Identifying resilience pathways to sanitary health problems in an unplanned ward of Dodoma, Tanzania

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The study explores water- and sanitation-related health risks among the urban poor and identifies the responses of different actors in averting and overcoming these risks. It is based on data collected from households and institutions in the unplanned settlement Chang'ombe of the Dodoma Municipality using quantitative and qualitative methods. We define social resilience as social actors' capacities to access resources, facilities and services not only to cope with and adjust to adverse conditions but to search for and create options and thus develop increased competence in dealing with water and sanitation related threats. The focus is on various structural and relational processes, which shape resilience pathways. We refer to a framework adapted from Langridge et al. (2006) to examine resilience pathways to sanitary health problems in terms of technology, capital, markets, knowledge, authority, and networks. For each of these aspects, interventions to strengthen resilience pathways are suggested for actors on various administrative levels, ranging from the household to the municipality.

[resilience pathways, access to health, water, sanitation, household, community, Tanzania]

Sub-Saharan African countries are witnessing an unprecedented reversal in spatial population distribution: urban dwellers are likely to account for a large share of the total population in the 21st century. African cities experience the fastest population growth rates at over 5% a year, and urban growth is expected to account for virtually all future population growth in Africa (APHRC 2002a). While urbanization is associated with economic growth in most industrialized and some developing countries, this is not the case for Sub-Saharan Africa. Between 1970 and 1995, African urban population grew by 4.7% per year, while Gross Domestic Product dropped by 0.7% (World Bank 2000). Increasing urban population growth coupled with the inability of the municipal authorities to respond to the demand of this population contribute to the fact that 40-60% of the urban populations in developing countries reside in informal settlements with limited access to shelter, safe water, sanitation and solid waste collection. Consequently, the lack of basic services including human waste management, drainage and solid waste collection services is a cause of sickness and disease as well as major environmental threat to global water resources, and an obstacle to

the advancement of human dignity (WHO, UNICEF & WSSCC 2000). Emerging evidence indicates that the African urban poor have less access to health services, and consequently exhibit higher mortality rates than residents from other population subgroups including rural residents (APHRC 2002b). In Tanzania the overall population growth is 2.9% but the urban population has been growing massively as exemplified by the Dodoma Municipality population growth rate, which is projected at 4.0% for 2002-2012. Although the country is reported to have high access rates to sanitation facilities in both urban and rural areas as portrayed by latrine coverage of 90%, further analysis shows that around 50% of these latrines are pits with shelters built of temporary building materials, and 72.4% of the latrines are without concrete floor. A study conducted by Water Aid in Tanzania in 2007 further found that coverage varies widely within the country; in nomadic communities, latrine coverage is as low as 12%; in institutions like primary schools, the coverage is 36%; only 31% of latrines have washing facilities; 50% of families wash hands in shared containers; and 15% of households had children faeces around the compound (Water Aid 2007).

Over 70% of diseases attended at health facilities appear to be water and sanitation related (United Republic of Tanzania 2007). Bradley's classification of water-related diseases includes waterborne, water-washed, water based and water-related insect vectors diseases (Thompson & Cairncross 2002). All these diseases have been reported in Tanzania's water sector status report (United Republic of Tanzania 2007). Infectious diseases with high degree of risk include diarrhoea, cholera, and typhoid (waterborne), trachoma (water-washed), schistosomiasis (water based) and malaria (water-related insect vectors).

This study uses an unplanned settlement of Dodoma in central Tanzania as a case study to assess sanitary health problems and identify resilience pathways which will enable social actors not only to cope with and adjust to adverse water and sanitation conditions but also to create new sustainable options for managing the diseases of poverty.

Resilience pathways: Theoretical and analytical framework

The concept of resilience has long been studied by ecologists (Holling 1973, Ribot 1995) who apply it to socio-ecological systems and link it to environmental sustainability (Folke et al. 2002). In this approach, resilience is defined as an internal capacity of the system to cope with and adapt to a stress (Adger 2000, Luers 2005). Recent studies have identified the following components and dynamics of socio-ecological systems as increasing resilience: flexibility and diversity in management regimes, ecological knowledge, multi-layered and accountable institutions with a capacity to learn, coalitions, networks and leadership (Trosper 2004, Tompkins & Adger 2004, Lebel et al. 2006, Walker et al. 2006, Langridge et al. 2006).

Only few researchers have paid attention to the ways in which social resilience is built. Langridge and colleagues (2006: 18) have argued that "the creation of social resilience is linked to the community's ability to access critical resources". Following

Ribot and Peluso (2003), they define access broadly "as the ability of a community to actually benefit from a resource, and includes a wider range of relations than those derived from property rights alone" (ibid.). To find out how a community gains, maintains, and controls access to a critical resource researchers have to analyze the means, processes, and relations, or mechanisms that facilitate access (Ribot & Peluso 2003). Such mechanisms, they suggest, include structural and relational processes like technology, capital, markets, knowledge, authority, and networks.

In this paper, we define social resilience as social actors' capacities to access resources not only to cope with and adjust to adverse conditions (>reactive) but to search for and create options (>proactive) and thus develop increased competence (>positive outcome) in dealing with water and sanitation related threats. While we agree that various structural and relational processes shape actors' capacities, we prefer to call them resilience pathways rather than access mechanisms. Moreover, we do not only focus on access to a resource (water), but to facilities (latrines or toilets) and services (water supply and distribution, human waste disposal). Drawing on the framework developed by Langridge et al. (2006) we assume that resilience pathways to sanitary health problems can be examined in terms of technology, capital, markets, knowledge, authority, and networks (Table 1).

Table 1 Resilience pathways

Resilience pathways	*Water and sanitation related examples*
Technology	Capacity to improve water supply and sanitation technologies
Financial resources	Capacity to pay for connection to water and collection of human waste
Markets	Capacity to provide and consume health, water and sanitation services
Knowledge	Capacity to understand relations between hygiene, health and disease
Authority	Capacity to assume leadership in and regulate public and private water and waste management
Networks and groups	Capacity to form community based organizations, water user groups, non-governmental organizations providing training and facilitating social and political processes

Adapted from Langridge et al. (2006)

By technology we mean the capacity to construct water supply and distribution systems as well as human waste management technologies, and/or the ability to adequately use these technologies. Financial resources include the capacity to pay for water connections and the collection of human waste. Markets imply that water and technologies are on sale; they can be provided and consumed. Knowledge includes concepts about the relations between health, hygiene and the environment as well as a basic understanding of disease transition patterns. Authority encompasses the capaci-

ties of government, private sector and community actors to assume leadership roles in regulating water and waste management. Networks and social groups range from community based organizations to water user groups and non-governmental organizations which provide training and facilitate social and political processes.

The study area and data collection methods

Dodoma has been Tanzania's capital city since the 1970s and is the substantive seat of the Union Parliament. Today the city has about 380,000 inhabitants with a strong yearly population growth rate of 3.4%. This high population growth rate is putting increasing pressure on the existing infrastructure. The present study was conducted in Chang'ombe, an unplanned settlement in Dodoma municipality with a population of about 50,000 (Ruheka et al. 2008). The neighbourhood was selected because it is the fastest growing area in Dodoma municipality (population growth rate of 5.45%).

We used quantitative and qualitative methods. Information on 173 randomly selected households was collected with a semi-structured interview. Questions addressed household characteristics including major economic activity of the respondent and ownership of assets; access to water; ownership and types of toilets; and management of human and solid waste. A total of ten focus group discussions (FGD) were organized: three with men, three with women, two with mixed groups of adult men and women, and two with mixed groups of young men and women. Each FGD had a total of eight to twelve members. Key informant interviews were held with government leaders at municipal, ward, and street levels and with representatives of non-governmental and community based organizations. FGDs and key informant interviews provided insights into community wide perceptions on access to safe and clean water and sanitation services, health risks related to poor waste management, community wide involvement in waste management and options for human waste management and averting health risks.

Assessing sanitary health problems

Living conditions in Chang'ombe are difficult. Participants in the household study were primarily self-employed in the informal sector (49%) and to a lesser extent involved in urban agriculture (19%), working as housewives (11%) or employed in the public and private sector (6%). Others were engaged in unpaid labor for the family or searching for a job. Most respondents had primary level education (78%).

The physical infrastructure in Chang'ombe is poor. Very few roads are passable by cars since they are severely eroded. A lack of social infrastructure such as health facilities and enough schools is a further problem. Transport has become more difficult due to road erosion, high costs, distance and unavailability, which further complicates the situation.

Getting water

The Chang'ombe residents get water from different sources, depending on their financial status. The Dodoma Urban Water Supply and Sewerage Authority (DUWASA) supply about 70% of the water for the community. A few houses are connected to piped water from DUWASA (10%), the others get tap water from three public water points. 30% of Chang'ombe residents use water from traditional shallow wells and hand pump wells. The DUWASA water points are managed by private operators. Traditional wells are individually owned. The owners are responsible for maintenance and repair and collect user charges. There is also a community well which is used for free.

The price for private connections to water pipes ranges between US$ 110.00-120.00 depending on the distance. Slightly better off community members have organized themselves and formed associations. These associations collect funds from their members and pay for the initial cost of bringing piped water to the neighbourhood. The connection costs are thus reduced for poorer residents who are later invited to become members of the association.

There are only three public taps in the community, which makes majority of community members to rely on private vendors for drinking water (79.2%). Water from shallow wells is mostly used for washing and cleaning. For tap water, the charge per 20 litres bucket is US$ 0.25 (a price set by the water authority), but private operators charge between US$ 0.40-0.50 in order to make a profit. For piped water, the user fees are even higher.

Chang'ombe residents made a distinction between 'clean' and 'safe' water, although their understandings differed. Clean water is the water flowing from the tap or a well but must be colourless (*meupe*). Safe water must be boiled and if possible filtered. (Female FGD, Mazengo Street).

Some defined clean water as that which is fetched from the tap, no matter what the water looked like. Others even considered water from shallow wells as clean. The majority of the residents, however, were aware that, due to the high water table, waste water from the pit latrines easily pollutes the ground water as well as the shallow wells.

> Water from the wells is dirty because in this area we use pit latrines. When you excavate a well, the water is already polluted by latrines; underground water currents pass through latrines. (Mixed FGD, Mkonongo Street)

> An investigation conducted jointly by MAMADO and the Health Municipal Council proved that water from the well is not safe. It is water originating from pit latrines that sieves downwards and settles in the well. (Male FGD, Chang'ombe Juu Street)

Indeed, according to statistics from the study of the Regional Health Department and MAMADO (2005), 99% of the shallow well water is contaminated by coli forms (E. coli).

During the FGDs, people described a vicious cycle: Poor economic conditions result in poor environmental management which in turn causes health problems which drain their financial resources and reduce the pace of development.

Difficult access to safe water was associated with an outbreak of diseases, in particular cholera, during the rain season (November to March). Statistics from the Municipal Health Department provide supporting evidence: Chang'ombe area leads in the outbreaks of cholera with 83 cases (13 deaths) in 2002, 63 cases (5 deaths) in 2003, 104 cases (6 deaths) in 2004, 53 cases (2 deaths) in 2005, and 73 cases (5 deaths) in 2006. The problem with cholera is not only with the number of cases but the social repercussion of the outbreaks. Even one case is shameful because it is related to drinking water contaminated with human faecal sludge. The occurrence of cholera in the community was reported in all FGDs discussions and in the household study. Other diseases mentioned include malaria, typhoid, diarrhoea, and dysentery.

When there is a cholera outbreak, about 30-40% of residents in Chang'ombe boil their drinking water. Some respondents use water treating agents, for instance WaterGuard tablets sold at US$ 10.00 for treating 20 litres of water. Moreover, the SODIS (Solar Water Disinfection) technology was recently introduced to about 200 households. SODIS is ideal to treat small quantities of water (SODIS 2008). Contaminated water is filled into transparent plastic bottles and exposed to full sunlight for six hours. This simple and low-cost treatment improves the microbiological quality of drinking water, using solar UV-A radiation and temperature to inactivate pathogens causing diarrhoea.

Disposing human waste

Most households in the study sample use pit latrines (about 80-90%), but the latrines are of poor condition and often collapse during the rains, oozing out waste water into streets. A few households do not have any facilities and go to their neighbours (about 3%). As has been noted in other African slums like Kibera in Nairobi (APHRC 2002a), plastic bags known as flying toilets are thrown into the pits of neighbours or into the streets.

> Pit latrines are available or seen only during the dry season, no latrine is seen during the rain season because they collapse. The soil here in Dodoma is like a biscuit [meaning that land is delicate or fragile]. (Male FGD, Chang'ombe Juu Street)

> Our economic status is low and we have low income. This is manifested in variables like lack of permanent pit latrines, flow of waste water in streets, filthy and smelly environment which acts as breeding sites of mosquitoes. The existing environment is not conducive for human health and the situation is worse during rain seasons. (Street Leaders, Chang'ombe Chilewa)

Not only constructing toilets but also emptying the pits is a challenge for the community. People cover the toilet and construct a new one; they dig side pit and let the sludge flow into the adjacent pit; they manually empty the pit using buckets; or they

simply allow the sludge to get washed away by rain water. Except for the first one, all of these techniques pose a threat to health.

> There is a man who does the emptying. He uses a bucket and disposes secretly wherever he knows, and then you just find dirty water flowing haphazardly. He does so at night. You can see waste water flowing in the streets in the morning without knowing the source. (Male FGD, Chang'ombe Juu)

> You just see black [filthy] water flowing in streets after rain. Some people celebrate when it rains, but they risk our life. (Female FGD, Chang'ombe Chilewa)

Manual emptying with buckets without safe disposal of excreta costs just a meal for the labourer. Digging a new pit costs US$2.00-3.00. In comparison, private pit emptying services with special trucks amount to US$ 25.00-30.00. The Municipal truck charges US$ 15.00 per trip, but there are long waiting times due to high demand. Moreover, many roads in Chang'ombe cannot be accessed by trucks.

By-laws regulate human waste management. When a pit is full, owners are normally given 21 days by the Ward authority to construct a new one. The fine for non-compliance is US$ 5.00. However, scarcity of land to construct new pits makes the enforcement of the by-laws difficult.

> Somehow even if we have by-laws and they are enforced, it reaches a point where you ask yourself, where is s/he going to dig another pit? The real situation is obvious, there is no space and perhaps it is not his/her mistake. (Ward Executive Office, Chamwino Ward)

Actors' roles in strengthening resilience pathways

The building of social resilience is a multi-layered process (Glavovic et al. 2002). Social actors on various social, political and administrative levels have to be involved in creating resilience pathways. In our study, we identified the following social actors, moving from the top of the administrative structure to the bottom:

1 The Municipal Council collects and transports human waste to the dumping points, improves the infrastructure and provides several social services such sensitisation and education on water and sanitation issues.

2 DUWASA supplies piped water and advises on sanitation issues.

3 The regional hospital offers treatment to sick people, especially when there is an outbreak of diseases such as cholera and diarrhoea.

4 NGOs and CBOs promote access to clean and safe water; provide support in human waste management; sensitise and educate on water and sanitation issues; mobilize people to participate in initiatives and programs.

5 The ward leadership develops water and sanitation plans and advocate for them on the higher levels; they enforce by laws on water and sanitation issues.

6 Water users' associations extend private water connections to the households.

7 The Street level Health Committees consisting of seven members (four women and three men) have been formed according to the local government by-laws but they have not been very active.

Various actors reported that communication and collaboration across these levels has often been difficult. This situation has started to improve since the Dodoma Urban Water and Sewerage Authority (DUWASA) has begun to collaborate with Water Aid and latter MAMADO, a Tanzanian NGO, in promoting the use of clean and safe water in Chang'ombe in 2000. They also have an exchange with the Centre for Community Initiative (CCI) who has started to support households in the construction of improved toilet facilities. Health officers, NGOs like MAMADO and the Community Health Based Initiative (CHBI) work together in educating the community about important health, hygiene and sanitation practices with a specific emphasis on diarrhoea and cholera awareness.

Resilience pathways

Based on these findings, various resilience building activities have been identified with reference to the framework of resilience pathways (see Table 2).

The water supply can be greatly improved by expanding the piped water system (technology). The Municipality plans to survey the area and to look into this issue. Due to the pervasive poverty of the community, most residents will not be able to afford the initial cost of a private installation of water pipes. The strengthening of water users' associations will be essential (networks). These associations may give loans and grants to residents in order to improve their access to piped water. The water users' groups should also be in-charge of managing the water facilities (authority). Moreover, supporting community based organizations of the urban poor to develop better water and sanitation provision helps to build good local governance from the bottom (UN 2003).

The expansion of the piped water scheme has to go hand in hand with the introduction of affordable user fees, preferably a flat rate per month instead of paying per demand (payment per bucket at the water source). The water fees should not be used for profit making but for the creation of a water fund for the operation and maintenance of the facility. Good examples already exist in Tanzania, for instance in the Rural Water Supply and Sanitation Program (RWSSP) supported by the World Bank (Kessy & Msongwe 2008).

In addition, the low-cost but effective SODIS technology should be further promoted (technology). This promotion should go hand in hand with a sensitisation of community members as well as leaders and professionals on the ward and municipal level concerning the effectiveness of SODIS (knowledge). As one member of the SODIS implementation team noted: "SODIS is too cheap to be true!" Sensitisation should further include interactive discussions about the benefits and challenges of different methods to produce safe water on the household level.

Table 2 Resilience pathways

Resilience pathways	*Water and sanitation related examples*
Technology	Introducing innovative cost effective water and sanitation technologies Promoting new types of toilets suitable for the kind of terrain Enhancing toilet emptying mechanism
Financial resources	Applying a reasonable user fee tariff defined by the community Creating a water fund
Markets	Promoting SODIS and other low cost technologies for the production and sale of safe water Training local artisans to provide improved toilet construction and maintenance services for locally affordable fees Introducing micro-finance for water and sanitation
Knowledge	Sensitizing community and authorities on water safety and sanitation issues including proper health seeking behavior
Authority	Expanding the piped water scheme Establishing an active emergency preparedness Unit at the Municipal Creating functional health facilities to handle emergency cases
Networks	Strengthening of the advocacy, management and technical capacities of water users groups and associations, MAMADO, the Centre for Community Initiative, Community Health Based Initiative and other NGOs and community based organizations (CBOs)

Given the fragile nature of the soils and land scarcity, the promotion of construction of well-adapted sanitary facilities is imperative (technology). Dry toilet-double pits with waste collection vaults and chambers built above the ground are particularly suited for areas with high ground water table. However, the construction of these types of toilets has to be accompanied by a proper system of transporting the human waste if the composed and dehydrated matter cannot be used on site (EAWAG/SANDEC 2008, Netherlands Water Partnership no date).

In addressing the financial constraints of households, innovative measures such as micro finance for improved sanitation need to be introduced (market). Potential clients include small-scale private providers and households (Fonseca et al. 2007). Micro finance can be used for the construction of household latrines and of public toilets, manual latrine-cleaning services and suction truckers which are used to empty pit latrines. By introducing micro finance for providers and consumers, the gaining of livelihoods can be strengthened (financial resources).

Technological improvements and economic incentives may not be enough. Discussions and perhaps even more drastic measures may be needed to change local knowledge and values concerning sanitation. A first step is to involve community members and local artisans in assessing the benefits and challenges of different types of toilets and waste disposal techniques. A second step may be a "walk of shame", a measure which has been successfully implemented by NGOs in Bolivia, Bangladesh, Sierra Leone and

Zambia (Black and Fawcett 2008). Facilitators take residents on a "walk of shame" around the neighbourhood, not only pointing out excrements and dilapidated latrines but labelling them with flags and the offenders' names. Such a strategy may build on the local value that having a cholera case in the household is considered shameful.

The resilience pathways mentioned so far address water- and sanitation-related health problems before they turn into a disease (ex ante resilience building), but specific actions are also needed to build resilience after disease has struck (ex post). Having an emergency preparedness unit at the Municipal Health Department and well functioning health services are essential for the provision of rapid treatment should the community be hit by an epidemic, particularly in a cholera outbreak.

Conclusions

In unplanned urban settlements like Chang'ombe, social resilience to health risks is, to a large extent, contingent on access to safe water and sanitation, which is managed by social actors on the individual, household, community, district, and regional level. Resilience building means to strengthen the capacities of these social actors who interact in various activities ranging from financial contributions to technical and advisory support. These activities can be grouped into resilience pathways emphasizing technology, financial resources, markets, knowledge, authority and networks.

Resilience pathways can be created and strengthened through a range of policies and interventions: from ex-ante measures such as the willingness of the state to expand the current piped water schemes, introduction and promotion of new water and sanitation technologies, continued sensitisation and education on proper sanitation methodologies and introduction of micro-finance for improved sanitation programs, to ex-post measures such as functional emergency preparedness unit and functional health facilities. Ex-ante policies and interventions are effective ways of reducing the exposure to health risks and will reduce the cost of ex-post measures.

Note

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References

Adger, W.
2000 Social and ecological resilience: are they related? *Progress in Human Geography* 24 (3): 347-64.

APHRC
2002a Health and livelihood of residents of informal settlements in Nairobi City. Nairobi: APHRC.
2002b Population and health dynamics in Nairobi informal settlements. Nairobi: APHRC.

Black, M. & B. Fawcett
2008 *The last taboo: Opening the door on the global sanitation crisis*. London: Earthscan and UNICEF.

EAWAG/SANDEC
2008 Compendium of sanitation system and technologies. Zürich: AWAG/SANDEC.

Folke, C. et al.
2002 Resilience and sustainable development: Building adaptive capacity in a world of transformation. *Ambio* 31 (5): 437-40.

Fonseca, C. et al.
2007 Microfinance for water, sanitation and hygiene: An introduction. Delft: NWP and IRC.

Glavovic, B., R. Scheynens & J. Averton
2002 *Livelihoods approach*. Available at: www.devnet.org.nz/conf2002/papers/Glavovic_Overton_Scheyvens.pdf.

Holling, C.
1973 Resilience and stability of ecological systems. *Annual Review of Ecology & Systematics* 4: 1-23.

Kessy, F & Y. Msongwe
2008 Initiative service delivery for the rural water supply and sanitation project (RWSSP): Narrative report for Morogoro rural district, Research report submitted to the World Bank, Nairobi.

Langridge, R., J. Christian-Smith & K. Lohse
2006 Access and resilience: Analyzing the construction of social resilience to the threat of water scarcity. *Ecology & Society* 11 (2) Art. 18.
Lebel, L. et al.
2006 Governance and the capacity to manage resilience in regional socio-ecological systems. *Ecology & Society* 11 (1): 19. Available at: http://www.ecologyandsociety.org/vol11/iss1/art19, accessed: 19 May 2008.
Luers, A.
2005 The surface of vulnerability: An analytical framework for examining environmental change. *Global Environment Change* 15: 214-23.
Netherlands Water Partnership
2006 Smart sanitation solutions: Examples of innovative, low-cost technologies for toilet, collection, transportation, treatment and use of sanitation products. Den Haag: Partners for Water. Available at: http://www.irc.nl/content/download/24282/273405/file/SSS_2006.pdf, accessed 15 March 2008.
Regional Health Department and MAMADO
2005 Quality of water sources in Chang'ombe. A baseline study for SODIS Project. Dodoma: Regional Health Department and MAMADO.
Ribot, J.
1995 The causal structure of vulnerability: Its application to climate impact analysis. *Geo Journal* 35 (2): 119-22.
Ribot, J.& N.L. Peluso
2003 A theory of access. *Rural Sociology* 68 (2): 153-81.
Ruheka, A., C. Luthi, & F. Kessy
2008 *Chang'ombe status assessment*. Dodoma: MAMADO and Zurich: EAWAG.
SODIS
2008 *Solar water disinfection – A water treatment process used at household level*. Available at http://www.sodis.ch, accessed 15 March 2008.
Thompson, J & S. Cairncross
2002 Drawers of water: Assessing domestic water use in Africa. *Bulletin of World Health Organization* 80 (1): 61-62.
Tompkins, E & W. Adger
2004 Does adaptive management of natural resources enhance resilience to change? *Ecology & Society* 9 (2): 10. Available at: http://www.ecologyandsociety.org/vol9/iss2/art10.
Trosper, R.
2004 Transformations in the U.S forest sector, 1970-2000: Implications for sustainable use and resilience. In: F. Berkes, J. Colding & C. Folke (eds.), *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge: Cambridge University Press, pp 328-51.
United Nations
2002 *Water and sanitation in the world's cities: Local action for global goals*. United Nations Human Settlements Program (UN-HABITAT) publication. London: Earthscan Publications Ltd.
United Republic of Tanzania
2007 Annual water sector status report-2006/2007. Dar es Salaam: Ministry of Water.

Walker, B. et al.
2005 A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology & Society* 11 (1): 13.
Water Aid
2007 Sanitation and hygiene status in Tanzania. Dar es Salaam: Water Aid.
WHO, UNICEF & WSSCC
2000 *Global water supply and sanitation assessment report*. WHO: Geneva.
World Bank
2000 *Entering the 21st century. World development report 1999/2000*. New York: Oxford University Press.a