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Annexure D – Case studies
Module 4: Climate change and Urban Water Cycle Management

LIST OF CASES BY CITIES, REGION AND CLIMATE CHANGE

1.0. Cities with Increasing Wetness – Durban (South Africa)

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CASE STUDIES

1.0. CITIES FACING INCREASING WETNESS

1.1. DURBAN (SOUTH AFRICA) PROJECTED CLIMATE CHANGE AND POSSIBLE IMPACTS ON WATER SUPPLY

In view of projected climate change, Town planners and urban water supply companies need to be aware of the nature of projected climate change for their regions and how this could affect water demand and supply to the city. This will enable them to put in place adaptive and mitigatory measures in advance. Since climate change is expected to vary with different regions of the world, urban water management plans are expected to vary accordingly. The case study that follows considers some projected impacts of climate change on water supply to the coastal city of Durban in the KwaZulu-Natal province of South Africa.

The City of Durban is situated on the eastern coast of South Africa and is projected to experience “more intense and erratic rainfall, more hot days and heat waves, higher mean sea-levels as well as higher and extreme temperatures” (Loftus et al., 2011; Mirza, 2003). The main sources of water supply to the City are two inland dams namely the Nagle and the Inanda dams. At present these reservoirs hold more than enough water to supply the city much more that only one of them (the Nagle dam) is operational while the other serves as a back-up reserve.

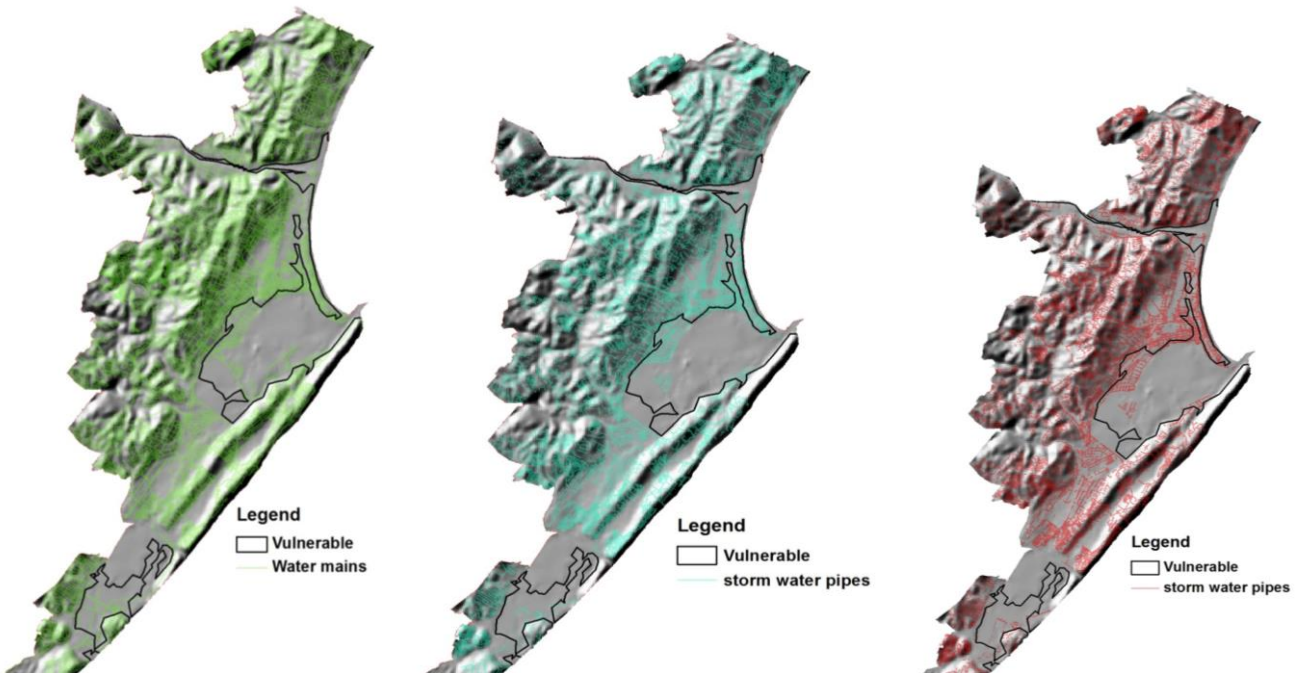
The water utility company, Umgeni Water, extracts water from the dams to a treatment facility close to the city (at Reservoir Hills) whence it is then piped to the Durban City for various uses. According to the water utility company, the supply is so abundant that projections of climate change and its impacts on water supply is an unlikely happening. However company officials acknowledge that reservoir levels necessitating withdrawals heavily depend on a healthy rainfall regime and river flows. This raises the concern on the quantity and quality of water supply to the city if the projected climate change materializes.

Even without climate change, the water utility company admits water quality is a constant challenge in terms of chemical treatment and odour removal together with their associated costs. Hence during periods of intense rainfall, catchment erosion will not only pose a sedimentation problem for the reservoirs reducing their storage capacities but organic pollutants washed from the catchments into the dams, together with increased turbidity will compound the already existing challenge.

Another likely problem presented by the projected extreme rainfall events is the possibility of increased volumes of city runoff above the carrying capacity of the present storm water design systems causing possible overflows and damage to infrastructures, necessitating repairs. This could also be the case with waste water system (pipes and treatment facilities) where increases in extreme rainfall events could likely result to an exceedance in the carrying capacity of the waste water/sewer systems and thus resulting to the discharge of waste water to the surface with possible effects on the human health and the environment. This could be compounded by possible sea-level rise and the flooding of existing low-lying coastal waste water/sewage treatment along the Durban coast and a possible failure of the waste water pumping stations.

During periods of extreme heat and temperatures, algal boom, mineral weathering and the growth of invasive weeds (for example, water hyacinth) could invade the reservoirs supplying water to Durban, presenting further water quality challenges.

Water mains, storm water & sewer pipes vulnerable to sea-level rise in Durban (Source, SAEES, UKZN)



Despite the water utility‘s seeming lack of concern on the impact of climate change on their ability to supply quantity and quality water to the city of Durban, some efforts have been made to educate the population on alternative water sources like rain harvesting and conservative use of water. However, these efforts are carried out as a measure to solve the high demand of water in the Durban city and to lighten the pressure on the water utility company and not as a climate change adaptation method. Moreover, these sensitization methods have not been carried out on a massive scale and there are no attempts to follow through.

A likely disincentive to the application of sustainable methods of water use in the city and the metropolitan area as a whole is the very low price for water which puts no restraint on the volume of water used by individuals. Therefore, despite the water company’s apparent confidence in the availability of water for the city of Durban, the question remains whether it will be able to supply quantity and quality water in future given the projected climate change for the region and other factors like increasing urban population, water demand and attitudes towards water use.

This calls for measures to reduce the likely vulnerability of Durban city to the impacts of climate change on urban water supply. This include among others increased awareness on the impact of projected climate change on urban water supply, a clear understanding of climate change water adaptation and mitigation planning methods, their implementation and follow through. Climate change is a fact proven by scientific evidences and observed variations of climate variables in the past and present. This has impacted on the global water cycle in general and on the urban water cycle in particular. Projections of future climate change and its foreseeable impact on the urban water cycle calls for strategic and sustainable planning, including a holistic and integrated approach.

2.0. CITIES FACING INCREASING ARIDITY: BESHAR CITY – ALGERIA

1. Name of practice: WATER RESOURCES MANAGEMENT. BESHAR CITY CASE STUDY (ALGERIA)

2. Location:

- At about 773 m up, the oasis of Beshar is situated Western- South of Algeria, within the "*Sawra* " region, at 1150 Km far from the Capital Algiers, along with the Bechar River.
- The latitudes and longitudes are 31° 37′ 00″ N, 2° 13′ 00″ W respectively.
- It counts about 171724 inhabitants (2009) living in almost 5050 Km², with a relative low density 34 inhab/ Km².
- The area has a continental arid climate having a long hot summer during five months, from May to October.
- The yearly temperature average reaches 20°C (minimum 1°C and maximum 43°C), while the total precipitations are estimated of 80 mm/ year (the dry period goes on for almost all the year).
- Yet the local aridity index[1] (2.66) designates a quite arid saharian region.
- The city is surrounded by mountains (between 1200 and 1900 m up) and crossed by the Beshar River.
- The surrounding landscape is typical of the saharian region, composed of vast rocky stretches ("*regs*") and 300 m high sand hills ("*ergs*")

3. Actors

Agence nationale des barrages et transferts: National Office for Dams and Transfer, in charge with planning, building and managing hydraulic works.

Algérienne des Eaux : Public Service for Water Supplying, in charge with managing the water urban network.

Assemblée Populaire Communale : The municipality, local government.

Direction de l'Urbanisme, de le Construction et de l'Habitat (DUCH): Public Office for urban and technical studies.

Local community.

Office national d'assainissement: Public Waste waters Service, in charge with managing the sewage network.

Protection Civile: Civil Defence.

URBAT: Office for urban and technical studies.

4. Local water issues addressed/ focus

- Beshar city has been selected as a short case study with regard to the serious local water challenges.
- Up to now, Beshar City is mainly supplied with surface waters coming from the *Djorf Torba* dam and the *Ouakda* dike.
- Under the local arid climate, the volume of dam's waters evaporated oversteps the volume consumed (REMINI, 2005).

[1] After De Martonne, the aridity Index can be calculated as follow : I = P / T+10
P= Yearly precipations
T: average of temperature.

- The regional ground waters also contribute to the local supplying as the number of wells has been multiplied during last decades.
  - However, the water public services are also suffering from the decay of the canalizations, and the silting up of the dam, and the extension of the agricultural zone.
  - At the same time, the wastewaters are directed towards the Beshar River at the rate of about 430 l/s, contributing to a serious environmental pollution.
  - Many local technical studies has been launched or finalized during last year, especially concerning the drinking water supply (transfer from other watersheds and new boring fields).

However, from 1993 up to date, the availability remains stable with 21 000 m³/day, when the demand has considerably grown from 32724 to 72 954 m³/day (KABOUR A & al, 2011).

After KABOUR & al, the local resources become no more sufficient to cover the local water drinking needs since the distributed volume represents only 50% of the volume required.

The city is regularly facing both the river and the dam overflowing, and the lack access to clean water and a proper sanitation. Indeed, between 1993 and 2003, the real daily consumption has continually decreased from 154 to 103 l/day. It is expected to reach 69 l/day by 2013 (KABOUR A & al, 2011). Yet the demand should be satisfied at only 28%.

5. Local water management

Since it is located in a dry region, the local hydrological balance is highly dependant from the temperature variability from a season to another. Referring to the regional climate change scenario, this variability would likely intensify aggravating the natural aridity (http://www.mate.gov.dz, 2001). .

Meanwhile, in addition to the climate change impact, the city is facing a continual population growth and subsequent notable increasing water demand.

Yet, the local water scarcity is not only due to the climate, but also aggravated by the over-exploitation, the contamination and the risky management of local resources.

The city is also continually threatened by many related risks such as surface and underground water salination-contamination and frequent flooding at the origin of important human and material damages.

In 2010, the municipality has launched the revision of the urban master scheme focusing on the land use pattern and the public networks rationalization (drinking water, wastewater, pluvial waters) with the objective of reducing the water management cost and improving the life conditions within the poor quarters.

In spite of that, last April (2012), after a quite rainy day, it has registered many damages when the sewage and the pluvial networks, recently renovated and extended, have overflowed interrupting the transport and the communication traffic.

6. What was/ is being done?

Face to such challenges, the Water Resources Ministry has opted twice again for the renovation of the supplying and the sewage networks, and the brackish water desalination and more especially the reinforcement of the groundwater exploitation.

In 2008 the Water Resources Ministry has presented its new regional water exploiting strategy for 2009-2015 that consists in intensifying the groundwater pumping from three near hydrologic basins (http://www.mre.gov.dz).

Even if the priority is placed on human consumption to meet basic needs, the Water Resources Ministry also opts for the creation of new economic zones and the development of an adapted agriculture.

Yet, to deal with the increasing shortage and the local increasing demand, the main planed adaptive resulting from the official policy decision seems to progress through more investments in structural measures providing immediate services through short term solutions.

That may aggravate the risk rather than reduce the local vulnerability and improve the resilience face to climate change and water related hazards.

For their part, the inhabitants adapt through some autonomous measures and reinforce their own stocking capacity using some biggest cisterns (1000 l) since the water distribution duration does not exceed 10h/24h, (KABOUR A & al, 2011).

7. Outcomes and impacts

With these hydraulic works, the municipality may expect a sensitive improving of their demand supplying by short and middle term.

The question then is whether the long term impact on the ground water is or not controlled since the region already suffers from salination and serious contamination?

With regard to this situation, there is a need to focus more on IWRM and urban regulation. As a response at the national level, Algeria has already addressed the IWRM issues, but at the local level, this strategy is not in place yet and may need enhancement.

As a result, in spite of the continual development of the hydraulic works, the city has neither made up the increasing shortage yet, or succeeds in protecting against floods.

Namely, the city has to use some adaptive measures to reduce vulnerability and take advantage of new climatic conditions to restore and renovate its urban and hydraulic heritage and conserve the local resources, and to use the surplus of flood waters, and to reuse the waste and brackish waters.

Such adaptive measures needs for policy adjustments and support and best public participation (AWC-UNDP/CEDARE, 2005).

8. Sustainability

To introduce this practice locally, the strategy should focus on the long term sustainability incorporating both the objectives of IUWM and the water sensitive urban design principles that are able to guarantee sustainable water supply, hygiene, water quality, improved quality and security of the living environment from flooding.

Strategic measures should combine among mitigation and adaptation on one hand, and regional and local levels on the other integrating multi-disciplinary and multi-dimensional approach in order to resolve the local water related risks that may be intensified (shorter winter, dryer and hotter summer, extreme events).

However, the region of the *Sawra* where is situated Beshar City has an advantage in adapting to aridity and water scarcity since its inhabitants share a traditional knowledge that may be adapted and applied nowadays. It consists in subterranean conduits named "*fugara*" through which ground waters are conveyed towards a public stocking cistern before being distributed among urban quarters.

9. Documentation

AWC/UNDP/CEDARE, *Status of IWRM Plans in the Arab Region*, december 2005, 82p.

KABOUR A & al, 2011, *Evaluation et gestion des ressources hydriques dans une zone aride. Cas de la ville de Bechar (Sud-Ouest Algérien),* in Larhyss Journal, ISSN 1112-3680, n°09, December 2011, pp. 7-19.

Ministère de l'Intérieur et des Collectivités Locales (Ministry of Domestic Affairs), http://www.interieur.gov.dz

Ministère des Ressources en eau (Water Resources Ministry), http://www.mre.gov.dz

Ministère de l'aménagement du territoire et de l'environnement, 2001, *Elaboration de la stratégie et du plan d'action national des changements climatiques*, Projet national ALG/98/G31, Mars 2001, 155p, http://www.mate.gov.dz

REMINI B, 2005, *L'évaporation des lacs de barrages dans les régions arides et semi-arides : Exemples algériens*, in *Larhyss Journal, ISSN 1112-3680, n° 04, Juin 2005, pp.81-89.*

REMINI B, 2008, *La Foggara*, Ed OPU, 132p.

LATIN AMERICA AND THE CARIBBEAN – MEXICO CITY

3.0. CITIES WITH SPECIAL WATER NEEDS

3.1. LATIN AMERICA AND THE CARRIBEAN (INCLUDING MEXICO CITY)

3.1.1. OVERVIEW OF LATIN AMERICA AND THE CARRIBEAN

In the Latin America and the Caribbean (LAC) the urban population has tripled over the past 40 years and is expected to grow to 609 million by 2030 (up from about 460 million today). There are many cities with more than 1 million inhabitants, and a recent trend has been the growth of population in medium-sized and small cities. “Latin America is already the world’s most urbanized developing region, with more than 80% of the population living in towns and cities.

Economic and social changes have obvious consequences for water use and the demands placed on the resource. With the exceptions of Mexico and some of the small countries of Central America, the countries of the region base much of their economy on the export of natural resources. The global demand for these products has increased notably in recent years. Moreover, much of the production of these goods is financed by external capital and many of the facilities are foreign-owned. The result is that the major engine of economic growth in the region with heavy demands on the water resources is subject to many factors outside the direct control of the governments of the countries of the region.

For water management, this dependence on many natural resource-based activities is complicated by their location. The expansion of copper and gold mining in Chile and Peru has mainly occurred in arid areas and has led to competition for scarce water with both export agriculture and the needs of the indigenous population. For example, water use for energy can be expected to rise throughout the region in line with economic growth. Hydropower produces 53% of the region’s electricity, and installed capacity grew by 7% between 2005 and 2008. Hydropower is expected to provide a significant proportion of the new energy demand. (United Nations World Water Development Report, 2011)

Latin America and the Caribbean (LAC) are particularly vulnerable to the observed and projected impacts of climate change because of its geographic location and reliance on natural resources for economic activities and livelihoods. Key impacts in the region by or about 2050 include the forecasted collapse of a significant portion of the coral biome in the Caribbean, disappearance of most glaciers under 5000 m in the Andes, reduction in agricultural yields of many staple crops, increased flooding and inundation of coastal zones, increased exposure to tropical diseases, destabilization of the hydrological cycle in major basins, and the intensification of extreme weather events (IDB, 2010).

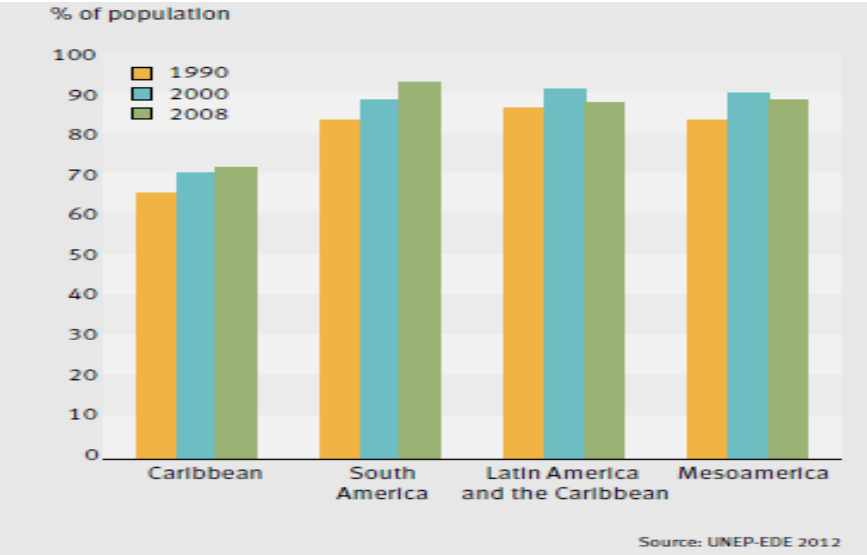
Estimated annual damages in LAC caused by the physical impacts associated with a rise of 2oC over pre-industrial levels are estimated to be of the order of over $100 billion, or about 2% of current GDP. Losses of this magnitude would limit development options as well as access to natural resources and ecosystem services (IDB, 2010).

Water sector related Climate change impacts in LAC include:

- major melting of glaciers in the Andean mountain chain, reducing capacity for hydropower generation and disturbing downstream water flow that is needed for agricultural production and water supply.
- Higher ocean temperatures and a sea level rise will result in severe coral reef retreat and salinization of coastal wetlands.
- More frequent and intense hurricanes will particularly affect the Caribbean and Central America, posing major threats to livelihoods and infrastructure.

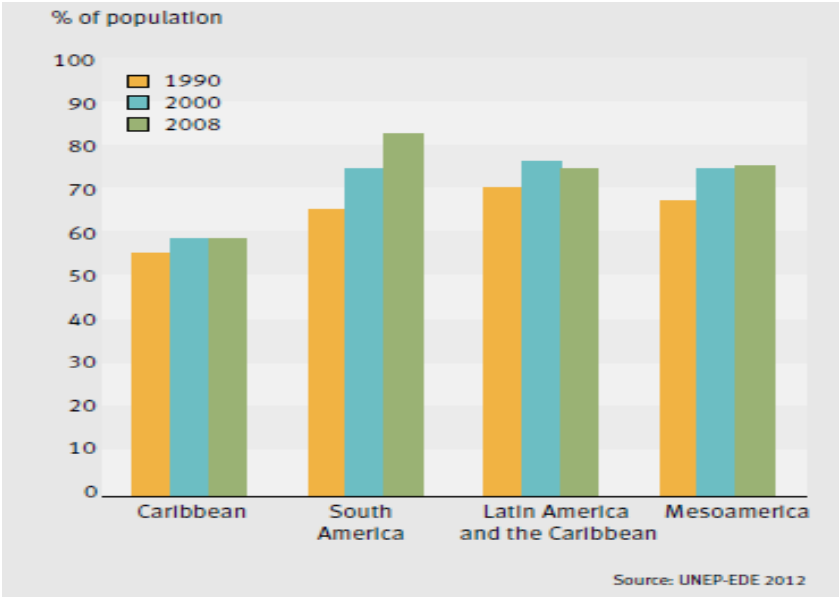
Population access to drinking water and sanitation in the region is shown below.

Population with access to drinking water. UNEP-EDE (2012). UNEP Environmental Data

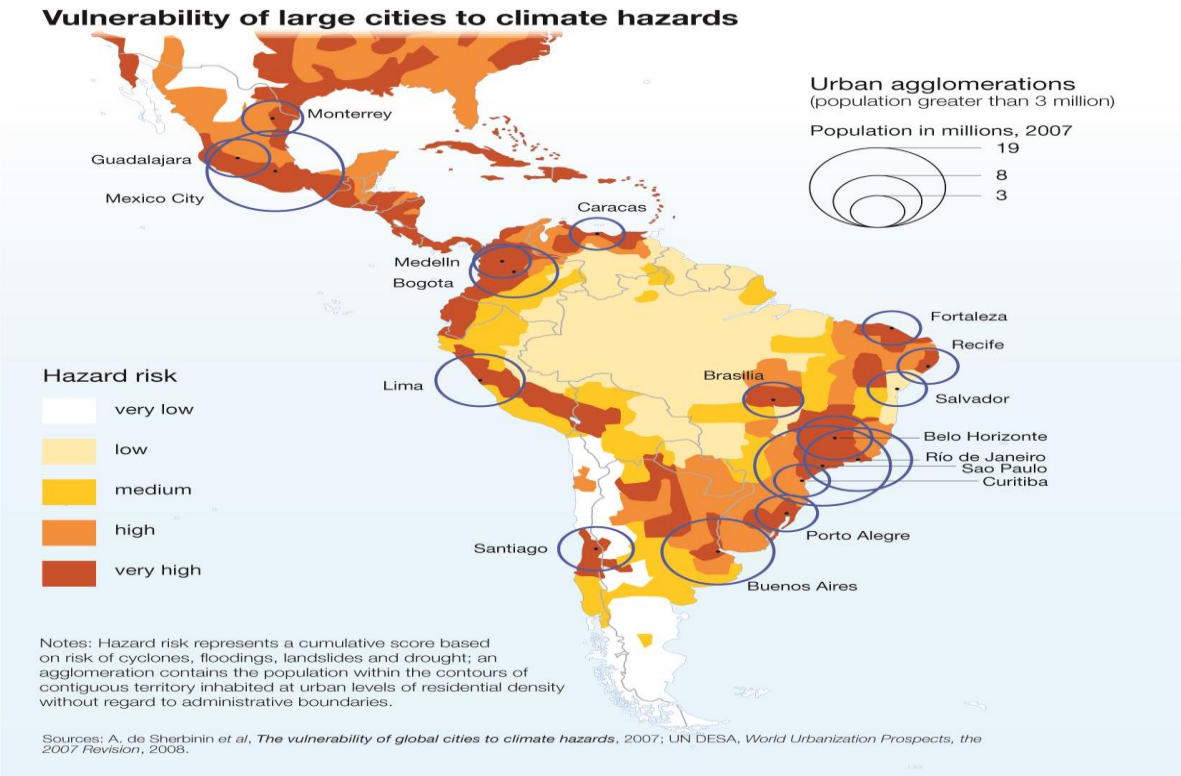


Explorer. http://geodata.grid.unep.ch/

Population with access to improved sanitation. UNEP-EDE (2012). UNEP Environmental



Data Explorer. http://geodata.grid.unep.ch/



The climate change challenges facing Latin America and the Caribbean. *Vital Climate Change Graphics for Latin America and the Caribbean (2010)* United Nations Environment Programme (UNEP) and Sustainable Development and Human Settlements Division of the Economic Commission for Latin America and the Caribbean (ECLAC) http://www.grida.no/publications/vg/lac2

3.1.2. CARIBBEAN

Approximately 70 per cent of the Caribbean population lives in coastal cities, towns and villages, a consequence of: the abundance of relatively easy to navigate and, therefore, very accessible natural harbours; the export oriented economy; the importance of artesian fisheries; and the tourism industry's coastal focus. More than half the population lives within 1.5 km of the coast and international airports, roads and capital cities are commonly situated along the coast (Mimura et al, 2007).

The potential economic impact of climate change on the countries of the Carribean Community (CARICOM) in the absence of adaptation actions estimated at US$11.2 billion. For all 20 CARICOM the total Gross Domestic Product (GDP) for 2007 (in 2007 US$ prices) is US$99.3 billion. That is, the estimated total annual impacts are about 11.3% of all 20 CARICOM countries' total annual GDP in 2007. The 2002 World Bank report on impacts of climate change on CARICOM countries (World Bank, 2002) estimated that a 0.13 meter rise in sea level and a 2°C increase in temperature from 1999–2080 will lead to an average 3% loss of land in CARICOM countries.

Following the assumption of an 8% land loss due to sea level rise, 8% of the telephone mainlines are assumed to be lost due to sea level rise. Thus, an investment need for 8% of mainline connections is estimated with the data obtained from two Bank reports (Jha ed. et al. 2005; Fay and Yepes 2003), which estimated an investment cost of US$400 for mainline connections per household. Assuming a 5% real interest rate and a 30-year life of mainline connections, the annual total for 15 CARICOM countries is US$3.9 million ca. 2080 in 2007 US$ prices.

Following the assumption of an 8% land loss due to sea level rise, an investment requirement of 8% of water connections due to sea level rise is estimated with data obtained from two World Bank reports (Jha ed. et al. 2005; Fay and Yepes 2003). The estimated investment cost is US$400 for water connection per household. Assuming a 5% real interest rate and a 30-year life of water connections, the annual total for 13 CARICOM countries is US$6.7 million ca. 2080 in 2007 US$ prices (World Bank, 2009).

Ongoing initiatives in water sector

The project by Inter-American Development Bank (IDB, 2012) on Pilot adaptation measures to climate change in the water sector will finance small local works to help mitigate the impacts of climate change and reduce vulnerability of agricultural production and the general population in Bolivia.

3.1.3. CASE STUDY MEXICO CITY

3.1.3.1. Overview on Mexico City Development

Mexico City's population exploded over the last century, growing from 1.75 million people in 1940 to currently over 21 million in the metropolitan area, making it the fifth largest metropolitan area in the world (City Mayor Statistics, 2011). The metropolitan area accounts for the country's highest concentration of economic activity – Mexico City and the state of Mexico produce 33 % of Mexico's GDP (Rojas et al., 2008).

GENERAL INFORMATION	
Inhabitants	City (Distrito Federal): 8,851,080[6] Total metropolitan area: 21,163,000[7]
Population density	5,912 person/ km² - Mexico City 2009 668 person/ km² - Mexico state 2009 (CONA-GUA, 2011)
Population growth	15%[8]
GDP (estimated in 2008, $bn at PPP)	US$ 390 billion (rank 8) (Hawksworth et al., 2008)
Contribution to national GDP	33% (IDB, 2008; Tortajada, 2006)
Area	7,854 km² (CONAPO, 2005)
Climate	Temperate semi-humid, Arid & Semi-arid; Temperate humid (SMA, 2005)
Altitude	2,240 m.a.s.l. (SMA, 2005)
Mean temperature	16°C (SMA, 2005)
Mean annual rainfall	Arid – 50 mm; Temperate humid – 100 mm (SMA, 2005)

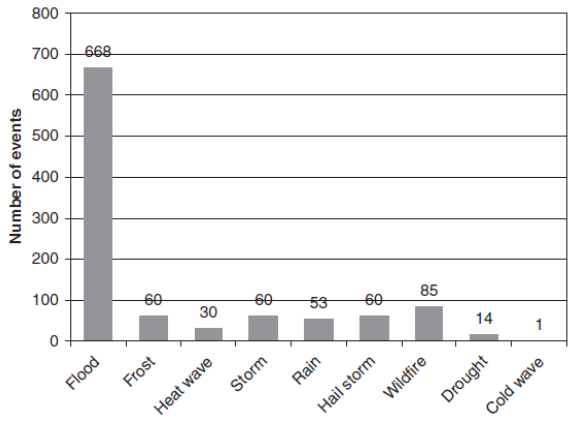
Big Cities.Big Water.Big Challenges WWF report 2011

WATER STATISTICS	
Domestic water use (liter per capita)	364 l Mexico City & 230 l Mexico state = 297 l on average in metropolitan area (Tortajada, 2003)
% households with water access	98 % (Mexico City) (CCA, 2011)
% water loss due to leakage in pipe systems	> 40 % (Tortajada, 2003)
Water price for domestic households	Mexico City = CONAGUA tariffs for 20m3 (US$/month)9: Popular $3.50, Low $5.10, Medium $14.90, High $17.00 (CCA, 2011)
% households with sewerage services	Mexico City = 94 % (CCA, 2011)
% wastewater treated	Mexico City = 7.9 % (CCA, 2011)
Main water sources	Groundwater Inter-Basin water Transfer from the Cutzamala & Lerma Rivers
Main water problems	Pollution Groundwater over-extraction Insufficient and leaking infrastructure Subsidence → flood risk

Big Cities.Big Water.Big Challenges WWF report 2011

3.1.3.2. Current Climatic Conditions and Climate Change Projections in the region

Immense overexploitation of available water resources in Mexico City and decreasing precipitation due to climatic changes are the main factors putting strain on water resources. Expected changes in extremes include the alternation of more intense droughts and heat waves with short episodes of intense rain (storms, hailstorms). These climate hazards might aggravate water shortages and floods, as well as increase risks from waterborne diseases.



Mexico City: hydro-meteorological events resulting in disasters (1980–2006)
Desinventar, http://www.desinventar.org/

Federal District: 2020 scenario		**State of Mexico: 2020 scenario**	
Total annual precipitation will diminish 5–10%	Mean annual temperature will increase 1.8–1.2°C	Total annual precipitation will vary +5 to –5%	Mean annual temperature will increase 0.8–1.2°C
Federal District: 2050 scenario		**State of Mexico: 2050 scenario**	
Total annual precipitation will diminish 5–10%	Mean annual temperature will increase 1–2°C	Total annual precipitation will vary +5 to –15%	Mean annual temperature will increase 1–2°C
Federal District: 2080 scenario		**State of Mexico: 2080 scenario**	
Total annual precipitation will diminish 5–20%	Mean annual temperature will increase 2–4 °C	Total annual precipitation will diminish 5–20%	Mean annual temperature will increase 2–4 °C

Changes in precipitation and temperature in Mexico City INE
http://www.ine.gob.mx/cclimatico/edo_sector/estados/futuro_mexico.html.

The Ministry of Environment (SEMARNAT) and the Centre for Atmospheric Sciences of the Universidad Autónoma de México estimate that by 2020 precipitation rates in the Metropolitan Zone of Mexico City could fall by 5% while temperatures may rise by up to 1.2 degrees Celsius, increasing evaporation.

3.1.3.3 Hydrology, Hydrogeology, and water supply

Both the current water system and the city have unique characteristics that amplify the impacts of rains, floods and other hazards that climate change is expected to aggravate. The first is the profound transformation of the hydrological cycle by the engineered systems described earlier, which has created irreversible changes in the regional water balance as well as changes in the basin's climate. Mexico City is now over-exploiting its water resources by between 19.1 and 22.2 cubic metres per second, depending on the calculations. This creates two kinds of vulnerability. Problems of water availability (scarcity), created by human actions, make water users vulnerable to the changes in the availability of water that are expected from climate change. According to projections where no consideration is given to global warming, between 2005 and 2030 the population of Mexico City will increase by 17.5 per cent, while between 2007 and 2030 available water will diminish by 11.2 per cent. The situation might get worse if – as expected – climate change brings lower precipitation. Those water users who already face recurrent shortages during the dry season or when droughts hit Mexico City will be especially affected. (Lankao, 2010).

The other vulnerability is related to the continuous downward displacement of groundwater levels, which historically has caused subsidence and continues to do so in some areas, thus undermining the foundations of buildings and urban infrastructure and increasing their vulnerability to such hazards as heavy earthquakes and rains (the intensity of the latter will be aggravated by climate change). As mentioned earlier, the location of the city puts its residents at risk from floods regardless of economic or social position – floods are the main source of disaster for 70 per cent of the sub-sections (delegations and municipalities).

Although fundamental to its change, the engineered hydraulic system was not the only factor contributing to the transformation of the regional hydrological cycle and to the increasing vulnerability of Mexico City to floods, droughts and other hazards. Equally important were the land use changes induced by primary activities and urbanization. Forest exploitation and some of the agricultural and farming practices in the basin of Mexico brought about deforestation and caused land surface erosion. These changing land use patterns also contributed to the accelerated desiccation of the lagoons and the obstruction of the drainage system with sediment from land erosion, while constructed surfaces negatively impacted the capacity of mountainous land areas to allow water infiltration to feed the aquifers.

Urbanization, as a determinant of land use changes, has been another factor in transforming both the hydrological cycle and the regional climate. The urban built environment is a source of heat (and a contributor to the heat-island effect), a poor storage system for water and an impediment to atmospheric movements. Driven by national policies and factors that attract investment (e.g. agglomeration economies), Mexico City saw large-scale growth in urban industries followed by an increase in immigration. From the 1940s to the 1970s, import substitution policies reinforced the concentration of various urban services and compounded the political power of Mexico City. These changes were an important underpinning of increased rural–urban migration. Of comparable significance was an increasing lack of economic prospects in the rural areas, including those immediately surrounding the central city (Lankao, 2010).

Over the last few centuries, Mexico City has been faced with wet years and floods alternating with episodes of drought. It has also had abundant water resources. The floods and droughts have been aggravated by environmental transformations and changes in the hydrological cycle along with land use changes induced by primary activities and urban growth. They are expected to be further aggravated by climate change. The hydraulic cycle has been profoundly and in many ways irreversibly transformed. This has created a paradoxical situation whereby, first, not even the most sophisticated drainage system has been effective in controlling the floods that continue to affect different areas and sectors of the capital; and second, storm and wastewater is pumped out of the basin while one-third of the total drinking water must be brought in from increasing distances and with increasing investments of capital and energy (and related emissions of greenhouse gases).

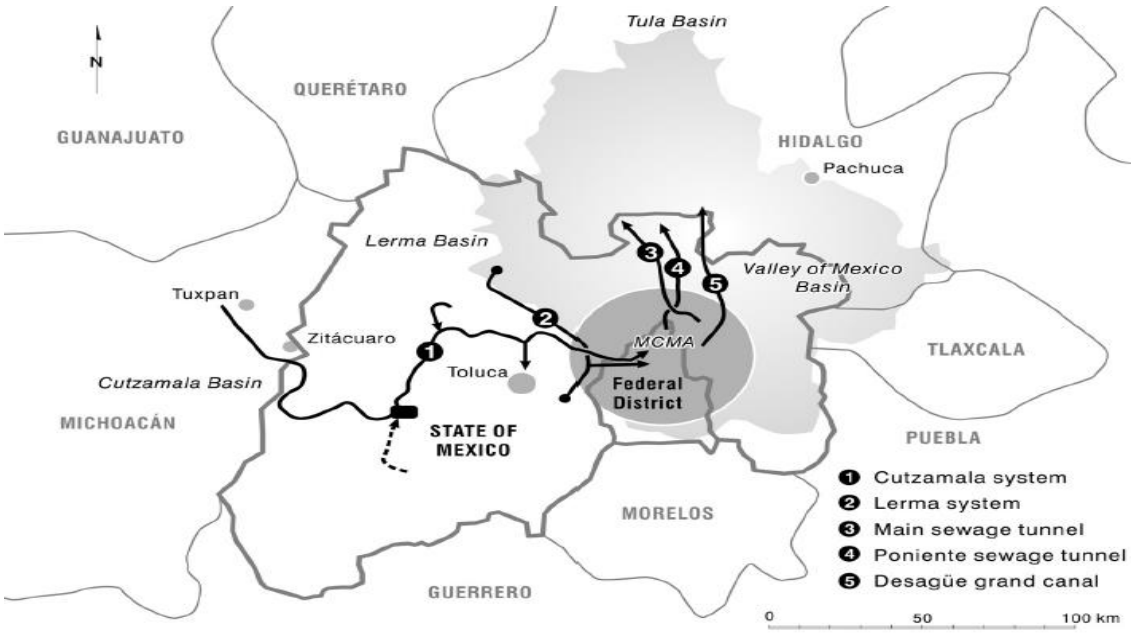
Besides causing changes in the basin's climate, the water system has irreversibly transformed the regional water balance and the availability of water. This, in turn, makes water users vulnerable to water scarcity and more intense droughts – and climate change will aggravate both of these. A continuous downward displacement of groundwater levels and subsidence in some areas dislodges buildings and urban infrastructure and increases their vulnerability to heavy rains. The regions that provide water to Mexico City have also become vulnerable to water scarcity, floods, waterborne diseases and other hazards that global warming is expected to aggravate. These transformations have negatively affected the livelihoods of the local populations and created indirect sources of stress for the city. The capital also faces other sources of stress, namely land use changes induced by primary activities, and urbanization pathways that increase the vulnerability of urban populations to floods, landslides and disease (Lankao, 2010).

3.1.3.4 State of the Art of Water Infrastructure

The metropolitan area of Mexico City lies in the Valley of Mexico basin, its water supply mainly stems from the northern aquifers of Mexico Basin, an extensive high mountain valley that is naturally closed, meaning there is no outflow to other water bodies. Nearly half of Mexico City's water stems from groundwater (Sosa- Rodriguez, 2010); however, 2007's extraction volume of 59. 5 m3/s was almost three times of the basin's natural recharge rate (Burns, 2009). The metropolitan area's second most important water supply depends on inter-basin transfers from the Balsas (Cutzamala River) and Lerma (Lerma River) basins that provide 43 % of the total supply (Sosa-Rodriguez, 2010).

3.1.3.5 Key Problems in Mexico City

Key problems in Mexico City are rapid growth of the urban area, significant water losses due to an obsolete water distribution system but especially pollution of water bodies due to untreated release of sewage water. According to Government statistics (INEGI) Mexico's urban areas generate 243 cubic meters of wastewater per second of which 25% drain off somewhere into the land-/cityscape, and only a third of which is treated. This does not account for leakage of pollutants due to waste and refuse such as Mexico City's "Bordo Poniente", the world's second largest landfill site that receives 12.5 thousand tons of waste on a daily basis. In addition, deforestation and land use change threaten hydrological cycles and the replenishment of aquifers.



The mega-basin of Mexico City
AEGR (2004), GIS services

Source	1950	1960	1970	1980	1992	2002*
Internal (well, springs, rivers)	10.8	16.6	26.0	41.8	44.4	45.2
Lerma		4.4	10.0	8.4	5.3	5.9
Cutzamala	–	–	–	–	10.6	14.9
Total	**10.8**	**21.0**	**36.0**	**50.2**	**60.3**	**66.0**

Sources of potable water supply in the metropolitan zone of Mexico City (cubic metres per second).
Romero Lankao, Patricia (1999), "Obra hidráulica en la ciudad de México y su impacto socio-ambiental, 1880–1990", Instituto Mora, Mexico.
Arredondo Brun, J C (2007), "Adapting to impacts of climate change on water supply in Mexico City", accessible at hdr.undp.org/en/reports/global/hdr2007-2008/papers/.

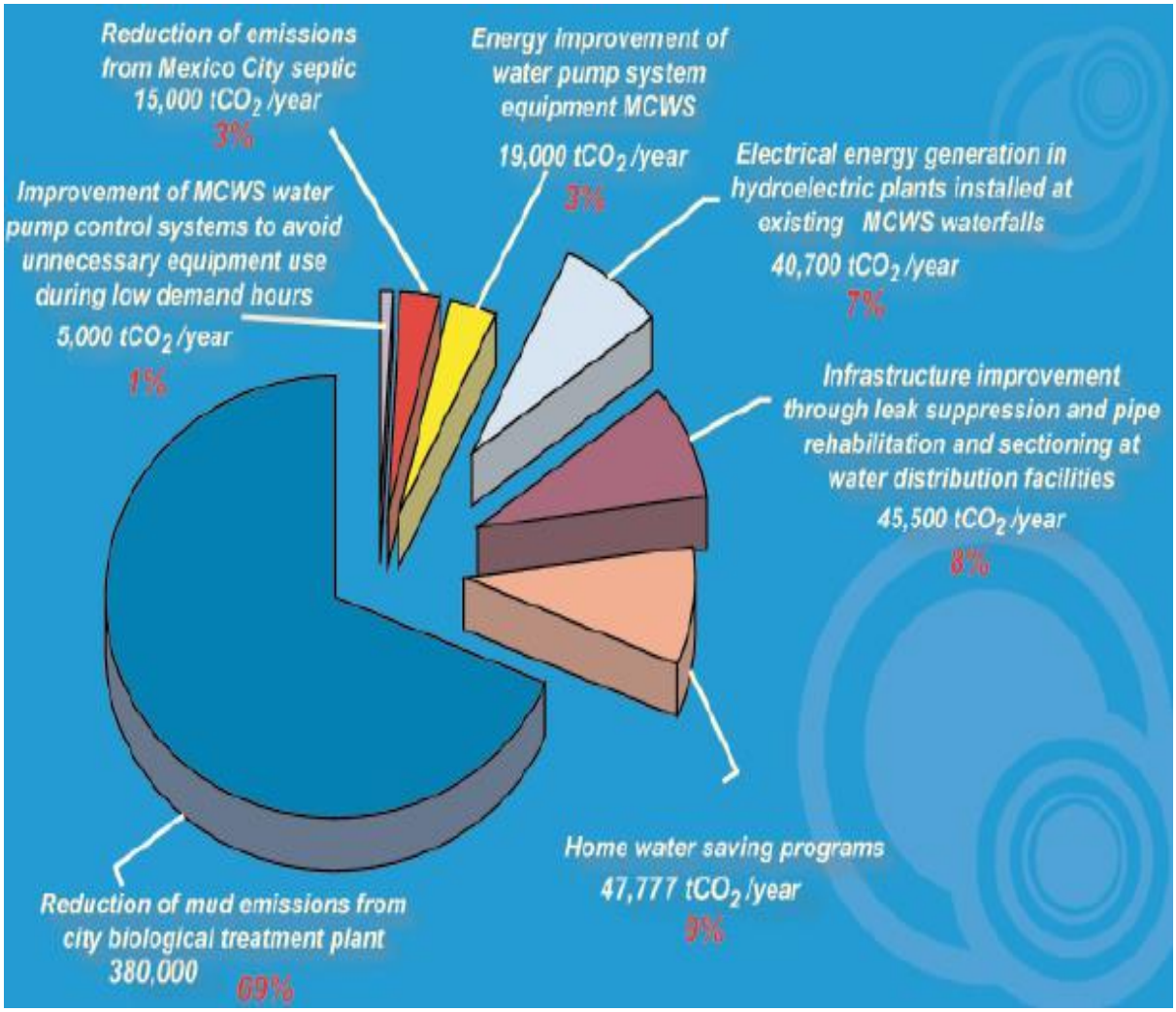
The sewage system, on the other hand is quite ineffective and water treatment plants usually lack maintenance and work poorly. Additionally there is no culture of water reuse. Moreover, rain water and raw sewage go through the same drainage system, polluting the former and making it totally unusable for other needs. Finally, the database of water users is outdated and incomplete, so there is a limited recovery of user charges and those that pay do so at very subsidized prices. (World Bank, 2010).

3.1.3.6 Over Extraction Subsidence

Over-extraction. As Mexico City's population exploded during the past century, existing infrastructure to supply water became insufficient to meet demand, which resulted in intensified groundwater extraction and water transported over greater distances (Sosa-Rodriguez, 2010). Currently, 4 of the 14 aquifers in the Valley of Mexico Basin are overexploited (CONAGUA, 2011). The per capita rechargeable water available for the Valley of México in 2010 is calculated at 163m3, whereas in 2030, it is predicted that rechargeable water per capita will be 148m3 (CONAGUA, 2011). Though the City has land set aside for conservation where groundwater sources could recharge, the frenzied population growth has led to many legal and illegal settlements, with 20 % of illegal settlers living in riverbeds (Sosa-Rodriguez, 2010; Tortajada, 2006). Especially in the southern area of México City, where the soil is ideal for water recharge, the City has become heavily urbanized and covered in asphalt. The over-exploitation of the aquifers has contributed to the continued subsidence of Mexico City, which sits below the current level of Lake Texcoco and increases the chance of catastrophic flooding (Sosa-Rodriguez, 2010). In the mid 20th century, Mexico City's ground subsided a reported 40 cm/year in some areas due to the increasing extraction of groundwater; current rates lie between five and 40 cm/ year (Jordan et al., 2010).

3.1.3.7 Governmental responses

Mexico City is expecting the start of the construction of what will be the world's largest water treatment plant, with a capacity of processing 23 cubic meters of water per second. Water treatment, the extension of sewage systems and access to potable water are also the priorities of Conagua. All these measures are of dire importance, yet as long as they are not coupled with activities that tackle not only symptoms but the actual root causes of the problem -pollution and overexploitation, due to bad planning at national and local level- Mexico will be ill-prepared to face water related impacts to climate change.



MEXICO CITY CLIMATE ACTION PROGRAM 2008-2012 Primera edición: 2008 © Secretaría del Medio Ambiente del Distrito Federal Plaza de la Constitución No. 1, 3er piso, Colonia Centro Delegación Cuauhtémoc, Código postal: 06068 www.sma.df.gob.mx

4.0 SAINT LOUIS (SENEGAL)

SENEGAL - Summary Questionnaire

1. Name of practices

TAKING IN CHARGE THE "NEGLECTED ISSUES OF WATER."
POVERTY IN WATER OF PEOPLE AFFECTED BY CLIMATE CHANGE IN THE NORTH-EAST OF THE CITY OF SAINT LOUIS (SENEGAL)

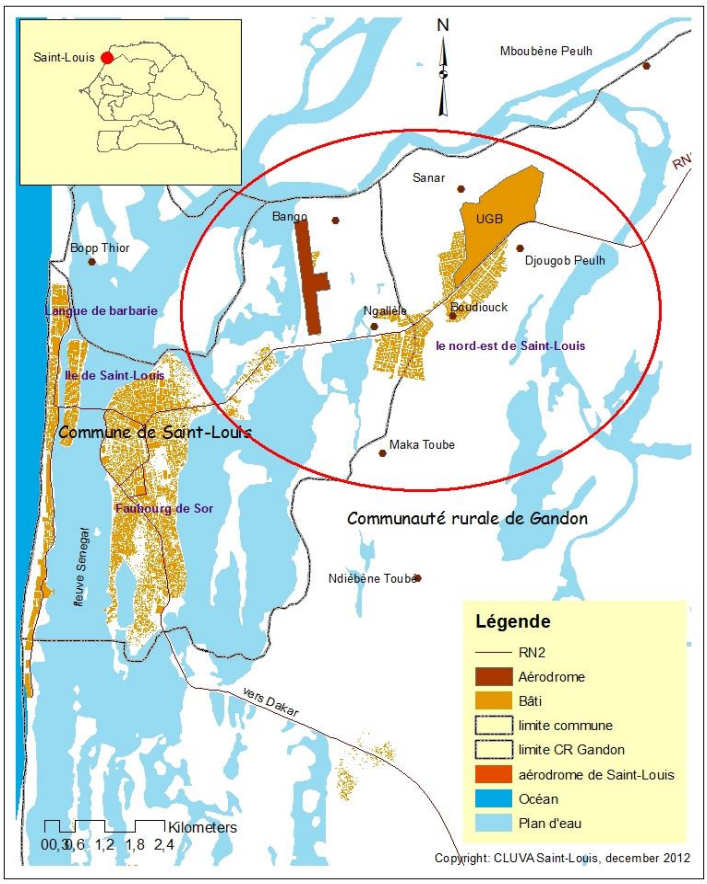
2. Location(s)

[List district/city/town & country.]

The site of the project is located at about 10 kilometers far from the city of Saint-Louis (map of location). This area is experiencing some territorial mutations due to the implementation of the University and some modern settlements upsetting the systems of local productions.

These changes are noticeable in the neighboring villages that do not yet benefit consistently from the advantages of the creation of the university. People in the villages bordering the University Gaston Berger of Saint-Louis (Boudiouck, Ngallèle, Sanar Peuhl and Sanar Wolof) face many problems of water. Indeed in these communities, if one part of the population have access to water through the supply network of COW (Company Of Waters), the majority do not have access to this water.

Due to social realities, these villages are divided into two parts: Ngallèle Cité and Ngallèle Village; Boudiouck Cité and Boudiouck Village). In the settlements inhabited by teachers, each house has a tap. It is rather in the villages inhabited by the indigenous people where the access to water is really difficult. In fact, in these villages more than 40% of the households do not have any tap.



Map of location

3. Actors

[List key partners and stakeholders as well as the roles of each.]

Campus Eau is first of all seen as a framework of reflexion and sensitization on water issues. Then, it was involved in the drafting of projects to facilitate the access to water for people of some given areas. Thus, it has always worked with some key partners namely:

The Department of Geography of University Gaston Berger

Heads of Districts

Global Education Network of Young Europeans (GLEN-GéCo)

Edéque

Organization for the Development of the Senegal River

National Company of Waters in Senegal

Company Of Waters

NGO

Government

The following table highlights the tasks of the different partners of the project

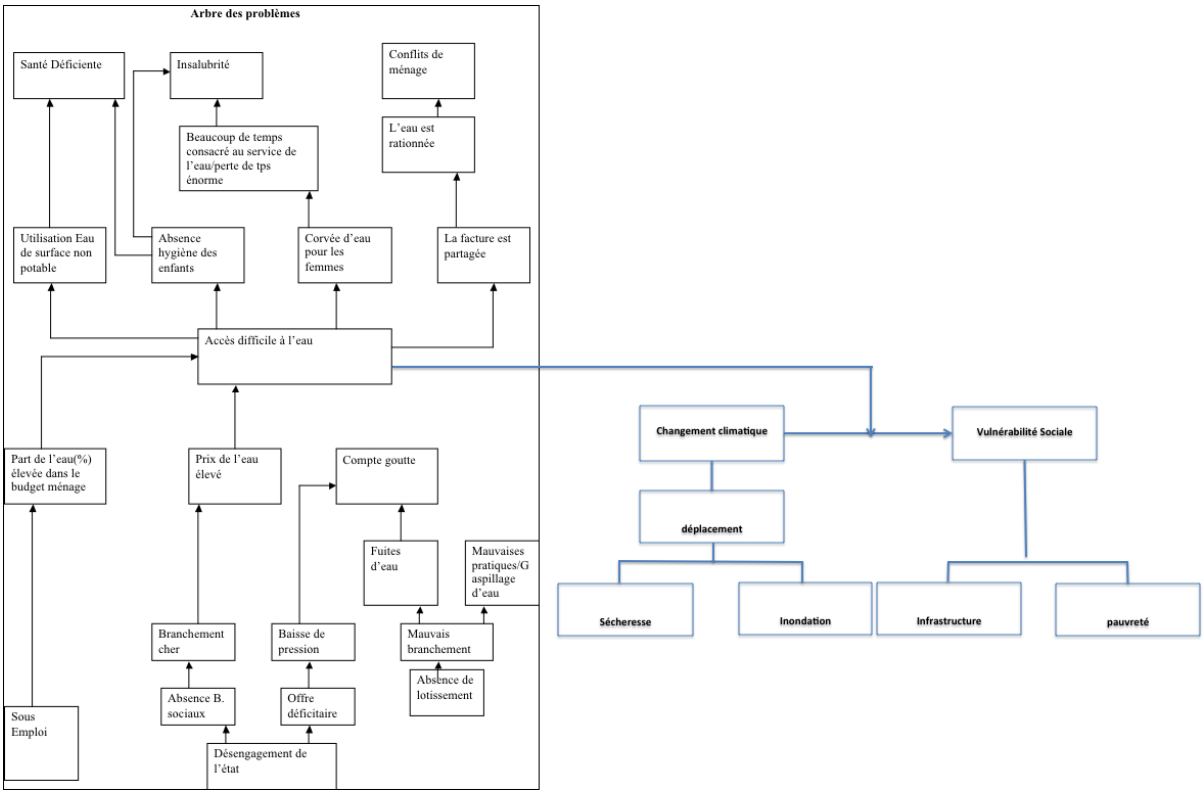
Input	Campus eau	Department of Geography	EDEQUE	Heads of Districts and notable	Global Education Network of Young Europeans (GLEN-GéCo)	ODSR	National Department of Hydraulics	NACOWWS	COW	NGO	Government
Information/ Sensitization of people	+			+						+	
Identification of target families	+			+	+						
Technical studies for the project's feasibility						+	+	+	+		
Accompanying people in the processes of connections	+										
Implementing a local committee of control	+			+					+	+	
Social	+			+							

mobilization										
Organization of conference	+	+	+							
Research action on issues related to poverty in water	+	+	+		+					
Finance									+	+
Implementation of the project	+			+		+	+	+	+	

4. Issues addressed/ focus *[1 paragraph]*

[Describe what challenges/gaps the practice is addressing; consider key co-benefits.]

Senegal claims the success of the MDGs which consists in halving the population that does not have access to water. Various activities of the Department of Geography show that there are still areas which undergo poverty in water. In the city of Saint Louis, the North-East, which has welcomed people victims of the drought of 1970 and people fleeing the flooding of downtown, has no universal coverage and records some pockets with water deficit which concern the poorest populations. The government's strategy based on social connections and social billing discards an invisible vulnerable group due to the proximity of parcels where live people with more substantial incomes. Campus Eau conducted a "political dialogue", a citizen action, which aims at highlighting a problem of key interest on the issue of water namely the one dealing with populations' water insecurity.



Stage of implementation *[2 paragraphs]*

[What year was the practice initiated? Is it partially or fully implemented/ functioning/ operational?]

Since 2006, Camus Eau has as main objective the promotion of the issue of water at all levels. The immediate environment of the University has been targeted through activities of social mobilization, of research action and of advocacy. The association is involved in the development of a project "Water for the Poorest" which allowed the formulation of a project, the development of an approach for advocacy "political dialogue", the organization of mass activities and scientific animation, the involvement of the university in research action around the University Gaston Berger. The process that leads Campus Eau will continue as long as water issues are not resolved and it includes new issues such as sanitation.

Activities	Description	Rate of achievement	Observations
Drafting of the project	This project has been drafted because an observation has shown that there is an unequal access to water for people living in the same geographic space	100%	Several surveys have been made within the area of the project so as to have reliable data
University research	3 master dissertations already defended, 4 reports of studies	100%	
Organization of scientific, educational and social activities	Organization of Campus Eau 72 hours Social mobilization per year	100%	
Inform and raise people's awareness on the activities of the project	2 European trainees and 3 Senegalese trainees	80%	There should be a control
Identify target families	The first part of the work has been performed thanks to the works of GAYE, 2009 ; GUEYE 2009, 2010 and some trainees	50%	The pursuit of fieldwork is necessary for the complete identification of vulnerable families and to update the data which have been already

			collected
Accompany people in the processes of connections	Poor and vulnerable people do not have substantial means to launch the processes at the level of the services	20%	
Implement a local committee of control (LCC)	The local committee of control will be implemented only further to the implementation of the project	10%	2 notable are already involved in the process
Raise people's awareness on some practices of water waste and water hygiene	Some strong campaigns of sensitization have been conducted with people during each edition of Campus Eau namely in the section social mobilization	100%	

5. What was/ is being done? *[2-3 paragraphs]*

[Describe how the practice works/ what it does, and why this particular approach was chosen. What are the key innovations and value-added of the practice? What is its scope and costs?]

Actions led by Campus Eau are: (i) a participatory research for the identification of vulnerable households which have some problems to access to drinking water ; as well for an analysis of the problem, (ii) sensitization of the leaders on the difficulty that undergo those people victims of drought and flooding and who have settled now on the North East periphery of the city, (iii) mediation of knowledge with participatory surveys (door to door), (iv) support for the technical conception of the project water for the populations in order to give it to some partners and each year (v) Campus Eau organizes, in the framework of the World Water Day, its action days with some scientific animations, exhibitions, field visits, cultural activities centered on water, a social mobilization with some mass communication actions, local radio broadcasts, a meeting with some local leaders.

The originality of this approach is to highlight a «neglected issue of water» through the mobilization of all the components of the University (all departments) to address a local issue through a citizen action (political dialogue).

6. Outcomes and impacts *[2-3 paragraphs]*

[What has been achieved and who is benefiting? In what ways is it pro-poor? What main factors for success would you emphasize?]

The results of the actions of Campus Eau are: (i) a project already drafted, (ii) three master dissertations already defended, (iii) 4 reports of studies on the vulnerability of these populations, (iv) 7 events, (v) many actors sensitized, (vi) a good knowledge of the pockets of poverty in water.

The action led by Campus Eau has allowed to shed light on the issue of poor people living around the settlements (City) to the point that the former Director General of NACOWS who is a key actor of Campus Eau has been able to advance with the realization of social connections in Saint-Louis.

7. Sustainability *[1 paragraph]*

[What is the strategy to keep this practice going over the mid and long terms?]

Campus eau has been institutionalized at the University and at the Governance. Its action is perpetuated thanks to «students' clubs» and neighboring people. These two types of actors help maintaining a certain tension on the issue and can carry it on for a short-term duration.

Then, Campus Eau offers a plat-form of reflexion and collaboration. Campus Eau has been able to develop a partnership with some big institutions such as the Organization for the Development of the Senegal River (ODSR), UNESCO, WWF, Wetlands International... in the framework of the World Water Day Celebration.

8. Replicability *[1 paragraph]*

[Can this practice or parts of it be replicated or was its success local context-specific? Has this practice or parts of it been replicated already, or is someone planning to replicate it?]

The strategy of Campus Eau has interested the Agency of the Basins of Senegal River which has supported this initiative and has invited Campus Eau to share its experience with the Universities in the subregion. This approach is easily reproducible in order to take in charge all the issues neglected by the managers and actors of water.

9. Documentation

[Please provide the details/ links of/to your sources of information.]

CAMPUS EAU 2010. De l'eau propre pour un monde sain : eau carrefour des 72 heures du campus eau, projet d'organisation, 9 p.

CAMPUS EAU, 2010. Qualité et quantité dans la gestion des ressources en eau, rapport de synthèse de la cinquième édition des 72 heures du campus eau, campus eau, 28 p.

CAMPUS EAU, 2011. De l'eau pour les villes : répondre au défi urbain, projet d'organisation, campus eau, 13 p.

CAMPUS EAU, 2011. L'eau pour les villes : répondre au défi urbain, rapport de synthèse de la sixième édition des 72 heures du campus eau, campus eau, 38 p.

GAYE A. 2008. Contribution à l'amélioration de l'accès à l'eau potable des populations vulnérables de la périphérie de l'UGB de Saint-Louis du Sénégal, Mémoire de DESS, école des hautes études de gestion (HEG) de Dakar, 60 p.

GRIPPOIX B. 2011. Elaboration du projet « eau pour les plus pauvres », rapport de stage, Campus eau, 20 p.

GUEYE S. 2009. Université Gaston Berger et périphérie : recomposition territoriale et accès à l'eau, mémoire de master 1, Université Gaston Berger, 75 p.

GUEYE S. 2010. Eau et dynamique territoriale dans le secteur nord est de Saint-Louis, mémoire de master, Université Gaston Berger, 100 p.

STENDZENIECE D. 2011. Elaboration du projet « eau pour les plus pauvres », rapport de stage, Campus eau, 23p.

5.0 DAR ES SALAAM – TANZANIA

This short case study is intended to help to capture a good practice which will be used to demonstrate the transformation of an existing state or practice into a better state or practice. The “short good practice” is intended to focus on a single issue of mitigation measures towards climate change induced hazards.

Summary

1. Name of practice

Reducing the vulnerability of Dar es Salaam’s poor through the Sustainable Dar es Salaam Project, and the Strategic Urban Development Plan (SUDP*)*

2. Location(s)

[List district/city/town & country.]

Hanna Nassif in Kinondoni Municipality, Dar es Salaam.

The SUDP, initiated in 1992, included management of hazardous lands and open spaces in its focus. The initiative was funded by ILO-Assist, UNDP-UNV, Ford Foundation, and UNCH-Habitat, and involved the Cowi Consult (which designs stormwater drainage structures), Kinondoni Municipal Council, the National Income Generating Programme and Ardhi University [then the University College of Lands and Architectural Studies (UCLAS)]. Residents were involved in land use planning and improvement of their areas. The program covered flood prone areas such as Hanna Nassif, located along the Msimbazi Valley. Some 20,000 people (or 5,045 households) lived along the edge of Msimbazi Valley, an area highly prone to flooding due to its location.

3. Actors

[List key partners and stakeholders as well as the roles of each.]

The Hanna Nassif community members participated in the planning and design of civil works. The external participants included the Dar es Salaam City Council and its various departments, Central Government departments, development partners, training and research institutions e.g. Ardhi University (then UCLAS), and the private sector. UCLAS as a training institution addressing the issue of human settlements in various disciplines was continuously involved in the implementation of the Hanna Nassif project. Initially, during the first phase, it was involved in baseline information collection, training and evaluation. In the second phase, UCLAS was involved as an executing agency and a trainer for capacity building (for details see table below).

Actor Input	Local Community and HNCDA	DCC, Ward and *Mtaa*	Govt. and Utility Institutions	Private sector, NGOs	Training Institutions (UCLAS)	International Organisations (Donors)
Leadership	+	+			+	+
Organisation	+	+			+	+
Finance	+	+	+	+	+	+
Materials	+			+		+
Land	+					
Legal support		+		+		
Professional advice		+	+	+	+	+
Operation	+			+		
Maintenance	+			+		
Monitoring and review	+	+		+	+	+
Information	+	+	+	+	+	+
Training	+	+			+	+

Notes: + = Input or support supplied, blank = no input or support was supplied

Source: Kyessi 2002:265

4. Issues addressed/ focus *[1 paragraph]*

[Describe what challenges/gaps the practice is addressing; consider key co-benefits.]

Seventy percent of Dar es Salaam's population lives in unplanned settlements, and over half of them live on an average income of $1 a day. These settlements lack adequate infrastructure and services, and are highly prone to adverse impacts of frequent flooding. Poor solid waste disposal and sanitation practices, combined with rainfall, result in contamination of water and spread of disease. Climate change will exacerbate these issues in the absence of sound, forward-looking planning measures.

The initiative of Hanna Nassif was implemented in three phases and involved (i) training residents (both men and women) in construction and repair of storm water drainage systems, (ii) provision of facilities for a credit association, dispensary, and water-vending kiosks, and (iii) creation of a community-based organization (CBO) for managing the credit facility and for improving livelihoods, as well as (iv) creation of a NGO for waste collection. Evaluation of the SUDP-Hanna Nassif initiative in 2000, by the I.T. Transport of UK and Institute of Resource Assessment (IRA-UDSM), indicated great success in the control of floods, and in disposal of crude sewage and wastewater (AURAN, 2011).

5. Stage of implementation *[2 paragraphs]*

[What year was the practice initiated? Is it partially or fully implemented/ functioning/ operational?]

The physical infrastructure initiative in Hanna Nassif was implemented in two phases [phase I (1994-1996) and phase II (1997-2000)]. It was completed as planned and made operational.

Physical outputs Phase I (1994-1996)

No.	Planned activity	Implementation	Achievement in percentage
1.	2.5 km. gravel road with lined drains	1.0 km gravel (murram) road with side drains (lined) constructed	40 percent
2.	1.5 km side drains 862 metres main drain	1.5 km of lined side drains 600 metres of main drains	80 percent 70 percent
3.	1.5 km improved footpaths	700 metres of footpaths along main drain	50 percent
4.	10 road drifts	More than 10 constructed	100 percent
5.	15 footpaths culverts	10 vehicular culverts crossing main drain and road construction	65 percent
6.	Protection to existing gullies in settlement	Gabions constructed for outfalls	100 percent

Notes: Severe erosion was reduced by at least 40 percent on roads and floods reduced by 60 percent. 14,500 worker days on employment were created

Source: Kyessi, 2002:258

Physical outputs Phase II (1996-2000)

No.	Planned activity	Implementation	Percent achievement
1.	262 meters extension of drain	335 metres constructed	128 percent
2.	2348 meters road side drains	1829 metres constructed	78 percent
3.	299 meters Main drains	325 meters Constructed	109 percent
4.	Improved market road	Gravel road improved	100 percent
5.	Protection to existing gullies in settlement - 2 out falls	1 outfall constructed	50 percent
6.	1799 metres of improved (other) roads (gravel level)	818 meters constructed	45 percent

Notes: Floods almost 100 percent controlled while 11,314 worker-days on employment were created

6. What was/ is being done? *[2-3 paragraphs]*

[Describe how the practice works/ what it does, and why this particular approach was chosen. What are the key innovations and value-added of the practice? What is its scope and costs?]

Hanna Nassif is one of the largest informal settlements in Dar es Salaam occupied with poor households spending less than a dollar per capita per day. The area with deficient basic technical infrastructure such as roads, drainage system, solid waste management, water supply and sanitation was upgraded using labour-based technologies (LBTs) and community contracts with the objective of creating employment and generation income. Flooding of the area during the rainy season has been reduced through the provision of drains whilst roads have been improved to increase accessibility within the area.

Hanna Nassif Community Development Association, a CBO, with a defined structure of administration and management was established and enabled to spearhead the infrastructure improvement in the area. Horizontal and vertical linkages was created between the public (local and central government departments), private sector, development partners, training institutions, HNCDA and community groups and the community in the course of the roads and drains improvement. Participation of the many actors (grassroots and external) brought in necessary human, technical, financial and material resources for the infrastructure improvement. External technical and financial support enabled to build capacity of the community in infrastructure planning and design, construction and maintenance. The project continued in its implementation of the other objectives up to the year 2004.

7. Outcomes and impacts *[2-3 paragraphs]*

[What has been achieved and who is benefitting? In what ways is it pro-poor? What main factors for success would you emphasize?]

Collaborative planning and design enabled community participation in planning and design of technical infrastructure in Hanna Nassif. This made continual negotiations with house/property owners possible especially in contribution of land for building roads and drains in the area. The community had local knowledge and the participatory approach used facilitated compromise between the existing development and the envisaged plan. It created a more flexible approach with regard to fitting the new infrastructure around existing assets (developments) in informal settlements. In order to generate employment and income for the purpose of reducing poverty in Hanna Nassif, the project adopted a labour intensive method. This necessitated the use of locally available human resource, the capital of the poor. Self-help in administration and organisation and negotiated payment rates in LBT were strategies applied to keep costs low; also, the community contracts kept costs low. The profit margin of the community in the case of Hanna Nassif was 10 percent on the basic costs covered in the contracts, which was used for maintenance of the provided roads and drains.

8. Sustainability *[1 paragraph]*

[What is the strategy to keep this practice going over the mid and long terms?]

An innovative feature of the Hanna Nassif initiative is the use of community construction contracts. From the beginning of the project all construction works on road and drainage were carried out by the residents themselves under the guidance of a Technical Support Team. This approach not only ensures that all the investment funds remained in Hanna Nassif but also imparted to the residents skills needed for maintenance of the infrastructure for sustainability. Community contracts provided the opportunity for on job training in technical, administrative and management skills for members of the community and the members of the TST. Service improvement was done on a step-by-step approach (small contracts) as funds were made available. Community contracts created and increased self-esteem and the feeling of ownership for the assets created among the community members and individuals. Although organising community mobilisation, community participation and aided self-help is a long process, these can however cut down supply cost and enhance basic infrastructure provisioning in informal settlements which are threatened by climate change induced hazards such as flooding.

9. Replicability *[1 paragraph]*

[Can this practice or parts of it be replicated or was its success local context-specific? Has this practice or parts of it been replicated already, or is someone planning to replicate it?]

The initiative has been replicated in other parts of the city through two major programmes of informal settlements upgrading: Community Infrastructure Upgrading (CIP) of the years 1996 to 2002 (2 settlements) and the Community Infrastructure Upgrading Programme (CIUP) of 2002 to 2012 which has just been completed (31 settlements).

10. Documentation

[Please provide the details/ links of/to your sources of information.]

AURAN (2011): Urban Poverty & Climate Change in Dar es Salaam, Tanzania: A Case Study, Unpublished Report Prepared by Ardhi University in Collaboration with Pan-African START Secretariat, International START Secretariat and Tanzania Meteorological Agency.

Kyessi, A.G. (2002): Community Participation in Urban Infrastructure Provision: Servicing Informal Settlements in Dar es Salaam, SPRING Research Series, No. 33, Germany.