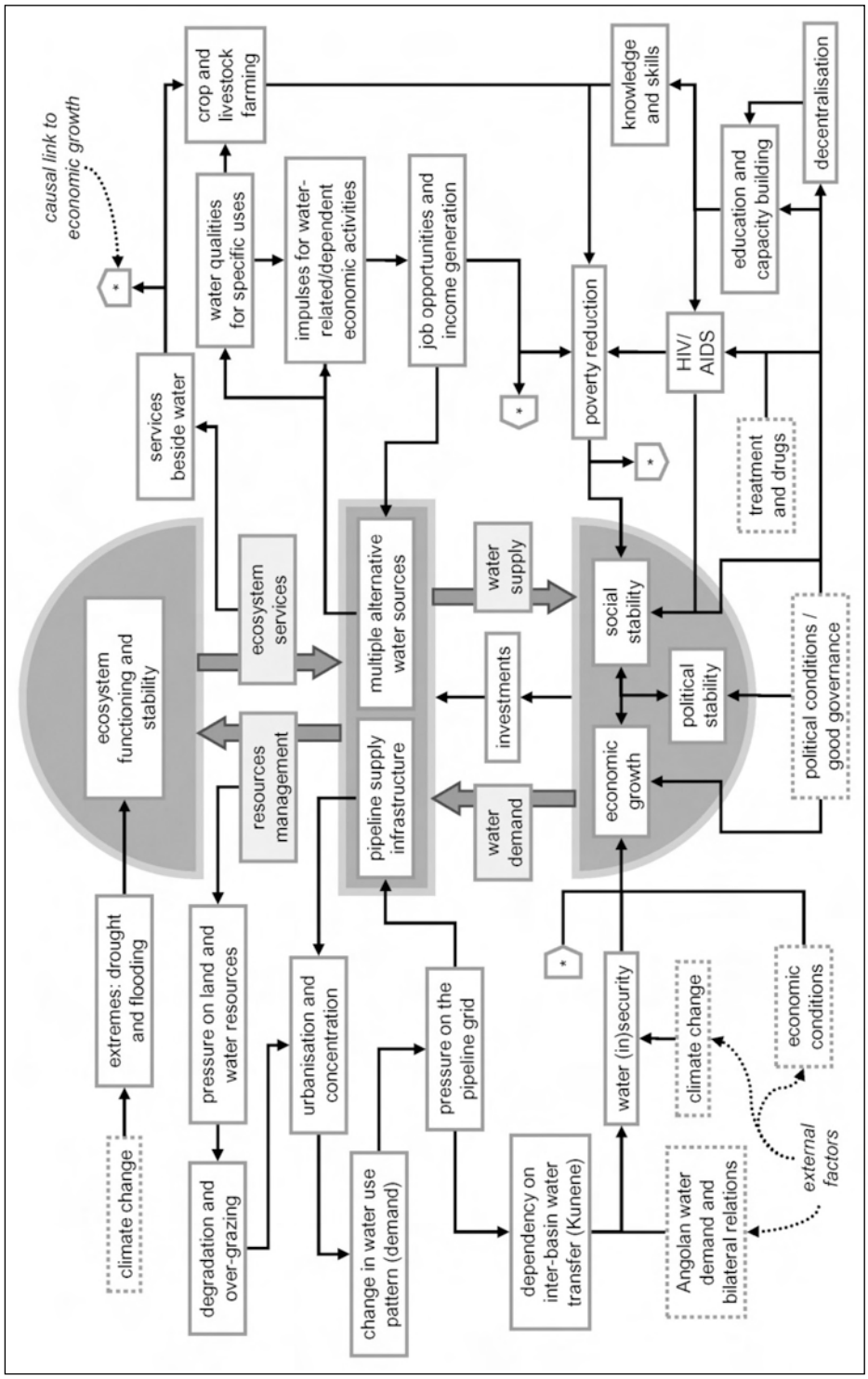


FIGURE 2: Model of the main causal dependencies and feedback loops that characterise the situation in central northern Namibia. In line with social-ecological systems thinking, societal and natural aspects are strongly coupled by interwoven connections constituting the system as a whole. The emphasised structure in the centre refers to the relation of those societal and natural factors that sustain the system's stability and functioning (and to water infrastructure – its integrating and bridging role affecting social and ecological system aspects).

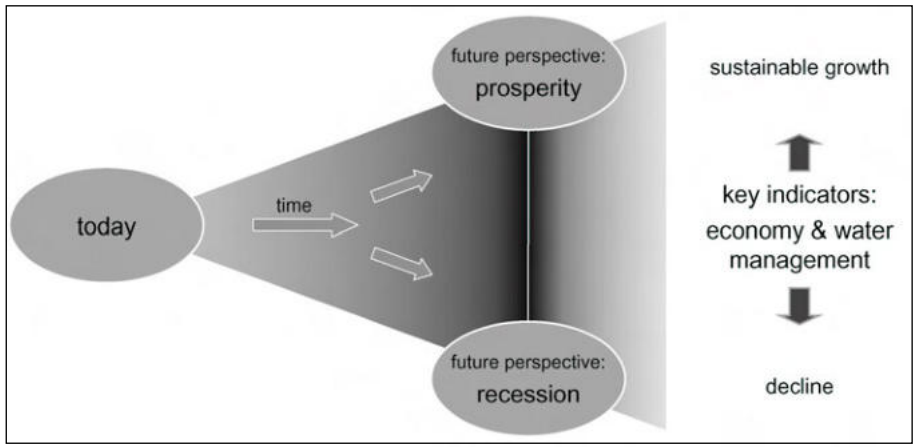


FIGURE 3: Corridor of possible developments, with economy and water management regarded as key determinants/indicators for sustainable growth or decline. Alternative future development paths capture the realistic range of possible scenarios.

THE "PROSPERITY" DEVELOPMENT PATH

The "prosperity" development path describes a possible future for central northern Namibia where economic development and water management are linked closely together and their interaction supports sustainable growth and a strengthening of the resilience of the region's social-ecological system. The development of capacities for water supply and sanitation goes hand-in-hand with the increase in water demand and the needs for sanitation and treatment facilities of the people and the strengthened economy. Political stability and a strong will for bringing national strategies and policies into practice on local scales secure a positive cycle of long-term investments for economic growth that address adapted water technologies and infrastructure as well as social and institutional capacities:

The fulfilment of water demand is based on a combination of the pipeline grid, additional alternative water sources and efforts for an increase in the efficiency of water use. The abstraction of water from the Kunene River and its distribution through the long-distance infrastructure remains the major water source of the region. Extensions of the pipeline grid lead to a new continuous and stationary water source in remote areas where formerly people only had access to intermittent water sources. The magnetic effect of the pipeline grid concentrates the population along the infrastructure, interfering with the traditional pattern of transhumance. Problematic consequences are that the improved access and higher availability of water increases the demand. Further, the concentration of people along the pipeline increases the pressure on the land resource with problems of overgrazing and deterioration of the nutrition quality of rangelands. Nevertheless, both aspects are mitigated by sustainable management due to improvements in the adaptability of governance and by the implementation of additional and alternative

water sources. Depending on the local conditions, different technology options such as rainwater harvesting, desalination and artificial groundwater recharge lower the pressure on the pipeline grid and, where these developments are sufficiently extensive, also on the rangeland resource nearby. Pipeline water is of high quality and, therefore, is mainly used for human consumption (it is too expensive for most other purposes). Alternative technologies make water of different qualities available for specific uses such as irrigation and livestock watering. In towns the pressure on the pipeline is also lowered by alternative water sources such as rainwater harvesting and sanitary installations with high water-use efficiency – leading, for example, to the reuse of washing water for sanitation and the introduction of other water-saving technologies. Water collection from roofs allows a low-priced possibility for urban gardening and contributes to poverty reduction, because additional food for households can be grown on small scales. The expectations of political stability and economic growth allow a balance of investments in shared facilities as well as in more cost-intensive individual concepts of supply and sanitation infrastructures with long-term profitability. Especially, improved sanitation reduces collective health costs; also, diversified supply opportunities allow side-by-side household based and commercial oriented activities that contribute to poverty reduction and economic development on a broad basis. Thus, the mutual linkage of water, land and economy establishes as a dynamic factor for development due to initiations of economic cycles around water with new products and new opportunities for services with a stronger commercial orientation leading to job creation and income generation. The water-related dependency on the Kunene River and upstream water uses such as irrigation in Angola is reduced slightly by the implementation of these alternative technologies, but stays high in general because the long-distance supply scheme is necessary and not replaceable by these measures. Most important, is the improvement of the Namibian position due to the extension of the supply scheme (negotiated with Angola) and the mutual involvement in further economic aspects (like trade relations).

Economic development is based on the one hand on a strong role of livestock farming and agriculture and on the other on the increased importance of production, trade and service providers. Livestock farming and agriculture remains the major economic basis, on both commercial and subsistence scales. However, commercialised crop farming leads to higher productivity and efficiency of the work force, as well as to an extension of irrigation and sustainable rangeland management. Improvements in conditions for livestock marketing concerning quarantine, production, transport, auctions, veterinary services and the veterinary cordon fence lead to significant increases in the efficiency of farming, whereas a parallel policy for limiting livestock reduces the risk of overgrazing. Urbanisation has only little influence on the livestock numbers and does not contribute to a lower pressure on rangelands. The role of cattle changes partly from a cultural good to a commercially produced and traded commodity. The establishment of production, trade and service providers is positively influenced by the newly built railway, the Export Processing Zone (EPZ) at Oshikango, favourable conditions for entrepreneurship and success of the government's education and capacity building activities. Financial services

with suitable bank loan conditions support the micro-economic initiatives of individuals. Nevertheless, industrial development is very limited and establishes in only in selected sub-sectors of manufacturing (e.g. sewing). The perspectives for production are mainly basic supplies such as food and cloth but also of vehicles and spare parts. The fraction of Namibian agricultural (high value) products on the market increases and the production reaches a point of saturation of the market with food. The improvements in the general marketing conditions also help to support subsistence livelihoods and to reduce poverty. Altogether, positive developments in the economic basis have an attraction function for further economic activities like up- and downstream businesses (e.g. food processing, plumbing services) and infrastructural development such as improvement of health services or educational facilities.

The new, and more, job and income opportunities in towns, as well as the availability of services and the expected higher living standard attract people to the urban centres. Rural areas lose (young) people and the most active work force leading to the decay of rural communities in some parts. In addition, rural communities lose grazing and settlement land to the expanding towns. Financial compensations by the municipalities are high enough to substantially assist affected communities, but only delay the process of urbanisation. Contrary to the urbanisation and concentration processes, a part of the rural population migrates away from the pipeline grid, especially to easterly neighbouring regions and interferes with the local population there. Only subsequent strong political and social efforts successfully avoid interregional conflicts. The classical pattern of the urbanisation process with a first phase of rural people occupying informal settlements and a second phase of either formalisation of these informal settlements or the movement of people from informal to formal settlements is barely resolved. However, urban institutions, infrastructure and services are of a reasonable standard and the provision of basic services for water and energy is managed properly through a tariff system, which on the one hand avoids discrimination of different social groups and on the other hand allows the recovery of operational costs. At the same time, the transformation of informal to formal settlements is promoted not only in policy statements but also in practice with positive consequences for the living standard and general wellbeing of the people and the sustainability of the natural environment.

The most important driving force in population dynamics is the urbanisation process. Beside this, demographic development is characterised by a growth of the population. This is caused by a positive internal population balance and a migration from other regions. The impacts of HIV/AIDS are decreasing slightly due to a level of acceptance of prevention measures as well as the effect of new and cheap treatments and drugs. Nevertheless, the disease reduces population growth and, worryingly, losses of knowledge and expertise persist. The distribution of water through the pipeline grid to rural areas intensifies the migration pattern. The formerly very high population fluctuation in towns during holidays, up to levels of threefold the base level, diminishes due to better opportunities in central northern Namibia and the lower proportion of people working permanently or temporarily elsewhere in Namibia.

Improvements in education and capacity building are strongly supported by the government, reach a major part of the population and constitute a decisive basis for the prevailing development. Specialised training covers themes such as sustainable farming, technical services and institutional issues. Particular attention is given to persons who are able to act as multipliers and spread knowledge in a very efficient and practical way. The loss of knowledge and expertise through HIV/AIDS is alleviated by the establishment of shared responsibilities in institutional contexts.

Climate change affects central northern Namibia in the form of declining rainfall and a small increase of extreme events such as drought and flooding. The diversity of different water sources and the available reserves in the abstraction of water from the Kunene River, within the maximal range agreed with Angola, allows an efficient adaptation to climate change and extreme events. Fluctuations in water availability are compensated by improved water security.

Sustainable and efficient water management is supported by institutional developments that address the issues of decentralisation and integration. Uncertainties concerning the time-scale of their implementation into practice are solved by top-down approaches in combination with bottom-up initiatives. Further, promising processes for decentralised engagement, commitment and institutional responsibilities have already come into effect. This development holds also for the sectoral integration of water, land and broad environmental management.

THE "RECESSION" DEVELOPMENT PATH

The "recession" development path describes a possible future for central northern Namibia where economic stagnation and high uncertainties in water availability have an impeding effect leading to system stagnancy or decline accompanied by a low degree of resilience. Increases in water demand, caused in particular by changes in water use patterns due to urbanisation as well as substantial needs for sanitation facilities, are in danger of not being fulfilled. Reasons behind this are: first, a problematic political situation with Angola concerning agreements on Namibia's volume of water abstraction from the Kunene River; and, secondly a decrease of precipitation and increased drought due to climate change. Fragile political conditions retard the practical implementation of already adopted national strategies and policies. These uncertainties are adverse for long-term investments for economic development, for improvements of water management and technologies as well as for building social and institutional capacities:

The water supply system is based to a large extent on the pipeline grid and sparsely distributed additional alternative water sources. The abstraction of water from the Kunene River and its distribution through the long-distance infrastructure remain the major water source of the region. Some development of alternative water sources lower the pressure on the pipeline grid, but a high dependency remains – exacerbated

by problematic bilateral relations with Angola. This country substantially increases its demand for water due to strong economic development accompanied by large-scale irrigation schemes and hydro-power stations, which are connected to the upper reaches of the Kunene River. These developments reduce the water flow of the river significantly. Shortages of water supply have been experienced in central northern Namibia – also triggered by extreme dry periods. Despite the efforts at calming the situation, fears and worries dictate the debate in Namibian politics and within communities. Important consequences of this are reflected in the absence of promising business and the migration of people seeking work elsewhere in Namibia – in order to sustain their families left behind in the region. Ongoing labour shortages in central northern Namibia restrict nascent positive developments. Extensions of the pipeline grid come to an end because of the aging infrastructure and vandalism. Illegal abstractions and a low willingness to pay for water use drive the financial balance far away from cost recovery. The magnetic effect of the pipeline grid concentrates the population along the infrastructure. Interference with the traditional patterns of transhumance is one consequence of this. Alternative water sources such as earth dams assist in preventing overgrazing and degradation of rangelands in some areas, but they are only sparsely distributed. Thus, in addition to international and bilateral diplomatic pressures, a strong support and promotion of implementation of alternative water sources is directed through national and regional strategies. In rural areas these initiatives give rise to the implementation of technologies such as rainwater harvesting, desalination and artificial groundwater recharge. In the urban centres water collection from roofs and streets, installations with high water use efficiency and appropriate water-saving and cheap sanitation concepts are considered. Community-based solutions such as sanitation centres and water points are well-balanced with individual solutions based on an infrastructural system.

Economic development is characterised by a strong reliance on livestock farming, agriculture and trade. Production and service providers are established slowly and only with much caution. Crop farming is partly commercialised leading to higher productivity and efficiency of the work force and an extension of irrigation. Educational and capacity building facilities are crucial factors for sustainable rangeland management, but current measures do not reach a sufficient proportion of the population. Market conditions for livestock concerning quarantine, production, transport, auctions and veterinary services are slightly improved, but a major hindrance is the outstanding decision (and implementation) relating to the movement of the veterinary cordon fence to the Angolan border. Urbanisation has only little influence on livestock numbers and does not contribute to lowering pressure on grazing lands. Cattle remain a strong cultural good and changes only slowly to a commercially produced and tradable commodity. The establishment of production and service providers is positively influenced by the newly built railway and the Export Processing Zone (EPZ) at Oshikango. However, stagnant economic development is a limiting factor. Financial services with suitable bank loan conditions are available, but many people are not aware of them. Industrial development is absent in central northern Namibia. Production supplies mainly food

and cloth, but cannot guarantee self-sufficiency and saturation of the domestic market. A high dependency persists within Namibia on imported food supplies and commodities in other sectors.

People are attracted to towns due to expectations of job opportunities and a higher living standard and also by the availability of services. In consequence, rural areas lose people and work force, especially the young generation, leading to decay within rural communities in some parts. In addition, rural communities lose grazing land to the expanding towns. Financial compensations are not sufficient and the urbanisation process increases unchecked. Contrary to the urbanisation and concentration processes, a part of the rural population migrates away from the pipeline grid, especially to easterly neighbouring regions and interferes with the local population there. Only subsequent strong political and social efforts successfully avoid interregional conflicts. The urban situation is characterised by rapidly expanding informal settlements, which increases the pressure for the provision of services, including water and energy. Job opportunities are rarely available and many people are frustrated by not being able to find work and sustain their livelihood. Illegal abstractions of water, vandalism and payment problems are severe sources of frustration for service providers. Initiatives for the implementation of new technologies such as sanitation centres and rainwater harvesting techniques are strongly supported by the communities because they allow the take-over of responsibilities from under-resourced government structures and facilitate income generation and a measure of food self-sufficiency, for example through urban gardening. It is commonly realised that changes in the tariff system with subsequent higher acceptance rates for payment are very advantageous for cost recovery in the long-term – such that adaptations of the tariff systems are on the way and hopefully will improve the situation. The process of transforming informal to formal settlements is slow due to the lack of financial, technological and institutional capacities.

The most important driving force in population dynamics is the urbanisation process. Beside this, demographic development is characterised by over population and resultant unsustainable pressure on available resources. Water scarcity complicates livestock farming and agriculture, forcing much of the rural population to move into towns or to migrate elsewhere in Namibia. The population in towns triples during holiday periods leading to severe, albeit temporary, pressure on water supply and sanitation as well as on other environmental resources (e.g. atmospheric absorptive capacity for emissions, firewood).

There is progress with education and capacity building, but this does not match the high demand within communities and government and other institutions. A lack of financial, institutional and human resources prevents significant improvements of the education system and allows only selective capacity building activities. HIV/AIDS continues to pose a big threat since tacit knowledge necessary to build and sustain the general wellbeing of the population is lost in proportions that match the high levels of mortality. There is some retention of knowledge, for example within regional

government institutions, through introduced systems of overlapping responsibilities; however, this comes at a high price in terms of efficiency.

Climate change affects central northern Namibia in the form of a decline of rainfall and increase in frequency in extreme events such as drought and flooding. Specific problems arise in Oshakati and Ongwediva where informal settlements are established in the oshanas, and harmful impacts of floods on human life are on the increase. Fluctuations of water availability and uncertainties concerning water abstraction at the Kunene River are inadequately compensated for by developments of alternative water sources.

Institutional setting is characterised by long time-scales for practical implementation of decisions. Frameworks for the transfer and execution of responsibilities are not properly situated in an adapted legal and institutional basis. Decentralisation and integration remain at the planning level with delays in practical implementation. Institutions are not prepared for prevailing pressures for, and consequences of, development. Corruption and misuse of power lead to mismanagement, demoralisation of people and lack of leadership acceptance.

CONCLUSIONS

Central northern Namibia faces important challenges associated with the dynamic interactions between economic, social and environmental system components and processes – insofar as these relate to sustainable development. At present, the prevailing structures of governance and provision of technical infrastructure are situated in central government control, despite the ongoing process of decentralisation. The CuveWaters project, aspects of which have been outlined in this chapter, is being guided by a theoretical framework aimed at maintaining the resilience of the complex social-ecological system that defines the region, and building capacity for adaptation to change – *inter alia*, climate change. The concepts of resilience and complexity emphasise the inadequacy of prevailing linear command-and-control management structures (Brand, 2005) in the face of non-linear system phenomena and unpredictability (see Cilliers, Chapter 2, this volume). Current structures also contrast the need for inclusive and adaptive governance structures involving different actors representing the diversity of interests and values within the system/sub-systems targeted for management. These governance structures exhibit clear signs of failure; however, they also exhibit a tendency to persist in spite of pressures for change. This chapter sketches some alternative institutional structures and experimental approaches to alternative technologies that can strengthen civil society, build social capital and memory and guide sustainable development within the region.

It has been suggested in the chapter that adaptive governance structures can, to some extent, compensate for relatively inflexible technological solutions relating to water

supply and management. It has also been suggested that adaptive technological solutions offer the potential to alleviate critical pressures on governance structures. More importantly, it is proposed that both adaptive governance *and* technological experimentation are essential for addressing risks and uncertainties associated with change – particularly relating to climate change. This is illustrated in Figure 4, which shows the possible dynamics of future developments within alternative scenarios of prosperity and recession, and the contribution of adaptive management and technological experimentation in mediating system shocks, through building and maintaining desirable resilience within the social-ecological system.

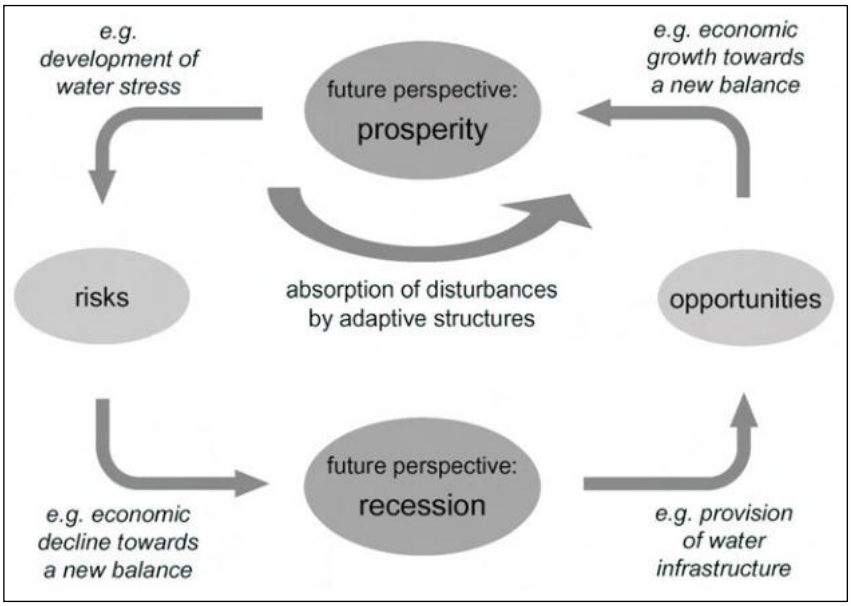


FIGURE 4: Possible future development dynamics within the scenarios of either 'prosperity' or 'recession'. Adaptive structures in management and experimentation with alternative water supply and sanitation technologies can mediate the effects of system shock, for example associated with climate change, and thereby build resilience.

Economic development opportunities exist in central northern Namibia. Market conditions and commercialisation are crucial for promoting developments in livestock and crop farming as well as the production of fruits and vegetables. The currently unutilised fraction of the total volume of water that Namibia may abstract from the Kunene River (negotiated with Angola) can facilitate this development – provided the conditions of consensual agreement persist. Improvements in transport infrastructure and export conditions can strengthen the manufacturing, production and trade sectors – either in parallel with agricultural development or in a second, next, phase. In combination with the urbanisation process, these developments can create a viable environment for business and service providers. However, these

opportunities can only be realised under broadly supportive conditions – amongst which, sustainable water supply and demand management is critical. Ashton *et al*. (Chapter 9, this volume) sketch a similar situation for South Africa.

It is important that an appropriate mixture of water sources is developed to sustain the economic and livelihood opportunities that have been defined. In this regard, the adaptation of water related technologies to meet the requirements of different social and economic sectors is essential. A measure of latitude in supply options must be developed to avoid an absolute dependency on the existing long-distance water supply infrastructure and alternative demand-side technology and incentive options must be explored. Technologies related to additional water sources such as rainwater harvesting, desalination, artificial groundwater recharge and water-saving/re-use techniques must complement the centralised water supply infrastructure and reduce the need for its further extension. Without this, the existing infrastructure will attract a range of interconnected social and environmental problems. Such technologies will need to account for the range of quality and quantity requirements of different water users – e.g. domestic, livestock watering, crop irrigation and production. Existing water supply and sanitary and wastewater treatment systems are inefficient and/or excessively consumptive – illustrated, for example, by the evaporative/oxidation technology used for wastewater treatment (when re-cycling options would be more appropriate). Experimentation with alternative technologies for sanitary systems and wastewater treatment offers possibilities for reducing water demand and, thereby, generating benefits in the form of economic development that is enabled by water availability (see Roland-Holst, 2006).

In order to facilitate the development opportunities, capacity must be built within the region's governance structures and in the range of water use sectors, with an emphasis on establishing a capacity for quick and adaptive response to change. The exact form of change is difficult, if not impossible, to fully anticipate and plan for in traditional ways. This must be supported by the introduction of alternative water management technologies with which to experiment in terms of appropriateness in a range of contexts (rural, urban, domestic, agricultural, etc.). In combination, these interventions offer every possibility that the region can achieve its food security and broader social and economic development aims.

Central northern Nambia is exposed to risk in a number of areas. Foremost, are the risks associated with climate change, which can be expected to aggravate existing risk to social-ecological system resilience posed by the degradation of natural resources – e.g. due to over-utilisation and mismanagement of rangelands. Substantial risk is also associated with the current limited water supply alternatives and a near-absolute dependency on the Kunene River – which assumes long-term political compliance with bilateral agreements and the absence of political conflict.

Population growth and changes in water use patterns point to an increase in water demand posing significant challenges in terms of responses. In this regard,

development opportunities will be compromised if demand exceeds the capacity for supply water. Such capacity must, in the first instance, be developed, retained and deployed in an integrated approach within and between the institutional structures mandated, for example, with water management, agricultural and other sectoral development, urban and regional planning, etc. Importantly, the capacity for reflection, learning and adaptation (Roux *et al*., Chapter 18, this volume) must be an integral part of the capacity building process, targeted from the outset at all relevant stakeholders (CuveWaters Project, 2008; Deffner *et al*., 2008).

In summary, the advancement of sustainable development within the central northern region of Namibia must be guided by decisions that take an open and adaptive perspective on development opportunities and the means to realise these. This is considered the optimal approach to dealing with risk and uncertainty – the scale of which is expected to increase as the impacts of climate change manifest locally. An important challenge will be to bridge the gap between the impossibility of fully understanding the region as a complex social-ecological system and the demand for simple and expedient interventions demanded by stakeholders. Neither complex nor overly simplified interventions are deemed appropriate. It is important that, whatever interventions are considered, these must be understood and continually re-appraised in the context of important system relationships, including causal and feedback relationships (e.g. linking water with social, economic and environmental 'health'). Policy and management interventions should aim to build desirable system resilience, with flexibility for self-adaptation of the system to change – much of which may be unexpected (Brand, 2005; Folke *et al*., 2005).

ENDNOTES

1. If not specified otherwise, the term 'region' is used as abbreviation for the central part of northern Namibia.

2. Endogenous water sources are recognised as being available and accessible within the boundaries of a particular water basin or some defined geographical unit. In the context of this study, the term 'endogenous' refers to the Cuvelai-Etosha basin, which represents the Namibian part of the Cuvelai basin.

3. The research and development project CuveWaters (www.cuvewaters.net) aims to promote the conceptual development and practical implementation of Integrated Water Resources Management (IWRM) in central northern Namibia. This project's activities are embedded in existing processes and adapted to specific environmental, political, social and economic conditions. CuveWaters started in November 2006 as a joint project of the Institute of Social-Ecological Research (ISOE), Darmstadt University of Technology and Fraunhofer Institute in Stuttgart (IGB), in close cooperation with the Desert Research Foundation of Namibia (DRFN), Ministry of Agriculture, Water and Forestry (MAWF), German Development Cooperation (GTZ) and Federal Institute

for Geosciences and Natural Resources (BGR). The project is funded by the Federal Ministry of Education and Research (BMBF), Germany.

ABBREVIATIONS

CBS	Central Bureau of Statistics, National Planning Commission
BMBF	Federal Ministry of Education and Research, Germany
DRFN	Desert Research Foundation of Namibia
EPZ	Export Processing Zone
GDP	Gross Domestic Product
GRN	Government of the Republic of Namibia
IGB	Fraunhofer Institute for Interfacial Engineering and Biotechnology, Stuttgart, Germany
IPCC	Intergovernmental Panel on Climate Change
ISOE	Institute for Social-Ecological Research, Frankfurt am Main, Germany
MAWF	Ministry of Agriculture Water and Forestry (since January 2005)
MAWRD	Ministry of Agriculture Water and Rural Development (prior to January 2005)
NCCC	Namibia Climate Change Committee
NCCP	National Climate Change Program
NDP	National Development Plan
NPC	National Planning Commission
MET	Ministry of Environment and Tourism
MLR	Ministry of Lands and Resettlement
MOHSS	Ministry of Health and Social Services
IWAR	Institute of Water Supply and Groundwater Protection, Darmstadt University of Technology, Germany
SADC	Southern African Development Community
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation

ACKNOWLEDGEMENTS

Funding for this research received from Germany's Federal Ministry of Education and Research (BMBF) is gratefully acknowledged. Critical reflections provided by Thomas Kluge, Alexandra Lux and Martin Zimmermann are valued, as are the insights and contributions provided by Mary Seely, Patrik Klintenberg, Piet Heyns

and Dudley Biggs of the Desert Research Foundation, Namibia. Review comments on an early draft of this chapter, provided by CSIR's Peter Ashton, Mike Burns and Alex Weaver, have enriched this final version. A special appreciation is extended to all individuals who made themselves available and who participated in the series of interviews that largely informed the research presented here.

KEY WORDS

Cuvelai-Etosha basin; integrated water resources management; Nambia; qualitative systems analysis; resilience; scenarios; socio-ecological research; stakeholder involvement; transdisciplinarity

REFERENCES

Alcamo, J., Leemans, R. and Kreileman, E. (Eds) (1998). *Global change scenarios of the 21st century* Elsevier Science Ltd., Oxford.

Beyer, U. and Jacobeit, J. (2002). Assessments of regional precipitation changes in Namibia due to man-made enhanced greenhouse warming. *Würzburger Geographische Arbeiten*, 97: 85-100.

Bird, K., Booth, D. and Pratt, N. (2003). Food security crisis in southern Africa: The political background to policy failure. Theme Paper 4 (London, Forum for Food Security in Southern Africa).

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R. and Yanda, P. (2007). Africa, in: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (Cambridge/UK, Cambridge University Press). Pages 433-467.

Brand, F. (2005). Ecological resilience and its relevance within a theory of sustainable development. UFZ-Report 03/2005. (Leipzig-Halle, UFZ Centre for Environmental Research).

Brock, C. (2007). The challenge of growing local production and finding markets for local produce. Paper presented to the International Investors' Conference, 31st October, 2007. (Windhoek, Namibian Agronomic Board).

CBS (2003). 2001 Population and housing census. National Report. Basic analysis with highlights. (Windhoek, National Planning Commission).

— (2006). Namibia household income and expenditure Survey 2003/2004. Preliminary report. (Windhoek, National Planning Commission).

CuveWaters Project (2007). Final summary report. Rural and urban assessments I & II. Internal Project Report, prepared by DRFN and ISOE. (Windhoek/Frankfurt am Main, DRFN & ISOE).

— (2008). Proceedings of the first CuveWaters stakeholder workshop,

held in Oshakati, Namibia, October 23-24, 2007. Internal Project Report, prepared by DRFN. (Windhoek/ Frankfurt am Main, DRFN & ISOE).

Deffner, D., Klintenberg, P., Mazambani, C., Moser-Nørgaard, P., Nantanga, K. and Seely, M. (2008). Selected results from socio-ecological participatory situation assessments in two sites in central northern Namibia. CuveWaters Papers, No 3 (Frankfurt am Main, ISOE).

FIRM (2003). The forum for integrated resource management: Putting communities at the centre of their own development process. A Case Study in the establishment of FIRM, based on the Napcod experience. (Windhoek, Desert Research Foundation of Namibia).

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, 16: 253–267.

Folke, C., Hahn, T., Olsson, P. and Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environmental Resources*, 30: 441-473.

GRN (2004). *Water Resources Management Act, 2004 (Act No. 24 of 2004)*. Government Gazette of Namibia No. 3357 of 23 December 2004. Repeals the Water Act, 1956. (Windhoek, GRN).

GTZ (2007). Strategic environmental assessment in land use planning. Workshop Outcomes and Evaluation Report, 21-24 August 2007. (Windhoek).

Heyns, P. S. v. H. (2003). Water resources management in southern Africa, in: M. Nakayama (Ed.), *International waters in southern Africa: Water resources management and policy*. (Tokyo – New York – Paris, United Nations University Press).

Hulme, M., Doherty, R. M., Ngara, T., New, M. and Lister, D. (2001). African climate change: 1900-2100. *Climate Research*, 17: 145–168.

IPCC (2000). *IPCC special report: Emissions scenarios – Summary for policymakers*. (Geneva/Switzerland, IPCC).

— (2007). Climate change 2007: Synthesis report – Summary for policymakers. Intergovernmental Panel on Climate Change Fourth Assessment Report. Contributions of Working Groups I, II and III.

Jahn, T. (2005). Soziale Ökologie, Kognitive Integration und Transdisziplinarität. *Technikfolgenabschätzung Theorie und Praxis*, 14(2): 32–38.

Jahn, T. and Keil, F. (2005). Social ecological research: A new approach towards generating, integrating and transfering knowledge for sustainable development, in: Kolleg für Management und Gestaltung nachhaltiger Entwicklung (eds.), 1st European Networks Conference on sustainability in practice: The conditions and requirements for a new European level of capacity building, April 1–4, 2004. Conference Reader: 122-129.

— (2006). Transdisziplinärer Forschungsprozess, in: E. Becker and T. Jahn (Eds), *Soziale Ökologie. Grundzüge einer Wissenschaft von den gesellschaftlichen Naturverhältnissen*. (Frankfurt am Main, Campus Verlag). Pages 319-329.

Klintenberg, P., Mazambani, C. and Nantanga, K. (2007). Integrated water resources management in the Namibian part of the Cuvelai Basin, central northern Namibia. CuveWaters Papers, No 2 (Frankfurt am Main, ISOE).

Kluge, T., Liehr, S., Lux, A., Niemann, S. and Brunner, K. (2005). Integriertes Wasserressourcen-Management (IWRM) im nördlichen Namibia – Cuvelai Delta. Preliminary Study, unpublished (Frankfurt am Main, ISOE).

Love, D., Twomlow, S., Mupangwa, W., van der Zaag, P. and Gumbo, B. (2006). Implementing the millennium development food security goals: Challenges of the southern African context. *Physics and Chemistry of the Earth,* Parts A/B/C, 31(15-16): 731–737.

Mano, R., Isaacson, B. and Dardel, P. (2003). Identifying policy determinants of food security response and recovery in the SADC region: The case of the 2002 food emergency. FANRPAN Policy Paper. Keynote paper prepared for the FANRPAN Regional Dialogue on Agricultural Recovery, Food Security and Trade Policies in southern Africa, held in Gaborone, Botswana, March 26–27, 2003.

Marsh, A. and Seely, M. K. (Eds) (1992). Oshanas: sustaining people, environment and development in central Owambo, Namibia. (Windhoek, Desert Research Foundation of Namibia and Swedish International Development Agency).

MAWRD (Ministry of Agriculture and Rural Water Development) (2000). National water policy white paper: Policy framework for equitable, efficient, and sustainable water resources management and water services. (Windhoek, GRN).

— (Ministry of Agriculture and Rural Water Development) (2003). Green scheme irrigation policy. Directorate of Planning. (Windhoek, Government of Namibia).

Mendelsohn, J., el Obeid, S. and Roberts, C. (2000). A profile of north-central Namibia. Environmental Profiles Project. (Windhoek, Gamsberg Macmillan Publishers).

MET (Ministry of Environment and Tourism) (2002). Initial national communication to the United Framework Convention on Climate Change. (Windhoek, Government of Namibia).

— (Ministry of Environment and Tourism) (2005). Policy review on issues pertinent to the improvement of land management and biodiversity conservation in Namibia. Extended summary. (Windhoek, Government of Namibia).

— (2006). Statement by Hon. Minister of Environment and Tourism of the Republic of Namibia Rev. Willem Konjore presented at the High Level Segment of the United Nations Framework Convention on Climate Change, held in Nairobi, Kenya, November 15, 2006.

MOHSS (Ministry of Health and Social Services) (2005). Report of the 2004 national HIV Sentinel survey. (Windhoek, Government of Namibia).

Nantanga, K., Mazambani, C. and Kruger, B. (2007). Small scale irrigation and aquaculture in central northern

Namibia. Internal Project Report. (Frankfurt am Main, Institute of Social Ecological Research).

Niemann, S. (2000). Wasserversorgung und Wasserverwendung in Namibia. Nutzungstraditionen als Grundlage eines nachhaltigen Ressourcenverbrauches im ehemaligen Ovamboland. Hamburger *Beiträge zur Afrika-Kunde*, No. 61 (Hamburg).

NPC (2001). 2001/2002-2005/2006, Second National Development Plan (NDP 2). Volume 1 Macroeconomic, sectoral and cross-sectoral policies, Chapters 23-47. (Windhoek, GRN).

Odendaal, W. (2006). The SADC land and agrarian reform initiative: The case of Namibia. NEPRU Working Papers No. 111. (Windhoek).

Office of the President (2004). Namibia Vision 2030: Policy framework for long-term national development. Main Document. (Windhoek, Government of Namibia).

Price Waterhouse Coopers (2005). Irrigation development in Namibia: Green scheme and horticulture initiative for Namibia – Cost/ benefit analysis. (Windhoek, Price Waterhouse Coopers).

Reid, H., Sahlén, L., Stage, J. and MacGregor, J. (2007). The economic impact of climate change in Namibia: How climate change will affect the contribution of Namibia's natural resources to its economy. Discussion Paper 07-02. (London, International Institute for Environment and Development).

Roland-Holst, D. (2006). Infrastructure as a catalyst for regional integration, growth, and economic convergence: Scenario analysis for Asia. ERD Working Paper No. 91. (Manila, Asia Development Bank).

Rosegrant, M. W., Cline, S. A., Li, W., Sulser, T. B. and Valmonte-Santos, R. A. (2005). Looking ahead: Long-term prospects for Africa's agricultural development and food security. 2020 Discussion Paper No. 41. (Washington, D.C., International Food Policy Research Institute).

Seckelmann, A. (2001). Development of urban settlements in independent Namibia. Namibian Economic Policy Research Unit. Occasional Paper No. 20. (Windhoek).

Tarr, J. (1998). An overview of Namibia's vulnerability to climate change. Volume 2. Prepared for the Desert Research Foundation of Namibia as part of the Namibia country study on climate change. (Windhoek).

Tarr, P. and Figueira, M. (1999). Namibia's environmental assessment framework: The evolution of policy and practice. Research Discussion Paper No. 34. (Windhoek, MET).

Werner, W. (2007). Integrated land and water management: Policy and institutional issues. CuveWaters Papers, No. 1. (Frankfurt am Main, ISOE).

WHO (2004). Guidelines for drinking water quality. Volume 1: Recommendations. Third edition. (Geneva, WHO).