Annexure B – Lecture notes
Module 4: Climate Change and Urban Water Cycle Management

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ACRONYMS /ABBREVIATIONS

CC	Climate Change
MDG	Millennium Development Goals
IUWM	Integrated Urban Water Management
IPCC	Inter- governmental Panel on Climate Change
LUP	Land use planning
UI	Urban Infrastructure
UN	United Nations
UUI	Underground Urban Infrastructure
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UPI	Urban Physical Infrastructure
UWI	Urban Water Infrastructure
WASH	Water and Sanitation, Hygiene
WB	World Bank

<u>SECTION I</u>: CLIMATE CHANGE AND WATER RESOURCES

1.0. Course Objectives and Learning Objectives

Objectives

i. To provide an overview of the impact of climate change on the whole water cycle, urban sustainability and public health.
ii. To help participants learn methods and tools of assessing the impacts of predicted climate change on their water resources and the urban cycle.
iii. To provide an inventory of mitigatory and adaptive measures (including structural and non-structural measures) related to climate change and urban water management.
iv. To help participants learn how to integrate mitigatory & adaptive methods in spatial planning decisions.
v. To inspire the learners to work at the local level and promote community participation.

Learning Outcomes

i. Participants would be able to acquire proper understanding of different components of the urban water cycle.
ii. Understand the impacts and assess the outcome of projected climate change on the urban water cycle.
iii. Participants to be able to discuss how climate change affects water demand and supply under different spatial and temporal scenarios'.
iv. Understand integrated climate change urban water management techniques and approaches available to different stakeholders (local & national governments; utility companies & local communities.

1.1. Climate Change Overview

Climate change is no longer a myth engendering doubts as in previous decades: it is now a generally accepted fact, proven by climate change records in the recent past (Houghton et al., 2001; Lambeck, 2010; The Royal Society, 2008; UNEP & UNFCCC, 2002). Further evidence of climate change is provided by recent extreme climatic events and their frequencies of occurrence (Mirza, 2003). These include extreme hot weather and rainfall events together with shrinking ice sheets and sea-level changes. These changes have impacted variably on different aspects of the physical and human environment. In this article consideration is given to the impact of climate change on the urban water cycle management.

The urban water cycle is a component of the global hydrological cycle, the later defined as the cyclical movement of water between land, atmosphere and the ocean during which water changes it form from liquid to vapour and back to liquid (Cech, 2005; Miller, 1996). As a component of this global cycle, the urban water cycle (Marsalek et al., 2006; Philip & Anton, 2011) includes water that is extracted from the water cycle and used in the urban area for various purposes. Hence “man” is a key actor in the urban water cycle because of his ability to intervene and extract from the natural water cycle. It is for this reason that the urban water cycle is sometimes referred to as the man-made water cycle.

Humans intervene in the natural water cycle by building dams and reservoirs on rivers, which also capture and store water from rainfall and runoff. Water is then piped from these reservoirs to treatment plants and then distributed to the city through a network of pipes for various uses (domestic, outdoor, public services, commercial and industry). The by-product waste water, sewage and storm water which is piped to treatment facilities for reuse or release back into rivers, seas and oceans (the natural water cycle).

There is evidence that climate change has already impacted on water supply and demand to the urban area, raising greater concern with further projection of future climate change. For example, the Nairobi Water Company in Kenya reports that climate change has diminished groundwater recharge and available surface water in the utility’s major catchment (Source). This is also true with some territories in Russia/Ukraine where serious water shortage has already been reported (Danilenko et al., 2010). Numerous examples of decreased river discharge and water supply to urban centres are cited in Arnell et al., 2001; Folland et al., 2001). It is important that town planning institutions and water utility companies operate bearing in mind projected climate change and how this will further affect water demand and supply in the urban area or the urban water cycle.

1.1.1. Some Basics of Projected Climate Change and Urban Planning

Components of climate that are predicted to change in future due to rising levels of greenhouse gases (Lambeck, 2010; UNEP & UNFCCC, 2002) in the atmosphere include among others temperature, precipitation, wind patterns, air humidity and cloud cover (Arnell et al., 2001; Folland et al., 2001; UNEP & UNFCCC, 2002). Of these, temperature and precipitation are the most cited in climate change literature because changes in these variables will have far reaching consequences on the physical and human environment and their activities (Frederick et al., 2002; Zwolsman et al., 2009; UNEP & UNFCCC, 2002). Climate change models variably project that by the year 2100, the following characteristics will change impacting on the urban water cycle:

- **a)** Global temperatures will rise by about 1.4 – 7^{o}C.
- **b)** Global precipitation will increase while some areas are predicted to experience reductions with variations at the local and regional scale (Cubasch et al., 2001; Houghton et al., 2001; Lambeck, 2010; UNEP & UNFCCC, 2002).

These changes are expected to affect various climatic regions of the world differently depending on whether they are inland or coastal.

Global models projecting these changes warn that they hide local and regional realities which may differ from projected large scale generalized patterns due to differences in topography, population concentration, urbanization and the presence of water bodies (Danilenko et al., 2010; White et al., no date). Climate Change impacts are further compounded by other factors that put pressure on the urban water cycle. These include industrial activities, agriculture, economic development, water supply and deteriorating water infrastructures (Danilenko et al., 2010; Philip, 2011; Philip & Anton, 2011).

Town planning institutions, water companies and government departments must realise that to effectively adapt or mitigate the effect of climate change on the urban water cycle, they have to integrate these variables when considering or planning climate change adaptation and mitigation. Such planning must also be done in collaboration with experts whose knowledge provide a better understanding to different aspects of climate change and its impacts. These include among others climate change model developers; and experts in demographic and hydrological modelling in relation to projected climate change (Arnell et al., 2001; Leavesley, 2002; Lins et al., 2002; Schulze et al., 2011).

1.1.2. Global Environmental Change & Water

Population growth, urbanization, and global warming are the most significant factors that govern global environmental change. In 2008, half of the world's population (about three billion people) were living in urban areas. It is estimated that in the next twenty-five years almost two billion more people will move into cities (World Urbanization Prospects, 2007). It was estimated that as 95 percent of the total population growth of the world occurs in developing world, 10 new megacities would appear in developing counties by 2010. Developed countries continue to urbanize at only a slightly lower rate than developing countries, despite a lower rate of population growth. Angel et al, 2005, estimated increase in built-up area in industrialised countries (from 300,000 km^2 in year 2000 to 700,000km^2 by 2030), and in developing ones (from 250,000 km^2 in year 2000 to 820,000km^2 by 2030).

Analysis of the above data suggests that urbanization in terms of global physical city area expansion (276% by year 2030) will happen much quicker than cities' population growth (66% by 2030). This huge gap can be explained by urban growth in developed world, as well as rising living standards in developing world. Both growth in built-up area and population growth imply a need to significantly expand urban physical infrastructure (UPI). Effects climate change include greater frequency of heat waves; increased intensity of storms, floods and droughts; rising sea levels; a more rapid spread of disease; and loss of biodiversity (IPCC, 2007). In the context of impacts on UPI extreme weather events and sea level rise (SLR) pose the major threats. World Bank suggests that for precautionary planning purposes, SLR in the range of 1 - 3 meters should be regarded as realistic (Dasgupta et al 2007). Indeed, recent data shows that SLR should be considered as in the context of meters in the next 100 years.

Nicholls, 2004, estimates that by 2080, up to 561 million people (under A2, 0.28 meter SLR scenario) could be living in coastal flood plains (area below 1 in 1000 year flood level). Mc Granahan et al, 2007, estimated that over 600 million people (360 million of whom are urban dwellers) are living within the coastal zone less than 10 meters above sea level. Comparison of these two findings suggests that a number of populations in coastal areas affected during extreme weather events like flooding could be much higher than 600 million.

Currently almost two-thirds of the world's cities with more than 5 million inhabitants fall in the 10 meter elevated zone, at least partly (Mc Granahan et al, 2007). Directly impacted by SLR urban land area constitutes 4.68 % of total world urban area in case of 5 meters SLR scenario (Dasgupta et al, 2007). However it is likely that over the years this figure will increase due to strong population growth in coastal zones, which is driven by urban sprawl, growing demand for waterfront properties and coastal resorts development (IPCC, 2007). This will be a major challenge as coastal areas have a high density of physical infrastructure. Gross Domestic Product (GDP) can be used as a proxy that reflects density of infrastructure. Coastal areas generate about 6% of World's GDP on about 1% of the area.

1.2. Water Resources

1.2.1. Water Sources Related to the Global Hydrological and Urban Water Cycles

The supply of water to the global and urban water cycles can be traced to various sources. Since the urban water cycle is a sub component of the global water cycle, it is preferable to discuss water sources within an integrated context of both cycles. Details of the global and urban water cycles (Figures 3.1 and 3.2) are discussed in Cech (2005), Marsalek et al. (2006) and Miller (1996). Generally precipitation in the form of rainfall, snow fall and ice (when melted) produces water which flows into surface water sources like streams, lakes and reservoirs. Some infiltrate and recharge underground water (aquifers) which may later discharge into the surface water sources and then evaporated into the atmosphere when subjected to solar energy. Ground water is also extracted by vegetation and discharged into the atmosphere through transpiration.

In the atmosphere, water vapour from different sources undergoes condensation resulting in different forms of precipitation back to the earth's surface, starting the process again. The different open water sources just discussed, contribute to the global water cycle through evapotranspiration which in turn feedback the various water sources through precipitation. As mentioned earlier, the urban water cycle is a sub-component of the global water cycle. Springs, rivers and streams which run into reservoirs and lakes are extracted and piped to water treatment plants for distribution to the urban area for different uses.
Water sources for the global and urban water cycles can be summarized as follows:

- **Atmospheric supply**: these include various forms of precipitation – snow or rainfall.

- **Linear sources**: springs, stream and rivers.
- **Water bodies**: lakes, reservoirs, seas, oceans, wetlands
- **Underground water**

In a catchment, these water sources do not operate in isolation but are connected forming the hydrological system (Arnell et al., 2001). Therefore having in mind projected climate change, town planning and urban water supply institutions should consider the hydrological system in general and not isolated portions of it (Danilenko et al., 2010; Mitchell, 2004; Schulze et al., 2011).

1.2.2. The Impacts of Climate Change on Water Resources and Supply

Literature and discourses abound on the general impacts of projected climate change (Arnell et al., 2001; Frederick & Major, 2002; Mulholland & Sale, 2002; UNEP & UNFCCC, 2002). For example, due to global temperature increase and the thawing of ice sheets, global sea-level is projected to rise resulting in the intrusion of saline water into urban coastal aquifers (Loftus et al., 2011; UNEP & UNFCCC, 2002). This will pose a challenge to coastal cities dependent on ground water supply.

Surface runoff, streams and river flows are projected to decrease in areas witnessing increased temperatures, low rainfall, high levels of evaporation and falling ground water table. However, in areas or during periods characterized by increased precipitation or extreme rainfall events, streams and rivers will flood.

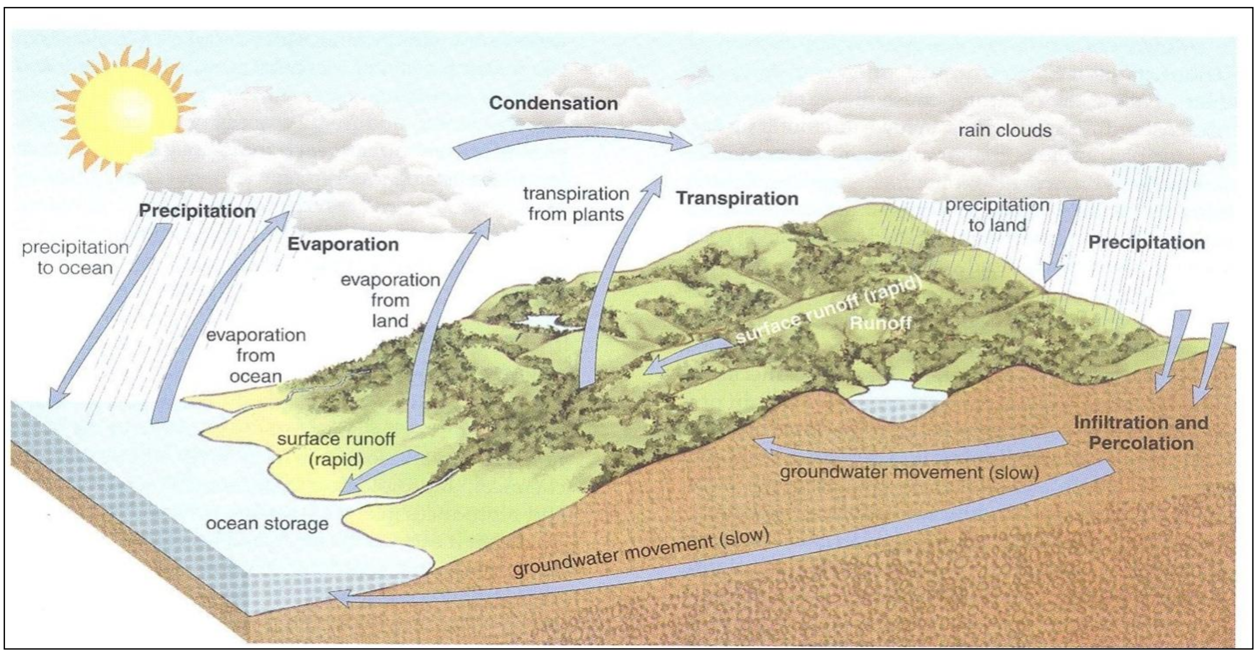


Figure 1. The global water cycle (Source: Miller, G.T 1996, p.117)

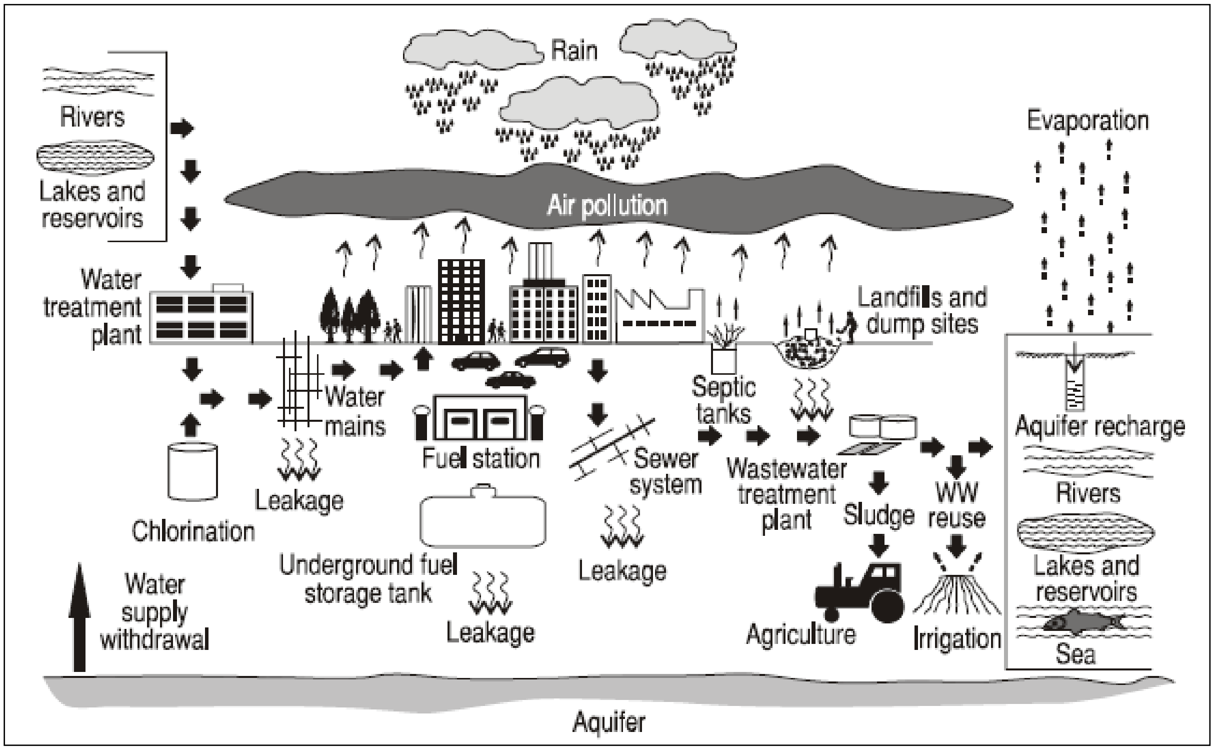


Figure 2. The urban water cycle (Marsalek et al., 2006, p.3)

During dry climates, projections on future impacts maintain that lake and reservoir levels will fall due to high temperatures, increased evaporation and falling ground water table, reducing water supply to urban areas. Increased temperatures may also result in higher bacterial activity and algal boom in reservoirs affecting water quality (Arnell et al., 2001; Zwolsman et al 2009). During such projected dry periods, the reduction of ground water table will also put stress on water availability in areas dependent on them (Danillenko et al., 2010; Zwolsman et al 2009).
However, increased precipitation may cause erosion and sedimentation of reservoirs, affect water quality and increase treatment cost (Loftus et al., 2011; UNEP & UNFCCC, 2002).

1.2.2.1. Regional Impacts of Projected Climate Change on Water Resources

Global climate change models hide regional variations and thus present a problem for proper climate adaptation planning (White et al., no date; Leavesley, 2002; Lins et al., 2002). This calls for global downscaling to regional and catchment models to aid climate change planning and adaptation (Lins et al., 2002, Giorgi et al., 2001; Schulze et al., 2011; White et al., no date).

Regionally, climate models project that the impact of climate change on precipitation will vary according to different climatic regions of the world. For example precipitation is projected to increase in the high latitudes, many equatorial and tropical regions increasing urban water supply but posing a water quality challenge. In the high latitudes, winter precipitation are said to increase, hence increased stream and river flows, while in spring and summer, precipitation and flows are projected to reduce. The mid-latitudes, sub-tropical, arid and semi-arid regions are projected to experiences increased temperatures and reduced precipitation cutting down urban water supply (Arnell et al., 2001; Houghton et al., 2001; Lambeck, 2010; UNEP & UNFCCC, 2002).

1.2.2.2. Impacts of Climate Change on the Urban Water Cycle

Having in mind the description of the urban water cycle (Section 1) and water sources (Section), projected climate change impacts on the urban water cycle can be summarized as follows:

a). Supply sources: These will increase in areas or during periods of high and extreme rainfall but quality will be affected. This is the case because high and extreme rainfall events increase the risk of catchment erosion resulting in water pollution and turbidity (Loftus et al., 2011). Drying climates will result in a reduction of water supply which can also affect quality water supply to urban areas due to reduced oxygen demand, eutrophication of reservoirs due to algal growth, clogging of pipes by algal and increased bacterial activity (Loftus et al., 2011; Zwolsman et al., 2009). This will be compounded by urban population growth, increased industrialization and domestic demand (Philip & Anton, 2011; Zwolsman et al., 2009; UNEP & UNFCCC, 2002).

b). Sewers: Flooding in low lying areas, along river banks and sewer outflows is likely to occur in areas projected to witness excessive rainfall; however corrosion, cracking and the resultant leakage of sewer pipes may occur during dry events (Loftus et al., 2011; Zwolsman et al., 2009).

c). Storm water: The same will happen as for sewer pipes. The situation may be worse in cases where sewer and storm water pipes are combined.

d). Waste water and water treatment facilities: In coastal and low lying areas these facilities may become flooded during extreme rainfall, resulting in spillage, damage to the treatment structures or limiting their abilities to treat or pump water. This will increase the cost of repairs and water or waste water treatment. Contrary, in areas experiencing higher temperatures and low rainfall, waste water treatment pipes may also crack like manner as in sewer pipes resulting in leakage (Loftus et al., 2011; Zwolsman et al., 2009).

e) **Sanitation and diseases**: The impact of climate change on the urban health will be a major challenge to those living in slums and informal settlements particularly in the developing countries of the South. Reduced water supply is bound to affect flushing of urban water toilet systems and reduction of domestic household water supply with public health consequences due to poor hygiene. Increase in waterborne diseases will be compounded by loss of economic productivity due to ill health. Increased run off, urban floods, transportation of sediments, detritus and solid waste into the urban area will affect the quality of the urban environment increasing cost and effort in urban cleanness. Increased morbidity would be expected unless mitigation measures both from spatial planning, health and institutional perspective. Hence the importance on an integrated approach to urban water management.

1.2.2.3. Climate Change Impacts on Urban Water Resources

Industrial sectors including infrastructures are vulnerable to the impacts of climate change (IPCC, 2007). Increased temperatures and changes in precipitation can contribute to increases in water demand, for drinking, for cooling systems and for garden watering (Kirshen, 2002). The effect of climate change on sanitation is likely to be less than on water supply (Wilbanks et al, 2007). Sewage treatment works are exposed to damage during floods, SLR will affect the functioning of sea outfalls (Wilbanks et. al, 2007).

1.3. Urban Water Infrastructure (UWI)

1.3.1. Urban Setting, Ecosystems and Infrastructure

The complex relationships are exhibited in the urban setting. An example of human welfare provision in an urban setting may be ecosystems and infrastructure correlation. The most intensive and diverse consumption of ecosystem and infrastructure services can be observed in urban areas. Neither ecosystems nor infrastructure can satisfy urban needs alone. Urban areas are quite important to human welfare since urbanization and population growth are the major trends of global change.

Examples of services provision by ecosystems and (alternatively) by physical infrastructure. Data collected during the Millennium Ecosystem Assessment shows that many ecosystem services have been in decline. Here we note ecosystem services related to Urban Water Resources (UWR) which are in decline and can be substituted by infrastructure are listed below:

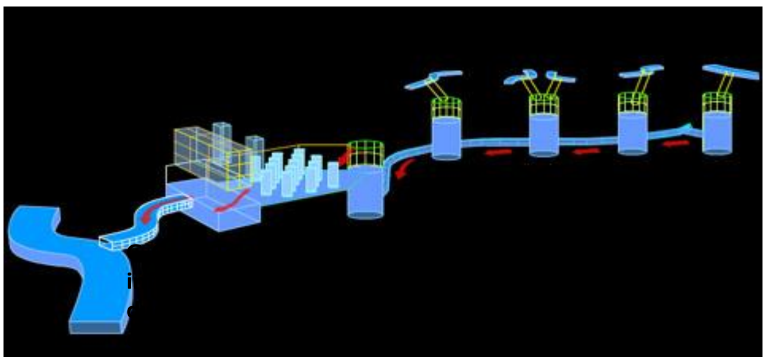
- Fresh water;
- Water purification and waste treatment;
- Natural hazard regulation.

1.3.2. Urban Water Infrastructure (UWI) [Supply & Discharge]

Infrastructure includes ‘physical’ (such as water, sanitation, energy, transportation and communication systems) and ‘institutional’ (such as shelter, health care, food supply, security, and emergency protection) components. Urban Infrastructure (UI) is a vital component of a city; it includes utility and transport networks, water and flood management structures, underground networks, etc. Urban Physical Infrastructure (UPI) is presented by bridges, roads, pipelines, transmission networks, etc.

UPI as a whole has two notable characteristics: interdependence and convergence. Both of these characteristics trend to increase during continuing UPI evolution (e.g. DTI Forersight, 2006). By UPI evolution we mean technological progress and increase in diversity and complexity of infrastructure as a whole. Many of the urban infrastructure elements can be considered as critical ones, which mean that city as a system depends on uninterrupted provision of their services. For instance, artificial coastal defences play a critical role in cities of Tokyo, Shanghai, Hamburg, Rotterdam, New Orleans and London (Nicholls et al, 2007). In cities of Saint Petersburg and Venice big projects of food defence barriers are under development.

The G-Cans project (G-Cans, 2006) in Tokyo, Japan is a remarkable example of Critical Infrastructure (CI). The G-Cans is an underground infrastructure for prevention of flooding during rain and typhoon seasons **(Figure 3 below)**. As extreme weather events that cause flooding will become more frequent due to climate change, we may see more development of similar storm water infrastructure in flood prone regions.



G-Cans, Tokyo is an underground infrastructure for prevention of flooding during rainy season or prevention of flooding during rainy season

Source: G-Cans project, Tokyo (http://www.g-cans.jp/)

1.3.3. Climate Change Impacts on Urban Water Infrastructure

Climate change has the potential to increase flooding risks in cities in three ways: from the sea (SLR and storm surges); from rainfall – for instance by heavier rainfall or rainfall that is more prolonged than in the past; and from changes that increase river flows – for instance through increased glacial melt (Satterthwaite, 2008). Impact of a flood on Urban Water Infrastructure (UWI) elements depends on their physical strength, i.e. whether they can withstand increased water flow. Sewers are the most threatened part of UWI.

1.3.3.1. Generic case studies

Published case studies of projected impacts of CC that include UWI include New York Metropolitan Area, reported by Bloomfield et al., 1999 and Rosenzweig et al., 2000; Boston Metropolitan Area (Kirshen et al. 2008); Los Angeles (Koteen et al. 2001), a number of cities in the United Kingdom (Holman et al. 2005).

a). A case study of Boston Metropolitan Area described in Kirshen, 2002 and Kirshen et al, 2008 concluded that compared to conditions of just population growth, CC impacts are significant on many infrastructure systems. The systems analyzed included Energy Use, SLR, River Flooding, Surface Vehicle Transportation, Water Supply, and Public Health (heat–stress mortality). Localized Case Studies were carried out for Water Quality, Tall Buildings, and Bridge Scour. The authors of this study used dynamic modelling of the period 2000 to 2100 to analyze the performance of UWI in Boston area (Kirshen et al. 2008). The authors concluded that many components of UWI are critical infrastructures; the impacts on each infrastructure system give rise to secondary impacts on other systems. These secondary impacts tend to be mutually reinforcing (negative impacts on one system create negative impacts on other systems), impacts measured for a single system in isolation will tend to be underestimated (Kirshen et al, 2008).

b). Floods

Impacts of floods on UWI structural elements very much depend upon their physical strength, i.e. whether they were designed to withstand increased surface water flow. Groundwater or near ground flows result in erosion (on the surface) and suffusion (in the ground) processes, which lead to washing away small particles of soil and the rest of the soil body loses its strengths which can result in uneven settlements and cracks in structures. These processes affect roads, bridges scour, sewers and conduits. Concrete UWI elements are most susceptible, metal pipelines can better withstand erosion and suffusion processes.

c). Sewerage

In spite of the estimations that effect of CC on sanitation is likely to be less than on water supply (Wilbanks et al, 2007), cities’ sewerage systems are a great concern as CC advances. Sewage treatment works are exposed to damage during floods, SLR will affect the functioning of sea outfalls (Wilbanks et al, 2007).

Sewerage conduits operate best in the range of intake they were designed for. Draughts and reduced intake lead to decreased waste and rainwater flows in servers, which lead to increased sedimentation in the servers and reduces their capacity. High concentration of sediments can also lead to premature tear and wear of pumps. The process of reducing sewerage capacity due to less water intake has been observed in “shrinking” towns (e.g. in Germany), where population moves out of the town due to socio-economic reasons. Less use of sewerage has led to necessity to arrange more frequent severs cleaning, to keep its normal operation.

Sewerage systems can be combined or separated. Separated sewerage system divides household sewers and rainwater ones. Rainwater sewers can be damaged by too high water velocities during flood. Household sewerage is not supposed to transport rainwater, thus it can remain unaffected. Cities with combined sewerage system faces higher flood vulnerability due to high functional damage in case of sewerage become temporarily non-operational. The worst case CC scenario for sewerage is a change towards more extreme seasonal precipitation, whereas long periods of draughts would be followed by heavy rain falls. In this case clogged up by sediments severs will not be able to accommodate overcapacity rainwater intake.

d). Structural damages
Extreme weather events represent the major threat to UWI in a short term. Sea Lever Rise (SLR) of some meters represents the major threat to UWI in coastal areas in the long term. Major structural failures of infrastructural elements exposed to rising surface and groundwater levels due to SLR are unlikely, except of inundation. However, UWI that would not be inundated, e.g. conduits, collectors, and severs can get minor damage. This damage will be caused by exposure of previously "dry" parts of underground structures to groundwater, and increased hydraulic pressure to lower parts of the structures; both of these phenomena will result in leakages. Leakages needed to be eliminated in a timely fashion to avoid serious damage.

1.4. Adaptation

1.4.1. Adaptation Typology

Numerous approaches to conceptualising, defining, and classifying adaptation have been developed in recent decades. These approaches are summarised in table 1 and discussed below. Disaster risk reduction and Climate Change adaptation communities are the two most notable groups of researches that have been developing adaptation studies. Extensive discussion highlighting different approaches of these research communities to defining and conceptualizing vulnerability, risk and adaptation can be found in Renaud and Perez, 2010. IPCC, 2007 and UNISDR, 2009 give a widely used definition of adaptation – the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

UWI can be considered a vulnerable to CC system (as described in the previous section), hence it has to be targeted in adaptation activities (adaptation means actions targeted at the vulnerable system, as specified by McCarthy et al. 2001). Adaptation also implies expanding the range of variability with which the system can cope (Wilbanks et al, 2007). Planning adaptation to CC mean actions undertaken to reduce the risks and capitalize on the opportunities associated with global climate change (Fussel, 2007).

Table 1. Adaptation Types in the Context of Climate Change Urban Water Infrastructure

Adaptation typology suggestions with references	***Adaptation types***	***Explanations***
Adaptation (IPCC, 2007)	Anticipatory	takes place before significant impacts of climate change are observed
	Autonomous (spontaneous)	does not constitute a conscious response to climatic stimuli, but rather is triggered by ecological changes in natural systems and by market or welfare changes in human systems
	Planned	uses information about present and future CC to review the suitability of current practices
Adaptation (IPCC, 2007; UNISDR, 2009)	Reactive	occurs as a response to CC effects, like natural disasters
	Proactive	measures that are taken before actual effects of CC are observed, magnitude of effects is based on predictions
Adaptation assessment approaches (Burton et al. 2005)	Hazards-based	Considers the incremental impacts of climate change
	Vulnerability-based	Assesses future climate change in the context of current climate risks

1.4.2. Research Needs

Key adaptation research needs identified by Yohe and Schlesinger (2002) includes reviewing options, considering local conditions and uncertainty, and calculating the costs of adaptation. These needs can be further detailed as methodological studies, monitoring and indicator studies, empirical research, field and experimental research, predictive modelling, scenario development, economic costing, integrated assessment, quantification of the impacts of extreme weather events, modification of existing coping strategies, testing and evaluation of adaptation measures, and stakeholder participation (Carter 2007).

Adaptive capacity is the ability of a system to evolve in order to accommodate external changes or to expand the range of variability with which it can cope (Wilbanks et al, 2007). Adaptation of UWI to climate change is its adjustment to new external conditions by means of structural, technical, and managerial measures. Adaptation of UWI needed to be anticipatory, i.e. take place before significant impacts of climate change are observed.

Structural measures to adapt UWI include strengthening waterproofing capacity of the structures, rigor maintenance and upgrading of sewers for transporting overcapacity amount of storm water. Storm water temporary storage underground tanks could be installed to mitigate impact of heavy rain falls. Structures needed to be checked and if necessary repaired or modified to withstand higher water pressure.

Adapting urban water infrastructure (UWI) includes the whole complex of disaster risk management measures, specifically:

i. preparedness - identifying weak components of infrastructures, analysis of their vulnerabilities and interdependences; and
ii. emergency response measures.

1.5. Land Use Planning and Climate Change Aspects

The main policy and practical steps towards CC adaptation are to be developed and implemented at a local (e.g. city) level, taking into account specific geographic and local climate conditions. These steps can be broadly described as well-established practices from disaster risk management (e.g. early-warning systems), coastal management (e.g. structural protection), resource management (e.g. water rights allocation), **spatial planning** (e.g. flood zone protection), **urban planning** (e.g. building codes), public health (e.g. disease surveillance), and agricultural outreach (e.g. seasonal forecasts) (Fussel, 2007).

UWI adaptation to CC needs to be locality specific, however developing common standards (e.g. updating building codes) is equally important as city **planning practice**. Thus in case of UWI the important role of institutions at all levels is accumulating specific technical studies and using them to mainstream CC adaptation into relevant legislation (e.g. codes and norms).

1.5.1. Spatial planning

Spatial planning is an important component of panned adaptation (for definition see table 2 - adaptation types). Adaptation by means of spatial planning brings many benefits in terms that potential adverse CC impacts are avoided in the first place, thus specific technical and disaster prevention measures would not be needed. Some case studies showed that it would be also the most “green” and cost-effective option (Kirshen et al, 2008). However CC adaptation by spatial planning strategy can be implemented only for long-term adaptation, and requires strong policies in built environment regulation and land property rights, which could require change in e.g. national legislation. Examples of such extensive policy initiatives could be prohibition of development on flood plains, creating buffer (any development exclusion) zones around vulnerable critical infrastructures (e.g. rainwater discharge open canals). Spatial planning strategy could be difficult to realise because it requires significant policy shift and legislative alterations, which would require bold commitments from institutional actors across tires of governance.

1.6. Technology and Climate Change Aspects

Technical measures to combat extreme weather events like floods include installing waterproofing barriers and doors; increasing capacity of pumps, including installation of emergency reserve pumps in facilities inundation of which can bring extreme damage (e.g. critical infrastructure facilities).

1.6.1. Best Practices

UWI can provide opportunities to mitigate specific hazards. G-Cans project can be one example. Another is “Flood control measures are using underground rivers” in the western part of Tokyo (Prasad, 2009). This UUI will be constructed based on a comprehensive flood control measure plan that includes measures for each river basin. In addition, the installation of adjustment reservoirs (water storage tanks) along rivers is planned (Prasad, 2009).

a). UWI – Engineering

The G-Cans facility in Tokyo, Japan provides water regulating services, which can be seen as natural hazard regulation, and UWR or urban adaptation to CC practice. Due to dense urbanization and widespread impermeable land cover (buildings, asphalt roads) that prevents rainwater infiltration, river basin ecosystems are unable to regulate surface runoff any more, and consequently, floods occur. To combat floods G-Cans underground infrastructure facilities were constructed. The infrastructure consists of five concrete containment silos with a height of 65 m and a diameter of 32 m, connected by 6.4 km of tunnels, 50 m beneath the surface, as well as a large water tank with a height of 25.4m, with a length of 177m, with a width of 78m, and a number of 14,000 horsepower (10 MW) turbines that can pump up to 200 tons of water into the Edogawa river per second. The question of effectiveness remains open since a lot of resources has been spent on G-Cans facilities construction and operation.

b). Reliability coefficients

Review of reliability coefficients specified in construction codes and UWI norms is an important task of enhancing anticipatory adaptation.

c). Managerial measures

Managerial (non-structural) measures are equally important in UWI CC adaptation as physical upgrading of infrastructures. By managerial measures we mean actions that do not require any physical changes (e.g. strengthening a dam by geotechnical ground improvement), but rather relate to policies, operation guidelines, and community engagement. One of examples of such measures can be river flood management (Bobylev, 2010a; Körvers, 2009). Services to human welfare can be provided by ecosystems as well as by artificial infrastructure (Bobylev, 2010a). River flood regulation can be achieved using physical infrastructure. This infrastructure includes a variety of artificial structures: dams, dikes, canals, locks, pumping stations, flood barriers. Alternatively, natural river retention areas can be expanded and used to accommodate flood waters.

The Netherlands has an advanced physical infrastructure systems for water resources management, however the recent increase in flood occurrence and projected impacts of CC prompted the Dutch government to develop a number of policies that would involve ecosystem restoration and nature development in an attempt to use ecosystem services to substitute failures or inefficiency of physical infrastructure (Bobylev, 2010a). A Room for the River concept, introduced by Dutch government in 2000 (Dutch Ministry of Transport Public Works and Water Management, 2006) can illustrate approaches to managerial measures development to adapt UPI to CC. A Room for the River concept combines technical (or structural) and managerial measures: it calls for more space for the rivers by excavating the river forelands, widening riverbeds, removing obstacles, creating retention areas, returning previously reclaimed land to the river system, creating side-channels and repositioning dikes further inland. Explicitly managerial measures include working with local communities to retreat their activities from the floodplain (e.g. agriculture), policies limiting construction and reconstruction in floodplains. Managerial measures also include disaster risk management, preparedness - identifying weak components of UPI, analysis of UPI vulnerabilities and interdependences, and development of emergency response plans.

SECTION II
CLIMATE CHANGE, LAND USE PLANNING AND INTERGRATED URBAN WATER MANAGEMENT (IUWM)

2.0. Introduction

This section constitutes a contribution to land use capacity planning for integrated urban water management in the light of climate change. It examines requirements for Integrated Urban Water Management (IUWM). It identifies the role of different stakeholders in land use planning (LUP) and Infrastructure Urban Water Management processes. Questions asked here are: How is urban water currently managed? How do existing interventions mitigate the negative climate change impacts? Which changes are necessary to protect and restore a good water cycle in urban areas? The class will review Integrated Urban Water Management basics and practices referring to effective water utilization, rainwater control, and hygiene and environment improvement. It also will emphasize the role of different stakeholders' contribution in IUWM. Besides group work, role games are used to demonstrate the importance of public participation, education and research in incorporating Integrated Urban Water Management in LUP and other programs with common objectives.

Secondly, the course examines the institutional and regulatory tools to achieve urban water in line with the UN- Millennium Development Goals (MDG). The Module comprises of lectures on strategic land use planning for integrated urban water governance in the light of climate change. Questions asked then are: To what extent is climate information integrated in LUP? Which LUP attributes are required in the face looming urban water challenges? How can existing institutional and regulatory tools be improved/refined to incorporate IUWM? Participants will learn from key LUP regulatory tools to demonstrate/identify weaknesses/problems; and strengths/successes of strategic planning in response to different climate change impacts. Participants will be asked to analyse current institutional and regulatory interventions utilized IUWM and LUP in selected cases studies from developing countries.

2.1. Urban Water Governance

2.1.1. Requirements for Integrated Urban Water Management

Water resources will be particularly influenced by climate change. Two main related impacts should be envisaged: lack of access to safe water and sanitation and increasing water related disasters. Under the combined effect of climate and urban growth, the natural events (floods, drought) may reach an exceptional intensity, extent and period. The immediate or progressive impact assessments should focus on consequences on both the natural and living environments. Referring to the emanating precautionary principle and sustainability objectives, there is a need to search for new urban alternatives and approaches to address especially, vulnerable cities from developing countries.

Currently interventions on the impacts of either lack of (dryness/aridity) or water's excess (flood) are mainly addressed through structural measures introduced by the water institutions. These are often short term measures (crisis response) which are not based on a given strategic plan. Since such measures have a momentary efficiency, they are perpetually looking for new resources whether conventional or none conventional thus multiplying or resulting into increasing the number of cross basin transfers, drillings and dams, sea water desalination and purified waste waters amongst others (AROUA,2005). Because of their disturbing effect on the water cycle, these solutions often turn into problems. They can aggravate the risk and increase the local vulnerability of cities/regions to climate change and water related hazards.

These critical conditions urgently call for some simple and inexpensive adaptive measures that may be beneficial if all stakeholders interact in the strategic planning process at national and local levels. IUWM process is the best method to recover an excellent hydrological water cycle in urban areas and includes measures such as rainwater control, effective water utilization and environmental improvement. IUWM considers water as a sophisticated cycle (not as a simple water circulation), an integral part of the ecosystem, a natural resource and a social and economic good. It should also be concerned with water supply, wastewater and storm water systems. The main objective of IUWM is to guarantee sustainable water supply, hygiene, water quality, improved quality and security of the living environment from flooding (UNESCO-IHE, 2010).

Now the question is whether existing urban water and land use planning institutions and practices are able to deal with climate change challenges integrating necessary institutional and regulatory arrangements involved with sustainable urban development. Indeed, even though IUWM has been in existence for many years (in 1992), it does not have a statutory basis which can lead to implement challenges (BRUCE, 2005). That is the reason why IUWM has to be incorporated into the whole strategic planning, managing and governance of cities in order to take advantage of synergies provided by coordination of diverse initiatives and to obtain credibility (BRUCE, 2005).

Consequently, there is a need for adaptive approaches and creative institutional arrangements to encourage sustainability, enable cities to adapt with changes within existing political and institutional settings and finally institutionalize sustainability as a social concern across all fields of public policy (ALFARO, 2004). Namely, there is a need to link IUWM to LUP and official plans to achieve connections among water, land and related resources, to integrate management of water and land interrelation at strategic and operational levels and implicate related issues for the design of institutions arrangement (AROUA, 2005).

Meanwhile, several studies have shown that up today climate information is not systematically integrated to LUP processes because of some constraints tied up with the conceptual based knowledge, the technical policy, or even the organizational items and market requirements. It is also observed that although urban climate can be influenced by LUP, "theory and practices are not always in phase" (INGEGARD, 2000). Indeed, it is often stated that the failure to implement the goals of sustainability is due to institutional failure or inappropriate institutional arrangements. Since institutional issues constitute the major challenges to effective protection and restoration, reform is then required and should concern existing arrangements because present institutional system seems to be "far more consistent with past rather than present knowledge and imperatives" (DOVERS, 2008). The organization of institutional rules, regulation and behavior should be changed as the organization is the changeable manifestation of the institutional structure. Without institutional reform little will be achieved or if possible changes are attempted, they are likely to persist (ALFARO, 2004).

2.1.2. The Role of Governments, Utility Companies and Local Communities

Major strategic challenges that cities face are due poor governance and weak institutions. There is often low stakeholder involvement; variety/multiplicity of institutions; piecemeal and sub optimal management of systems; incompatibility of national and supra national legislation; inability to take the best strategic decision in balancing environmental, economic and social consideration; difficulty in choosing the acceptable risks at strategic level; difficulty to enhance synergy between science and research; finally difficulty to maintain a strong relationship between LUP and IUWM and to guarantee equity, right to water, sanitation and safe environment.

Thus cities and their local governments have an important role to play in mitigation-adaptation by providing guidelines and regulations to LUP and IUWM in order to meet the key objectives of UN-Habitat Cities and climate change initiative. The aim of the initiatives is to promote active collaboration between local governments and their associations; enhance policy dialogue to establish climate change on the agenda; support local governments in making climate sensitive changes and to encourage education and other measures that support implementation of policies (www.unhabitat.org).

The state government plays a fundamental role since it has the responsibility for guiding and regulating land use principles that may determine the development model adopted which would lead to the design of better institutions (RANDOLPH, 2004). Any decision can be made at the national level by identifying constraints and providing guidelines to implementing institutions at the local level. In order to help cities that may wish to invest in a new governance paradigm and take advantages and opportunities from some potential climate change impacts, state government has to standardize main principles of LUP and IUWM.

Given the expected and already experienced climate change impacts in the cities all over the world, there is a need to call upon more local participation to give a voice to the local interests and reduce the pressure of national agencies. Indeed IUWM and LUP is a result of the interactions of people and institutions and are therefore best met by a decentralized approach even if larger scale (over watershed) provides guidance and resources to smaller-scale planning and implementation efforts (RANDOLPH, 2004). Strategic measures should combine among mitigation and adaptation working at the local level. Local action must be initiated in a national perspective though country level action must be done in a regional perspective.

To work at the local level, all regulations should have some basis in locally adopted public policy such as the municipal plan. Technical and financial support may proceed from regional sub watershed or state level whilst actions and measures come from sub watershed and catchment scale. Since watershed and ecosystems rarely conform the jurisdictional boundaries, IUWM usually requires inter jurisdictional collaboration (RANDOLPH, 2004). To achieve this objective, it is necessary to connect research, teaching and practice to provide mechanisms that enable urban players to interact and access update information (tools, guidelines, resource packages, documents...).

Likewise state agencies are important for coordinating and supporting local IUWM with financial and technical support. It is also well known that IUWM requires an integration of science, planning, policy and politics. From their part, education and research can have an immediate, substantial and indispensable institutional role to play (SALETH and DINAR, 2005).

2.2. Institutional and Regulatory Response of Urban Water

2.2.1. Climate Change and Integrated Land Use Planning

LUP evolved from a design profession to an applied urban form on to which a broader skill set is required in order to address the range of problems experienced in the cities and changing objectives including environmental quality and IUWM (RANDOLPH, 2005). To contribute to water cycle protection and conservation, LUP should happen at a more local catchment level which is the appropriate spatial unit for sustainable LUP. Local drainage catchment becomes quite a useful geographical boundary for planning and managing water resources. As a continuous management process with a long term perspective (15 to 40 years), it should incorporate new data, technology investments and regulations, and infuse new practices into the existing planning process following an adaptive approach (UNESCO-IHE, 2010).

The best planning strategy should be selective and sequentially linked to reforms focused on institutional components and sectoral context. The strategic measures should not be reactive or proactive but integrative in order to achieve the three objectives of sustainable development (RANDOLPH, 2004). However, the comprehensive approach should be more useful at strategic level whilst integrative approach is more focused and selective and therefore more useful at tactical and operational levels (BRUCE, 2005).

To target reform, climate considerations have to be incorporated in laws applicable to IUWM and LUP at local, national and the regional levels, in order to achieve the main objectives of sustainable urbanization (AROUA, 2005). Also efforts and investments should be temporally prioritized.

LUP refers to some regulatory tools (zoning, ordinances, etc) and non-regulatory tools (land acquisition, policies, etc) (VPIC, 2007). Regulatory tools include zoning regulations, site plan regulations, subdivisions (protected areas, infrastructures, etc), planned unit development, official map, phasing development and transfer of development density. Since regulations are not subject to change over time, relying on them alone may not be enough to accomplish long term goals and objectives. As such other non-regulatory tools should be used including landowner incentive and assistance programs. Successful programs take advantage of the synergies provided by coordination and collaboration of diverse initiatives (RANDOLPH, 2004).

2.2.2. Climate Change and Strategic Planning for Integrated Urban Water Management.

Appropriate planning regulations needed at national decision making level may include environmental security and eco-hydrology (KINGA et al, 2007). Integration of IUWM, LUP and Landscape design may lead to optimal management of the whole water cycle; contribute to sustainability of urban areas and provide conditions for attractive human-scale living environment (AROUA, 2005). Thus institutional arrangements at different watershed scales should be complementary, coherent and well organized amongst the different geographical scales: sub national (regional), basin (multistate), sub basin (state), watershed (sub state), and sub watershed (local), catchment (site scale). Rigidity of legal and institutional framework should be corrected so that urban development choices must be defined by social, environmental and economic demand and not by law (ALFARO, 2004).

IUWM has to be incorporated into the whole strategic planning process but with an appropriate prioritizing and timing of actions (short, medium and long term). Planning horizon may need to extend and focus on 50 to 100 years to meet IUWM objectives as much as urban water cycle must be considered as two integrated processes related to water supply management and water excess management (UNESCO-IHP, 2009). A dynamic LUP strategy for IUWM includes the identification of the local hydrological system and components, the dynamic relationships among them and the strategic planning procedure (AROUA, 2005). Watershed or local catchment management must then team with other programs with common and compatible objectives such as natural hazards mitigation, soil erosion arrest, farmland preservation, polluted runoff treatment, drinking water resource protection, impaired waters restoration, forest management, air quality improvement, wetland benefits protection, fisheries management, recreation and open spaces management and finally enhancing quality of life.

Likewise LUP and IUWM may interact with one another through closer coordination and must be supported by a set of policies and provided with proper institutional arrangements (customs, laws, and underlying rules). To achieve this objective, some priority themes need to be reformed such as governance, environmental planning and management, water management and urban planning. Efforts should be made to develop and improve existing structures through alternative approaches and tools rather than enforcing new ones (www.unhabitat.org).

Strategic planning for IUWM has to adapt existing water institutions including institutional structures (governance structure) and institutional environment (governance framework). Water sector performance depends on both. Water institutional structure consists in organization, law and policy whilst water institutional framework includes political system, legal system, demography, economic development and policies, resources and environment. The factors that affect water institutional change may be endogenous (internal to water sector) or exogenous (outside the water sector). Although endogenous factors are often undermined, but exogenous factors may be more prone for change (such as macroeconomic crisis, political reforms) (SALETH and DINAR, 2005).

2.2.3. Integrated management: Towards local and regional sustainability

Local and regional sustainability is fundamental for most urban settlements. Attempts have been made to achieve the Millennium Development Goals (MDG) through international programmes such as **WASH "**Water, Sanitation and Hygiene", the Sustainable Cities Programme and the Healthy City initiative. The concept of "Healthy City" was initiated by the World Health Organization in 1986. It aims "to reach a state of complete physical, mental ad social well-being" (Ottawa Charter, 1986). All sectors are involved in the Healthy City program acting at different level and combining complementary institutional, financial and organizational systemic approaches. Since health is quite dependant on other issues, water management should be emphasized as a basic goal. WASH international program more focuses water issues, whilst "Healthy City" are to establish a local healthy public policy involving LUP. However both aim to achieve MDG following the UN and WB strategy to ensure environmental sustainability through the improvement of water resources management, the reduction of climate variability or change impact, and the development of the technical knowledge.

3.0. PRACTICAL WORK – STUDENT-LED LEARNING

3.1. CLIMATE CHANGE AND WATER RESOURCES (SECTION 1)

Studio Work/GIS Laboratory and Group Discussions

a). Studio Activity1: Mapping Urban Water Sources

Materials: 1:50.000 topographical map sheet, 1:10.000 or othophotograph, transparent tracing paper, marking pens or pencil, and ruler.

GIS lab material: Rivers, streams, seas and other water bodies shape files; cities or urban areas shape file.

What to do in Studio

- Display the map sheet or othophotograph
- Use the transparency to draw to trace all water resources related to the urban area
- Produce a map or layout of water urban water resources for your area

b). Discussion group(s)

Can also include group discussion of the urban water sources, vulnerabilities to climate change, alternatives, mitigation and adaptation measures.

Studio Activity2: Identify Areas Vulnerable to Flooding

Manual approach

Materials: 1:50.000 topographical map sheet, 1:10.000 or othophotograph, transparent tracing paper, marking pens (rotring pen), and ruler.

What to do

- On the topographical map, identify cities close to rivers, seas or oceans.
- Study the contour lines on the map – indicate heights above sea-level etc.
- Places located in areas with low contour values that are close to rivers, seas and oceans are likely vulnerable to flooding.
- Use transparent paper to trace the vulnerable cities, rivers and other vulnerable properties.
- Use a ruler to produce a 20 and 30 m buffer away from the river, seas or ocean (vary the buffer according to national or regional standards).
- Include a scale and legend.

GIS Laboratory Activity3: Flood Vulnerability Analysis in GIS

GIS lab materials: Scanned and geo-referenced image of the city (aerial, orthophotograph or topographical map), 5 or 10 m contour shape file, river, cities and other urban properties shapefiles.

What to do

- Display an image of your choice.
- Add an overlay of contour lines.
- Produce a DEM, Hillshade and calculate the slope of the area.
- Overlay city and other property shape files.
- Query and Identify areas at certain vulnerable distances to the floodable water bodies
- Produce suitable buffers
- Create a layout map
- Add other essential map properties (scale, north arrow, legend, etc.)

Group Discussion Activity4: The Urban Water Cycle (UWC)

Select an Area (city/sub-region/region)

Identify the following :

- **Services provided**
- **Constraints and projected impacts**

Discussion Materials: Notebooks, pens, etc.

What to do:

- Split into groups.
- Discuss the Urban Water Cycle in your area.
- If possible include sketches or diagrams.
- Discuss their present limitations in the face of climate change and impacts already noted & perceived in the past year (s) and possible projected impacts.
- Suggest adaptation and mitigation measures.
- Each group present feedback in terms of a report and/or PowerPoint presentation (s)

GIS Lab Activity5: Climate Change and Urban Water Infrastructure (UWI)

Select an Area:

- **For example: Neighbourhood; Coastal Region; City; Province etc.**

Materials:

- Shape files of water mains, sewage pipes, waste/water treatment facilities, storm water drainage, etc.
- Shape files of cities, place names, rivers and water bodies, etc.

What to do:

- Display and create a layout for each urban water infrastructure.
- Create overlays where possible and be careful to avoid overcrowding of information on the layout.

Discussion Group(s)

i. Can also be performed in the Studio: produce a layout of urban water infrastructure for your city in relation to urban water sources.
ii. Include a group discussion and feedback of their status quo, vulnerability, mitigation and adaptation measures.

3.2. CLIMATE CHANGE, LAND USE PLANNING AND INTERGRATED URBAN WATER MANAGEMENT (IUWM) (SECTION II		
I.	**Issues - Question**	**Activity**
1	**Requirements for Integrated Urban Water Management (IUWM)** Knowing what is at stake, we can identify what needs to be strengthened: information? Money? Capacity (decision making, planning, coordination)?	Debate - Discussion
2	**The role of governments, utility companies and local communities.** General principles of sustainable development adopted by governments and other actors have their limits because of different spatial and temporal scales and possible limitation to human activities. Water institutions performance can be assessed through an analytical matrix showing "who do what and where?" to identify gaps (lapped responsibilities regarding areas and issues) and recommend appropriate measures.	Assessment activity using an analytical matrix.
3	**The role of governments, utility companies and local communities.** Local level is the starting point for LUP and presents some advantages and disadvantages that have to be envisaged. Advantages consist in more participation of local communities that may express their experiences and interests. Disadvantages may come from a lack of high investments, difficulty to integrate local plan into a high level, need for high level support.	Debate - Discussion
4	**Climate change and integrated land use planning (LUP)** LUP should refer to reformed guiding principles such as: ability to be revised, robustness, sensitivity to motivational complexity, publicity and variability. LUP can be assessed after these criteria using a multi-criteria analysis method.	Assessment activity following a multi-criteria analysis
5	**Climate change and strategic planning for integrated urban water management.** To assess the water sector performance, the local hydrological system's components should be presented in a conceptual DSR framework (driving force, response and state) reflecting the local real life and possible options.	Assessment activity using a conceptual DSR framework.
6	**Climate change and strategic planning for integrated urban water management.**	Debate - Discussion

	Spanish experience shows the limit of a complete decentralized approach in implementing an integrative management system and provides social equity since communities are totally autonomous. Territories and water resources should make profit on a common management strategy. →French experience shows the limit of the Water management and arrangement scheme (SAGE) since it mainly focuses technical issues. It proposes to reuse the first tool of “River contract” to deal with different political objectives within a common watershed.	

CLIMATE CHANGE, LAND USE PLANNING AND INTERGRATED URBAN WATER MANAGEMENT (IUWM)

3.2.1. Student-Led Learning Adaptation and Transformability Indicators

The questions to be considered here are:-

a) How is urban water managed today?

b) What are the existing/prevailing conditions?

c) How are authorities trying to avert negative climate change impacts?

d) Which changes are necessary to protect and restore a good water cycle in urban areas?

The aim is to focus on adopting a policy-based approach analysis to assess the water management's resilience with regard to the local related risks so that existing institutional and regulatory tools should incorporate Integrated Urban Water Management.

Referring to the Hyogo Protocol and recent scientific literature, we define the water management's resilience as being adaptation and transformability, represented respectively by some pertinent indicators. They will be discussed and analysed after a notation scale evaluating their difficulty to be controlled within the local vulnerability context. The performance of the locally adopted adaptation measures will also be estimated by referring to the precautionary principle.

The considered indicators are listed below:

ADAPTATION INDICATORS	***TRANSFORMABILITY INDICATORS***
They should describe: *- the local systems of prevision protection,* *- the alert and assistance,* *-the implementing capacities.*	*They should describe:* *- the sustainable development strategy,* *- the low impact alternatives,* *-the implementing capacities.*
Institutional (related laws): *Prevention,*	***Political**:* *Local sustainable strategy,*

Stakeholders working and decision making system, *Local governmental services.*	*Comprehensive urban scheme,* *Energetic strategy.*
***Regular (local comprehensive scheme)**:* *Water resources management plan,* *Water related risks management plan,* *Assistance organization.*	***Juridical**:* *Water planning tools,* *Urban planning tools,* *Local development plan.*
***Operational (local planning scheme)**:* *Assistance acting plan, NGO,* *Safety-device operating mode,* *Public health and assistance office.*	***Economical**:* *National/international investment opportunities,* *Local resources.* *Local means.*

4.0. Suggested Case Studies

CITIES VULNERABLE TO CLIMATE CHANGE (DEVELOPING COUNTRIES)

Regional approach		Case study	Water issue	Required information
1	**Coastal cities**	***Algiers (ALGERIA)** **Durban** **Latin America & Caribbean (Mexico City)**	**Water supply** Urban water management and urban planning. How much are they locally incorporated? Increasing wetness (sea level rise) Over urbanization & issue of subsidence.	All available.
2	**River deltas.**	**Douala (CAMEROUN)** **Saint Louis-(SENEGAL)**	**Sanitation** Assessing the Water sector performance.	**1. Water institutional structure (Governance structure):** Water law: water rights, conflict resolution, accountability, scope for private participation, etc. Water policy: use priority, project selection, devolution, privatization, technology policy, etc. Water organization: government layers, structure of water administration, finance,

				pricing, regulation, information capability, technical capacity, etc. **2. Water institutional environment (governance framework):** <u>Political system</u> <u>Legal system</u> <u>Demography</u> <u>Economic development and Policies</u> <u>Resources</u>
3	**Inland cities (arid climate, etc.)**	**Addis Ababa (ETHIOPIA)**	**Strom water management** Vulnerability to water related risks and adaptation capacity. Assessing Vulnerability level face to storm water risk.	1. **Environmental factors:** Climate – Hydrography – geomorphology. 2. **Anthropogenic factors:** Socio-economic – urban – technical. **3. Structural factors:** institutional – regular – operational.

5.0. Key Readings

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Links

www.unhabitat.org (See: Urban development and management – Water and sanitation infrastructure).
www.unesco.org (See International Hydrological Program - IHP).
www.switchurbanwater.eu (See: Approach to Urban Water management – UWM).
www.who.int (See: Healthy City – WASH “Water and sanitation – Hygiene”).
www.newater.info (See: IWRM and adaptive management)
www.gwpforum.org (See: IWRM ToolBox)

6.0. Methods and Tools Reading List

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Defining an ecosystem approach to urban management and policy development, United Nations University/Institute of advanced studies UNU/IAS, Mars 2003, 22 p.

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Facing the facts. Assessing vulnerability of Africa's water resources to environmental change, UNEP, 2005, 63p.
Integrated Flood Management. Concept paper, Edited by Technical support unit, World Meteorological Organisation & Global Water Partnership, The associated programme on flood management, 2004, 28 p.

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6.1. Methods and Tools Web-based Sources

http://www.switchtraining.eu/modules/: The SWITCH Training Kit Modules.
www.catnat.net
www.unicef.org
www.mre.dz
www.wbdg.org
www.Aqueduc.info
www.durable.com
www.geo.fr
www.lesechos.fr
www.greencities.org
www.livingcities.org
www.water.gov.ma
www.ramsar.org

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