INTEGRATED URBAN WATER RESOURCES MANAGEMENT INITIATIVE

LATIN AMERICA AND THE CARRIBEAN

Case Studies

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CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

Back in 1900, only 13% of the global population lived in urban areas. In 2008, more than half of the world's population is living in urban areas, occupying only 2.8% of global territory. The forecast for 2050 is that 69.6% of the world's population will be living in cities (UN, 2009). The world is becoming increasingly urban as a result of the economic development and employment distribution. In developed countries the population has stabilized during the 20th century, but in developing countries the population is still growing at expressive rates. In 2050 the world population will reach approximately 9 billion people and most of this grow will occur in urban areas. This will be particularly notable in Africa and Asia where the urban population will double between 2000 and 2030. By 2030, the towns and cities of the developing world will make up 81 per cent of urban humanity (UN, 2009).

An increase in urban population leads to a growth of a concentrated demand for natural resources coupled with social and economic conflicts. Competition between water uses for economical purposes and water supply to attend the demand of this increasing urbanization, as well as its related impacts, is one of the main water resources challenges for developing countries (2030 Water Resources Group, 2009). Developed countries have difficulties with such population concentration also, since in 60 percent of European cities with more than 100,000 people, groundwater is being used at a faster rate than it can be replenished (UN, 2009).

The development of water resources management and use occurred in a fragmented manner, by the different sectors such as energy production, agriculture, industry, navigation and water supply services. This lack of integrated management resulted in water conflicts, water shortage, water quality impacts, flooding and also in the increase of water related diseases. These effects were also responsible for an increase in poverty, mortality rates and a decline of quality of live.

The United Nations approved the MDGs (Millennium Development Goals)[1] to improve the living conditions of the population in poor countries. Most of the goals are related to water resources management such as: water supply and sanitation, poverty and population vulnerability. Sustainable Water Resources Management at the river basin level is based on being able to maintain water quantity and quality aspects to support human competitive water needs and water conservation. Cities often abstract water from upstream sources for supply and discharge its effluents downstream, creating impacts due to the reduced quality conditions. Integrated Water Resource Management (IWRM)[2] has been a general approach proposed to develop sustainable solutions at the basin level, trying to accommodate water uses and its related impacts. Urban areas are always located in one or another watershed and so Integrated Urban Water Management

[1] http://www.undp.org/mdg/basics.shtml

[2] Integrated Water Resources Management (IWRM) "*is the process that fosters coordinated development and management of water, land and related resources to maximize the economic and social outcome in an equitable way without compromising the ecosystem's vital sustainability"* (GWP, 2000).

(IUWM)[3] intends to bring the same approach to the level of municipalities, but inserting it into the IWRM at basin level.

Urbanization in developing countries has been fast, spontaneous and disorganized, with many impacts such as water shortage, water quality degradation, flooding, land misuse and diseases proliferation. Deficiencies in urban land use planning, in provision of water services and environmental conservation, together with a together to lack of sound institutional management were the main source of the problems.

In 2009, the Water Anchor of World Bank prepared a first draft of a practical tool to conduct a rapid assessment of the key urban water issues in developing countries under the main principles of Integrated Urban Water Management (IUWM). Two cases studies were developed, Jakarta in Indonesia and Medellin in Colombia (Tucci, 2009).

1.2 OBJECTIVE

The objective of this study is to propose a framework for urban water studies and formulation of integrated solutions to be applied in the rapid growing cities of Latin America. Three case studies will be used to assess the applicability of the methodology and cities with a certain level of water management development already implemented were identified with this purpose: Medellin in Colombia, Monterrey in Mexico and São Paulo in Brazil. Three other pilot studies were chosen to test the proposed methodology: Tegucigalpa in Honduras, Aracaju in Brazil and Bogota in Colombia.

This report is expected to fill an analytical gap of the water practice of the World Bank that is hindering to scale up the operational and policy dialog with client countries when addressing complex water issues in urban areas. Therefore, it is expected that this rapid assessment would be a helpful first step to outline a long term engagement strategy between the World Bank and government authorities in charge of water investments and services in large urban areas.

The motivation for this study is the recognition that traditional approaches to urban water investments are rather fragmented and frequently unsustainable since they generally do not take into consideration the multiple dimensions and cross cutting issues of urban water management. As a consequence, when urban investments are not evaluated in an integrated way and over a long period of time, it frequently leads to suboptimal decisions. This is particularly relevant when addressing the needs for large and complex water investments, which is the case of many large cities in the region where there is a large backlog of water infrastructure.

[3] The Integrated Urban Water Management is the development of urban waters – water supply, sanitation, urban drainage and solid waste – with efficient and rational use of the resources, taking into account the entire basin and its management, including urban land use management, in order to minimize water contamination, to guarantee environmental conservation and to reduce water related diseases.

1.3 OUTLINE OF THE REPORT

This report is organized in seven chapters. Chapter 1 presents a general situation of urban growth in the world and its main impacts; Chapter 2 presents a summary of the main issues in Urban Waters in developing countries, particularly in Latin America; Chapter 3 presents the main concepts related to IUWM to support the application of the methodology.

Chapter 4 presents the methodology of assessment and the development strategies with the step by step procedure on IUWM assessment, strategy planning and implementation.

Chapter 5 presents a summary of three cases studies used to assess the methodology. This chapter is based on the analysis of water management issues in three important cities in Latin America with different problems, levels of institutional implementation and results. Medellin, São Paulo and Monterrey are the cities here presented. A detailed report with the main findings in each of these cases is presented in the Annex.

Chapter 6 presents the development of the pilot cases, Tegucigalpa, Aracaju and Bogota, with the summary of each case, results and findings. In each case, the methodology presented in Chapter 4 is applied, with the description of results.

Chapter 7 presents the lessons learned from the case studies and pilots, as well as recommended procedures for the Bank to use in its actions and general recommendations.

1.4 USE OF THE REPORT

This report was developed aiming to help task managers and Bank staff responsible for policy development and with operational responsibilities in water and urban projects. The report is expected of interest to government officials, water practitioners, planners and decision makers committed to building a long term strategy to fulfill the demand for urban water infrastructure.

This report outlines a practical tool to prepare a rapid assessment of the most relevant water issues in cities. It intends to be only a first step in building a long term engagement strategy of development agencies and governments.

2. WATER RESOURCES ISSUES AND IMPACTS

Water is a limited resource both in quantity and in quality, and its availability depends on climate, environment, and anthropic conditions. As a consequence of the intensive population growth of the 20th century, the demand for water increased very fast, together with its related impacts. Water use has been growing at more than twice the rate of population increase in the last century. The main issues have been identified (2030 Water Resource Group, 2009) as:

- Competition among multiple users within a river basin for a scarce resource;
- The increase in urbanization process, the consequent pressure on various natural resources (air, land and water) and related impacts;
- Sustainability of arid and semi-arid regions;
- Water resources vulnerability to climate change.

The first two issues are highly related to the increase in *demand*, whereas the last two are related to *risk on natural supply of water* which is governed by climate conditions.

Water issues are of interdisciplinary nature, but most of the water resources development in the 20th century occurred within each specific sector such as Water Supply & Sanitation, Agriculture, Energy, Industry, among others. It lead to a fragmented development, generated many conflicts due to water scarcity and created impacts due to vulnerability to floods, droughts and diseases.

The present study is intended to focus in urban areas and the related water issues, taking into account the insertion of the urban area in the basin(s), the multitude of users and potential impacts.

2.1 WATER CONFLICTS AND VULNERABILITIES

Intensive water use may induce conflicts and vulnerabilities from upstream to downstream in the basin related to:

- *Water availability x demand*: Water availability is the natural physical limit of the existing amount of water in time and space. The water demand is generated by the economic, social and environmental needs. An increase in population reflects in an increase in water demand in all sectors, agriculture, water supply and industrial production. In urban areas the increase for water supply and industry is aggravated by the fact that the demand is concentrated in a relatively small area. It must be considered that this increase in demand may reflect inappropriate practices due to the lack of water demand management;
- *Water quality deterioration of aquifers and surface waters* is the result of pollutant from different activities; water quality degradation reduces water availability and generates potential impact on human health and on the environment;
- *Flooding:* urbanization increases storm water peak due to impervious areas and high velocity in pipes and channels; population living in lower areas and floodplains is impacted, as well as business and industries;

- *Institutional vulnerability:* Lack of institutions (or weak institutions), inappropriate or inexistent legal instruments, lack of technical and institutional capacity and low investment capacity are conditions that enhance conflict and produce vulnerability.

The cause and effect relationship of water induced problems in urban areas may be summarized as presented in Table 1.

Table 1 - *Cause and Effect* relationship of the impacts

Cause	Specific aspects	Impacts
Unsustainable urban development	High density, impervious areas; non-regulated spaces.	• Disorganized occupation • Flood plain impacts • Low quality of life and diseases
Lack of urban water services	Lack of: water supply, sanitation, solid waste and storm water services.	• Lack of access to safe drinking water; • Water sources contamination; • Water quality degradation; • Water related diseases. • Environmental impacts • Increase in flood frequency
Cross-cutting issues: Institutional, Social and Economical	Lack of regulation and management; of investments and of social policies	• Transferring floods to downstream; • Water conflict; • Difficulties in cost recovery. • Lack of societal improvement

2.2 WATER PROBLEMS IN URBAN AREAS: MAIN CAUSES

2.2.1 Urbanization

Urban development accelerated during the second half of the 20th century, concentrating population in relatively small areas. Countries such as Brazil moved from a percentage of 55% urban population in 1970 to 83% of urban population today. Urban areas in Brazil occupy only 0.29% of the country's total area, resulting in a *mean urban density*[4] of 65 persons per hectare (6,500 per km^2) (Embrapa, 2008). The two largest countries in population, India and China are respectively with 29.2% and 42.2% of urban population but are moving up in this urbanization scenario very fast. In Africa and Asia the urban population will double between 2000 and 2030 (UN, 2009).

Due to the concentration, urbanization increases the competition for the same natural resources (air, land and water) to sustain human needs on living, production and amenities. The environment, here considered as encompassing natural resources and population, is a living and dynamic being that generates a set of interconnected effects, which if not controlled, can lead the city to a chaos.

[4] **Urban density** is a term used in urban planning and urban design to refer to the number of people inhabiting a given urbanized area.

Urbanization increases with economic development, since employment and income move from agriculture to industry and services. Urban areas provide more easily facilities for education, shopping, housing, recreation and others. These facilities lead to the existence of the so called mega-cities. Large urban areas like the Metropolitan area of São Paulo in Brazil, grew from 200 thousand inhabitants in the beginning of 20th century to 17 millions in the year 2000, which represented a mean yearly rate increase of 8.0%. There are 388 cities in the world greater than 1 million inhabitants (McGranahan and Marcotulio, 2005) and 16 above 10 millions. By the end of the year 2010, it is expected that there will be 60 cities with population over 5 million.

During the 20th century, the pattern of urban development was a reduction of population in the central areas and an increase towards the urban fringes, leading to an under-populated center with a strong tendency to urban degradation. Difficulties with transportation routes, traffic increase, insufficient transportation capacity, pollution and lack of water services were all consequences of such model and this have led to an important loss of quality of life.

In developing countries, this growth of the peri-urban areas was caused also by the price of land and the result is a high contingency of the population living in irregular or informal settlements, usually called *slums*. Since the highest rate of population growth occurs in low income families, the slums had a significant increase in the last decades almost in all large urban areas of the developing world. Slums are usually overcrowded dwellings of poor quality which occupy unregulated areas without property rights. Nowadays, all over the developing world one will find in urban areas a *formal* and an *informal city.* Urban management and services usually reaches only the former. To the latter, usually there is almost a complete absence of the services such as water supply, sanitation, drainage and solid waste collection which results in important environmental impacts and severe threats to human health with the spreading of many diseases. The municipality is usually managed in a fragment manner, by sectors, without an integration to plan and to operate the city's infra-structure.

2.2.2 Urban impacts related to water and water services

Overview

Urban development usually follows a pattern of expansion from downstream to upstream in the basin, and from coastal areas to continent in coastal cities. Water is supplied by sources from the upstream basin, from a neighbor basin or from groundwater (or from a combination of these sources). After the water is used by the population, the effluent must be collected and treated, since the discharge in streams or treatment in by septic tanks will dump a very impacting pollution load in the rivers and groundwater. Pollution in rivers and groundwater reduce water availability for water supply due to health risks and treatment costs.

Unsustainable water supply and sanitation practices uses clean water upstream (or not so actually!), dumping polluted water downstream. Since the urban development spreads upstream, urbanization usually threatens its own clean sources. In addition, urbanization competes with agriculture for area and for water. Since the water supply utility usually does not have capacity to supply all the water, the population is forced to find its own solution, which is usually unsustainable also, such as a disorganized use of groundwater, or is unsafe, increasing water related diseases.

Urbanization increases impervious areas and storm water is conveyed through pipes and channels. The consequence of such unsustainable practices is the increases of flood peak and the flood frequencies for the same rainfall. It also increases the flow velocity and sediment and solid waste transportation capacity. If the solid waste collection service is poor, most of the solid waste produced in the area will be transported by storm water flows and wit ends clogging the river, reducing its flow capacity, increasing flood levels and producing a pollution impact.

Pumping groundwater, together with the reduction in water infiltration due to impervious areas, may cause subsidence in low lands areas. Low land areas can be formed with decreased drainage capacity by gravity and a result of an increase in flood frequency. In this situation, the area can be flooded by backwaters and by the sea (in coastal cities).

Urban waters in many developing countries are in a contamination cycle as presented in Figure 1. This is the result of contamination of water supply sources due to the lack of sewage treatment, flood increase due to large impervious areas and channelization, occupation of risk areas, water pollution, increase of sediments and solid waste in the rivers and land subsidence. The consequences are a high impact on the basin environment, on coastal areas and an unsafe situation that threatens public health.

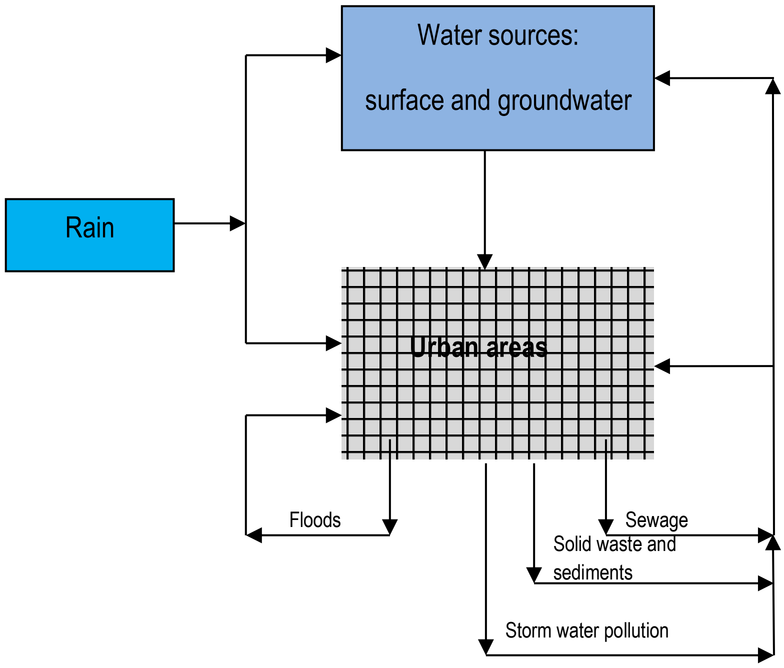

Figure 1: Contamination cycle of urban waters in developing countries.

Water Services Issues

The main urban services related to water are: water supply and sanitation, storm water (urban drainage) and solid waste collection. Solid Waste is here included since the lack of efficiency in this service may have severe consequences on the other water related services.

Quality of life, protection of human health, sustainability of economic growth and protection of the environment are closely correlated to good provision of water related services in urban areas. In developing countries due to a multitude of reasons, from low investment capacity to lack of institutional organization, or from lack of technical capacity to difficulties in the involvement of the general population in good practices, there is a service deficit that restrains the achievement of the afore mentioned adequate conditions for proper urban living.

In this chapter, the present report explores the reasons why such services suffer from ill management in urban areas of developing countries.

Water supply deficiencies: There are several reasons for the reduced coverage of water supply services or for deficient service: (a) limited water sources; (b) limited investment to improve/expand water treatment and supply services; (c) contamination of the water sources; (d) excess of non-revenue water due to physical losses or illegal connections; (e) poor operation and maintenance of the system; (f) absence or weakness of demand management strategies.

Limited availability can be related either to (i) seasonal or inter-annual flow variation caused by climate variability or climate change or to (ii) demand increase, caused by population growth and/or by poor efficiency or poor conservation practices[5]. Poor efficiency in cities of developing countries can result in non-revenue water varying from 15% up to 60 %.

Sanitation: Reduced coverage of sanitation services and lack of wastewater treatment is a major issue in developing countries. In Brazil, it is the service with the lowest coverage of all services that are provided to the population. Several situations are present in urban areas in developing countries: (a) absence of collection, the waste is disposed in the streets, in trenches or directly discharged in creeks or other water bodies; (b) absence of a sewage network, where the sewage is discharged into storm water drainage systems, in an unplanned combined sewage system and discharged without treatment into water bodies; (b) with network but without treatment plants: raw sewage is discharged into the rivers deteriorating water quality and affecting downstream population; (c) with network and treatment plants but with low coverage or without mandatory rules to connect all houses, with strong impacts over the reduced cost recovery of the investment and with raw sewage still reaching water bodies. In Ghana, after 20 years, only 130 household connections were made to a sewer system designed for 2,000 connections (Wright, 1997).

Low coverage, inefficiency in collection and poor treatment performance are major issues in sanitation systems performance.

Urban sanitation networks are usually classified as *separate* or *combined* systems. In the former, storm water and sewage networks are separate. In a combined network, sewage and storm water flows use the same network. Usually the flow capacity of a sewer network is much smaller than the storm water, in a proportion of 1 to 40.

In the combined system, the pollution load suffers a large variation along the time, mainly on rainy days. This variation decreases the efficiency of the treatment plants. There are many technologies to avoid this problem such as reservation facilities to regulate the flow to the wastewater treatment plants. The other limitation is the odour, disease propagation in warm climates and during flood events, when an overflow is expected. Separate networks are more efficient in controlling the performance of the system.

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[5] There is a difference in efficiency and conservation. Efficiency is when the services are badly operated and maintained with significant losses in the networks. Conservation is related to implementation of good demand management practices that induce a decrease in water use.

In developing countries, other situations may be observed. For instance, the existence of only the sewer system, without drainage system, where the rain water flows directly over the street, causes frequent floods with the increase in urbanization. In Barranquilla, Colombia the population cannot leave home during rainy days. Another situation is to develop first the drainage system and, years later, the sewage network. When the sewer system is constructed it is very difficult to separate the two systems.

Surface water contamination: Every day, 2 million tons of human waste are disposed of in water courses and, in developing countries, 70 percent of industrial wastes are dumped untreated into waters where they pollute the usable water supply (UN, 2009). Many large cities around the world were developed in upstream basins or in areas with low water yield and a very limited assimilative capacity for discharging effluents. The solution has been to use neighbor basins for water supply and/or for effluent disposal. This is usually a very conflictive solution, since there may be a potential for urban growth within in the neighbor basin. Contamination of nearby sources is pushing water withdrawal for drinking water purposes farther away from the cities, with an important increase in cost of drinking water production

The standard procedure of looking for the “next” source every time the current source is no longer sufficient or it does not meet quality requirements is unsustainable and more difficult and more costly. Sustainable paths are those of (i) increasing the efficiency of the water supply and sanitation services, reducing losses and controlling discharges impacts; (ii) decreasing the demand and (iii) reusing the water, where the benefits come from both sides of decreasing treated drinking water volume and at the same time decreasing effluent discharge.

Storm water*:* Urban floods can be caused by: (i) an excess volume in the storm water network of pipes and channels, also known as local floods; (ii) high flows that uses the natural floodplain, both with the potential of causing major damage. Between 1991 and 2000 over 665,000 people died in 2,557 natural disasters of which 90 percent were water-related events (UN, 2009).

Excess flows that overcome the capacity of the storm water system may occur due urbanization effects that increase floods. Flood Plain impacts are related to the occupation of the existing flood plain risk areas. This subject is presented below in 2.3.4.

Storm water facilities are developed to convey rain water flow in an urban environment in a way that does not disturb much the city’s activities. Urbanization changes the natural environment, creating impervious surfaces such as roofs, walkways and streets. Infiltration is reduced and rain water will flow from impervious surfaces to gutters, pipes, channels, with an important increase in speed. Both facts, an increase in impervious areas and in flow velocity affects very much the way flooding will impact the urban area. It results in an increase:

- of runoff volumes and peak flow (maximum discharge) by 6-7 times, when compared with the previous situation, as shown in Figure 2;
- of the amount of solid waste and sediments in the drainage system, decreasing the channel flow capacity and impairing water quality.

Flooding occurs when the peak and volume of flow exceeds the river channel capacity. Urbanization usually develops from downstream to upstream as shown in Figure 2. The population located in downstream areas suffers all the impacts (of floods) due to the new development upstream. The population located upstream, responsible for generating the problem, does not suffer with the impacts they help to create. This is the reason why there is the need for a strong public management in order to avoid the transference of impacts.

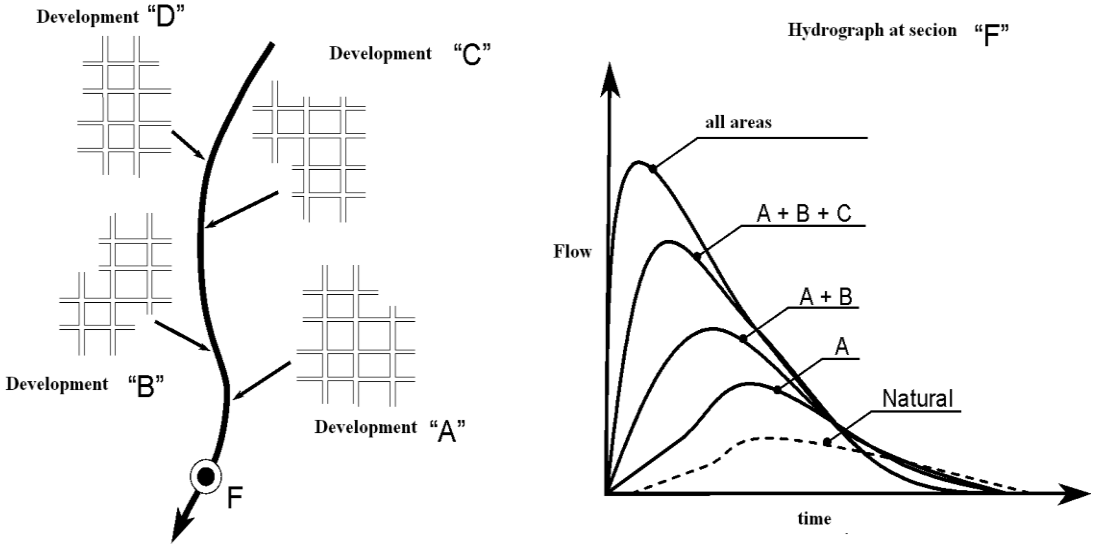

Figure 2 : Flood peak increases with new developments implementation.

Flood management policies to control storm water in most developing countries are not adequate to minimize the problem. The unsustainable solution usually used is to increase the capacity of pipes and channels to send away the high flows as soon as possible. This outdated design assume the water has to be sent to downstream as fast as possible (flow capacity increase), which increases the velocity of flow and transfers the floods to downstream areas at high costs. In addition, the water quality impact is high, since the higher velocities have an increased capacity of carrying sediments and solid waste.

Storm water measures can be selected based on the stage of the urban development. When the city is already developed, the main objective is to correct the existing impacts or recover the river systems. In order to correct the existing problems, the current practice is to work over the existing drainage, trying to improve its capacity and efficiency. When the city still has open spaces, the sustainable development and use of urban spaces is the best choice, since this concept allows for the preservation of the natural functions of the land and aquatic systems. In this case, it is extremely important to implement source control measures.

Sustainable solutions may be developed under the framework of a Stormwater Plan which comprises the following topics: (i) Policy definition, establishing objectives, principles and strategies for urban development, water, sanitation and solid waste control and risk assessment; (ii) Identification of the existing problems of floods in the urban area and the assessment o the institutional aspects of the solution; (iii) structural and non-structural measures. The main output of the Plan are: (i) regulation of storm water for future development, (ii) definition of economic management instruments to give financial sustainability of the drainage system, (iii) plan of action for each basin in the city with cost recovery options (iv) storm water manual and (v) a long term program for land and environment restoration.

Solid waste and sediments: solids produced in the urban environment are: (i) sediments and vegetation carried by rainfall and erosion (flow velocity); (ii) solid waste generated by the population such as plastic, papers and others, which is improperly collected or dumped in streets and channels. Sediments are an important source of pollution loads to the river systems since organic and chemicals that arrive in the aquatic system come adsorbed to the solids. Solid waste may cause severe impacts since it can be highly non degradable and cause clogging.

In the urban development there are two stages of sediments and solid waste production: (1) In the beginning of the development, there is a large amount of sediment produced when compared to the natural conditions because of deforestation and urban works; (2) after the urbanization is developed, sediments still represent an important part, but solid waste production increases mainly due to human activities and lack of efficiency of collection services, of street cleaning and waste dumped by the population.

Solid waste and sediments in an urban environment comprises the amount collected in households and buildings in general, the total collected by the activity of street cleaning and the amount that arrives in the drainage due to erosion and transport processes. There is a strong need for improved efficiency in managing solid waste collection in order to have a minimum amount discharged into the rivers and environment. The efficiency of the services is dependent on: (i) population education and training; (ii) complete coverage of the waste collecting services with adequate frequency. In many cities in developing countries the collecting services does not cover all city because of the difficulties in truck mobility in slum areas and in narrow streets, and even due to violence and drugs (iii) low efficiency of street cleaning; (iv) lack of management in controlling sediments and solid waste in construction sites.

Recycling waste is much dependent on population education and infrastructure to collect and send it to reuse centers. In developing countries the main incentive is the possibility of generating income to poor population that works in recycling centers.

When solid waste collection services are not efficient, a large amount is carried to the storm water system. Solid waste and sediments in the drainage leads to a decrease of the conveyance of the storm water flows aggravating flood condition. When the services are not reliable the consequences are: (i) increase in the cost of operation and maintenance of the urban drainage; (ii) environmental degradation by erosion and transport of polluted sediments; (iii) obstruction of urban drainage and losses of hydraulic efficiency of the drainage.

Solid waste recycle is being improved by education, economic incentives and enforcement. In developing countries solid waste recycle increases (reducing the waste in the drainage) when it has economic value, since it is an occupation of part of the low income population. Aluminum cans have high rate of recycling (> 80%) because of its economical value. The problem with plastic is that usually it does not have economical value for recycling. In Brazil, the plastic content in solid waste is increasing, but organic matter still represents from 30 to 70%, paper 25 to 50%, and metal, glass and plastic are about 10%. Plastic is the solid waste more frequently found in the storm water system and in the environment. In cities of South Africa, Australia and New Zealand, Marais and Armitage (2004) reported that plastic is the main solid waste found in the drainage. Improving the regulation in the use of these materials could decrease the amount of solids in the drainage.

2.3 IMPACTS ASSESSMENT

The lack of proper management and adequate investment in the water sector usually lead to a series of impacts commonly found in many urban areas of the developing countries of Latin America. These impacts can be briefly summarized in impacts over water availability and quality and population hazards related to water-borne diseases and flood damages. Sustainable environmental conditions are mainly a function of proper institutional arrangements to plan and control the acceptable impacts.

2.3.1 Water shortage

Water abstraction and lack of control in land use may decrease the flow and may lower the water table. Urbanization increases the impervious surfaces, decreasing infiltration to groundwater. Water supply sources may be affected and in coastal areas salinization of groundwater may occur due to salt intrusion.

Water supply demands an important amount of water and often it must compete with other uses. Conflict among water users or among neighbour basins in dispute for water enhances the necessity of proper institutional arrangements to establish sustainable and fair water rights, to mediate conflicts and to define investments, with the support of users and local society.

2.3.2 Water quality

Water quality of surface water and groundwater become polluted when the urban water services are not efficient or when controls are not properly enforced. The main potential sources of contamination are:

- Pollution loads from raw and poorly treated sewage from households, commercial and industrial facilities, and discharged into rivers, streams and lakes;
- Contamination brought by sediments and solid waste. Most of the nutrients enters aquatic systems when aggregated to sediments;
- Contamination by runoff flow over urban surfaces (storm water quality impacts). The pollutant sources are atmospheric deposition, sediments, solid waste, organic matter and toxics produced by cars;
- Groundwater contamination introduced by ill managed fuel tanks, solid waste disposal sites, septic tanks, leakage from sewage and drainage networks, among others.

The impacts will be more important during (i) Dry seasons, when the flow is lower and the river dilution capacity also decreases, resulting in high concentration of pollutants such as BOD (Biochemical Oxygen Demand and Faecal Coliform, among others); (ii) Rainy days when the storm water loads are higher and discharged together with the raw sewage loads.

Water pollution problems are felt in spreading of diseases, in impaired landscape views and reduced recreational activities around water. The assessment of water quality condition is dependent on the source of pollution and/or the water use of the stream.

2.3.3 Water related diseases

Human health depends on the provision of safe, adequate, accessible and reliable drinking water supplies. Human populations were acquainted with the concept of relating clean water to health for a long time, even before the relationship was fully understood towards the end of the nineteenth century.

Water-related diseases are responsible for 1.8 million deaths every year (88% is attributed to unsafe water supply, sanitation and hygiene (WHO, 2009). More than 50 communicable diseases are associated with poor sanitation, which results in millions of deaths, mainly children. For instance, Bangladesh has twice the infant deaths in urban slums than in urban areas as a whole (Wright, 1997). Sanitation can reduce the incidence of infectious diseases by 20% to 80% by inhibiting disease generation and interrupting disease transmission. Adequate water supply and sanitation decreases 55% children mortality (World Resources Institute, 1992).

The main pathway for the transmission of water-related diseases is through the contamination of drinking water supplies. Safe drinking water means that it will cause no damage to human health. It means that it is free from organisms capable of causing diseases, and also from other substances that potentially can induce physiological damages. The concept of safe water is becoming more and more difficult to establish. In 1925, drinking water standards in United States of America were established for physical (aesthetic) conditions, bacteriological and 4 chemical constituents (lead, copper, zinc, excessive soluble material) (Cotruvo and Vogt, 1990). In 1980, the Directive established by the European Community set 66 standards; organoleptic (4); physicochemical (15); substances undesirable in excessive amounts (24); toxic substances (13); microbiological (6); and minimum concentration for softened water (4) (Gray, 1994). In 1993, USEPA had established more than 130 drinking water standards, the major part related to maximum concentration of toxic chemical compounds.

Water-related diseases can be divided in five categories: waterborne-microbiological diseases, water hygiene diseases, water contact diseases, water vector habitat diseases and waterborne-chemical diseases (McJunkin, 1983).

Diseases transmitted through the ingestion of contaminated water in which pathogens, i.e., a disease-producing agent occur. Sources of drinking water are contaminated by human excreta from someone who is either ill or is a ‘carrier’. Diarrhea remains the second most common cause of death among children under five globally. Nearly one in five child deaths - about 1.5 million each year - is due to diarrhea. It kills more young children than AIDS, malaria and measles combined.

Diseases related to poor hygienic habits and sanitation are usually due to insufficient quantities of water for hand washing, bathing, laundering, and cleaning of kitchen utensils. They include those of skin and eyes. It also includes most of the fecal-oral transmission diseases – with the same pathogenic agents as the waterborne-microbiological diseases, usually transmitted by food and hand-to mouth contact.

Skin contact with the pathogen in the water is the pathway for those diseases. The most important is schistosomiasis and it currently infects more than 200 million people in 74 developing countries (WHO, 1999). Leptospirosis is the next most important of the contact diseases and the pathogens are transmitted through skin when immersed in water contaminated with the urine of infected rats.

Water habitat vector-borne diseases form a slightly different class because they are not transmitted directly by water but by pathogens associated with animal vectors living all or part of their lives in water. Malaria is unquestionably the most important of this class of diseases. Over 40% of the world population lives in areas with malaria risk and the incidence of the disease is in the range 300–500 million clinical cases annually. Some 1.3 million people die of malaria each year and it severely affects children (WHO, 2010). Also transmitted by mosquitoes, the incidence of yellow fever is declining due to immunization but the incidence of dengue has increased due to urbanization growth.

Waterborne chemical diseases affect both developed and developing countries. A variety of health effects are produced by chemicals in the environment (AWWA, 1990):

- toxic, causing a deleterious response in a biological system, depending on the dose and exposure;
- neurotoxic, destroying nerve tissue; • carcinogenic, causing uncontrolled growth of aberrant cells;
- mutagenic, altering inheritable genetic characteristics; • teratogenic, causing nonhereditary birth defects.

Investment is an important part in controlling water related diseases. In developing regions, the return on a US$1 investment in water supply and sanitation improvements was in the range US$5 to US$28 of benefits (Hutton and Haller,2004).

2.3.4 Flood plains vulnerability

Inundation in the flood plains occurs when the river overflow its banks as a natural process. It occurs with a frequency of 1.5 to 2 years return period. The main natural causes of the floods are related to rainfall intensity and its space distribution, basin soil and coverage, geomorphologic conditions such as basin area, slope, and river length. Artificial conditions can change the flood risk such as deforestation, change in agriculture practice, urbanization, reservoirs, and channel changes. The combinations of these factors are the main causes of the floods at a specific river section.

The impact is related to human and environment conditions and it can be described as:

- Loss of lives, usually due to flood levels and velocity of the flow near to the rivers or landslides;
- Direct economics losses in houses, commercial and industrial buildings due to water depth and velocity;

- Indirect economic losses of: working hours, profit reduction, production reduction in industry and agriculture.

When no reliable urban plan or land use regulation exists, the population tends to occupy the flood, since these areas have a flat and convenient topography and have a low cost. When an important flood occurs, flood damage is significant and the municipality is forced to invest in flood protection in this area to build control structures such dams and dikes. Flood levels, return period and proper use of such areas are usually unknown concepts for most of the population.

Planning the occupation of the floodplains is not new. More than 3.000 years in the past there existed planning of the floodplains areas in Egypt.

There are many examples around the world of planned occupation of the flood plains in order to create a more sustainable situation regarding floods. The pressure for occupation of these areas increases with population and economical grow but there must be discipline in this type of occupation.

2.4 INSTITUTIONAL ISSUES

Institutional aspects are related to: (i) Legal framework which determines the non-structural approach to aim for sustainability; and (ii) Institutional arrangement to deliver the actions and its implementation to achieve the goals. There are important aspects related to capacity building and monitoring of water related situations and also how to provide proper operation and maintenance of water services.

Water management in urban areas usually faces the following main issues:

- *Lack of institutional arrangement* when the institutions are too weak in order to develop the proper management and decision processes. For instance, a storm water utility usually does not exist in the cities in developing countries and it is left together with general services provides by the municipality. As such, it will suffer with low efficiency results. Other aspect is that in many countries the concept of Basin Management is still not developed or does not have economical and institutional sustainability;
- *Fragmented investments,* the existing institutions do not take into account the interactions of the systems. In many regions Water Resources Management is still not developed and urban water or sanitation is developed without any interrelation with other water uses in the basin;
- *Lack of knowledge and/or technical capacity*: the general public and professionals in different fields who do not have enough information or training on the problems and their causes;
- *Sectoral views of urban planning*: planning and development of urban areas are conducted without considering factors related to the different components of water infrastructure and land use.
- *Lack of management capacity*: municipalities do not have the structure for the planning and management of the different aspects of water in the urban environment.

Building proper institutional arrangements to lead a process of Integrated Urban Water Management is a task that must be supported by three main pillars:

a) **strategic planning**

i. Objectives well targeted;

ii. An aggregative force that is able to keep the system focused on the previous defined objectives;

b) **management instruments**

iii. Legal support with good laws and an enforcement system;

iv. Command and control instruments to make the enforcement system to be possible;

v. Incentive mechanisms;

vi. Financial support;

vii. Good urbanization practices;

c) **institutional arrangements**

viii. Coordination among all the agents (government, users, population)

2.5 SOCIAL, ECONOMICAL AND ENVIRONMENTAL ISSUES

In developing countries, an important part the city population lives in slums. These are unregulated areas with an important lack of infra-structure, under the severe risk of disease spreading and producing a high impact on the environment. The current management of the cities is developed mainly for the regulated areas, since the investment in slums is costly with difficult cost-recovery results.

In order to improve the development of the city there is a need to develop a social, economical and environment program to deal with slums areas in order to improve quality of live, economics and the city environment. This should be part of a sound investment.

Water and sanitation services may have its efficiency greatly increased by the implementation of metering and implementation of social tariffs to give subsidies to low income families.

There are two main aspects in the financial support of urban water services: (i) funds for investments in the improvement of the services; (ii) cost recovery of the investment and subsidies. These two aspects are interlinked, since the first cannot be developed without the second. Water supply and sanitation can have tariff structures associated with it and this can lead to a plan for investment return and cost recovery objectives.

The challenge is the development of cost recovery in solid waste collection and storm water system. The former is in place in many cities but with a lot of shortcomings in its development since the cost is uniformly distributed without incentive to its reduction or management. Storm water is the main challenge since usually there is not a specific service for it and most of the cities still did not understand how to deal with this issue. In developing countries, population is usually paying high taxes with poor services, since the funds are lost in bureaucracy and corruption. The main reason for the lack of integration in all the services is that the Water and Sanitation companies do not want to deal with solid waste and drainage. This is a municipality issue, but the best management solution is an integrated service. Brazilian Sanitation legislation of 2007 states that these four services must be offered together and it gives support to the cost recovery in Solid Waste and Storm water Services. Storm water cost recovery can be developed taking into account impervious areas and environment compensation principles with a mean cost of US$ 4-6 property/month.

2.6 CLIMATE CHANGE VULNERABILITY

Climate change may impact on water resources in altering the main variables used in design of the services. Usually the design is developed based on stationary series of temperature, rainfall, evapotranspiration and flow. Since the climate change forecast shows changes in these variables, the uncertainty will increase, changing the risk design to be adopted. Climate change impacts in the services are mainly related to drought and floods in the cities which are:

(i*) Drought* impacts are: the reduction of water yield for supply, decreasing capacity for receiving water body in sanitation, with consequences on water quality and environment of urban environment. In addition, the increase in temperature increases the demand of water and energy. These effects may increase the conflict for water use with irrigation in the water supply basins;

(ii) *Floods and natural disasters vulnerabilities*: The increase in flood events forecast by climate change models could increase the cost of damage in the city infra-structure due to the floods in the streets and housing. It is more serious in the slums part of the cities, since it is risk areas and the population has high vulnerability to floods.

Climate change needs to be assessed to cope with this potential impact. It can be done in the design or latter using mitigation such as forecasting of critical events. However, prevention is always the best approach and climate change can be introduced in the plan stage of the services as an additional uncertain to be assessed.

2.7 SUMMARY OF COMPARATIVE SCENARIOS

In most developed countries water supply, sewage treatment and quantitative aspects of urban drainage are no longer an issue since its service coverage is high. The main issues are the control of the storm water quality and managing flood hazard as shown in Table 2. However, for developing countries access to sanitation is still an important issue, wastewater disposal without treatment impacts the amount of clean water available for supply and new investments have to be made to maintain and improve supply.

Table 2 presents the common scenarios found in developed and developing countries with important variation for less developed countries. Usually developing countries already have a large proportion of water supply for the cities but the coverage of sewage collection and treatment is low.

In less developed countries the water supply is still the main issue, with high risk of developing water related diseases.

The main cross cutting issues are related to the institutional aspects of regulation and management of the services and its relation to urbanization and other infra-structures in the city, social, economical and financial aspects for development of the services, and the new challenge of climate change.

Table 2 Urban water management of developed and developing countries

Facility	**Developed country**	**Developing country**
Water Supply	Total coverage with some risk from non-point source pollution	Lack of supply and contamination of water sources due to lack of sanitation services
Sanitation	High coverage of sewage networks and sewage treatment	Low coverage and low efficiency in existing treatment and network systems
Storm water	*Quantitative control*: Floods are controlled by combination of non-structural and structural measures; *Water quality* is still an important issue under development	• Lack of measures for water quantity or quality with high level of impacts; • The cost of the impacts are transferred to the public or to environment; • Poor investments which usually increase floods.
Flood Plain Management	Mainly non-structural measures with insurance, zoning and flood alert	• Occupation of flood plain without control; • Poor investments in structural solutions; • Occupation by the poor with high impact during flood season;

3. INTEGRATED URBAN WATER MANAGEMENT

3.1 WATER RESOURCES MANAGEMENT

Integrated Water Resources Management (IWRM) was introduced with Dublin principles and Rio 92 Conference on Environment and Development. In order to meet these principles, the 2002 UN Conference in Johannesburg recommended the Implementation of National Water Plans as an essential tool towards IWRM. Few countries engaged in the process by approving national laws in Water Resources and constructing institutional arrangements in order to create new paradigms for water management. In Latin America, Mexico, Brazil and Chile were the first countries to build its national legislation and institutional framework. Ecuador, Paraguay and others developed more recently its national systems. In Table **3** the water resource institutional development in Brazil is shown.

Table 3: Institutional development in Brazil (Tucci, 2010)

Phase	Period	Characteristics
Sectoral approach	1934–1997	Water management was fragmented and dominated by user sectors
National integrated water institutions	1997–2000	Establishment of National Legislation, National Water Council, National Water Agencies
Decentralization of Government	2000–2006	New institutions at the state level, Basin committees and new legislation for different sectors
Sustainable development	2006 – on going	Economic and political sustainability for water management and visible outputs to society and environment

The operation of water resources management systems must be based on a flexible and competent set of instruments, in order to provide a feasible and efficient implementation of the management actions. The integrated water resources management (IUWM) instruments most commonly used are:

- *Water Resources Plans*: National, Regional and Basin Plans to define general goals, for assessment and decision regarding quantity and quality aspects of water, for enforcement rules and for directives to the implementation of other instruments;
- *Water permits* is the regulation principle to discipline and authorize water use based on the Water Plans, and also to provide integrated water use assessment;
- *Water charging* to recognize the economic value of water and to promote sustainability;
- *Water quality and environmental goals* to guarantee water quality, ecosystem protection and environmental sustainability of water use.

The institutional arrangement must be developed in a way that it combines ample participation of users and society with executive institutions responsible for implementation of actions. In Brazil and in Mexico there is a National Water Authority (ANA in Brazil and CONAGUA in Mexico), other executive institutions at lower levels (state and/or basin) together with different councils opened to participation of society. In Brazil there are councils at the national, state and basin levels and in Mexico at the basin level. At the basin level, the actions are more focused in local problems and this is the appropriate level for participation of municipalities as a water user and potential polluter of the basin.

A common problem in many countries is that there is a lack of connection between the institutional arrangement together with its pertinent decisions and the necessary and strategic investments. In other words, decisions supported by the institutional system are not implemented because the investments are still being governed by sectoral decisions. In general, the institutional arrangements are weak with low level of measurable outputs. It is fairly common to observe a very weak connection between water resources management at the basin level and the water & sanitation management at the city level.

3.2 WATER RESOURCES MANAGEMENT AT BASIN LEVEL

Planning at the basin level must take into account principles, guidelines, goals and targets defined by National or/and Regional Plans. At the city levels the planning instrument is the Integrated Urban Water Plan, which must consider the inter-relations with Land Use planning and other infra-structures systems, as shown in Figure 3.

The Integrated Urban Water Plan must be developed taking into account all water uses and environment impacts in the urban area, together with its consequences on social and economic development. The main impacts of urban areas in the basin are:

- water use and consumption reduction (demand management), both from surface and groundwater sources;
- water quality impact on surface and groundwater sources;
- increase in flooding vulnerability due to urbanization.

Planning at basin level means establishing limits to water demand, water quality and flood risk, in order to prepare the mitigation of these impacts considering all users and also infra-structure investment levels.

To articulate these two levels of planning, basin level and municipality level, is one of the key elements in the IWRM and IUWM development. Table 4 presents a set of different components recommended to foster integration. Box 1 shows an example of the Guayllabamba Basin Plan developed under this framework to integrate both levels.

The main difficulties usually found in this type of institutional arrangements are:

- In some countries the basin committee have only an advisory role and the decision system is under a government agency; this arrangement weakens the participative process and the collective “ownership” of the basin;

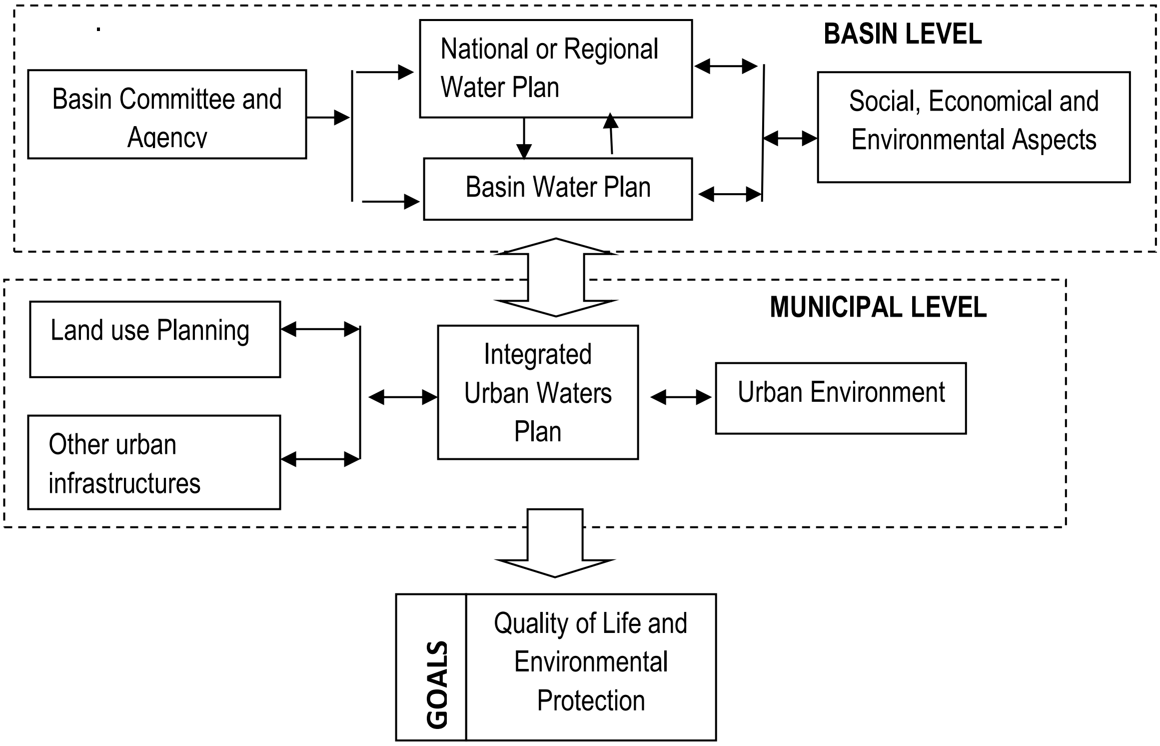

Figure 3 Integrated Water Management at basin and Municipal levels.

Table 4 Basin and Municipal IWRM (Tucci, 2010)

Scale	Administration	Management	Instruments	Characteristics
Basin[1]	Nation or State	Basin Committee and Agency	Basin Water Plan	Sustainable management of quantity and quality of water sources to minimize impacts.
Municipality[2]	Municipality	Water Agency or Municipality	Integrated Urban Water Plan	Sustainable development of urban water facilities, minimizing downstream impacts and based on the Basin regulations and guidelines.

[1]-Large basins (> 1000 km^2); [2]–Area covered by the municipality and its major drainage basins (< 50 km^2).

- Lack of integration between national and local levels (municipalities); in many cases, large investments, such as those in Water Supply & Sanitation, are managed at the national level and do not take into account the integration with other actions that occur at the municipal level or with the Integrated Urban Water Plan;
- Lack of institutional capacity to deal with more complex and integrated problems, since this requires different technical and managerial skills to deal with integrated decisions shared by several agencies; there is also an important gap of technical capacity usually more deep in municipal agencies that must be overcome with strong capacity building programs;
- Lack of long term permanent investments and commitment on strategic planning in order to keep and meet the goals: The process of developing basin committees, with participation of society and users, as well as good IUWM instruments may help to guarantee the

continuity of the previously decided set of actions. Having basin committees organized and operational is important, but it does not necessarily means integration or efficiency and, most of all, to prove its usefulness its performance requires measurable output.

▪

Box 1 Guayllabamba Basin Water Plan (Tucci, 2009)

The Metropolitan Area of Quito, Ecuador, with 2 million people, is located in the Upper Basin of Guayllabamba. The most important issues in this basin are an important water demand for agriculture, water supply for the population, discharge of sewage without treatment, high risk of natural disaster and a fragile environment. The basin water committee is under implementation after the approval of a new national water law. A Basin Water Plan was developed taking into account the overall situation of the basin and the related Quito urban water issues. The proposed Basin Plan framework is presented in Figure 4. The Plan has two basic components dealing with Institutional and Information needs and other four strategic components: water quantity, water quality and environment, urban waters and natural disasters.

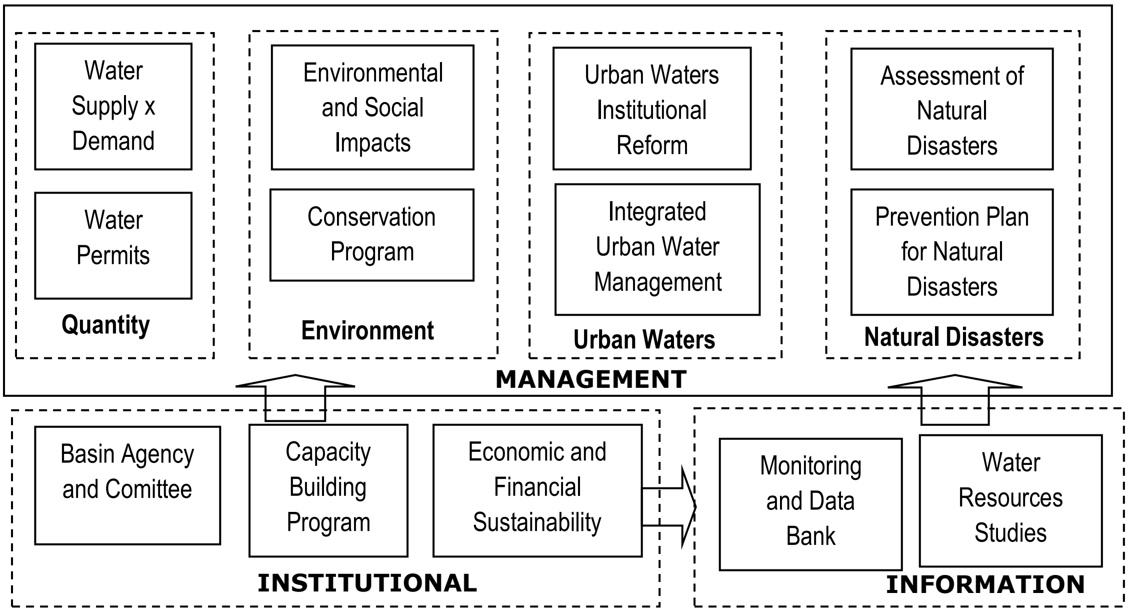

Figure 4 Integrate Water Resources Management in Upper Guyallabamba Basin, Ecuador (Tucci, 2009)

3.3 INTEGRATED URBAN WATER MANAGEMENT

IUWM is a component of the Urban Sustainable Development goal and it must be developed within the management structure of the municipality, with its several components and correspondent interactions. The existing literature illustrates its concepts and examples that justify why good practices in IUWM are needed.

3.3.1 Urban Sustainable Development

Urban sustainable development is a concept developed with the purpose of coping with the conflict between economic and social pressure of land development with protection and conservation of the natural resources in order to allow an overall reasonable sustainable living.

The objective of *sustainable urban development* is to improve the quality of life of the population as well as environmental conservation. Good living standards are only possible in a well conserved environment that provides for the needs of the population.

The main components of urban system, as shown in figure 5, are:

Social and economic aspects: The social and economic processes are the main drivers of the urban development, since it creates opportunities for jobs and better living conditions, and also allow the development of modern facilities;

Land use planning and management: occupation of the land must be disciplined in order to help implementation of infrastructure and essential facilities, to reduce risk and to organize urban zoning in order to, at the same time, facilitate living conditions and improve living standards. Usually a land use master plan is developed;

Infra-structure system: it comprises water, energy, communication and transportation systems infrastructure that must be planned and managed to support land use occupation and development. It can be implemented by public or private agencies, but it must be regulated by the municipality;

S*ocio-environmental management*: the management of the urban environment may be conducted by municipal, state or federal entities, according to the local institutional arrangement rules. It involves the evaluation and approval of projects, monitoring and inspection to aim for a sustainable urban development;

Institutional development: it comprises policies, legal framework and institutions that make the management of the cities possible and it is implemented by an arrangement of legal, economical and social instruments.

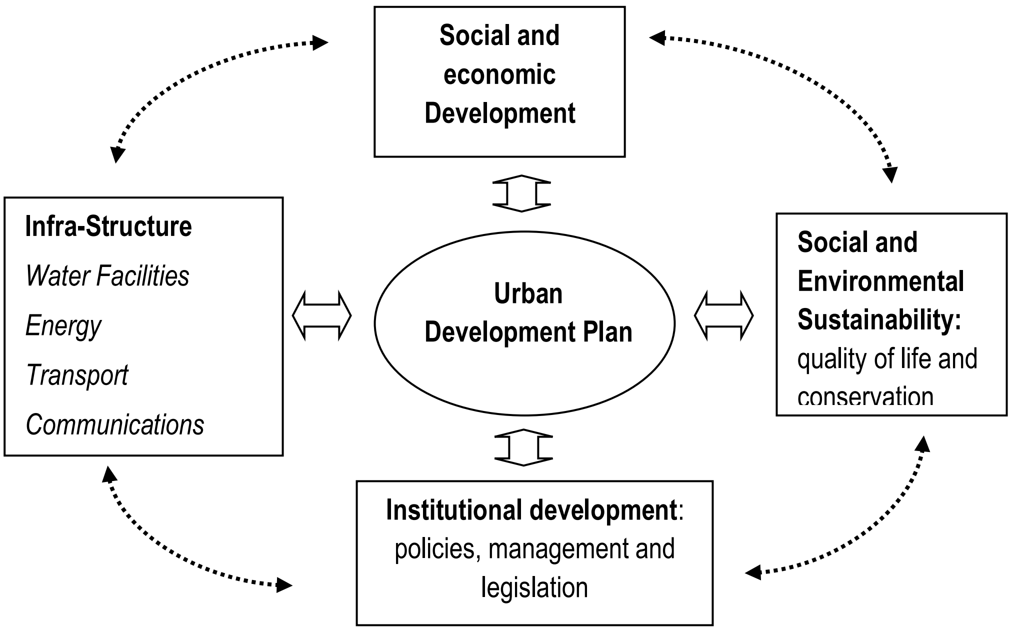

Figure 5: Urban System Components

3.3.2 Why IUWM?

Urban management evolved in a fragmented way and frequently with urban planning disassociated from urban water facilities and without health and environmental goals. Urban water facilities were also frequently developed in a fragmented way, with water supply, sanitation and drainage developed without common goals and often conflicting implementation actions, usually creating more problems than bringing solutions.

Figure 6 shows an urban channel in Assunción (Paraguay) with an array of problems very common in Latin American cities: population invasion of conservation areas, lack of proper sanitation, solid waste dump in the channel, high flood risk, high risk of diseases and environmental impacts. This is a typical situation that needs to be addressed in an integrated manner such as an urbanization plan developed together with integrated water and environmental facilities.

Figure 6: Paraguay Creek in Assunción, Paraguay.

In the urban environment the driving force is the real-estate development, with construction of new houses, business and facilities. The most common demanded water infra-structure is water supply and sanitation facilities (WSS). Storm water infrastructure and solid waste collection are not managed together with WSS systems. *Urban water related services* provided by the cities should include the four components: water supply, sanitation, storm water and solid waste. To achieve the goal of a sustainable urban environment, which includes environmental conservation, health, economic and social aspects, management off urban development must be developed in an integrated way (figure 7).

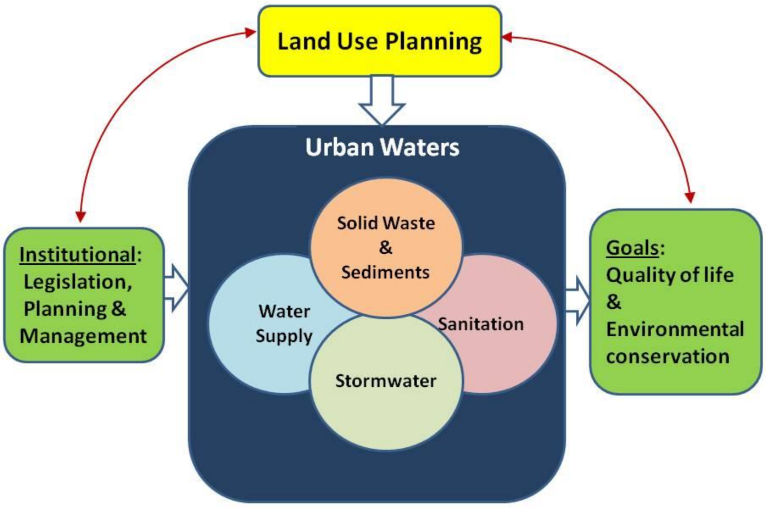

Figure 7: Conceptual view of the components of Integrated Urban Water Management (Tucci, 2009).

Urban water facilities and urban development are interdependent and have many overlapping areas. They are usually managed by different systems and institutions. Even within the so called urban water facilities it is fairly uncommon to have them implemented, managed and operated by the same institution or, at least, under an integrated arrangement. This condition creates enormous difficulties in managing common issues. Some of those common issues may be:

- *Water supply and other water services*: (a) wastewater and storm water discharges pollute the water supply source*;* (b) leachate from landfill sites pollutes groundwater and/or downstream rivers; (c) erosion may affect water supply sources;
- *Sanitation and Storm water: (a)* combined network for wastewater and storm water affects the efficiency of treatment; spill of pollution to rivers, plus odor and disease transmission, more critical in warm climates; (b) in separate system the major challenge is to avoid the connection of rain water in sewer network and also the

opposite, sewage in storm water network; (c) lack of collection coverage will impact storm water sewers because they will receive sewage through illegal connections;

- *Storm water and solid waste:* (a) storm water network efficiency is affected by lack of street cleaning and solid waste services, since it can clog pipes and channels; (b) drainage and erosion control require common strategies because sediments will affect the performance of the drainage system.

To provide integrated management of water related facilities is usually very difficult due to the following reasons:

- Traditionally these services were provided by different institutions and it is very difficult to change and create a new integrated institution or to make them work together;
- Some are not quantifiable and the public perception of the benefits tends to be low. As a result, there is low feasibility for charging and for cost recovery of investments; this is the case for storm water and in some cases even for solid waste management;
- There is lack of law enforcement and frequently the regulatory agency does not exist. In this case, there are no measure of utility performance and no efficiency indicators for the services; the usual consequence is that price is high with low efficiency of the service.

Cities that were able to integrate those services show a better performance than the others. The population perceives the quality of the service and usually is willing to pay for improvements. Another important aspect is that when the services are provided by the same agent, they can be billed together which facilitates the payment, the control and also the punishment for those who fail to pay. When the services are provided separately it is very difficult to charge for services such as storm water drainage and solid waste collection and disposal. If the user fails to pay, there is not an easy form of enforcement. The total budget for the services is better managed if the revenue is collected together. When the services are provided by different agents usually the drainage and solid waste services are maintained with public budgets and this almost always means low investment capacity.

If it is not possible to manage all the services under one institution, at least there must be an effort to operate under the same plans, guidelines and goals to try to improve performance and efficiency.

3.3.3 Background on IUWM

Urbanization in the 21st century is facing new dilemmas, since the size of the cities grew to unprecedented levels. Currently there are 8 mega-cities over 20 million people, 18 over 10 million and 450 cities with more than 1 million people. The vast majority of these large cities are in developing countries. The world has now megacities with population numbers higher than many countries. The quality of life is decreasing in these urban agglomerations, mainly in developing countries, and becoming unsustainable due to transportation and traffic difficulties, energy and water shortages. The impact of those unsustainable cities are felt in hours lost in traffic, human and property losses in floods, health hazards, environmental degradation, and so on. The existing strategies that promote this type of development are completely outdated, since they are based on the concept of unlimited natural resources.

The main reasons for such problems in developing countries are related to the lack of institutional capacity together with fragmented urban planning and infrastructure implementation and also a low investment capacity.

New concepts for improving cities are based on making cities greener and healthier places for their inhabitants and protecting the resources for a better environment (Leitman, 1999). Modern cities must replicate nature functions of closed cycles, promoting reusing and recycling of natural resources, mimicking nature functioning in reproducing the hydrological cycle and closed systems, and others. The principles of Integrated Urban Management are meant to help in organizing the integration of urban water services in order to fulfill such premises.

During the 19th century and the most part of the 20th century, the main purpose of WSS systems was to supply the population with safe water, to remove, as quickly as possible, the sewage and other potential sources of contamination, to drain storm water and wetlands to control spread of diseases, with the sole purpose of improving hygiene and eliminating health hazards (Chocat et al, 2001). This traditional approach was based in centralized water supply and sanitation systems, together with fast conveyance structures for storm water drainage. The consequences were environmental impacts in water quality, erosion and sedimentation, floods, low flow reduction, flora and fauna impairment, among others (Vlachos and Braga, 2001, Marsalek, 2008). Modern cities are now facing difficulties with high cost of rehabilitation and replacement of aging infrastructure, with urban sprawl that requires more water and high investment in effluent collection, with increase in vulnerability to natural disasters and climate change and threatened water supply sources..

New paradigms such as IUWM, emerged in last decades (Marsalek et al,2001) to contribute to a holistic approach to water supply, sanitation and drainage management (Grigg, 1999, Heaney et al 2000). In developing countries solid waste and sediment management was included in the process since it causes an important interference in the other systems (Tucci, 2007). In 2007, Brazilian legislation defined water supply, sanitation, drainage and solid waste as the four components of the Basic Sanitation Plan. Mitchell (2006) presented the principles of IUWM as follows:

- Consider all parts of the water cycle, natural and constructed, surface and subsurface, recognizing them as an integrated system;
- Consider all requirements for water, both anthropogenic and ecological;
- Consider the local context, accounting for environmental, social, cultural, and economic perspectives;
- Include all stakeholders in planning and decision-making processes;
- Strive for sustainability, aiming to balance environmental, social, and economic needs in the short, medium, and long term.

3.3.4 Strategy for IUWM

A sound strategy for the integrated urban water management should be based on the principles shown in Table **5**. These principles are based on the following premises:

. to develop new urban standards taking into account the sustainability of water issues;

. to protect water supply sources using a set of mechanisms, including command and control instruments to discipline land use and effluent discharges, economic mechanisms to motivate good practices; to include housing policies and investment as an intrinsic part of water management;

. to improve the water supply system with the overall objective of sustainability, introducing practices to control and reduce the demand as a means to make the best use of the supply sources;

. to improve the sanitation system aiming, not only at the general objective on environmental protection, but as a means to guarantee water availability for other users;

. to fully integrate flood control practices with land use planning, construction codes and restrictions, using economic incentives and command and control mechanisms;

. to manage solid waste as a part of environmental management of the city, which includes not only reduction of waste and recycling, but also introducing practices to minimize impacts of solid waste and sediments on the drainage system.

Table 5: Overall strategies IUWM

Principles	Tools	Benefits
Sustainable urban development	(i)balance densification and impervious areas (ii) planning of green spaces linked to urban water management (iii) restrictions and economic incentives to protect of municipal water basin (iv) incentives to green buildings construction	Quality of life; environmental protection; sustainability of urban water services
Preservation of water supply sources	(i) regulate and enforce land use in the water supply basin (ii) use of command- control mechanisms, economic incentives, payment for environmental services	Conservation of water quality; health risks reduction
Conservation and efficiency of water use by controlling demand	(i) metering water use (ii) use of a sustainable tariff structure (iii) reduction of financial and physical losses (iv) incentives for new appliances and equipments for demand reduction (v) incentives for water reuse (vi) education for water use.	Eliminate the need of new water sources; reduction of energy use, reduction of sewage volume both for collection and treatment; reduction of the risk of water shortages
Improvement of sanitation services	(i) incentives for households connections (ii) incentives for industrial and agriculture reuse (iii) reuse in urban irrigation of green spaces (v) distributed systems	Better environmental conditions; restoration of rivers and lakes; reduction of the risk in groundwater contamination
Sustainable storm water management	(i) on site measures of infiltration and green building practices (ii) storage and reduction of runoff (iii) good practices to improve water quality (iv) rules and practices integrated to urban land use and environment	Flood frequency reduction; water quality improvement; erosion control; reduction of damages and hazards
Sustainable solid waste and sediment control management	(i) implementation of recycling practices (ii) implementation of charging for the service by volume or weight in order to decrease waste production (iii) control of civil construction waste (iv) control of sediments in construction sites (v) disincentives for the use of plastic bags and plastic containers	Reduction of disposal sites; reduction of costs in solid waste collection and disposal; environmental protection; reduction of costs in drainage maintenance; reduction of flood risks
Institutional practices	(i) integration of services in only one institution (ii) stimulate cost recovery practices (iii) enforceable laws and regulations (iv) environment certification (v) public participation (vi) capacity building	Improvement of services; reduction of investment needs; reduction of operational and maintenance costs; environmental protection; improvement in quality of life

3.3.5 IUWM framework

IUWM strategy needs to be developed in three major steps, as shown in figure 8.

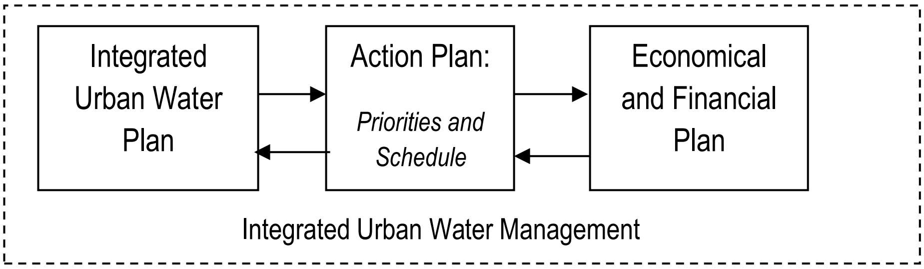

Figure 8 Integrated urban Management

Integrated Urban Water Plan

Table **6** shows the most common issues and respective consequences that validate the implementation of IUWM practices and which planning strategies and mechanisms can be used.

The main mechanism for this phase of action is to develop three sets of plans: (a) Urban Master Plan; (b) Integrated Urban Water Plan; (c) Institutional Reform Plan. The three parts will compose what is called an **Integrated Urban Water Plan**.

The overall framework of the Integrated Urban Water Plan is proposed in figure 9 which describes the combination of policies, plans, measures and expected outputs.

Policies: definition the principles, objectives, goals and strategies of the Plan; due to the complexity of such Plan, many strategies must have its definition based on the selected goals and in expected difficulties for the implementation. It is very important to define Urban Scenarios, which must include an assessment of the city expansion taking into account slums and the informal city dynamics. The plan has to be prepared for time spans of 10, 20 and 30 years, considering the local economical and social changes as well as the regional and country development. It must also include a risk assessment for extreme events, natural disasters when pertinent, and other risks that may impact the region.

Assessment: two major components must be assessed: the urban water services (water supply, sanitation, urban drainage and solid waste) and impacts that will be produced by either having or not having proper services (on health, environment, vulnerability to floods or natural disasters and amenities – facilities and recreation). This assessment must take into account urban development situation, investment capacity, institutional arrangements and desirable goals.

Measures: measures are divided in two groups (i) non-structural: new policies, legislation, institutional reform of institutions and good practices in the city, including “command-control” (enforcement), economic mechanisms and incentives, certification practices; (ii) structural: related to construction of infrastructure for implementation of water related services.

Table 6: Issues, consequences and strategies for IUWM

Issues	Consequences	Planning strategies	Mechanism
Unsustainable Urban development	High density occupation; lack of recreation areas for public use; increase in impervious areas; unprotected sources; expansion that generates high sediment yield (erosion) together with degraded areas	*Non-structural measures:* regulation of new constructions, building codes, economic incentives for conservation and preservation areas; *Structural measures*: recuperation of degraded areas, rehabilitation of urban spaces	Review or development of the Urban Master Plan
Limited implementation/ coverage/quality of urban water services	Population without water supply; lack of sewage collection and treatment; lack of solid waste services; lack of urban drainage and flood control management; water pollution	*Non-structural*: economic incentives for reducing water demand; regulation for urban drainage impact transference; regulation for household connections to sewer's network; education for solid waste reduction; recycling incentives. *Structural*: water supply and sanitation investment to the expansion of the systems; urban drainage infrastructure; expansion of solid waste services and proper disposal	Integrate Urban Water Management Plan developed accordingly to basins / areas in the city.
Lack of integration in city management	Fragmented institutions without common goals, lack of attention to the client; lack of integrated development.	New legislations and Reform of the Institutions dealing with Urban Waters management in the city	Institutional Reform Program

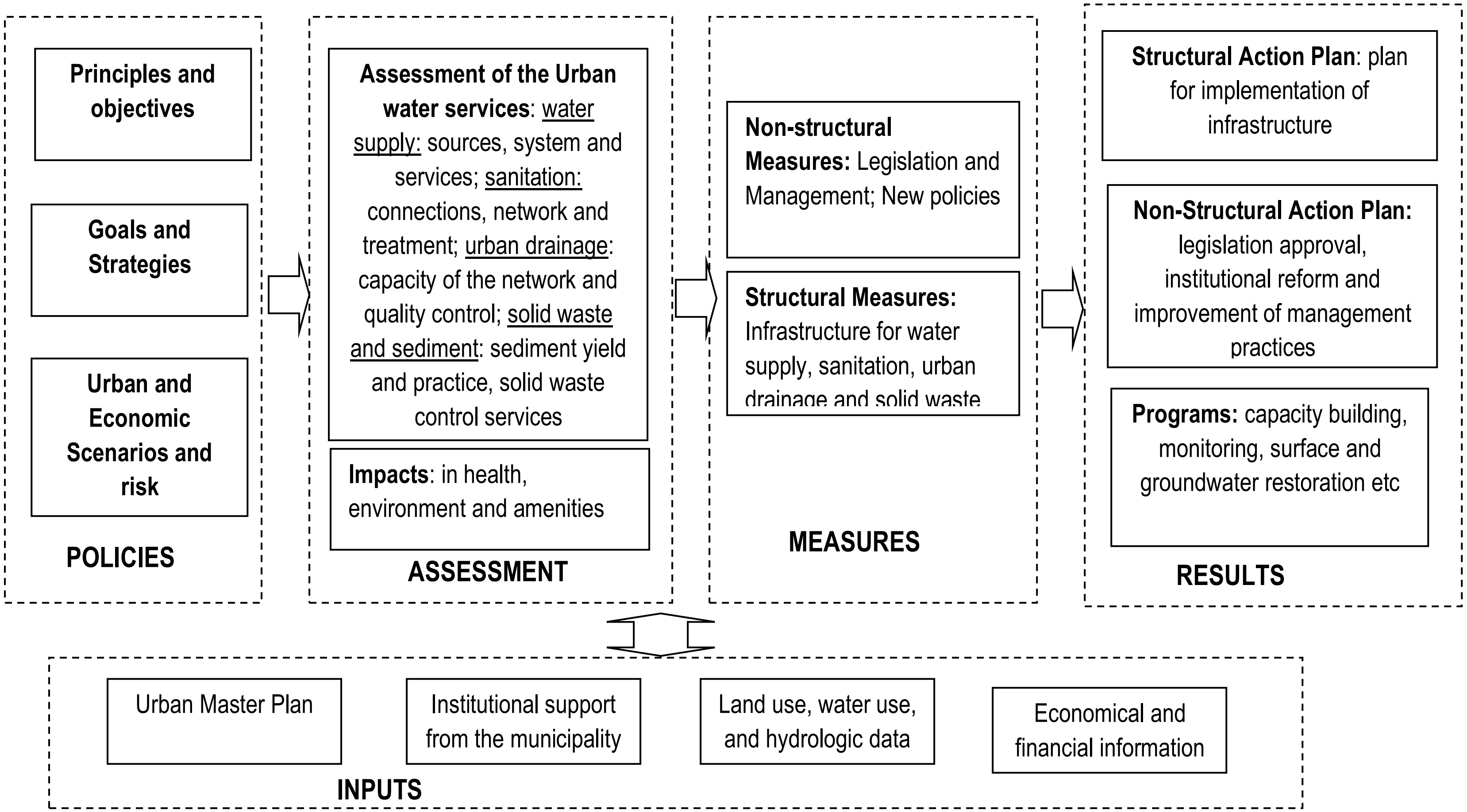

Figure 9 Integrated Urban Water Plan.

Results: Three sets of actions will result from this activity: (i) the **Structural Action Plan**, that will present the infrastructure to be implemented, priorities, budgets and schedule of implementation, taking into account the investment capacity and cost-recovery possibilities; (ii) the **Non-Structural Action Plan**, with the need for institutional reform and new laws, regulations and management instruments; and (iii) the set of **Programs**, which presents the list of activities to be developed to complement and support the Structural and Non-Structural Plans, in the short, medium or long term, in areas such as identification and recuperation of degraded areas, capacity building, monitoring, surface and groundwater restoration, implementation of conservation and preservation areas, water supply basin protection, among others.

Action Plan

The Action Plan is the implementation phase of the Plan and it requires strategic preparation that must be developed along the planning effort.

The framework to develop the Action Plan is presented in figure 10 and the time schedule may be defined here as:

- Short term: the activities developed in the following 2-3 years;
- Medium term, from 2 to 5 years;
- Long term from 5 to 10 years period of implementation.

The Action Plan must be developed considering a long term urban scenario development of 10 to 30 years.

This time span here suggested must be analyzed in accordance to each local reality of institutional, social, political and financial constrains.

The kind of action that must be developed in each time span period varies and they can be separated in the following categories:

Short term: Usually referred to emergency measures. In this phase it is important to implement the most urgent structural measures and also begin the implementation of non-structural measures in order to hold the impacts in the basin. Some of the usual actions are:

- *Protecting urban water sources*: (i) evaluation of the pollution load; (ii) regulation proposal to control the occupation of the urban water supply sources basin; (iii) priority projects to implement sewage collection and treatment system in the existing urban occupation of the water supply sources basin. These activities have to be developed as soon as possible in order to hold the contamination of the urban water sources and to support the future implementation of a comprehensive water supply plan.

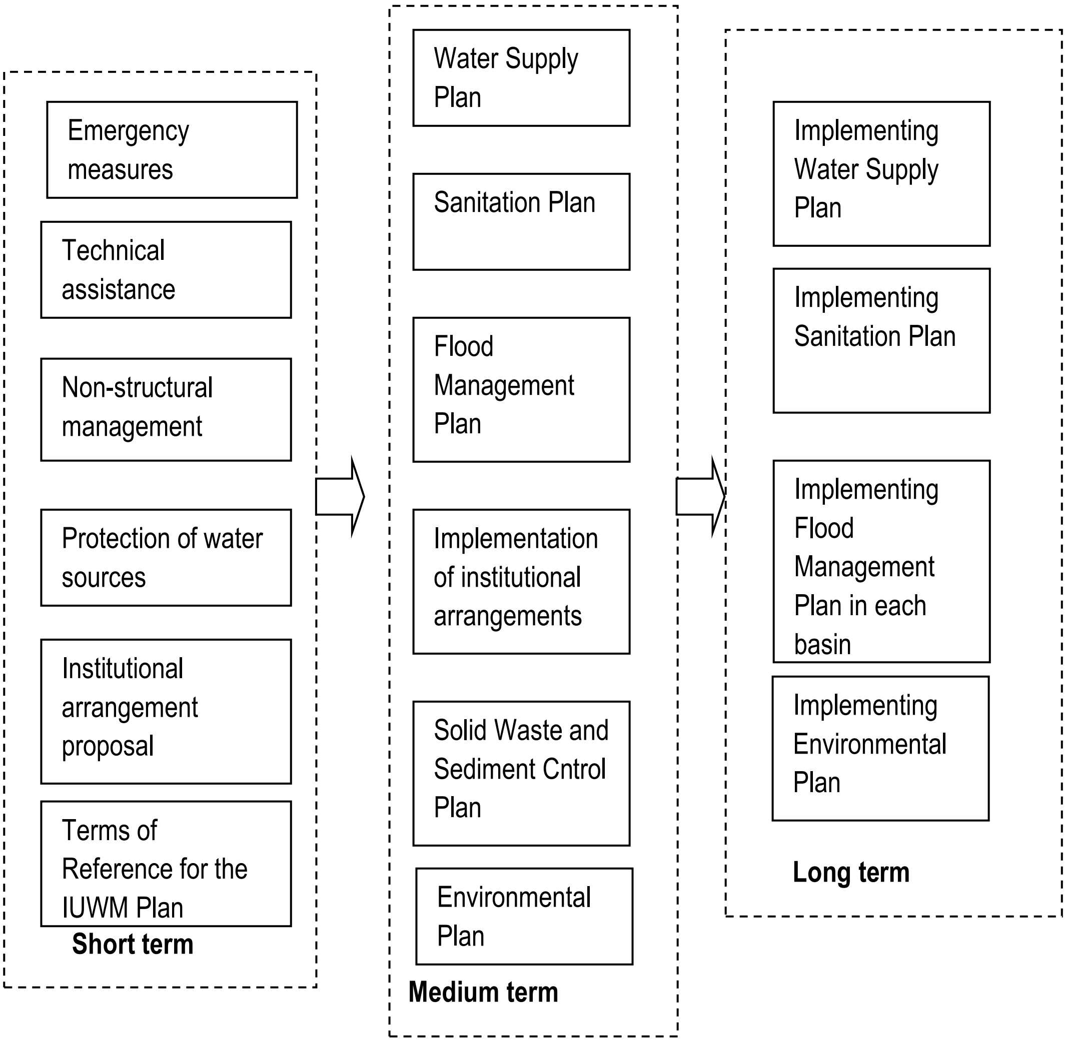

Figure 10 Steps of Action Plan proposal

- *Institutional arrangements proposal*: these activities would take into account the institutional aspects of the basin in order to propose a comprehensive way of management the overall urban waters. The main actions are related*: (i*) legislation for urban drainage, solid waste and water quality control; (ii) legislation for implementation and cost recovery of sewage systems; (iii) water supply economic mechanisms;
- *Terms of reference of IUWM* and contracts: First assessment, terms of reference of the plan, biding and contract development.

Medium term:

- *Water Supply Plan and Sewage System Plan (water & sanitation):* it is very important to be an integrated plan, since the actions should prioritize the recovery of the water supply basin and these two major components of urban water should be planned in an integrated way;

- *Flood Management by Basins:* the plan should be developed by basin for the existing impacts. In the short term activities the sequence of basin Plan and its implementation has to be defined based in the issues and priorities. In this phase a major effort has to be developed to plan the solution for each basin in the urban area.
- *Implementing Institutional Arrangements:* In this phase the institutional arrangement planed in the short term phase has to be implemented in order to cope with all development which is under development in the basin such as the Plans and the implementations.
- *Implementing the Solid Waste Plan:* This Plan implementation could start in the previous phase, as a pilot, but in this phase the implementation should cover all the area. It should take into account the institutional structural reform of the previous component.
- *Environmental Plan:* Development of a plan for the basin with the definition of costs in order to recover its natural assets and develop the conservation of the areas together an improvement of recreational conditions for the population.

In the development of the plan it is important to construct the overlapping aspects in order to develop integrated solutions. These plans should be developed together at the same time in order to develop the integrated components.

Long term: This phase is to conclude the implementation of the all planned actions. It could start in 5 years or less, depending of investment capacity and it could end in 10 years.

Economic Assessment

The first economical assessment of the suggested activities will allow the decision makers to form an idea of their capacity to implement them, in time and money. They will need to decide the sources of the required amount of funds needed, if they need to borrow it from central Government and/or from international banks and/or multilateral agents and/or private sector.

Cost of the Implementation and Operation of the Services: In annex D there are tables presenting the unit costs for implementation and operation of water supply, sanitation, urban drainage systems. There is an important interval of variation of the costs due to local conditions in each city. These numbers are global and are to be used as a first estimation.

In water supply and sanitation the simplest estimation is obtained by the number of persons to be supplied by the services. In urban drainage indirect methods are used and there are the costs for implementation of a new drainage system and costs to control the impacts of floods with the existing drainage. Solid waste systems are dependent of the number of persons, extension of the public areas and distance of disposal sites.

Operation and maintenance costs are estimated based on the annual proportion of the investments.

Investment capacity: The investment capacity is related to the city tax income and in population income to support new investment and cost recovery of the new implemented utilities. The water supply and sanitation bills, together with urban drainage and solid waste bill should represent a small proportion of the income of household owner. There are many structures of cost recovery which could be used based on the social and economic conditions of the communities for investments and for services.

The cost recovery on the investment can be developed by:

Subsidy: the subsidy can be given by the government, using with national funds; it can be as cross – subsidy, by the higher income population paying for the lower income population using different tariffs by city areas or consume; it can be by using general and uniform taxes independent of the level of service use, which may be unfair and it may lead to low conservation of the resources;

Full cost recovery: In this scenario there are two major costs: investment and operation and maintenance. The investment costs are financed and charged along the time to the owner of the benefitted properties. The operation is the service cost which is permanent and for water, sanitation and solid waste must be dependent on the use of the service; for urban drainage must be dependent on the impervious area and it is a fixed cost along the time per property. Solid waste may be assumed as constant cost.

The total cost of investment must be evaluated together with the cost of operation and maintenance in order to have a more real assessment of the payment capacity and the cost recovery possibility by the population since it will have to be paid together services fees.

3.3.6 Institutional aspects

Institutional construction of Urban Water Management is based two main components: (a) legal regulations which represents the main aspects of the policies adopted; and (b) governance of the services in the city with the related economic aspects of services sustainability.

Some of main institutional issues in urban waters have been described in chapter 4, but in here some selected aspects are emphasized in order to guarantee the sustainability of the investments.

Governance

Governance of the services has to be planned to all services. Most of the cities in developing countries have a fragmented management, with Water Supply and Sanitation services being provided by public or private companies, very frequently uncoordinated with the municipality, and a much disorganized way of providing Urban Drainage and Solid Waste services, very frequently without sound governance and cost recovery policies. The result is a large amount of solid waste in streets and in rivers with frequent floods.

Usually the best arrangement is to have in the same institution (private or public) all four services due to: (a) scale of economy in the services and in the charging services; (b) better management of interface conflicts such as: sewage in storm water network and vice-versa, solid waste in the drainage, cleaning of networks and detention ponds, among others; (c) accountability, since it is easy for the population to identify the service providers and check its performance; (d) services performance can be better measured and linked to the institution.

When there are three institutions (water supply & sanitation, urban drainage and solid waste), the responsibility of the service is fragmented and it is common to have conflict among the institutions and professionals with loss of service performance.

In many cities there are opportunities for the existing water & supply institution to assume all the services, but usually the cost recovery of the additional services are not well developed. Plus, the funds are mixed in the overall budget of the municipality, with difficulties in changing administration and negotiating yearly budgets.

There is an urgent need to institutionalize urban drainage and solid waste utilities. Solid waste utilities are fairly common but urban drainage utilities are almost nonexistent. In Brazil, with more than 5,000 municipalities, there are only two cities with a Storm Water Utility (both public), but both with a weak cost recovery policy. Usually the main difficulty to implement a new utility is to charge a new tariff of the population, because it is politically difficult for the decision makers.

The governance model is strongly dependent of the economic arrangement for stormwater and solid waste. The alternatives usually are:

- One institution for all four services:
- Two institutions, one storm water and solid waste, keeping water supply & sanitation in another existing company;
- Three institutions: storm water, solid waste and water & supply and sanitation with the third one;

There are also combinations of the above three alternatives, since the city may have its own institutional complications.

It is recommended that the governance together with economic sustainability should be a component of the planned investments for the city. The output should be an integrated governance system with cost recovery policies.

Economic sustainability

The cost recovery policy of the utilities has important differences in developing countries. In water supply & sanitation services it is possible to charge based on water use and the infrastructure is designed to support an increase in consumption. Solid Waste services are also based on the amount of the produced solid waste, but in most of the developing countries service is charged by a flat tariff per year which does not allow conservation or even increase the efficiency of the services. In Storm Water services the cost should be based on the amount of overland flow generated by the proprieties which is a function of the impervious areas. However, most of the cities are funded by a common tax in the county budget which usually results in lack of maintenance and prevention to urban drainage floods.

The cost recovery policy of storm water utilities is based on the impervious areas of the properties. Usually an impervious area generates 6 times more overland flow than a pervious area. The mean tariff in West Coast cities of United States is about US$ 6/month/propriety. In a city of about

1,000,000 inhabitants with a density of 80 people/ha, a mean size lot of 400 m^2, and a mean tariff of US$ 5/propriety/month will result in a total revenue of US$ 18.750 million /year for the service.

In solid waste services, the cost should be related to the volume produced by the population, since it will stimulate recycling. One of the frequent economic mechanisms used in some countries is to charge the cost of the service in the packing used for the solid waste disposal.

It is recommended that the institutional reform must include a strategic plan for the improvement and implementation of the utilities of these services.

Legislation/Regulation

The legislation and/or regulation is a key aspect in supporting governance. Some of main aspects which should be address in the legislation are:

- *Concession of the services* and definition of the indicators of performance with assessment by an independent institution;
- *Conditions for charging for the services* as mentioned above. The jurisprudence of each country in the water services may change. In Brazil, tariff is for water supply and sanitation, for solid waste and drainage is tax. The first charge by consume and the tax is a flat value changing depending of the permanent use of the service;
- *Legal incentives and enforcement:* there are many sanitation systems in developing countries which do not work because of the lack of connections to the households. Usually this happens because it will mean an increase in the water bill, or due to the existing septic tank, but mostly due to lack of enforcement; in urban drainage the legislation should not allow the increase of the overland flow to the system from an individual property; incentives can be created to conserve water supply basin areas by the owners through payment for environmental services; penalties and economic incentives in solid waste could also be created.

3.3.7 Assessing the urban areas actual situation

Figure 11 shows the interconnections of the urban planning, urban water and the desirable goals for the sustainability of the cities.

The IUWM Plan development requires an assessment of the actual situation and the most urgent necessities of the case study. For a developed city the level of requirements are completely different from a municipality where there is not enough water supply, sewage and solid waste are in the streets near people posing a high risk of diseases. In the definition of the Action plan the emergency actions are to supply the basic needs of the population, but considering since the beginning the main principles of IUWM. There is not a standard approach for all cities; every local is different and it requires solutions based on: Climate, Water Resources, Land Use, Environment and mainly Institutional situation.

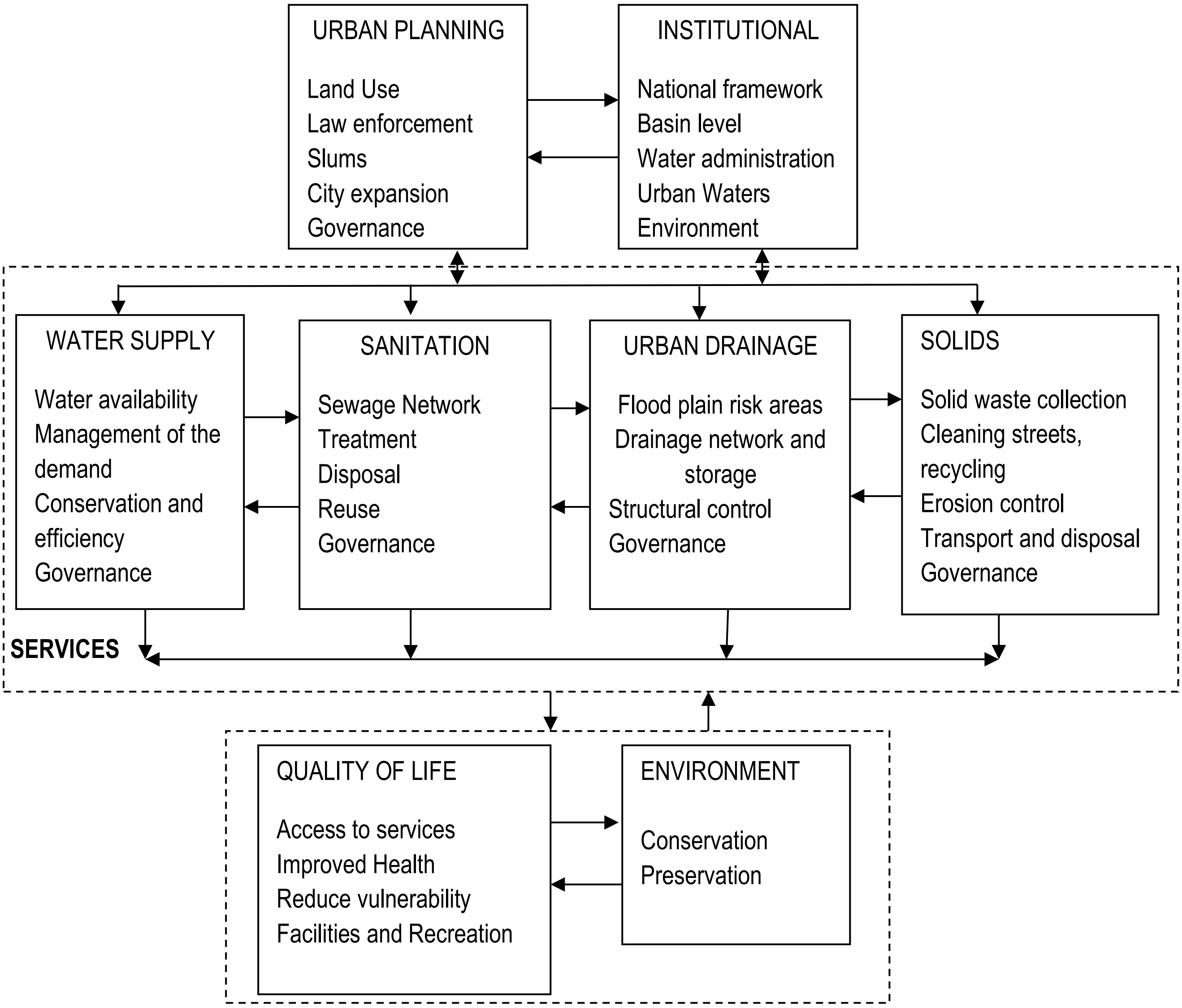

Figure 11: Components of Urban Waters and its interactions.

The development procedure described in the next chapter will describe the assessments that are necessary in order to find out the actual situation and the emergent needs in order to develop the strategy. The basic framework must be based in the real local conditions.

4. FRAMEWORK FOR URBAN WATER ASSESSMENT AND STRATEGY

This chapter describes the methodology for assessment and strategy development in IUWM that can help decision makers in planning and prioritizing investment in Latin America cities, and it may help support decisions in other areas of the globe as well.

4.1 ASSESSMENT FRAMEWORK

The objective here is to delineate a strategy to assess and to propose solutions for the most common urban water problems presented in the previous chapters. The strategy is based on the concept of INTEGRATION. It is clear that an integrated approach has the potential of creating a more efficient and sustainable set of solutions, to provide good living standards and environmental protection. The methodology is developed along the following five phases and in figure 12 a tentative schedule for implementation is suggested.

Phase 1. AGREEMENT PHASE: It is a preparatory phase which has the objective to identify which government levels must be involved in the process (municipality, county, state, national), as well as other stakeholders that may be involved as partners (private sector, NGO's) in the process of developing IUWM. This agreement phase is to seek commitment of the entire community to act in the preparation of the plan and also in the implementation stages;

Phase 2. RAPID ASSESSMENT AND STRATEGIES: This is a phase planned to identify the PROBLEM, or the main issues, and the related viable strategies. It must produce a qualitative assessment based on secondary information that can be gathered fairly quickly, it must be developed by local partners and it must be supported by the main financial institution;

Phase 3. UPDATE PHASE: This is the phase for a detailed quantitative assessment of the issues identified in the former phase, using: (i) tools such as models (a combination of land use, water balance, water pollution, drainage, and other required components) appropriated to the specific situation; and (ii) evaluation of the managerial, economical and financial circumstances, in order to decide the appropriate investments. It must be developed by the local planning team with support from a task force able to provide technical and financial assistance. The output of this phase will be an updated assessment and management plan.

PHASE 4. STRATEGIC PLAN FOR THE URBAN AREA: The updated Assessment Plan developed in the former step is validated through a series of participative meetings to discuss issues and strategies and to foster commitment of the involved stakeholders. The output of this phase is the reviewed report with the Strategy and Action Plan, including investment priorities and potential funding. It is also meant to close the gaps of knowledge and to create or strengthen institutional coordination among involved entities. It results in the IUWRM strategy report.

PHASE 5. IMPLEMENTATION AND MONITORING PHASES: Implementation phase is when the projects are detailed and implemented following the Strategic Plan. During this phase itis important to monitor the results and to develop a periodic review of the strategies in relation to institutional changes, economic constrains, and others.

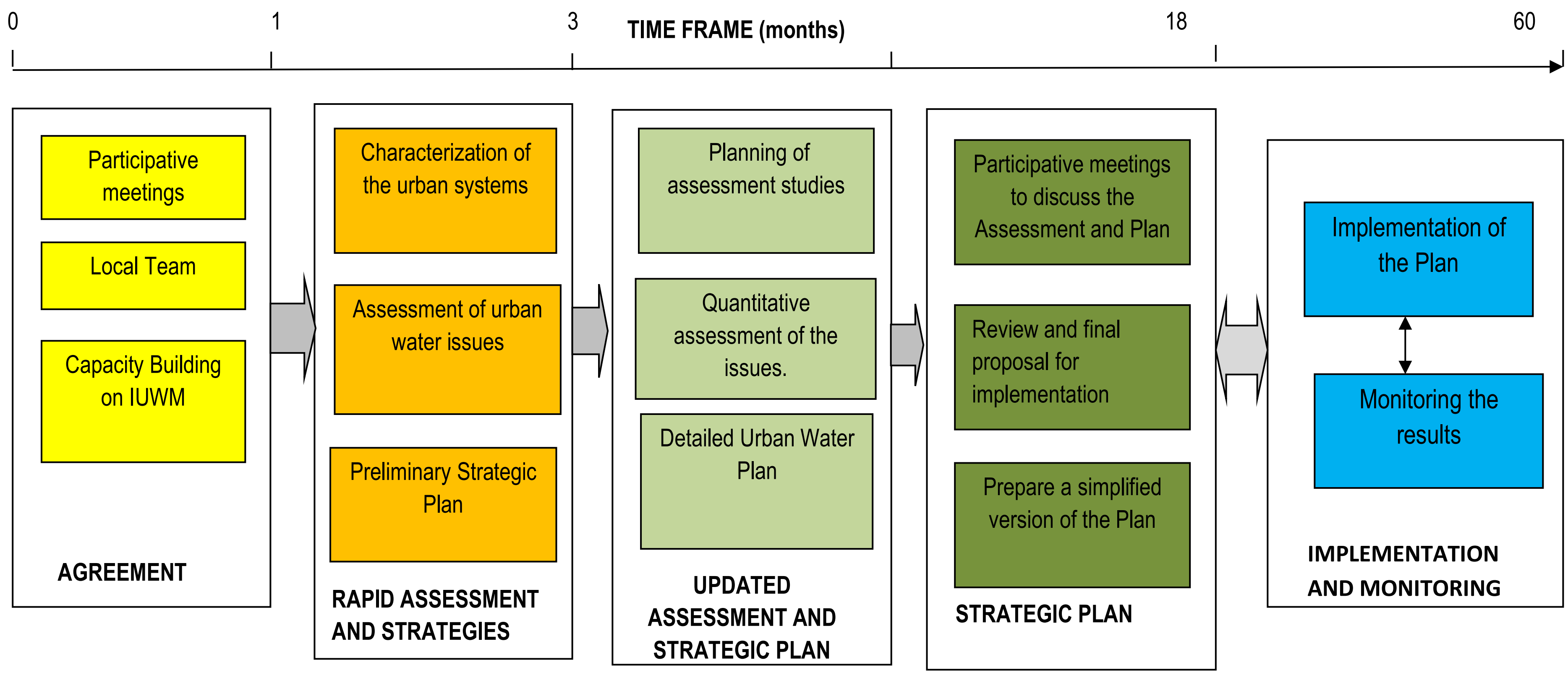

Figure 12: Framework of the methodology.

4.2 AGREEMENT PHASE

In this phase it is necessary to identify the government representatives from the municipality, and/or from other government levels, that will have a take upon the coordinating role in the development of the IUWM. This phase can be developed through the following steps, as shown in Figure 13: Agreement phase:

A.1 Identification of government (municipality and other levels) representatives and stakeholders related to or interested in water issues;

A.2 Development of the kick-off workshop, with the key institutional players, in order to confirm their interest and commitment in the preparation and development of an IUWRM diagnosis and strategy. The activities of this workshop are: (a) presentation of the main concepts and the methodology for IUWM implementation; (b) discussion of the scope for the pilot case; (c) agreement on a Local (technical) Planning Team with representatives from all relevant stakeholders as well as local consultants to support the activities;

A.3 Plan of activities to be executed in the coming phases, based on the first workshop results and listed in the proposed methodology;

A.4 A second workshop, organized to discuss the plan of activities and to launch the capacity building on IUWRM; organization of a first assessment of the urban water system with the support of a task force to provide technical assistance.

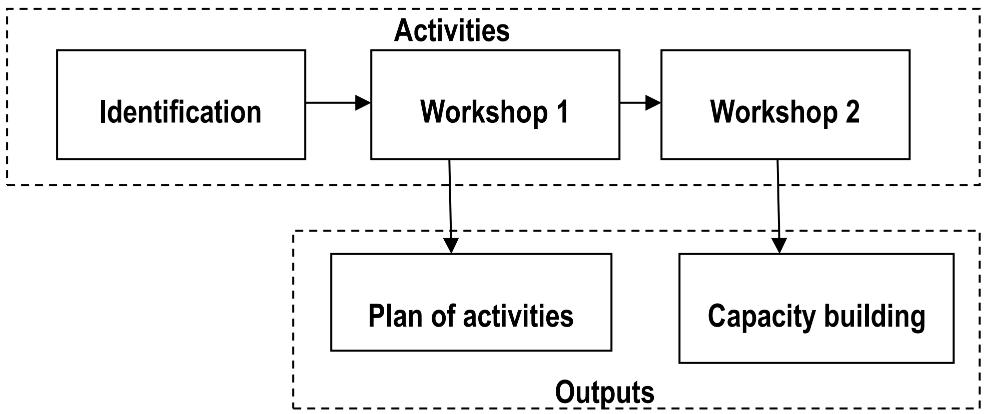

Figure 13: Agreement phase

4.3 RAPID ASSESSMENT AND STRATEGIES PHASE

This phase is designed to have the overall picture of the issues and to present a global strategy to solve it. It is very important to use this opportunity to clearly define the PROBLEM.

This phase is planned to produce a qualitative assessment of the urban water issues. It can be developed in three steps, *preparation, assessment and analysis*, as shown in figure 14.

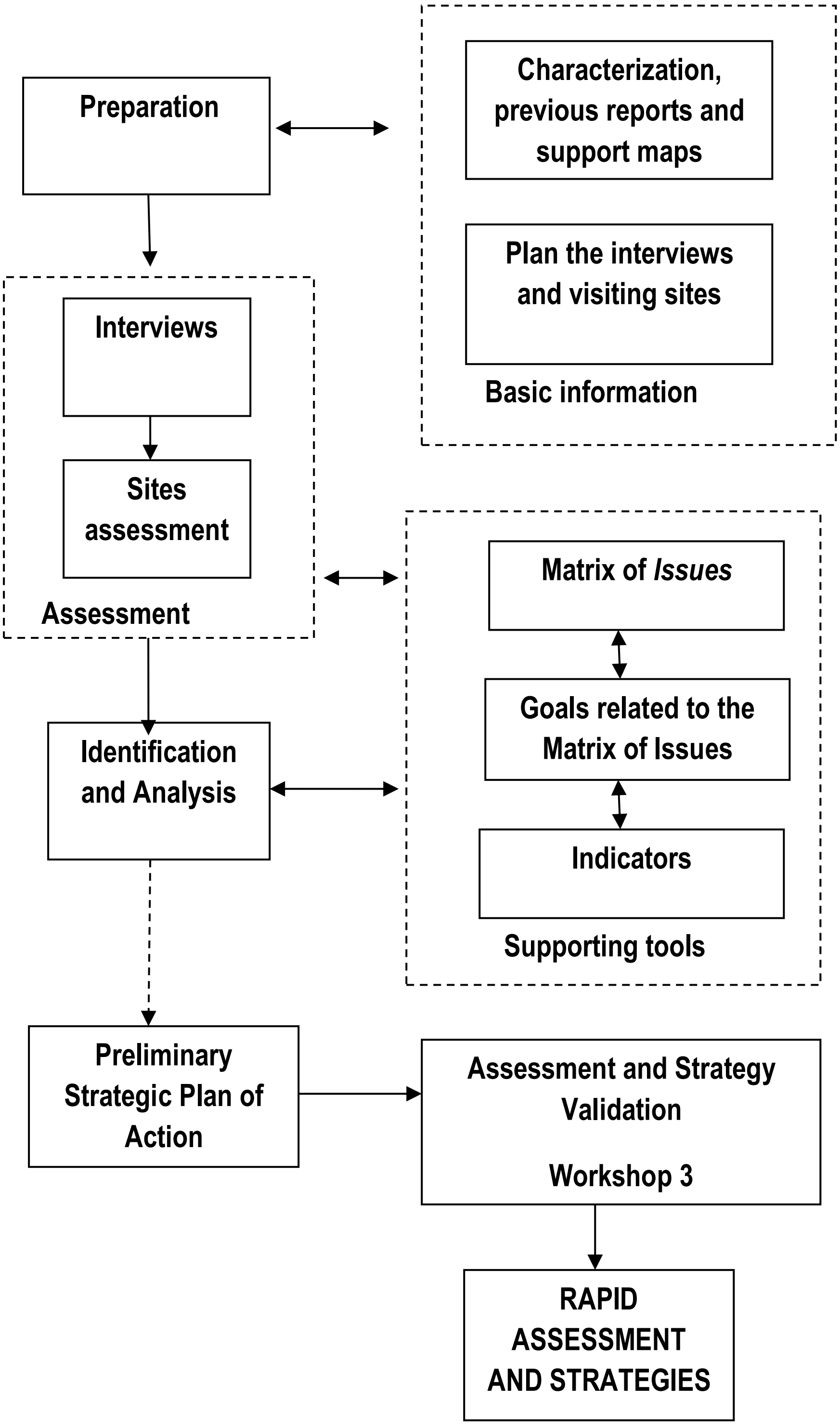

Figure 14: Activities to develop in the assessment

4.3.1 Preparation and Assessment

This step is used to have a first insight about the city, identifying main characteristics and issues.

Review the existing information such as: (i) previous existing reports about the country and water issues; (ii) existing basic information in the internet; (iii) existing maps with the urbanization, drainage and basin data.

Identification of the main stakeholders to interview: identification of people related to the following services provision:

- water services: water, sanitation, storm water and solid waste;
- urban development and planning;
- environmental conservation and licensing;
- water resources management;
- regulators and city managers.

The QMI Qualitative Matrix of Issue is presented in Annex B and it can support the definition of interview questions. Instructions for the interview are also shown in Annex B.

Identification of the sites to be visited*:* The preliminary information can be used to help defining a very first evaluation of the problem and site visiting may be of interest to complete the appraisal of the situation. The more important sites to visit are those related to municipal water sources; major urban drainage; floods sites observation if there is solid waste dumping in streets or water bodies; poor population and informal settlements; treatment facilities and the overall city environment. Maps and pictures are important pieces of information during this phase.

4.3.2 Supporting tools

Information and the preliminary local assessment results are put together to help the identification of the main issues related to urban waters. The interviews will help to outline a first insight on how the water managers and stakeholders view the situation. A first assessment can be concluded and the guidelines for task are shown in Annex B, under *selected issues* and *cause-effect relationships* tables.

Selected issues**:** The task is to fill the matrices with:

(a) Services: fill one matrix for each service (matrices in Annex B for each service); in the first column, list the major components of the service; for each component, fill the line with one problem per column.

(b) Goals matrices: select the desired goals and list them in the first column; for each goal, fill the row with the main impediments to achieve them.

Cause-effect relationship: The task is to merge the two tables developed in the first step, identifying for each impediment which are the services that are causing it.

For each identified cause-effect relationship, it is necessary to prepare a short text to justify the findings showing:

- Description of the issue
- Justification and evidence of the issue;
- Main causes of the issue and potential impacts

- Description of the potential solutions (if it was identified)

This step-by-step procedure is presented here only as a suggestion. The purpose is to get an overall feeling of the problems and consequences to make sure that any important issue will be missed.

At this phase the assessment is mainly qualitative and some indicators can be used to summarize the information. Suggestions for some indicators are presented in Annex C

4.3.3 Preliminary Strategic Plan of Action

The Preliminary Plan of Action must list a set of actions that represents a first approach to the needed solutions in order to put in place an IUWM strategy. As a preliminary plan, it will be submitted to the appreciation of the community and it will probably receive many contributions and alterations. Nevertheless, this preliminary plan is very important to give an idea of the magnitude of the task that the stakeholders will have to face, and also to give an idea of the amount of investment needed.

Action Plan: Prepare a list of the actions needed to solve the issues identified in the cause-effect relationship of the previous step. Distribute the actions along a time-frame and set priorities for each of them. Estimate the investment needed for each action. Evaluate the institutional arrangement that is needed to develop and implement the action. Prepare a list of non-structural actions to support institutional development, management and planning, to develop programs and technical support for the decision process. Prepare a list of structural measures to expand infrastructure.;

Economical and Financial Assessment: To assess required level of investments to implement the Plan, considering institutional and investment capacity of the stakeholders.

4.3.4 Strategic Report

Figure 15 shows the conceptual framework of the studies that will form the base upon which the Strategic Report will be prepared. The qualitative assessment and the indicators for each of the components that were evaluated in the prior phase are important inputs to the report. The report may be subdivided in:

- CHARACTERIZATION: is a summary of the main aspects related to urbanization, economic and social aspects linked to the water resources features. It is useful to have an overall description of the city and its insertion into the country’s situation. It is meant to give a first perspective of the country’s and urban conditions (see annex A).

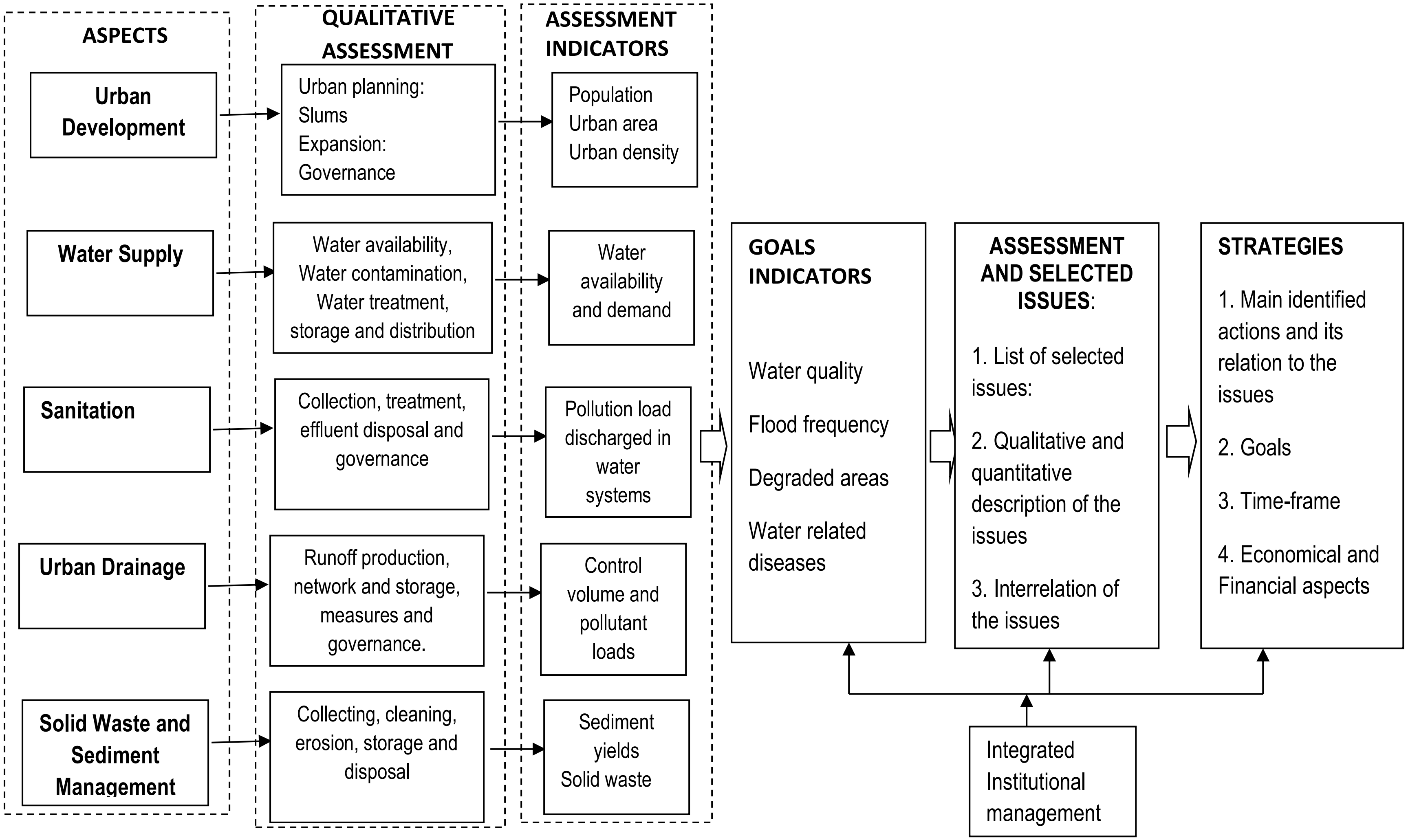

Figure 15 Framework of the Rapid Assessment and Strategic Assessment

- ASSESSMENT (diagnosis): is a qualitative identification and description of the main issues based on the matrices (Annex B). At this stage some indicators may be selected depending of the secondary information's (annex C).

- STRATEGIES: a first strategic set of objectives, goals and actions to face the issues and to propose solutions within the institutional, social, economic and technical settings and considering all these aspects in an integrated manner.

4.4 UPDATE PHASE

In the previous phases a qualitative approach due to time restrictions. The main purpose of this phase is to prepare a detailed quantitative assessment to develop a more deep analysis of the solutions in order to have a better evaluation of costs and investments. The development of this p phase is based on three steps: planning of assessment studies; quantitative assessment of the issues, detailed urban water plan.

4.4.1 Planning of the assessment studies

The qualitative assessment of the previous phase must be reviewed to provide a quantitative assessment of the issues in order to provide the basis for the conception development of the solutions.

The activities are:

1. To review the studies previously prepared to achieve:
   (a) Quantitative assessment of the issues;
   (b) Conceptual development of the final plan;
   (c) Institutional and integration needs to sustain the Strategic Plan.

   The first is developed with the objective of confirming the previously identified issues and to detail its characteristics in quantitative terms. The second is used to define the correct cost of the set of actions and the third are developed aims to identify the main management and integration difficulties;
2. To prepare terms of reference for the studies that are necessary to update the Strategic Plan for Urban Waters;
3. To identify the team that will be responsible for the preparation of studies.

4.4.2 Quantitative assessment of issues

Quantitative assessment will require technical studies such as modeling of water systems, both in water quantity and quality, land use planning studies, environmental evaluation and institutional analysis. The usual studies normally prepared to support the planning effort are listed in Table **7**. The basic content of the Strategic Plan is showed in Table **8**.

Table 7- Examples of Assessment Studies

Component	Issue	Assessment
Urban development	Land Use	• Urban Master Plan development and implementation • Assessment of social and economical aspects of urban development
Water Supply	Lack of water supply services	• Hydrologic studies of water yields from surface and groundwater sources • Assessment of the water supply services.
Sanitation	Lack of sanitation services	• Identification of the population without services and efficiency of the existing services • Impact of the effluent discharge in water bodies
Storm water	Floods and water quality	• Mapping storm water floods • Assess the main causes of the excessive flows • Assess the storm water quality ; • Assess the flood plain area and its occupation
Solid waste and sediment yields	Clogging of water courses and diseases	• Assess the solid waste services and the discharge of waste in the streets and drainage; • Assess erosion, sedimentation and degraded areas and its causes.
Environment	Environmental impacts	• Integrated assess of the urban water environment impacts.
Institutional	Inefficiency of the services	• Legal framework • Management of the services • Economic assessment of the services

Table 8 – Contents of the Strategic Plan

Component	Objective	Content
Urban Planning	Mitigation of social impacts	• Develop a solution for informal settlements linked to the water infra-structure implementation • Land Use and Environmental Planning
Water Supply	Improve water supply	• Plan for increase in water availability and expansion of services
Sanitation	Improve sanitation	• Plan for expansion of coverage linked to water quality restoration of water bodies
Storm water	Reduction of flood impacts	• Storm water plan for flood control and reduction of impacts • Measures for controlling losses in the flood plain
Solid waste and sediment	Improve services and restoration of the degraded areas	• Plan for expansion of solid waste services; • Restoration plan for degraded areas and control of erosion
Institutional	Institutional and economical feasibility	• Institutional reforms with legislation, regulation and management arrangements; • Development of feasibility studies to evaluate investment capacity

4.4.3 Detailed Urban Water Plan

The Strategic Urban Water Plan must be detailed and updated, integrating the studies prepared in the previous phases. It can follow the same structure as before, but using consolidated information about the issues, impacts, costs and management targets.

4.5 STRATEGIC PLAN

This phase is the final preparation of the strategic plan of action. The document prepared in the former phase must be evaluated by the municipality and other stakeholders in participative meetings. The Strategic Plan of Action must contain the list of actions, priority, cost, duration and the responsible agent for its implementation. The suggestions and recommendations developed at this stage must be evaluated and included in the final version of the Strategic Plan for Urban Waters. In addition, it is recommended the preparation of a simplified summary for ample distribution.

4.6. IMPLEMENTATION AND MONITORING PHASES

The implementation of the Plan requires continuous monitoring of the outputs for possible reviews of the Action Plan. Difficulties related to implementation in certain components or changes in institutional arrangements may require a new set of actions or a revision of the proposed ones. Monitoring must be well documented in order to consolidate the experience with the participative planning process. It is very useful for the stakeholders to accompany the evolution of the urban area and to compare investment costs and goals. It is recommended a yearly evaluation of the urban development and the review of the goals.

5. CASE STUDIES

This chapter presents the result of three case studies in Latin America, the cities of Medellin, in Colombia, Monterrey, in Mexico and São Paulo, in Brazil. These cities were chosen for having developed a certain level of management practices aligned with the main principles of IUWM. A first assessment was conducted and the methodology for implementation of IUWM procedures here suggested will be compared to evaluate its applicability.

The report presents, for all three cases, a short description of the situation in each city with its main characteristics regarding the urban development, social and economic conditions, natural resources, services provision and their main current problems and impacts. A summary of the assessments and a comparative analysis are also presented.

5.1 CASE STUDIES SELECTION

The case studies were selected as a representative sample of Metropolitan Areas (MA) of Latin America[6] both in size and economy. Two of the MAs are in South America and one in North America:

- **São Paulo in Brazil** is the largest Metropolitan Area of South America in population with almost 20 million inhabitants; it is an urban agglomerate of 39 municipalities with its urbanized area entirely within the Upper Tiete river basin;
- **Monterrey in Mexico** is the third urban area of the country with 3.6 million inhabitants and ranking seventh in Latin America in GDP, with 9 municipalities in the San Juan river basin, a tributary of Bravo River which divides Mexico and United States;
- **Medellin in Colombia**, is the second largest metropolitan area of the country, with 3.2 million inhabitants, with 10 municipalities in the Medellin river basin at Aburrá valley;

A summary of indicators for the three case studies is presented in the Table **9**, with the main relevant aspects of urban development and population, natural resources, urban water services and problems/impacts.

Some common aspects of these three examples are:

- They represent median to large size MAs in Latin America with rapid population and economical growth during the last decades but with important social challenges and land use problems
- In the three cases the cities were able to reach an acceptable level of service provision and an evolution in the institutional arrangements;
- They represent some of the largest per capita GDP in Latin America; all of them are important economic centers in three of the largest economies in the region;
- Medellin and São Paulo are in the humid regions with annual rainfall above 1,500 mm and Monterrey is in a semi-arid region with about 500 mm of annual rainfall;

[6] Latin America has an area of approximately 21,069,501 km² (7,880,000 sq mi), almost 3.9% of the Earth's surface or 14.1% of its land surface area. As of 2008, its population estimation was over 569 million (Wikipedia, 2010).

- In each of the three examples the institutional arrangements area different but they all present some level of integration between government levels and stakeholders.

Table 9 Information and Indicators of the Case Studies

Indicator	Medellin	Monterrey	São Paulo
Country	Colombia	Mexico	Brazil
State	Antioquia	Nuevo Leon	São Paulo
Largest city information			
Population (inhabitants)	2,223,078	1,133,814	11,037,593
Area (km^2)	380.64 (110,6[3])	295	1,523
Density (people/km^2)	5,840	3,843	7,216
Population growth rate (%)	1.5 (1985-2005)	2.1 (2000-2005)	5.3 (2000-2008)
Urban Master Plan (year)	2006	2009	2007
Illiteracy rate (%)	3.37	3.7	4.0 (2000)
HDI	0.808	0.872	0.841
Per capita income (US$)	8,891 (2007)	21,788 (2007)	20,370 (2009)
Metropolitan Area			
Population (inhabitants)	3,442,197 (2005)	3,565,489	19,889,559
Area (km^2)	1,326.39	5,560	8,051
Density (persons/km^2)	2,907	923	2,503
Urban population (%)	94.3		94 (2000)
Number of municipalities	10	9	39
Hydrology			
Main river	Medellin	Santa Catarina	Tiete
Basin	Aburrá-Medellin	San Juan/Bravo	Tiete
Mean rainfall (mm)	1658	530	1376
Altitude (m)	1.538	580	760
Wet/dry periods	Mar-Nov/Dez-Febr	Jun-Oct/Nov-Mar	Oct-Apr/May-Sep
Climate	Sub-tropical humid	Semi-arid	Sub-tropics
Water Supply			
Production (m^3/s)	10	11.3	68
Coverage (%)	99[1]	99[1]	99
Network losses (%)	36	24.9	25
Household cons. (m^3/mont/unit)	17.9	16.4	13.4
Service cost (US$/$m^3$)	0.63	0.033 - 2	0.75 [8]
Sanitation			
Separate/combined (%)	47/53	Separate	Separate
Collect sewage (%)	99	99	85
Local disposal (%)	-	-	-
Treatment[2] (%)	100% (2012)	100%	67%
Service cost (US$/$m^3$)	0.77	0.008 -0.5	0.75[8]
Stormwater floods[5]	Yes	Yes	Yes
Occupation of Flood Plains[6]	Yes	Yes	Yes
Solid waste			
Coverage (%)	98[4]	95	94
Production (kg/person)	0,455	0,800	0.87
Cost (US$/person/month)	1,285	-	-

1 – Population that is not covered is located in illegal settlements; 2 – Proportion treated from the collected sewage; 3 – Area of urban occupation, which represents an urban density of 201.7 persons/ha; 4 – In Medellin; 5 – Floods due to urbanization; 6 – Flood Plains risk areas; 7- based in monthly consume, 4 person per unit and 30 days in the month – 8 – for 10 m^3/month. The price increases with consumption, for 20 m^3 US$2/$m^3$ for both services. The cost of sanitation does not imply treatment.

5.2 ANALYSIS OF THE CASE STUDIES

5.2.1 Medellin

Characterization

Population and Economy: Medellin is the second largest city of Colombia with a population of 2.4 million. The Metropolitan Area, with 10 municipalities, has a population of 3.2 million, 94.3% in the urban area, covering near to 370 km^2. This Metropolitan Area is part of Antioquia Department of Colombia. Medellin grew from 1.5 to 2.4 million from 1985 to 2005 (20 years), which represents a yearly rate of 1.5%. Colombia has a GDP of US$ 442.8 billion (2007) by parity price and a per capita of U$8.891. The Metropolitan Area of Medellin represents 11% of the GDP of Colombia which is about US$ 48.7 billion with a per capita of US$ 15,221.

Colombia has six levels of prices for public services. For the first three levels of Colombia classification of housing conditions (see table 3) the price of water receives subsidy (78% of the consumers for Metropolitan Area in 2008). Level 4 does not receive any subsidy (11% of the consumers) and levels 5 and 6 pay the subsidy for the others (total of 11%).

Land Use and Water Resources: The Metropolitan area is located inside of the Aburrá Valley where the main river is the Medellin River that crosses the city. It is situated in a narrow valley with a width of 1500 m which makes the city to be surrounded by steep hillsides. Urbanization is moving to upstream and climbing the hills in the sub-basins of Medellin River, the more dense area. Urbanization is also developing in the downstream and upstream directions following the Medellin River.

There are 10 cities in the Metropolitan Area and its major part is located within the Medellin river basin. The basin area is 1,250 km^2 and the metropolitan area is 1,156 km^2. The river length is 104 km with the altitudes varying from 1300 to 2800 m. Mean year rainfall in the basin varies from 1400 mm to 2800 mm, in a tropical climate with mean temperatures varying from 20^o C to 24 ^{o}C. Mean annual flow in the basin varies from 30 to 40 L/(s.km^2), or 1150 to 1300 mm of mean flow (flow coefficient of about 0.55 t0 0.68), a high yield when compared to other climate regions. The basin is characterized by a steep slope and an important difference in flow when comparing minimum and maximum values.

Water Supply: The service is provided for the totality of population that lives in regular areas. Population occupying illegal settlements is not serviced because the municipality does not allow provision of services in these areas. Water losses are still important and in the last year it was 36%. From this total, 60% are physical losses and 40 % commercial losses. There is a program for reduction of physical losses. It is a challenge to improve water supply network with mean hydraulic head of about 40 m.

The mean consumption is 17.9 m^3/month/residential unit. The mean price (without subsidy) is US$ 1.39/m^3 for water supply and sanitation. In that cost 45% is water supply and 55% is sanitation.

Sanitation: The coverage of sanitation network is almost 100%. About 1% of population is not connected to the sanitation network. Part of this network is CSO (Combined Sewer Overflow:

sewer and storm water in the same pipe system) and part is separate (sewers and storm waters), respectively 47% and 44% of the network system. There are collectors in the tributaries and interceptors along the main river, representing 9% of the network.

Solid Waste: The mean solid waste production in the city is 50 kg/month which represents about 0.455 kg/person/day. The total collected is 130,000 ton/year. The relationship between weight and volume is 1.36 ton/m^3. The regular tariff is US$ 5.14/month/installation. The cost per person is US$ 1.45/ month.

Construction activities solid waste production with no identification of the owner totalizes 14,000 t/month. There are others users such large construction sites and industrial production that are responsible for their own disposal practices after presenting an environmental plan for disposal. The collection of hospital waste is 1.8 t/month, with 745 clients. There are companies specialized in collection and disposal for hospital and clinics. In the streets the amount of collected residues is 13,300 t/year, covering 3,000 km of streets.

Storm water: Storm water in Medellin is a combination of minor drainage in dense areas which flows to creeks that come from the hills. These creeks flow downstream to the Medellin River. Since the slopes are very high, flow velocity and rainfall with high intensity and low duration produce a steep hydrograph with a very small time of concentration. During rainy season the flow brings a lot of sediments due to erosion and may develop into a debris flow. The intense flood events are dangerous to infra-structure and people, since it can lead to land slide. The protection of these areas is a combination of drainage improvement and physical protection of the slopes.

Several risks are relevant in the urban area of Medellin:

- Increase of the peak floods in Medellin River due to urbanization;
- Urbanization in the sub-basin is increasing from downstream to upstream in the hills and in the sub-basin of downtown Medellin. This is dangerous since it will aggravate the existing risk conditions and it will increase the peak and flood volume, if no flood management is developed or a severe urbanization control;
- Currently the cost of urban drainage impacts produced by private owners is being paid by government;
- Floods and landslides are very frequent, occurring every year. Medellin is also in a high-risk zone for earthquakes;

Institutional: Table **10** shows a summary of the current institutional arrangement for urban planning and urban water services, water resources and environmental control in the Medellin Metropolitan Area. The main issues related to urban water services are:

- Urban planning on risk areas;
- Solid Waste is managed in Medellin by VARIAS, which is a municipal company with solid economic sustainability. However, in the other cities of the Metropolitan Area, this management is fragment and managed by several institutions;
- For storm water there is not an integrated service and it is completely fragmented by area of service and by type of service.

Table 10: Management in Medellin Metropolitan Area

Service	Medellin	Metropolitan Area
Urban Planning	City a	Cities
Water Supply and Sanitation: water supply, treatment and distribution; sewage collection, wastewater treatment and disposal.	EPM	EPM
Solid Waste: collecting, cleaning and disposal	VARIAS	Private and public services in each county
Storm water: implementation and maintenance	EPM for minor drainage system; City administration for major drainage.	EPM for minor drainage system; Major drainage managed by the cities
Water Resources: river management and water permits	Area Metropolitana	Area Metropolitana
Environment: conservation and license	Secretary of Environment and Area Metropolitana	Area Metropolitana

EPM – Empresas Publicas de Medellin.

Assessment Matrices

The main aspects related to impacts generated by the Metropolitan area of Medellin are:

- Vulnerability to natural and anthropic disasters such as: in the rain season, landslides and floods in the high slope basins of the tributaries of Medellin River; Earthquake area;
- Flood plain damage and storm water floods related to urbanization due to the increase of the impervious areas;
- Contamination and sedimentation of water supply storage reservoir outside of Aburrá Valley due to agriculture practices. These reservoirs are used to supply Medellin Metropolitan Area;
- River protection, conservation and degraded areas due to erosion in the Valley.

Table **11** and Table **12** show the summary of the issues presented in this identification and analysis of Integrated Urban Water Assessment of Metropolitan Area of Medellin. This urban area has sound urban development policies in spite of its economical and social constraints. The urban water services institutions are public and present with very good management practices with economical sustainability. The investment has been done a planned cost recovery policy and subsidies are applied depending on the income classes identified by housing facilities.

For some of the issues identified in the Table **12** there are already actions being implemented.

Table 11: Urban Water Assessment Matrix

Main Aspects	Selected Issues		
Urban Planning	Urbanization planning for reduction flood flow	Improved housing for the poor	Reduction of vulnerable population on the hills
Water Supply	Reservoir contamination and sedimentation from agriculture areas	Important water losses: physical and revenue losses	
Sanitation	Part of the poor population still do not have sanitation	Not a good evaluation of BOD and DO as water quality pollution indicators	
Storm water	Manage the floods in the storm drainage system	Impact of urbanization on flood flow increase	Lack of maintenance in the major drainage system
Solid waste and sediments	Lack of a recycling program and solid waste collection	Lack of prevention policies such as street cleaning	
Institutional	Lack of a specific utility and cost recovery policy for storm water	Fragmented management for Solid Waste and Storm Water services	Lack of integrated management of urban water services

Urban development: To improve the housing for the poor and to avoid irregular development in risk areas in order to control the urbanization in direction to upstream in the sub-basins; there is a need for sustainable urbanization in order to avoid flood impacts;

Water Supply: It is important to manage the municipal basin in order to protect the reservoir, reducing sediment and nutrient loads by improving agriculture practices. This action can be stimulated by the payment for environmental services. The reduction losses program is already in place in EPM and the gain in the efficiency in service would help lowering the costs.

Sanitation: There is still a small part of population leaving near the creeks where the cost of sanitation implementation may be high or very difficult to implement. These are poor neighborhoods in need of special attention and subsidy policies.

Storm water: It is necessary to implement good management practices to reduce potential and existing floods in the storm water system; urbanization is under development from downstream to upstream increasing the peak flood and the impacts in many creeks in the sub-basins of Medellin. This process must to be controlled using non-structural and structural measures. Poor maintenance of creeks and main channel is also an important problem.

Solid Waste: in order to improve the solid waste service and to reduce its impact in the drainage there are some measures which could be developed: (i) incentives for recycling programs; (ii) improvement of the street cleaning previous to rainfall days; (iii) restriction of use for some types of plastic.

Institutional: The Storm water system is the most affect by the fragmentation in institutions and absence of cost recovery policies. In Solid Waste management, there is a need for integration of the service in Metropolitan Area of Medellin. In general, there is a lack of integration in the provision of urban water services.

Table 8 shows the main impacts that restrain the achievement of the general goals for the society and environment in Metropolitan Area of Medellin. The main impacts are vulnerability of floods and landslides, health hazards in some specific poor neighborhoods' lacking sanitation, environmental conservation and potential impacts due to storm water quality.

Table 12: Matrix of the impacts related to the goals

Main Aspects		Selected Issues	
Health	Risk for the population without sanitation	Diseases related to floods	
Floods	High frequency of flood impacts, mainly due to urbanization	Mud flow and landslides	
Amenities	Need for improvement of amenities in poor neighborhoods'		
Environment	Improve River conservation	Degraded areas from land slide and erosion	Pollution from storm water and industrial effluent

Strategy

The main issues in need of management actions are related to:

- Storm water management and control of the flood impacts;
- Improved institutional arrangement to avoid fragmentation of urban water services;

Two main actions are recommended in the strategy planfor the Metropolitan Area of Medellin:

- Storm water Master Plan; and
- Institutional Reform on Urban Water Management.

Summary

Medellin presents a solid development in urban waters, since it has strong institutions, working for the reduction of impacts, improvement of quality of life and environmental control. There is enough water for supply and the risk of contamination or conflict is small. Coverage of water supply is almost complete and sanitation is under development. In a short period in the future the sanitation coverage will be near to 100%.

Storm water is the main challenge and it still has many important issues related to the institutional arrangement and development. Solid waste services are good and an improvement on that and on soil conservation will result in a better environmental protection.

The development of urban waters is in the management improvement stage since most of the investment in infrastructure has already been done. The actual goals are to improve the existing services in the urban drainage system and in water quality restoration to aim a better environmental control, besides improving the quality of life for the poor.

5.2.2 Monterrey

Characterization

Population and economy: Monterrey is the capital city of the northeastern Mexican state of Nuevo León. It is located at the foothills of the Sierra Madre Oriental, 900 km North of Mexico City. It is the third largest metropolitan area in Mexico, after Mexico City and Guadalajara. In 2005, the city population was estimated to be 1,133,814 and its metropolitan area (AMM) had a population of 3.565.489 million. The metropolitan region comprises 9 municipalities, and the population growth rate, between the years 2000 to 2005, was 2.1%. Monterrey is an industrial center with a GDP of US $ 78.5 billion (2006) and per capita of US$ 21,788. Part of the urbanization is occurring in the direction of the foothills, occupying higher risk areas.

Climate and Hydrology: The region is semiarid with warm period in spring and autumn, extremely hot in the summer (it can reach 42 °C and overnight lows of 25 °C). Winters are mild. The average January high is 17 °C and the average low in January is 7 °C. Most extreme weather change occurs with rainfall in summer, which changes extreme heat to cooler temperatures. The mean annual precipitation in Nuevo León is 504 mm. June to October is the rainy season and the dry period is from November to March. March is the driest month and the most humid is July. Monterrey area is part of the San Juan basin, a tributary of the Rio Bravo that divides USA and Mexico. The mean total annual runoff of the San Juan basin is 35.7 m3/s, but with an expressive variability from year to year.

Water Resources Management

Basin organization: The Metropolitan region of Monterrey is part of the Rio Bravo Cuenca and its waters are managed by the Organismo de Cuenca del Rio Bravo (Rio Bravo Watershed Commission). The totality of the Organismo de Cuenca comprises 5 Mexican states, 124 municipalities and 9 million people. The major part of the territory is arid thus the water management is an essential part of the sustainability of populations and economic activity.

The Rio Bravo watershed divides Mexico and United States and its total area is 457,275 km^2, of which 226,275 Km^2 belong to Mexican territory and 231,000 Km^2 belong to US territory. In 1944 a treaty was signed between the two countries and part of this treaty states that the total flow of the Rio San Juan belongs to Mexico. This is the main river that supplies the Metropolitan Region of Monterrey. The Organismo de Cuenca del Rio Bravo is organized in one central office, 13 local offices in different sub-basins and 20 regional offices.

Basin committee has is an assembly of users with water rights (50%), government (35%) an others (15%). CONAGUA pays the expenses 50%, users 25%, state 25%. The member are permanent and the users only come when its interest are in discussion.

Water use and permits: CONAGUA- National Water Commission is the federal organism in charge of the management and conservation of the national waters in Mexico. CONAGUA is also in charge of pollution control. CONAGUA is organized in central offices, watershed commissions (organismos de cuenca) and local offices. Surface and Groundwater water abstraction must be authorized by CONAGUA. Domestic uses have priority over other uses. In the whole area of the Cuenca, the proportion of the main uses is presented in Table 13.

Table 13 Main uses of water in the Cuenca del Rio Bravo

Uses	Source (%)	
	Surface	Groundwater
Irrigation	65	66
Domestic	25	10
Industry and Power Generation	9	23
Other	1	1

Charging System: Irrigation is not charged (greater user). Domestic, industrial and other uses are charged. Pollution is charged if its load is above a required level. The value is defined by the national law, which makes any change very political and very difficult. Every user prepares a statement of use every three months and the payment is based on the volume that is used and not on the authorized volume. This requires a metering system but it is perceived as more acceptable by the user. The Organismo de Cuenca has a routine checks for compliance and uses fines and penalties to punish. In the area of the Organismo de Cuenca del Rio Bravo there are 1,000 users and the compliance is above 96% both in declaration and payment. This is a very high rate for compliance and the officers credit the Cultura Del Agua (program developed by SADM - Servicios de Agua y Drenage de Monterrey) and also the certification process that industries seek for this success. In the rest of the country, only 60% of the users pay water charging. The revenue that comes from the charging represents around 1/3 of its total budget. The federal government complements the budget for two reasons: the agricultural use does not pay and also CONAGUA invests in hydraulic works. The revenue of the water charging is, therefore, applied again in the basin. The water utilities can also be benefited from this investment but, in this case there is the need of matching funds in a 1 to 1 rate.

The San Juan Agreement: There is a competition for water between urban areas and irrigation. This agreement came after a negotiation of this water conflict and it resulted in common rules for operation of a system under scarcity conditions. This process started in 1989 and is still under development due water needs and urban and irrigation expansion. The improvement has been in the increase of flow regularization and water efficiency, but it has a limit.

Urban Waters Services

Water Supply and Sanitation: Water is a scarce resource and the region invested extensively to implement water and sanitation infrastructure but there are serious conflicts over water usage. Monterrey is supplied by surface (61%) and groundwater (39%) sources. The current sources are sufficient to supply metropolitan Monterrey until 2015. 95% of the water produced by the system is consumed by domestic users and only 5% by industrial users. The flow from the surface sources are regulated by three dams: La Boca (volume of 39.5 Hm3), Cerro Prieto (300 Hm3)[7], 130 km of Monterrey and Cuchillo (1,123 Hm3), 110 km from Monterrey.

The groundwater sources comprise 49 deep wells, 65 shallow wells, 3 tunnels which extract water recharged in the mountains and several other small systems. A Water distribution is optimized in the Metropolitan region by a water ring of 70 km which interconnects supply sources. The ring is a continuous pipe of 70 Km that interconnects all the supply sources with more than 8,600 Km of secondary pipes. Losses in the network are in the level of 24.9 %.

The average water consumption per household is 16.4 m^3/month in 2008. The tariff system charges 0.42 pesos/m^3 up to 25.7 pesos/m^3 (US$ 0,033/m^3 to 2,0/m^3) for water supply. For commercial or industrial users the tariff varies from 3.81 pesos/m^3 to 34.34 pesos/m^3 (US$ 0.294 m^3 to 2.64 m^3), depending on the consumption level.

Four wastewater treatment plants are currently in operation in the metropolitan Monterrey and together they have a treatment capacity of 8.95 m3/s. The system is sufficient to treat all the wastewater produced in metropolitan Monterrey, with secondary biological processes. The present operation is very good and their efficiency is proved by the quality of the effluent, which is discharged with 30 mg/l BOD and 30 mg/l TSS. Reuse is in place and the treated wastewater is sold to 86 clients among industries, irrigation of golf courses and power generation. The revenue SADM gets form this selling is around 8.4 million pesos/month.

When wastewater collection and treatment is also provided, the water tariff increases in 25%. The households are not obliged to connect to the public collector, only the industries and commercial buildings are. SADM is implementing an incentive program for low-income households. In 2008 there was an increase of 8% in connections, when the average was an increase of 5%. Also the treatment is not charged and this is something SADM is trying to change.

SADM is currently investing 500 millions of pesos to increase the treatment capacity to 12.6 m3/s until 2010. This is part of a new program called Monterrey which is being constructed under an IDB loan (60%) and public and private banks (40%)

Solid waste: The data informed show that the average monthly collection per person is 24kg, 14 % of the buildings are serviced with special collection for separated solid waste and an average per person of 3 Kg of solid waste is collected in public areas.

Urban drainage and Floods Management: The steep of the slopes combined with irregular precipitation make the metropolitan region very vulnerable to extreme events. It was confirmed by SADM officials that the city suffers from these extreme events 3 or 4 times per year. The State of Nuevo Leon is currently investing in two new dams for flood control. SADM is still working in drainage systems but only under the mandate and money from the State. The system is separated from the sewage collection, but there are many clandestine interconnections between the two systems.

In addition, since 1600 there are floods plains impacts in the main river of the cities. The municipality of Monterrey recently published in their site the "Atlas de Riesgo de la Ciudad de Monterrey", (The Atlas of Risk for the City of Monterrey), which presents a very comprehensive

[7] $H = 10^6$

study of all the flood prone areas, as well as the number of buildings under major risk in the city. (http://www.monterrey.gob.mx/pdf/atlas_de_riesgo/atlesderiesgo09.pdf). Emergency actions are a responsibility of the Junta de Contingencia, a special group for protection and rescue of people.

Institutional: The services are provided by SADM - Servicios de Agua y Drenage de Monterrey for Water supply and Sanitation. Solid waste collection is a municipal responsibility and in the municipality of Monterrey, the services are provided by the Secretaria de Servicios Publicos. The drainage system of Monterrey was under the control of SADM until 2007 when it became a shared responsibility of the municipalities and CONAGUA. Even though it seems that there is a lack of coordination among the various jurisdictions in charge of the control of the drainage system.

SADM is managed by an Administrative Board formed by members of the State government, the Municipal government and the private sector, and its president is the State governor. Currently the private sector is represented by the Commission of Commerce, Services and Tourism of Monterrey, Commission of Real State Business and Commission of Industries, plus a representative of the users. The Board has the mandate of approving the annual budget and also the tariff structure to be applied to all users. The Board is organized in technical commissions to deal with Infrastructure Investments, Finances and Tariffs. The information given by the managers and employees shows a very technical board with minimum political influence in its operation. The Executive Directory is formed by career employees and SADM has about 4,200 employees in the Metropolitan region, with 4.23 employees per water meter, or consumption point, and 801 employees outside the Metropolitan region, or 3.86 employees per water meter, or consumption point.

Main Issues

Based on the above information itis possible to identify some of the major issues related to the assessment of Monterrey:

- The use of water is very intense throughout the whole area and the demand-availability balance is negative in the basin. Groundwater is also explored in volume near to its recharge volume.
- The city is located in the foothills of Sierra Madre Oriental and part of the growth of the urban area is occurring up the hillsides, increasing the risk of higher floods in the storm water (upstream – downstream effect);
- The city is crossed by Rio Santa Catarina, an intermitent river, where extreme floods have been reported since 1616, when a severe flooding event caused the city to move to higher grounds;
- Storm water and Flood Plains management does not have a local institution to deal with this service; the result may be higher impacts in the future because it delays the implementation of prevention policies and a more compatible land use development

5.2.3 São Paulo

Characterization

Population and Economy: São Paulo is the capital of State of São Paulo in Brazil and its Metropolitan Area have 39 municipalities, covering an area of 8.051 km² and with a population of 19,9 million (2009) inhabitants. The extended metropolitan area of São Paulo is an agglomeration of 3 contiguous metropolitan areas that have grown into one, plus 3 micro-regions. These contiguous regions have today a total of 27 million inhabitants and 23.000 km^2, representing 14.7% of the country population. The city of São Paulo has 11 million inhabitants in 1.582 km^2 with a population density of 7.216,3 km^2. Urban population is higher than 94% (2000), occupying about 1.000 km^2. From 2000 to 2008 the population growth rate was 5,3%, which means an annual rate of 0,65%. An area of 31 km^2 of São Paulo is covered with about 2,000 slums ("favelas"), usually in risk areas and within water supply source basins.

Metropolitan Region of São Paulo represents 19.4 % of the Brazil economy and a GDP of US$ 355 billion with a per capita income of US$ 17.890. The city of São Paulo alone represents 12.26% of Brazilian GDP and has per capita income of US $ 20.377. It is the economic capital of the country. The inequity in the Metropolitan Area of São Paulo is very important and disturbing.

Water Resources: The Tiete River is the main river crossing the area and it flows through Metropolitan Area of São Paulo. The Metropolitan Region is encompassed by its basins of about 5,000 km^2 (at Edgard de Souza Dam, Figure 16). The two major tributaries are Pinheiros and Tamandauateí rivers. The Metropolitan Area of São Paulo urbanization can be seen in Figure **16**. Urbanization is pressuring the boundaries of the region with high rate of expansion with informal settlements (Figure **17**).

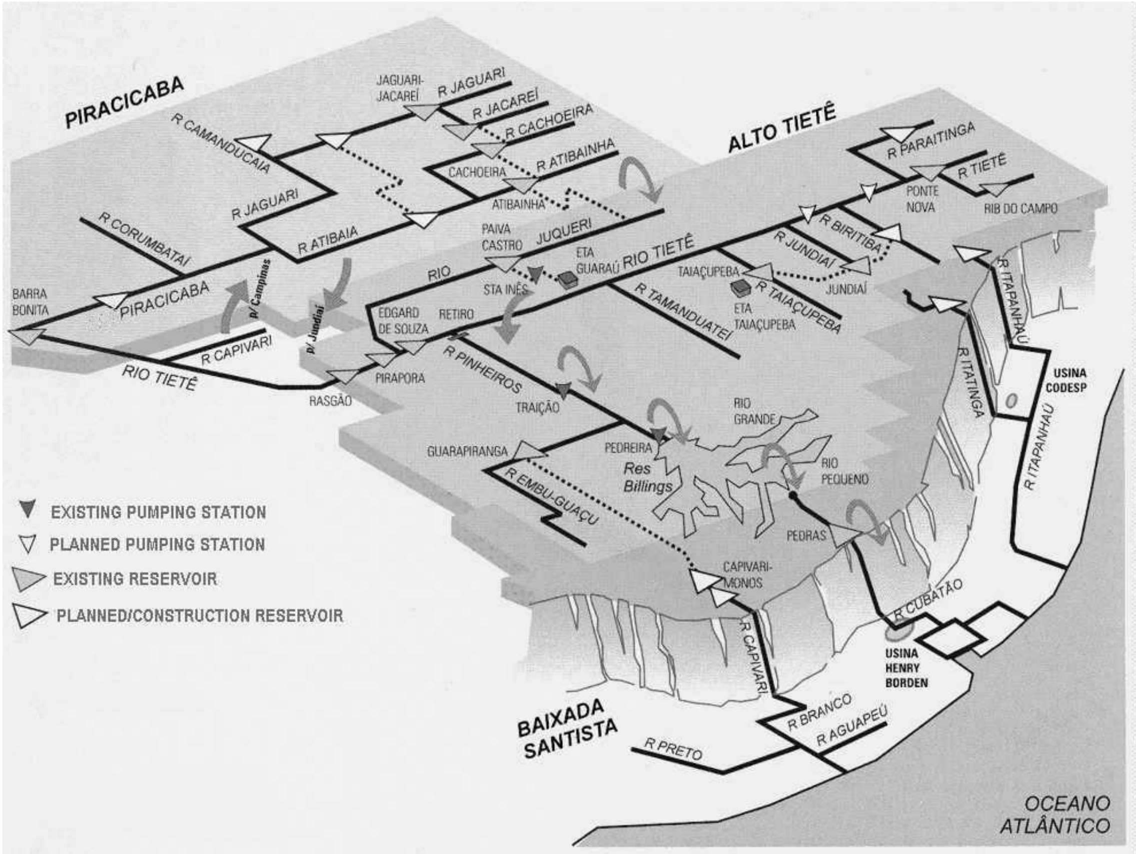

Figure 16 Schematic representation of River flows and transfers in Tiete River Basin in Metropolitan Area of São Paulo (source:)

Urbanization and Water Supply Sources: Urbanization is developing at a higher rate in the direction of the water supply sources as it can be seen in the Figure **18**. The pollution and lack of control of the informal city increases the pollution loads and decrease the water quality of the supply sources. Table 10 presents the water sources availability and production. The main water supply source is the Cantareira System which is a transference of water from a neighbor basin, the Piracicaba River. The second main source in production volume is the Guarapiranga – Billings which is a system with multiple uses, with to energy production and flood control objectives.

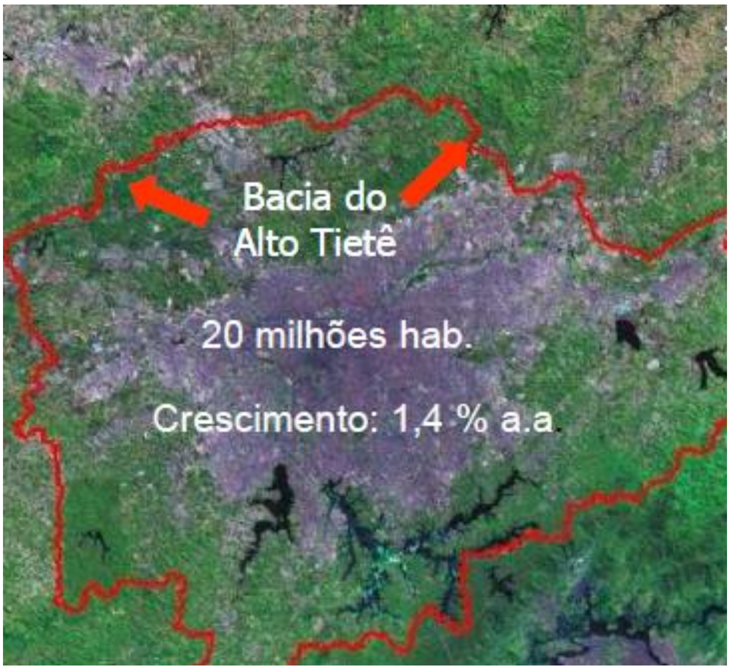

Figure 17: Urbanization and Water supply basins

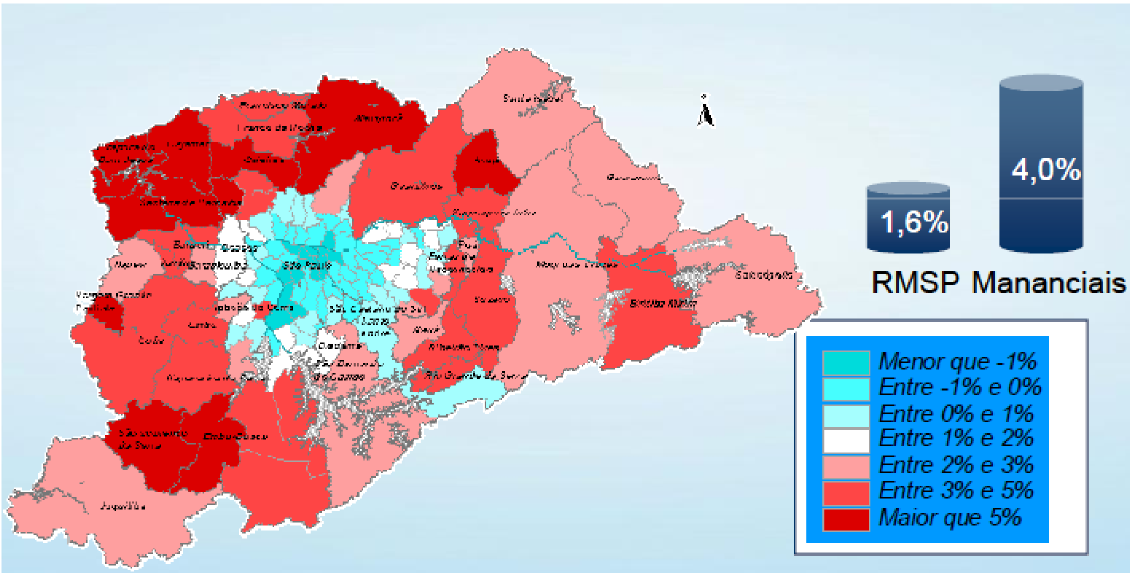

Figure 18 Urbanization rate of expansion ((Tardelli,2009).

From 1998 to 2007 the unit water demand decrease from 17 to 13.4 m^3/unit/month for residential consume. This reduction is related to the decrease of person per unit from about 4 to 3 persons and conservation. The actual demand of RMSP is about 65.6 m^3/s (2008). In addition, network distribution losses (only) decreases from 22 to 13 % from 2006 to 2009. The total losses (frauds, equipments, distribution and main system from water sources) decrease from 33 to 26.5 in the same period. There is a plan to drecrease total losses to 15% until 2028 (Tardelli,2009).

The Water Supply Plan developed in 2004 forecasted that in 2010 the demand would be 73 m^3/s and an offer would be 71 m^3/s, indicating water shortage. The demand today is about 66 m^3/s due to efficiency increase and conservation measures. The availability is currently 71 m^3/s.

Table 14 Water sources of Metropolitan Area of São Paulo

System	Rivers	Water Avaliability m^3/s	Water Demand[1] (2008)\ m^3/s
Cantareira	Jaguari, Atibainha, Cachoeira e Juqueri	31.3	30.4
Guarapiranga	Embu Mirim, Embu Guaçu, Capivari, etc	14	13.5
Alto Tiete	Tiete	15.6	11.2
Rio Grande	Billings	4.8	4.9
Rio Claro	Ribeirão do Campo	4.0	3.6
Alto Cotia	Cotia	1.1	1.0
Baixo Cotia	Cotia	0.8	0.9
Ribeirão da Estiva		0.1	0.1
Totais		71.7	65.6

1 – Water Supply of 19.4 millions inhabittants

Sanitation: Sanitation in the city is developed by separate networks with 84% of collection and 70% of the amount collected is treated. In that way, 58.8% of the sewage is collected and treated, leaving 41.2% of load to be discharged into the streams and in the soil of the Metropolitan Region of São Paulo. Assuming a concentration of 300 mg/L of BOD (Biochemical Demand of Oxygen) for untreated sewage and 30 mg/l for the treated effluent, together 80% of return flow, the total load in the water systems is about 634.5 thousand tons/day of BOD. Part of this volume is been used for reuse, but it still represents very small volume if compared to the total treatment production.

Water quality of the rivers and small streams in RMSP is very bad, which is theresult of the dimension of the problem. The State of São Paulo and SABESP, which is the main Sanitation Company in the area, is developing a program to clean small creeks in the city, with success but due to the dimension of the problem it will take still a many years to have the river system restored.

Solid Waste: In the city of São Paulo (11 million persons) 14,290 ton of total solid waste are generated daily. Household collection represents 63% of the total collection. The collection covers 1.523 km^2, using 3.2 thousand workers. The streets cleaning cover 6,900 km and 270 tons of solids daily. Table 11 presents the distributed daily volume. The RMSP generates approximately 25,600 ton of solid waste daily.

Energy and Floods: In 1901 the city needed energy and water supply. In order to provide energy, the utility company, Light Company, designed a system to divert the Pinheiros flow to Billings reservoir to generate energy with about 700 m of hydraulic head in Cubatão (800 MW). Edgard Souza Dam downstream managed the upstream levels and part of its flows is diverted (50 m^3/s) by pumping the water through Pinheiros using two larger pump stations (Traição and Pedreira) to Billings Lake. During flood events, Retiro station closes Pinheiros river and theTiete connection, and then the pumping stations drains the Pinheiros basin into Billings Reservoire with maximum pumping capacity of 290 m^3/s.

Table 15 Solid Waste collected in 2008 (source: São Paulo Municipality)

Type	Weight Ton	Management
Household	9,500	Municipality
Health	90	Source[1]
Street Cleaning	270	Municipality
Inert: construction, demolition, excavation	3,000	source
Selected[3]	130	source
Other[2]	1,300	source
total	14,290	

1 – Managed by who generate the solids; industrial, ports and airports,etc; 3 selected for reuse.

This system was implemented in the first part of 20th century. With the urbanization expansion without sewage treatment all these rivers come to be completely polluted and in 1992 the justice prohibited the pumping during periods without floods, which decreased the firm energy of the system. The pumping system is only allowed to work during flood events. The problem is that, due to the impervious area increase, the hydrograph and peak floods increased but the amount of solid waste in the river also increased thus reducing pumping stations efficiency. The result is a higher frequency of floods along the Pinheiros River.

Storm water management was developed by major construction of channels in the city, transferring the impacts to downstream areas. Since the 90's the city changed the way of dealing with floods and developed a strategy to construct detention ponds. The construction of detention structures is under way but the challenge is how to deal with sewage discharge into the system.

Institutional: The Tiete River Basin has a basin committee and developed a Basin Water Plan in which the mains aspects are related to Urban Water Management in the Basin.

In Brazil, the Municipalities have the responsibility of urban water services management. In The basin RMSP there are 39 municipalities and 21 of them selected SABESP, the Water and Sanitation Company owned by Sate of São Paulo, to be responsible for their water and sanitation services provision. Three of them operate municipal services and eight municipalities operate a mixed solution by buying water from SABESP but the operating the supply service.

Solid waste is developed by the municipalities and urban drainage services are a mix of municipal and state operation.

Main Issues

A summary of the main issues are:

- Water supply sources in RMSP are in their limit of availability and urban sprawl is still important. It must be noted that the urbanization expansion on the city boundaries is increasing the contamination of water supply sources, threatening the RMSP the existing availability;

- Sanitation is also a major problem since the non treated load is one of the main causes of contamination of the water sources. The size of the problem is such that, even if all the sewage were collected and treated, the residual load would still keep the main river polluted. There is a need for development of high efficiency of treatment and improvement in reuse to restore water quality;
- Storm water floods paralyze the city every summer and the economic losses are extremely high. An Urban Drainage Plan is in implementation but there is a need for change in urbanization patterns and for development of the green spaces. There is a strong need for better institutional practices and larger investment budgets.;
- The fragmented institution management in the cities that form the MRSP, in all services, creates massive difficulties in dealing with the main water and land use related problems.

5.3. COMPARATIVE ANALYSIS AND MAIN FINDINGS

Table **16** presents a summary of the assessment in the cities used as case studies. A comparative analysis of these three cities can be summarized as follows:

I. Growing mobility of the population the Metropolitan Areas, attracted by economic development, results in informal land occupation without water services or other basic services. It creates a social pressure on the municipalities which usually are not prepared to deal with it;
II. Water supply sources expansion and management is not a challenge for Medellin, but for Monterrey and São Paulo is one of the main issues, since there are not new ones due to conflict with other users. In the Monterrey, there is a high demand in a region of water scarcity and with conflict with irrigation; and São Paulo the scarcity is due to contamination of the water sources and conflict with neighbor basins. Monterrey and São Paulo need to reduce the demand to cope with the conflict;
III. In Medellin and Monterrey there is not lack of sanitation (collection and treatment), but São Paulo is far way from a solution due to the size of the city (high density of population in a small area) and the lack of sewage treatment. The amount of investment in innovative management and techniques of treatment and reuse is still very small, but it could be a solution for these large cities;
IV. Floods in storm water systems and flood plains are a common problem in the cities. It is related to land use and occupation, sanitation and solid waste and sediment management. The main limitation is the lack of an appropriated institutional arrangement and sustainable practices in urban development;
V. All cities have basin management in the basin but they are not much effective to deal with urban problems. The Water & Sanitation companies are robust, but require a step ahead on the innovation and application of Sustainable Measures. The Water & Sanitation Companies operates in very traditional and conservative way.
VI. Solid Waste service is developed by each city with different levels of services and environmental protection. Neither of the cities have important investments in recycling or in reduction of the solid waste. This evolution will need modern sustainable measures.

VII. Storm water management does not exist. Cost recovery practices are difficult to implement and the impacts of this lack of management will be very costly in the near future;

VIII. Close integration of the water management of the cities and its correspondent basins could be an important step to reduce institution fragmentation, to develop economic sustainability of the services, to improve efficiency in the use of the water and to achieve common goals. This integration could demonstrate all the benefits of managing the basin from downstream to upstream in order to finally reduce externalities.

Table 16 Summary of the assessment in the cities

Service	Medellin	Monterrey	São Paulo
Land Use	• Poverty reduction and informal occupation; • Hillside urbanizations	• Hillside urbanization; • Flood prone areas;	• Informal occupation; • Risk areas occupation; • High urban density
Water Sources	It is not critical	• Limited availability; • Water use conflicts	• Limited availability; • Contamination of sources
Water Supply	• Good coverage • Important losses	• Good coverage	• Good coverage, efficiency and conservation programs
Sanitation	• Good coverage;	• Good coverage	• High loads in the rivers and medium coverage
Solid Waste	• Good coverage • Low recycling and other sustainable measures	• Good coverage • Low recycling and other sustainable measures	• Good coverage • Low recycling and other sustainable measures
Storm water & Floodplains	• Without services and plenty of impacts	• Without services and plenty of impacts	• Without services and plenty of impacts
Institutional aspects	• Fragmented management	• Fragmented management	• Fragmented management
Environment	• Improving water quality	• Improving water quality	• Overall bad water quality environment

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ANNEX A: CHARACTERIZATION

Characterization of the urban area is a summary of the main facts about the fundamental aspects related to urbanization, economic and social aspects together with water resources characteristics. It is used to have an overall background of the city and country processes which could help in developing the assessment and plan the strategy to solve the issues. It is based on some basic information's which are usually easy to find in the internet, supplied by the client, World Bank data or other means. It gives a first perspective of the country and urban conditions.

Below is presented some of the main aspects which could be used to describe the city and its development. Together with that is presented an example.

The main information's, quantitative or descriptive, which could give this background are:

- Urban area and population;
- Economics of the Country GDP, together with per capita;
- Social distribution of the incomes, proportion of slums, basin area (one or more) in which the urbanization is in development;
- Urban waters: Climate characteristics such as temperature, rainfall and discharges (when there are); water uses and main environment assets.

A.1 Urban area and population

Urban development is the main external condition in the planning urban waters. Most of the conditions are related to urban density, existing and future space occupation in the basin, together with its physical characteristics such as topography, geology, streams network, among others.

Urban area is the space of the urban occupation and not the total administrative area of the city. Urban population usually explains the residential areas, but not the industrial and commercial spaces. These aspects are studied when some major industrial or commercial component is one of the issues, such as a petrochemical complex.

The information about urban population, its trend and forecast can be found in some sites in the internet such as: http://www.demographia.com/db-intlua-cover.htm and the United Nation site on population with many statistics of the city and countries on the population: http://esa.un.org/unpp/. In each specific country it is possible to have more updated data from the country statistical organization.

Urban density is an indicator of the urbanization and it is used for urban planning. This parameter explain some of the key aspects of the urban development (WDI, 2009).The temporal and spatial modification of the urbanization shows how its process and its trend for future. It is also important to compare this process with the country. Table **17** shows that recent cities in developed countries use to have urban density below 25 persons/ha, old European cities are in a larger range, but developing countries are usually above 70 persons/ha and the cities with highest density are in Asian Countries.

The overall density does not describe most of the city, since there is a large difference of density between a regular neighborhood and a slum. Usually the density increases by vertical construction such as building with many apartments in a same area as compared to houses and by irregular occupation such as slums which usually has a very high horizontal concentration.

Based in a density is possible estimate the area of the urban settlement. For instance if in a city the urban density is about 50 people/ha a city of 500,000 uses a space of about[8] 10,000 ha or 100 km^2. The statistics data usually does not have the space of the urbanization area. It is estimated based on all geographic area of the country. It does not reflect the urban development. The procedure to estimate the urban area and density based on limited information is described in the annex A.

Table 17 Large Cities densities[9]

Region	Density People/ha
US and Australian cities	< 25
European cities	25 – 75
Tokyo	110
Hong Kong	360
São Paulo	72
Mexico City	85
Seoul	100,5
Lagos	86

A.2 Economic, social aspects and institutional

Economic

The overall economic and social information's of the city and the country allow a first perspective of the country in terms of investments, population grows and conditions, facilities such as water & sanitation, slums development and governance. Some of these information's are in Table **18**.

Urban governance can be defined as the sum of the many ways individuals and institutions, public and private, plan and manage the common affairs of the city[10]. UN-HABITAT is currently developing and testing an index to measure the quality of urban governance in order to get a global and local view. The main principles used are the: effectiveness, equity, participation and accountability. In relation of the basic information's on governance the main information's at this stage of the assessment are: levels of the country administration, city and urban waters management. Assembling this information's gives the first perspective of the issues.

[8] Area = population/density and 1km^2 = 100 ha.
[9] Combine sources: http://www.demographia.com/db-intlua-cover.htm and Newman et Kenworthy, 1989; Atlas Environnement du Monde Diplomatique 2007.
[10] http://www.unhabitat.org

Table 18: Country basic information's

Index or indicator	*Description*
City Population and its annual grow	Usually population grows is strong correlated to urbanization. It's grows decreases with urban population. A country stabilized its population when there a mean of 2.1 children's per couple.
City Proportion of urban population and the proportion of informal population	The urban population is important to understand the dimension of population concentration. The proportion of informal population is needed in order to understand this social issue related to water services.
Urban population density	It is the population which occupies the urban area. It gives an idea of the mean urban development and soil use. For high density the complexity of urban waters aspects are higher.
Income per capita (country and city)	The amount of mean income of the population, which GNP/population. It is not a good indicator, since it can have high standard deviation, but is used a beginning information.
Income of lowest 20% of population	It is an indicator to understand the level of poverty of the city.
Gini indicator	It is a social inequality indicator

Social

A social indicator of the urban development is the amount of slums in the urban environment as compared to the city. The Table **19** shows the slum population as a proportion of the urban population in major global regions. The tendency is the decrease of the slum proportion with increase of economic income of the country. This information is from 2001 and its projection until 2020 is in UNHABITAT, (2009).

Informal population is the part of the population which occupies unregulated areas, does not pay tax or services. Informality in the city is an important issue for water since most of that population does not have conditions for planned services and may need some type of subsidy.

Slums are the main type of informality which has been found in major cities. This type of dwelling grows decreases with urban population, but essentially it is related to the social and economic development of the country. Major cities of developing and poor countries are those which have the largest proportion. Latin America, Northern Africa, Eastern Asia, South-eastern Asia and Western Asia are almost at same levels of population in slums, varying from 28.2 to 36.4 % of the population. However, Sub-Saharan African and South Asia are in another level, with 71.9 and 59 % respectively. In water services this type of informality requires innovative type of solutions in supporting the population with safe water sanitation and in reducing vulnerability to natural disasters. Most of the time the social and economic conditions of the population is outside of management conditions of water services, but an important part of the improving living conditions are inside of the water management.

Table 19: Slums distributions by global regions in 2001 (UNHABITAT, 2009)

Region	Total population In thousand	Urban population in %	Slum population in % of Urban
Nothern Africa	145,581	52	28.2
Sub-Saharan Africa	667,022	34.6	71.9
Latin America & Caribbean	526,592	75.8	31.9
Eastern Asia	1,364,438	39.1	36.4
South Asia	1,419,417	29.6	59.0
South-eastern Asia	529,764	38.3	28.0
Western Asia	175,322	65.7	35.3

A.3 Urban waters information's

The main information's related to urban waters issues are:

- water and sanitation coverage in the area of interest;
- solid waste coverage
- descriptive of extreme events drought and frequency of floods;
- Affected people and diseases.
- Environment impacts

Some of this information's are descriptive and other are quantitative such as water and sanitation coverage. This information's can be related to social and economic conditions of the country or the city. Figure **19** shows how water and sanitation coverage changes with the country income per capita. Income per capita does not show the great social difference, but in some way gives the total capacity of city or country in investment.

Water and sanitation statistics together health statistics can be found by country in the following site: http://www.who.int/whosis/en/index.html. It is important to take the indicators careful. The United Nations statistics are mainly for local solution which is efficient for small communities. When the small village grows until became a city and after that when it became a large metropolitan area, these solutions are not more reliable, because of the synergic effect of the load increases. Since the soil does not have capacity to receive the load it flows to rivers it flows to the drainage. It is transferred from some houses to the rivers and affects other population downstream. For instance, Argentina has 91%, Brazil has 77%[11] and Indonesia 52%[12] of sanitation, but cities of these countries are completely polluted with important risk for disease. This pollution is result of lack of sewage treatment and local solutions in major cities.

These statistics does not reflect the reduction of the contamination, but the transference of it to downstream by rivers or groundwater. Since in large metropolitan areas, downstream of the

[11] Taking into account the amount BOD load, still 89.3% return to the water systems in Brazil.
[12] In Jakarta, Indonesia the river are completed polluted and there is less than 5% of sewage collect and treated.

source load there are other dwellings, they are affected by this untreated waste. In that way this statistics are unrealistic for a healthy population and environment sustainability of median and large cities (> 100 thousands persons). A sound statistic would measure how much load still comes back to the river after it is used and/or the supporting capacity of the water systems.

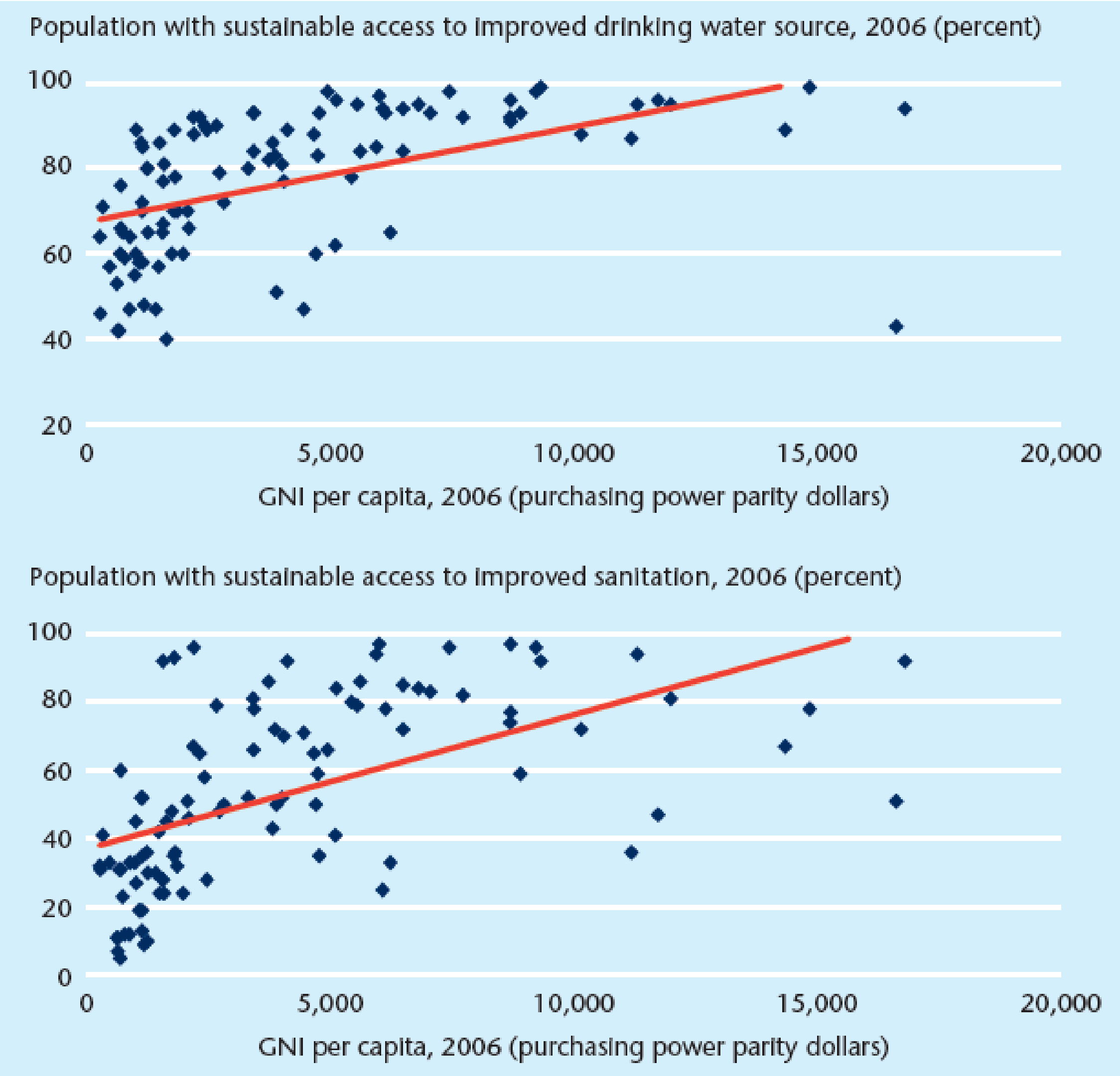

Figure 19 Population with sustainable access to improving drinking water and improved sanitation (source: World Assessment Progam,2009)

ANNEX B: QUALITATIVE MATRIX OF ISSUES (QMI)

B.1 Matrices

In order to support the identification of the urban water issues was prepared a Qualitative Matrix of Issues (QMI). It is an extensive description of the problems which could be found in developing countries cities related to urban waters services. This is the first insight of the matrix which should be updated including future experiences.

There are two groups of matrices: Services and Goals matrix group.

There is a natural interconnection of both groups, since as consequence of the lack of water services there are impacts on the main services goals, which are the Impact on the society and in the environment. This separation was made because is important to understand the separation of services processes and the identification of the impacts in the end objectives.

There are structural issues and specific issues. Structural issues are mainly those problems which require global solution from a big picture of the issues, such as Lack of Water and Sanitation Plan. Specific issues are aspects specific of each service such operational aspect of a treatment plant. In this document QMI presented more structural issues, not specific.

The matrices presented below were constructed by main aspects in each one of the above themes and the identification of the issues inside of it together with the interconnect aspects. Below is presented a summary of the identified issues presented in the matrix.

B.1.1 Planning and Urban Services matrix QMI

In Tables 20 to 25 is presented the QMI for each theme and some description of this issues is presented below by subject.

Urban development

In urban development the following aspects were identified (table 16):

Urban development Master Plan (UDMP): This is the main tool for soil use planning in the city. It plans how the population will going to use its space for service, commerce, industrial and housing. The main questions are: Is this a UDMP? Is this new or old? Is this UDMP enforced? in what proportion? Is this reflecting the urban water services and environment?

Unregulated or informal occupation: Low income population used to develop long term unregulated occupation. What is the proportion of this occupation in the city? Is this any plan for this population? Is the population vulnerable? The population can be vulnerable to floods, water transmitted diseases or others. In this urban waters facilities in these areas?

Urban expansion: is related how the city is growing in the space and time. Usually the tendency is to grow in its borders by migration and decrease downtown by deterioration of space use by drug traffic and gangs which decreases the propriety value. The main questions are: Is the border expansion important? Is this done by unregulated development? in what proportion? The reasons can be related to the lack of income and social pressures, invasion of public areas, lack of investment in infra-structure. Impacts are in the contamination of water sources of the city.

Table 20: Urban development

Sub-topiccs	**Main Aspects**						*Integrated Main aspects*
	Legal	*Management*	*Assessment*	*Economic and social*	*Water*	*Environment*	
1.1 Urban Planning Urban Master Plan	There is not a Master Plan or the existing is outdate	The Master Plan is not enforced	There is not a monitoring of the urban development and problems	There are two much pressure for construction outside of Plan limits	Urban Plan does not take into account the water capacity and sustainability	There is not environment aspects in the Master Plan	Lack of regulation in a sustainable urban waters development
1.2 Informal occupation Proportion of informal/slum areas	There is not a policy for the informal population	Informal population is outside of the city management	There is not assessment of the population and conditions	The population is vulnerable: death and health	Lack of most of the water services in the slums areas		High impacts on urban waters in small spaces
1.3 Urban Expansion	High proportion of unregulated urban expansion	There is not management actions in mitigation of unregulated developments	Lack of assessment on the city expansion	Invasion of public and private lands by the poor; lack of income	Lack of infrastructure: paved streets, energy, water services	Contamination of water sources and environment	Impact on the water supply and increase impacts related to urban waters services
1.4 Governance at local and Metropolitan Level	Lack of legal : local level and instruments for integrated planning in the Metropolitan Areas	Bad management: at local levels and lack of metropolitan coordination	Lack of assessment of integrated impacts at metropolitan and local levels	Weak institutions, lack of investments and funds	Lack of qualification and knowledge in planning		Lack of public participation

Governance: Is related how de urban development is management and regulated in the city. Usually the main issues are related to the: lack of legal instruments which is used to implement the policies. For instance there is an Urban Plan, but no legal instrument to implement it; Bad management: There is not goals, investments or efficiency on the services; Weak institutions and lack of funds; lack of political will and law enforcement; lack of qualification and knowledge. The implication for the other services is the difficulty in the control of the soil use and implementing the management of the urban water services.

Water Supply

In the table 17 is presented the main aspects related to Water supply which are:

Water availability: it is the quantitative limitation to water availability for water supply in the city. The limitation and issues related to this aspect are: Lack of information about the water sources; the increase demand for the existing water yield; the decreasing capacity of the existing works by its design live or lack of maintenance; uncertainty of the water yield by change watershed conditions, climate change or climate variability; Lack of investments in increasing water availability; Irregular occupation on the municipal basins; Contamination of water sources: urban and rural pollution sources

The water source contamination can happen by loads (point pollution) from industrial, commercial and housing developments, if the effluents were not treated in a level which the water systems has the capacity to absorb. The loads could be from stormwater and agriculture lands (non-point pollution), contamined sediments and solid waste and land fill, which can produce long term contamination of aquifer and toxicity in surface systems such lakes and rivers. The main cause of that is lack of sanitation services and the impacts are in all other services, health and environment.

Water Access: the identified issues related to water access by the population are: lack of information of about the lack of water supply; Lack of projects for improvement of the water access; contamination at local level (surface and groundwater) when population uses alternatives sources; lack of education and hygiene; risk of spreading diseases; Lack of investments and funds in water access; Population without capacity to pay for the services and Reduction of water table by over-exploration

Water Treatment and Storage: Storage can be an issue when the system does not have enough volume for regulation during draughts resulting in lack of water. There are scenarios where the Water Company increase the treatment capacity, but does not increase the water yield or regularization from water sources, which results in lack of water during draught because the system has a demand greater than its source can supply.

The other main issues are: Lack of international standard treatment procedures; Lack of monitoring of the water supplied by the source' and water quality treated; Lack of auditing in the procedures in water treatment, distribution and unsustainable disposal of the residuals from treatment. The quality of receiving water could not have conditions which require measures in the treatment in order to attend the water quality standard for the population. A common scenario is when the water source is contamined by nutrients, resulting in eutrophication and toxicity in water.

Table 21: Water supply issues

Issues	Potential Source of the problems						Integrated Main aspects
	Information/ Institutional	***Plan/projects***	***Risk***	***Economic***	***Social***	***Environment***	
2.1 Water availability: Quantitative limitation on the water an access (*Lack of water*).	Lack of information about the water sources	Increasing the demand or lack of storage for regularization	Lack of water sources; risk on water yield: Climate variability or climate change	Lack of investments in increasing water availability	Irregular occupation on the municipal basins	Contamination of water sources: urban and rural pollution sources	Conflict with other water uses in the basin
2.2 Water Access	There is not information related to lack of water access and use	Lack of projects for improvement of the water access	Contamination at local level; lack of education and hygiene; risk of spreading diseases	Lack of investments and funds in water access	Population without capacity to pay for the services	Reduction of water table by over-exploration	Lack of sanitation which impacts all other services, health and environment
2.3 Water Treatment and storage Limitations of water services	Lack of standard monitoring inflow and treated water quality	High demand for the treatment capacity and demand	lack of treated water or international standard treatment procedures	Lack of investments in increasing water treatment	No safe water	Unsustainable disposal of the residuals from treatment	Quality of water services
2.4 Water distribution Limitation of water services	Intermittence on the service	Lack of network expansion; High proportion of network losses	Contamination in the network and in house reservoirs	Lack of investments in increasing water distribution	No safe water	Contamination in the network by intermittence	Quality of the service
2.5 Water Governance	Lack of political will and weak institutions; lack of regulation	Lack of plans and projects	Bad services and lack of supply	Lack of investments and cost recovery	Lack of capacity of payment for the services;	Lack of water and environment standards	Difficulties in integrate policies

Water Distribution: is related to network and deliver to the end user. There are many issues related to this component in the water supply assessment which are*: Intermittence on the service*, when energy, treatment or water availability is limited, together with higher demand, the intermittence can be higher; *High proportion of network losses*: when the network is old or with construction problems or when there are use of water without payment; *Contamination in the network*: it usually is linked to intermittence when the networks losses pressure and allow contamination of the water supplied; *Contamination in house reservoirs*: it is very common to use house reservoirs for regulate the water for a couple of days but it could be a source of contamination when it is not often cleaned. Usually it is not related to the service distribution but is user responsibility, but for uneducated population could be a source of diseases.

Governance in Water supply: Governance is strongly dependent of the service regulation. The usual issues related to management are lack of: project, plans and investment, which results and lack of coverage to attend the demand. It could be related the lack of cost recovery on the services and investment, which increase the difficulties of investments and is related to the lack of political will, resulting in weak institutions with weak technical capacity. It usually is developed when the there is not an independent auditing of the water services.

Sanitation

In the table 18 are described the main issues based on the following aspects:

Sewage in the source: The main issues are related to: (i) when there is not sewage network, septic tank is often used. It can be source of contamination in the upper layer of the soil, where the population may uses for pump water for supply. Other critical scenario is when the soil does not have capacity of infiltration or the water table is too high. In this situation, sewage flows in the streets or through groundwater; (ii) When there is sewage network and the houses are not be connected to it, since the population does not want (or does not have capacity) to pay for the service. These scenarios results in stormwater contamination.

Sewer Networks: there are a few issues often found such as: separate network with sewage flowing in drainage and stormwater in the sewer network; Bad design and construction, frequent spill to the streams, collapse of the network by erosion of corrosion, bad smell and contamination during floods.

Sewage Treatment: Treatment of sewage could be developed in different levels and water quality parameters conditions, depending of the receiving water capacities for receiving it. For organic source of sewage and normal streams with some dilution capacity the secondary treatment with reduction of DBO and coliform usually are the standard design, but for receiving waters such as reservoir and lakes a tertiary treatment is required because of the risk of eutrophication.

The main issues are related to: lack of treatment; low load treated and efficiency; unsustainable residual treatment and disposal; treatment interruption and sewage flowing to the river; bad smell for neighbors.

Table 22: Sanitation

Issues	Potential Source of the problems					Integrated Main aspects
	Management	*Technical*	Economic	Social	Environment	
3.1 Sewage at the source	Lack of house connection to network	Low infiltration and high load with spill to drainage	Population does not want connections to network to avoid the payment	Poor population without capacity to pay for services	Contamination of wells and neighbor areas	Contamination of surrounding and water sources
3.2 Sewer network	Bad design and construction; Lack of maintenance	Separate system with Stormwater in the network; Collapse due to external effects such as erosion	Lack of networks due to lack of funds and cost recovery	Floods from combined system with diseases	Bad smell and overflow or combined sewer system	Impacts in the streams and water sources
3.3 Treatment	Lack of treatment; operation with bad performance	Low load for treatment and efficiency	Lack of funds and cost recovery for investments and operation	Bad smell for neighbors; space in the city for treatment plant '	Treatment interruption's; overflow; Unsustainable residuals disposal	Impact on receiving waters
3.4 Effluent disposal	Lack of monitoring the receiving waters	Concentration of load without treatment	Lack of investment in conservation	Potential diseases development	Lake eutrophication; Lack of dilution capacity in the receiving waters.	Health and environment risks
3.5 Governance	Bad management: maintenance and operation.	Lack technical capacity	Lack of political will, investments and cost recovery	Lack of services assessment and goals; lack of cost subsidy.	reuse opportunities; Lack of managing industrial and high risk loads	Difficulties in integrate policies

Effluent disposal: It is related to the water body which is receiving the effluent. When the sewage infiltrate, the contamination in the basin is diffuse and spread, but when it is collected by stormwater or sewer network and dispose without treatment in a water body, the impact is concentrated. The main aspect is the water body capacity in receive the load, treat or untreated. Low water body capacity requires more efficiency in treatment in order to have stream or lake conservation.

Governance: bad management in operation and maintenance, unqualified personal; lack of political will, investments and cost recovery (the price of the service is below the cost). There is not monitoring of river water quality and lack of independent assessment of the services and goals; No regulation of the services which assess its efficiency; the cost of the services is charged to the population when there is only collection of the sewage (sometimes even without it). In this scenario why this company will invest in order to have all the services?

Stormwater

Table 19 presents the stormwater issues based on the following sub-divisions of it:

Drainage in the source: It is stormwater of the property which is managed by its owner. At this level the main impacts are related to the increase of impervious area, reduction of infiltration, soil erosion and solid waste which could lead to a degraded area and contamined surfaces.

Network and storage: Public stormwater systems usually have a network of channels, conduits and storages (detention or retention ponds) integrated in order to flow the rain water. The issues of this system are related to the following: sewage in the drainage network for separate systems. The high proportion of sewage in the drainage contaminating the receiving waters; Collapsing of the system by corrosion when there is sewage or by high velocity of drainage; High proportion of solid waste and sediment can decrease the flow capacity of the drainage allowing flood conditions; Floods in the networks as result of flow increase or bad measures upstream; for natural stream or storage the erosion and sedimentation together with sewer in the drainage may result in degraded areas.

Measures in major drainage: the main issue in the major drainage are floods for lack of storage or flow capacity which results from upstream flow increase, downstream level control, flow reduction capacity by solid waste and channelization upstream (bad solutions); Increasing total solids upstream during urbanization and lack of control of this sources which results in decreasing capacity of the flow in the network and storage together with degraded areas; Water quality of rain water after it flows in urban contamined surfaces such as roof, side walk, streets and commercial and industrial areas brings important load to the stream. For modern urban drainage management this water needs a treatment in retention or detention ponds together with a connection to treatment plants which requires an integrated lay-out.

Governance: Usually there is no a “utility” to develop urban drainage services. The municipality uses some existing department to attend some of the issues without any real management. The main issues are also: no regulation on source areas which deliver impacts to downstream, transferring the private responsibility to the public; bad management since there is not operation and maintenance and law enforcement; limited knowledge in urban drainage since most of the engineer does not identify the source of the problems.

Table 23: Stormwater

Issues	Potential Source of the problems					Integrated
	Urbanization	Technical	Economic	Social	Environment	Main aspects
4.1 Drainage in the Source At property level	High level of impervious areas and high density	Increasing flow and velocity, erosion	Transference of impacts and cost from private to public	High vulnerability to floods	Degraded areas and water quality contamination	Reduction of infiltration and recharge
4.2 Network and storage Micro and major drainage	Obstruction in drainage due to bridges, building piles and others urban constructions	Collapse of the network by erosion or corrosion; sewage in the network	Lack of network due to lack of investments	Frequent floods in the networks	Bed erosion, sediment yield and solid waste deposition	Impacts on population and receiving waters
4.3 Measures in the major drainage	Lack of Integration of drainage solutions to urbanization; lack of space for storage	Flood transference in the drainage;	Lack of funds for measures at major drainage	Increasing flood vulnerability by flood transference	Lack of sediment or water quality management	Impacts on environment and water sources
4.4 Governance	No regulation for source areas impacts	Bad management: operation and maintenance and law enforcement	There is not an utility for the service and cost recovery	Limited knowledge in stormwater management	There is not environment license for stormwater projects	Difficulties in integrate policies

Total Solids

Total solids are the sediments from erosion and solid waste. Table 20 shows the matrix with the main aspects, which are:

Solid Waste collecting services: It is related to the usual service to collect the waste in homes, offices and industrial installations. The collecting and disposal of highly contaminated waste is assumed as specific aspect to this report as mentioned above. There are many scenarios such as: most of the city without services of collecting or receiving centers; no home collecting services, low frequency services which increase the time of storage in the source, allowing diseases vectors, bad population habits which usually through solid waste to streams. There are also scenarios, where the city may have good services, but some areas are of difficulty access because of narrow or bad conditions of the streets, gangs and drug dealers control of the area.

Cleaning streets and public areas: it is the service which should be provided by the municipality. The issues related are the following (table B.5): There is not service or low frequency of cleaning, bad management and dumping of waste by the population are the mains issues

Soil erosion and sediments: During the development of the urbanization there is a high increase of the sediments because the vegetation is removed and constructed streets without protection of the surfaces. During the rainy days the increase of laminar erosion in the unprotected surface due to flow velocity increases in the impervious areas. It also can generate concentrated erosion and degraded areas. Usually it happens when there is no land protection in the construction and in the urbanization, which should be enforced by the municipality.

Storage Transport and disposal of the solid waste and solids collected in the streets: After the home and street cleaner services were developed the solids are storage and transport to a disposal site. The logistic of these services is important in the development a sustainable service which lack of contamination in the storage and transportation and low cost. The land fill has to be developed in sustainable way in order to avoid contamination of the soil and surface waters

Governance: the main issues are related to a: the existence of a sustainable service with cost recovery, bad management of the existing services, lack of independent assessment of the service, policy or program for decreasing solid waste by recycling.

Institutional and integrated management

Along the analysis of the services in the former matrices the governance are identified since most of the institutional issues are cross-cutting issue. The overall Institutional issues is related mainly to integration of the governance and water resources management at basin and administration are presented here.

Table 21 shows the main institutional aspects and integrated management issues related to the overall urban water services and its integration to Water Resource Management at National and Regional levels. The main aspects are:

Table 24: Total Solids

Issues	Potential Source of the problems					Integrated Main aspects
	Urbanization	***Service***	***Economic***	***Social***	***Environment***	
5.1 Solid waste collecting service	Waste from construction sites	There is no home services or low frequency	Lack of funds and cost recovery services	Lack of education; use of drainage for solid disposal	Solid waste and degraded areas	Large amount of solids in receiving waters and decreasing flow capacity and floods impacts
5.2 Cleaning streets and public areas	Narrow streets	No services or Low frequency of cleaning	Bad management services	Dumping waste by the population in the streets	High amount of solids in the streets and stormwater	Decreasing flow capacity of the rivers and environment impact
5.3 Soil Erosion and sediments	No construction practice for erosion control	No design control for downstream areas and streams protection	High cost of river cleaning	Solid waste near to population and spreading diseases	Deforestation without protection; degraded areas	Degraded areas, pollution to downstream streams
5.4 Storage, Transport and Disposal	Lack of urban space	contamination of storage areas; Bad logistic	Lack of funds for services	Poor population collecting waste	Land fill without monitoring or maintenance or in recharge areas	Surface and Groundwater contamination, lost of funds
5.5 Governance	No utility for the service and cost recovery	Bad management of the services	No policy or program for recycle; lack of cost recovery	Lack of management of service of poor population	Lack of license and environment regulation	Difficulties in integrate policies

Table 25: Institutional and Integrated aspects

Issues	*Potential Source of the problems*			
	Legal	***Management***	***Economic***	***Environment***
6.1 National Water Framework	No National water policy or integrate legislation	No National Water Authority; fragmented management	There is not sustainable investment in water at national level	Limited environmental and institutions
6.2 Water Resource Management at basin	Lack of national or regional legislation on urban waters	There is not basin organization	Conflicts of water use; lack of economic support for basin management	Impact from the cities are exported to downstream in the basin
6.3 Geographic and water administrations	Conflict of jurisdiction on water	Conflicts of management	Institutional Economically weak	Conflict of jurisdiction on environment
6.4 Integrated Urban Water services management	Fragment services on urban waters; no regulation	Different levels of management for water in city	There is not cost recovery for the services	Different levels of management for environment in city
6.5 Environment assessment and enforcement	There is not legal framework of urban waters impacts	Lack of monitoring and data for planning	No funding for environment	There is no environment assessment or conservation in the city

National Water Framework: It is important for the urban management if the country has a policy for Water Resource and uses the concepts related to IWRM? Together with that the Country has a policy for urban waters? The country has a National Authority for Water? These are important aspects in order to construct a trend for solutions of the urban water issues.

Water Resource Management at basin level: It is important to know if there is any management at basin level, such basin committee and agency relate to the basin decision and support. In that way is important to understand if the basin organization applied any limits or incentives for the city's urban water management and control of its impacts. In addition to that an important aspect is to find out if there are institutional conflicts among cities and how the impacts from one city to another are managed.

B.1.2 Goals matrix issue

The main aspects related to the impact on the society and environments are on the:

HEALTH OF THE POPULATION and related to diseases proliferation related to water sources and urban water lack of services. The water and sanitation diseases usually are related to lack of safe water and sanitation. Some common diseases related to this lack of services are: diarrhea, cholera, and other bacterial transmission.

The water related diseases can be classified by (Proust, 1993):

- *Water borne diseases* are related to water quality and they depend on water for their transmission. A few years ago cholera spread through South America mainly to areas where the coverage of safe drinking water was low, such as Peru, the Amazon and the Northeast of Brazil;
- *Water-washed* diseases are related to hygienic practices which depend mainly on the social and health improvement of the community. They are related to skin, ear and eye infections;
- *Water-related* and *Water-based* diseases in which the agent uses water. Prost (1993) reported that any project which increases water surface results in the development of the Anopheles mosquito vectors of malaria and of one of the fresh water snail vectors of schistosomiasis. Another example is leptospirosis a disease that can develop after a flood due to rat's urine.

NATURAL FLOODS: when the river leaves its lower bed and floods the plains near it. The impact is the result of the occupation of risk areas near to streams by the population as a lack of soil use planning. Others risk area which can resulted in impact to the population are in hill slope since during flood season the soil in the hill moves down because of water weight damaging houses and killing many persons. The main aspects related to flood management were presented in table 22 which are:

- Large part of the population occupying risk areas (flood plains and hill slopes). It is an issue when a city is crossed by a river which often overflows its natural banks. Poor population usually occupied these areas since it is public area and is near the jobs and facilities. In resettling this population other comes to the same space, which requires a long term sustainable regulation and planning of the space and social arrangements;

Table 26: Impacts in the Goals

Issues	*Potential Source of the problems*				
7.1 Health	Water borne diseases	*Water-washed*	*Water-related* and *Water-based* diseases		
7.2 Natural Floods	Large population in flood plain risk areas	Lack of risk area mapping	Lack of regulation and law enforcement on the occupation of flood plains	No alert system of management of the impacts	Incentives by no refund funds without prevention
7.3 Environment	No regulation on urban water environment	Lack of law enforcement	No Conservation and preservation areas in the city or small part of the city	Rivers impacts: Long extension of rivers without fauna or preservation of banks vegetation	Large extension of degraded areas
7.4 Amenities	Small urban area for recreational use: green and water related spaces	Large number of degraded recreational areas	Risk of water use for recreation in the urban space	There is no amenities related to water in the city	

- Lack of risk area mapping: without knowledge of the risk area and without including this issue in the urban plan (bad planning) it is natural that the population will occupy the space more flat, which usually is the risk one. In some cities with many hills the population with lowest income move to steep slopes without much infrastructure which could move down during floods.
- *Lack of regulation or/and law enforcement in flood plains*: The process mentioned above is mainly due to lack of regulation of the space or law enforcement when it exists.
- No alert system: The alert of the floods are used to mitigate the floods, informing the population in advance and give support to its difficulties. The lack of a system such as that will increase the impacts;
- Incentives by refund funds without prevention. Usually the countries try to mitigate the floods after it happens using no refund funds, but it will delay the prevention, since the local population knows that during the events.

ENVIRONMENT: There are many related to environment in urban areas. It is impossible to bring in the assessment all of the aspects. The main issues are:

- No regulation on urban water environment The primitive condition is a complete lack of legislation for environment control in the country and in the cities;
- Lack of law enforcement: Even when exists legislation it is common to find a lack of law enforcement and environment planning for the city;
- Small space for conservation and preservation areas: Urban environment conservation requires some spaces for the more important areas such as wetlands, hill slope, among others. These are conservation and preservation areas more sustain part of the environment. It is important to understand how the city deals with that.
- Rivers impacts: Rivers are the ultimate area where what is done in the basin reflects in its course. The common issues are the lack of oxygen and aquatic live, sometimes the river is closed in order to get more space for cars and to covers the pollution. How it is important in the city what is left from vegetation near the banks which supports its conditions, together with erosion and sedimentation.
- Degraded areas: The effect of soil erosion, urban development without soil protection, urbanization and velocity increase is likely to develop many degraded space in the city. It is important to understand how this issue is important for the assessed city.

AMMENITIES: Quality of live is related to the safe live, where the city services improve the service to eliminate the water related diseases, avoid floods impacts and improve environment. Another important component of the quality of live is the amenities which the city can offer to its population. Some of these amenities are related to water services in the city. Some of the main important are:

- Small area for recreational use: what is the space for population recreation, is it important? In the city urban perspective?

- Large number of recreational degraded areas: the existing recreational area are degraded by many reasons such as lack of maintenance and population lack of care;
- Risk on the recreational use of the water: the water is used for recreation, but there is a risk for health or even floods conditions.
- Lack of amenities related to water in the city: the limited existence of amenities related to water is a condition in the city and it is an important issue.

B.2 Instructions

B.2.1 Plan of the visit in the city

Before travel is recommended to have an overview of:

- Municipality main aspects in relation to urban population and economic and social developments. I think this information we can get in the internet but they could have a summary.
- Urban waters: water supply, sanitation, urban drainage and total solids basic information which could be obtained in report summaries or send us some reports they think it give us information.
- Other documents and reports which addresses issues and planning in the city in the last years which could inform us. Internet survey gives information of floods and natural disasters, news about urban waters services. The main key words for survey are: name of the city followed by the subject such as urbanization, floods, land slide, water supply, sanitation, health, slums, poor, etc.

In planning the agenda the suggestions are:

- Schedule in order to interview representatives of the institutions in charge of Urban planning, water supply, sanitation, stormwater, solid waste, environment and water resource authorities;
- Schedule in order to interviews ONGs, outside of municipal govern consultants, World Bank specialists on the subject and Central Govern authorities
- Travel through the city looking for major drainage, high and low income neighborhoods together with main areas and take a overview of the main sub-basins.
- Some installation such as wastewater treatment plants and Water supply reservoirs and Water Treatment Plants would be recommended.

It is likely that all above recommendation is impossible to develop in a week. Sometimes would be better to stay a few days longer and improve the knowledge about the city.

In the end of each day is recommended a discussion among the persons in the mission. In the last day is important to have a complete discussion and a preparation of the outline of the report about the case study.

B.2.1 Instructions

An excel file called Issuesmatrcices.xls was prepared to help in the assessment. This file has the following tables (table 23 to B.25) to support the development of the assessment. Others supporting table can be found in the file.

Table 27: Instructions

A. What ?	Description	Support information for the task
Contents:	In this file are presented the main matrix of issues	
B. Matrices	The matrices are organized by main urban water aspects : urban planning, water supply, sanitation, urban drainage, total solids, institutional and qualitative matrix of impacts	
C. Matrices contents	Previous identification of the main issues in urban planning and urban waters and its main impacts in society and environment	
D. Procedures	1. Identify which issues are related to the specific case without given them priority. It is likely that most of the issues are found in the cities but you need to judge its importance;	In the analysis of the issues we recommend the interview of govern officials, NGOs and bank consultant in the country which have some knowledge about the city.
	2. You can add new issues using the last line of each matrix.	From the interview you cand add more information to the matrix and send us to updated it.
	3. In the end there is a sheet to be filled with the selected issues, called **Selected issues.**	The excel file is a support file prepare to help the filling and analysis. You can updated it with your own practice
	4. Use colors in order to give priorities for each issue. RED for maximum priority; YELLOW for issues which are not a problem but could be in the future; GREEN for minor issues.	This is a subjective procedure and you can ask other people from the city if they agree with your assessment or fill it with them. Since it is subjective it is good to have another option about.
	5. Identify and describe the issues which are related to more than one aspect (integrated issue)	This relationship of aspects (urban waters, institutional and urban planning) is important for identification the interconnection of problems in the city
	6. Develop a cause-effect relationship together with the first guess of the measures	This description will give perspective and you could develop a flowchart relating the main causes, issues and impacts. In the end is important to propose some measures
E. Conclusions and findings	7. Describe your conclusion about the findings	The conclusions should be summary of the findings, selecting mainly the red issues and integrated aspects.

Table 28: Some previous questions

Questions	type
1. What do you thing are the main urban waters issues of the city? (Define the meaning of urban waters since most of professionals do not know)	Geral
2. What do you think are the main institutional difficulties?	Management
3. Do you think the administration has political will to invest in urban waters issues?	Political
4.What do you think would be benefits of improving urban waters for your city?	Perception of the benefits
5. What level of priority the aspects of urban waters have for this administration ?	Political
6. Do you know that Urban waters investments are for long term and the public perception of the results may occur after this administration? What should be reaction of this administration to this perception?	Political
7. How much of the budget you think can be use for investments in these problems along the time?	Financial
8. Do you know that in order to solve the problems you have to rise the taxes and charge more to the population?	economic
9. Go through the matrices asking in his perception which are the more important issues	urban waters
10. What are the reports and documents you think I should read?	
11. Ask to him or her if there are any addition issues he would like to address	urban waters

Table 29:. List of interviewed persons

Name	age	background	position	Your comments

ANNEX C: INDICATORS

This ANNEX presents some of the quantitative aspects of the assessment developed. The analysis presented in this chapter is related to the dimension of some issues related to urban waters, based on existing indicators of urban development and water services, together with the assessment of the impacts.

In the following item is presented how this assessment is developed in the space, taking into account the upstream – downstream effects in the basin and the urban development. In the second item is presented the selected indicators for urban water services assessment together with impact and goals indicators which are used for an overall assessment of the issues. In the third item is presented some suggested criteria's based on the indicators to find the level of the issues and required measures.

The objective was to use the simplest methods in order to have a first step assessment, leaving the modeling and specific tools for other stages of project preparation. The importance of this analysis is to justify in quantitative terms the main issues, as a preparation for a strategic plan of investments.

C.1 Spatial discretization

There are the following analyses of the urban system and its water management:

(a) Overall schematic view of urban development and urban waters interaction. It is used to have a big picture of the space relation of urban waters;

(b) Spatial discretization of the assessment where the city urban water is sub-divided in basins and upstream - downstream relationship in the urban waters interactions.

Overall assessment: In order to have a big picture of the urban development and the water resources, a map with the following layers would be recommended: administrative borders, rivers networks, basins borders and space of urban occupation. Other layers could also be included but it could pollute the map view. This type of the map can be found in the city administration, but usually they do not include the basin limits which should be included. It can be drawn by hand taking into account topography or by GIS.

The map scale is function of its practical use, dimension of the basins and urbanization. Sometimes is impossible to have everything in the same map. In that way, it is possible to draw a map of water supply for the city and another map with the basin limits of the major drainage and the city, where the relationship of upstream and downstream has effect. This type of map allows the mean assessment of water demand x supply in the space.

Spatial discretization: The mentioned above map could be sub-divided in sub-basin where the water supply, sanitation, urban drainage and solids are assessed, together with the impacts and goals for the city management.

C.2 Indicators

Table 26 presents some indicators which could be used in the assessment developed in this document. In the coming items are described the meaning of this indicators..

Table 30 Indicators for urban waters assessment

Indicator[1]	**Aspect**	**Justification**
Population of the city (P) and informal area p (%)	Urban development	It is base for consume and impact in the urban area
Urban area (UA) (ha)	Urban development	It is space or the urban settlement
Urban density (Ud) (persons/hectare)	Urban development	Indicator how the infra-structure is developed and planned in the city
Total Water demand (L/s or m^3/s)[1]	Water supply	It is the base to estimation of water use for the city
Access to safe water (ASW) (%)	Water Supply	Proportion of total population which has access to safe water in the city
Water availability (L/s or m^3/s)	Water supply	It is the existing water availability for city supply.
Access to basic sanitation (%) and Access to full sanitation (%)	Sanitation	The proportion of the population which does not have minimum sanitation (septic tank or sewage collection) but without treatment; Full sanitation is assumed here as the proportion of population which has collection of sewage and treatment.
Sanitation Load Indexes	Sanitation	Relates the load generated by the cities and its effective treatment
Detention volume	Urban drainage	Assess the require volume needed to mitigate the peak flow increase by urbanization.
Stormwater load	Urban drainage	Assess the load from the urban drainage for the same water quality parameters of sanitation and for metals.
Support Capacity	Sanitation & urban drainage	Assess the capacity of the water bodies in receiving the city loads.
Sediment increase (LS)	Total solids	The increase in sediment yield in relation to its natural conditions
Solid Waste in the drainage (Sw)	Solid Waste	The proportion of solid waste in the drainage is an important indicator of the efficiency of the services.

1 – There are other indicators which could be used in order to support the assessment which are described inside of each item.

C.2.1 Urban development indicators

The main indicators in relation to urban development are:

Population of the city and population in informal areas: It describes the number or persons which needs the urban water services and are the source of the urban soil use and potential impacts;

Urban area: It is the space where the population lives in a city. It is important to distinguish from the total administrative area of the municipality, since it covers rural areas together with urban. Usually this information is not available. Some of the procedures used to estimate the urban area is in item C.3.

Urban density: this indicator shows how the city develops its infrastructure. It may have a large variation inside of the city. Usually urban planning is done by the distribution of urban density.

In higher urban density, the cost of water utilities and transport are lower, together with the unit cost of infrastructure and real estate profit maximization, but it may result in less quality of live (amenities and health). Some of the factors which could influence the quality of live are: (a) temperature (high density); (b) loss of time in traffic jam (high density); (c) increase cost of transport for long distance (low density); (d) large water supply and sanitation systems (low density); (e) frequent floods (high density); (f) high environment impacts (high density).

There is a need for equilibrium and innovative urban development in the way to find a balance in urban density, housing distribution and job areas (commerce and industry spaces) together with environment conservation. This is the process of development or renovation of a city and finding its sustainable balance.

C.2.2 Urban waters indicators

Urban waters indicators were selected for each service. They have connection with urban development based on urban density (or population).

Water Supply

There aspects selected are related to demand and water availability relationship. Some of the indicators are: Water demand, access to safe water and Water availability. Other indicators can be use in order to complement the assessment which are: intermittence, losses, coverage of low income population and others. The former parameters are selected to have a broad overview of the needs.

Water demand (Wd): the amount of water used in the city is usually obtained by the mean water consume per capita (Wu) (L/day/person) multiplied by the population. It could also be mapped taking into account the density through the city.

Demand usually covers not only the per capita consume, but also the lack of efficiency[13] of the services in losses by the system such as the network (item D.3 shows the estimation of water

[13] Efficiency is related to reduction of demand by the efficiency of the service; Conservation is related to the consume by the population

demand). The Wu is also function of the conservation[16] by the population. Usually in some developed country the efficiency is high but the conservation is low. In developing countries the efficiency usually is low because of the large amount of water lost in the networks distribution. Wd can be assessed by using information existing in the city or by the use of the population and the Wu estimated by comparison with other cities.

Access to safe water (ASF): the proportion of the population which have safe water. This information should exist in the utility.

Water availability (Qa): it is the flow available in the water supply basin in order to attend the demand. The water availability is

$$Qa = Qy\text{-}Qe\text{-}Qod \qquad (C.1)$$

where Qy is the flow availability or water yield from the basin (natural ore regulated by a reservoir). The procedures to estimate the values are described in Annex item D.3; Qe is the environmental flow which should be left in the river in order to allow environmental sustainability. This flow should have a variation along the time. The estimative of this flow, as a first guess for this assessment, can be a proportion of the mean flow (~3 - 10%, depending of the natural conditions); Qod is the sum of other water demand in the basin.

In addition, is important to understand the water rights in the basin and the distribution of the flow from upstream do downstream. In some countries the water rights is bought in the market (West of USA, Australia and Chile). In others the water rights are given based in many conditions where the human consume has the highest priority in the potential conflict (Brazil).

The analysis of water supply using the indicator should be in: (a) the existing lack coverage; (b) the available water and required coverage; (c) lack of infra-structure of regularization, treatment and distribution; (d) What are the required investments?

Sanitation

Sanitation assessment is based in the load from the city and the capacity of the water to receive this load. Sound solutions is to develop sanitation based only minimization of load left to the environment, but there are many stages and capacity of investment in a city/country in order to achieve its optimum sanitation. In that way it is important to estimate the capacity of the water body to receive this load and plan the strategy in order to achieve taking into account social and economic requirements.

Access to basic sanitation (ABS): the proportion of the population which has septic tank or sewage collection from network. In addition, the proportion of the population which has full sanitation (named used here) which represent the sewage collection and its treatment at least at secondary level.

Load Index: The load index is the relation between the loads left to environment to the gross generated load by the city. The best sanitation is obtained by minimizing its value. There are the following types of water body which receives the load: Groundwater (Gl) and Surfaces flow systems (rivers, lakes and reservoir) (Rl) and coastal:

Groundwater: The sewage can be disposed in the groundwater by septic tanks or infiltration systems used in the city

Surfaces: the sewage disposed in the streams, lakes, reservoirs and coastal.

These indicators are estimated as described in the item C.3, and represent the amount of waste delivered to the water bodies.

Support capacity (Sc); It is the capacity of the natural system has to support the load. There is groundwater support capacity and surface support capacity.

Groundwater support capacity (GSC): This index is function of the load and the infiltration capacity of the soil. When the communities are small with a low urban density the contamination and the soil has capacity to infiltrate and dilute the sewage, it can be used as preliminary solution.

Stream support capacity (SSC): this index represents the receiving water body (stream or reservoir) load capacity. In this scenario the capacity has to be related with the total loads from sewage and stormwater mentioned below (see item C.3).

Taking into account the existing conditions is important do access: (a) how much of treatment is required? (b) How much of the network is required? Based on the indicators is possible to estimate the required investment in treatment and network.

Urban Drainage

Urban drainage assessment is based in quantitative and qualitative indicators. The peak flow increase with urbanization, in order maintain the peak flow inside of the drainage capacity, avoiding floods, a detention volume is required. In this study the detention volume is defined as the required volume in order to decrease the urbanized peak flood to its existing capacity. It is used as an urban drainage quantitative indicator.

The qualitative indicator used is the load from stormwater which is delivered into major drainage and streams. This indicator is based on the load from the stormwater which is estimated for the same water quality parameters used in sanitation load. Item C.3 presents the methodology developed in order asses these indicators in the urban environment.

The main questions in this scenario are: Is there floods in the stormwater? Is the city moving from downstream to upstream without control of volume and peak increase? If the answers are positive for these questions, the indicators can give you the first guess of investments.

Total Solids

Totals solids are the sum of *land erosion* which results in sediments on the streams together with degraded areas and *Solid waste* which are not collected by the services in the city, resulted from leaves, litter and waste produced by the population. As it was described in the chapter 1, the source of these types of solids is from different actions in the city. The erosion is developed by bad practices in the development of new construction, leaving the surfaces unprotected, which allow the erosion eroded by rain and flow velocity, after urbanization. This process usually is the source of the degraded areas in the city.

The Solid Waste is consequence of bad habits of the population, lack of sound services in collecting and cleaning streets and disposal.

The indicator used for the sediments is the change in the sediment yield in function of the urbanization in relation to its natural conditions (Ls). The indicator used for solid waste is the efficiency of the services or the proportion of solids in the drainage (Sd). Some information which can be used in the estimation of these indicators is presented in the item C.3.

These indicators are very difficult to find, but they were included in here in order to help plan the future monitoring and preparation studies for the projects.

C.2.3 Urban waters impacts and goals indicators

Urban water impacts and goals indicators shows if the there are sound services in the city. Assessing this information is possible to understand the city sustainability in short medium and long term goals. There are also indicators of efficiency which usually are specific to each service. The conservation indicators on urban waters are those which minimize the impacts on the environment and on the people.

The urban waters indicators proposed in this document will be difficult to assess at this stage because of the lack of information's but they could be used as suggestion along the investment and future assessment and a guide and goals to measure the output of the investment. Table 27 presents the recommended indicators of goals.

Table 31 Urban waters Impacts and goals indicators

Indicator	Justification	Objective
Water quality	Assess the management services of sewer, urban drainage and solids and water supply conditions of the basins.	Sustainability of the urban services for the city
Flood frequency	Minimize the floods places in the city by eliminating the events for a selected risk	Reduce social and economical losses
Degraded areas	Eliminate the degraded area in the city as result of pollution and erosion or sedimentation. Improve amenities in these areas	Improve quality of live for citizens in degraded area with amenities
Health	Reduction to WHO standards the water related diseases such as diarrhea, leptospirose, dengue,etc	Increase live expectation and reduction of children's death index

Water quality

Most of the countries have legislation related to water quality downstream of the pollution source and classification of river for environment license. Water quality parameters such as BOD, OD and Coliform assess the conditions of rivers downstream of the treatment plants, taking into account river capacity and Nitrogen and Phosphorus for lakes and reservoirs (see tables in item C.3).

In order to assess the water quality along the city, as result of the urban water services is important to understand that there are two critical flow conditions:

(a) During draught the natural flow is small and the dilution capacity of the streams is small. For permanent loads such as from domestic and industrial sewers this is the critical condition. Assessment of water quality concentration has to take into account the flow in order to correctly assess the conditions of design the services related to sanitation.

(b) During storm conditions the load from stormwater is important, since in the beginning of the storm the pollution the load is high (see chapter 1) and even with more dilution capacity it is likely to have a high concentration downstream of the city. In the stormwater water quality parameters it is not the organic matter which are important but the metals which comes from washing surfaces.

Taking into account the above information it is recommended to ask for monitoring information from water quality parameters taking into account the discharge of the streams and level and volume of the reservoirs.

Flood Frequency

It can be assessed using existing information of the city such as:

(a) Mapping flood distribution and frequency in the city. Usually the municipalities have a map of the places which the flood is frequent;

(b) The sub- basins with urban occupation and flood map allow a qualitative evaluation the main source of the problems;

(c) Recommend a survey of the flood distribution by interviewing professionals, ONGs and population nearby the flood places. This information is very important in order simulate the previous floods and quantitatively assess its impacts.

The assessment and strategic plans goals is the elimination of the flood places and frequency for a specific where the investments are lower than the damage cost.

Degraded Area

In the urbanization process, if the velocity increase is not controlled, drainage develops erosions creating degraded area. A degraded area can also be developed by sediment deposition when the flow capacity to transport the sediments is small. The assessment is done by:

(a) Mapping of the existing degraded area;

(b) Identification of potential degraded areas based on the urbanization and starting process of erosion or sedimentation.

(c) Identification of the main causes which could be mitigated by non-structural mechanisms and structural recovering.

Health

Assessing the existing statistics related to diseases related to sanitation, as discussed in chapter 1, and its evolution in time, allow the evaluation of the results from the sanitation services. It is recommended to take into account:

(a) Identification of the main water related diseases taking into account the reported cases in the city;

(b) Identification of the main causes of the diseases, mainly developing the lack of the water services and the diseases numbers;

(c) Recommend the monitoring of indicators for assessment of the investments.

C.3 Estimative of the Indicators

C.3.1 Urban Development indicators

Population: Population is the number of persons which leaves in the city. This information is basic information available in every city

Estimative of Urban Area: it is the region of the municipality a density usually greater than 5 -10 persons/ha. The alternatives for estimation are:

a. Urban density is a known variable

$$Ua = \frac{P_o}{Ud}$$

where Ua is the urban area (ha); Po is the population; and Ud is de urban density in person/ha.

b.The urban density is not known. In this scenario there are two options:

(b.1) use the Google Earth or other satellite image and take a look on the urban space and estimate the area. It does not to need to be precise. It is only a rough estimative of the dimension of the space of the city;

(b.2) assume an urban density for the city based on the information from the site mentioned in chapter 3 or the density typical of this type of city and region. For instance in Brazil Embrapa (2008) developed a study for the State of the country.

Urban density: Urban density may vary from 10 person/ha to 300 person/ha depending of some urban planning parameters which are:

(a) Proportion private areas based on the total or urban area (α);

(b) Number of persons per housing unit (P);

(c) Mean dimension of the plots, (s in m^2);

(d) Mean number housing unit per plot (r).

The urban density is

$$Ud = \alpha . P. r.10.000/s$$

Some of these parameters are standard for a region or a city, since the urban development could be similar. Table 28 shows some of these values and in the file indicators.xls there is spread sheet for estimation of the density in function based on these parameters.

Table 32: Indicators for urban density estimation

Parameter	Simbol.	Range[1]	Description	Information
Proportion of private areas in relation to total area(%)	A	15 – 40	It includes green public areas, sidewalk, streets, etc.	Old cities and poor countries it is usually near to lower limit (high density)
Mean number of person per housing unit	P	2 – 10	Residents in each unit	Decrease with the income
Mean size of the plots (m^2)	S	20 -1500	Plot araea	Some countries have lower limit as 120 – 200 m^2. It Decrease with the decrease of income. For buildings it requires also larger areas.
Mean housing unit per plot	R	1 – 100	Number of house or apartments in the same plot	It varies, depending on the combination of plot size and height of the building.

1 – In Brazil usually is α =35%; p = 3,5; s= 300 - 500 m^2

The hydrologic indicator is the Impervious areas in the urban environment. It can be related to urban density. From this relation is possible to identify the amount or impervious areas/person. In Figure **20** is presented some of these relantionship for USA and Brazilian cities. The slopes of relantionship for New Jersey cities, three Brazilian cities and APWA are almost the same which shows the trend of the relantionship of density and impervious areas.

The difference among the curves are the starting level, which is likely to represent part of the public areas. Using a straight line, the estimation of this coefficients in the range of urban density between 30 to 80 person/ha is presented in table 29.

Table 33 relantionship of urban density and impervious areas

Source	A	B
São Paulo /Curitiba/PortoAlegre (Brazil)	0.50	5
New Jersey cities	0.50	21
APWA	0.55	30.5

Impervious area (%) = A.[density in person/ha] + B

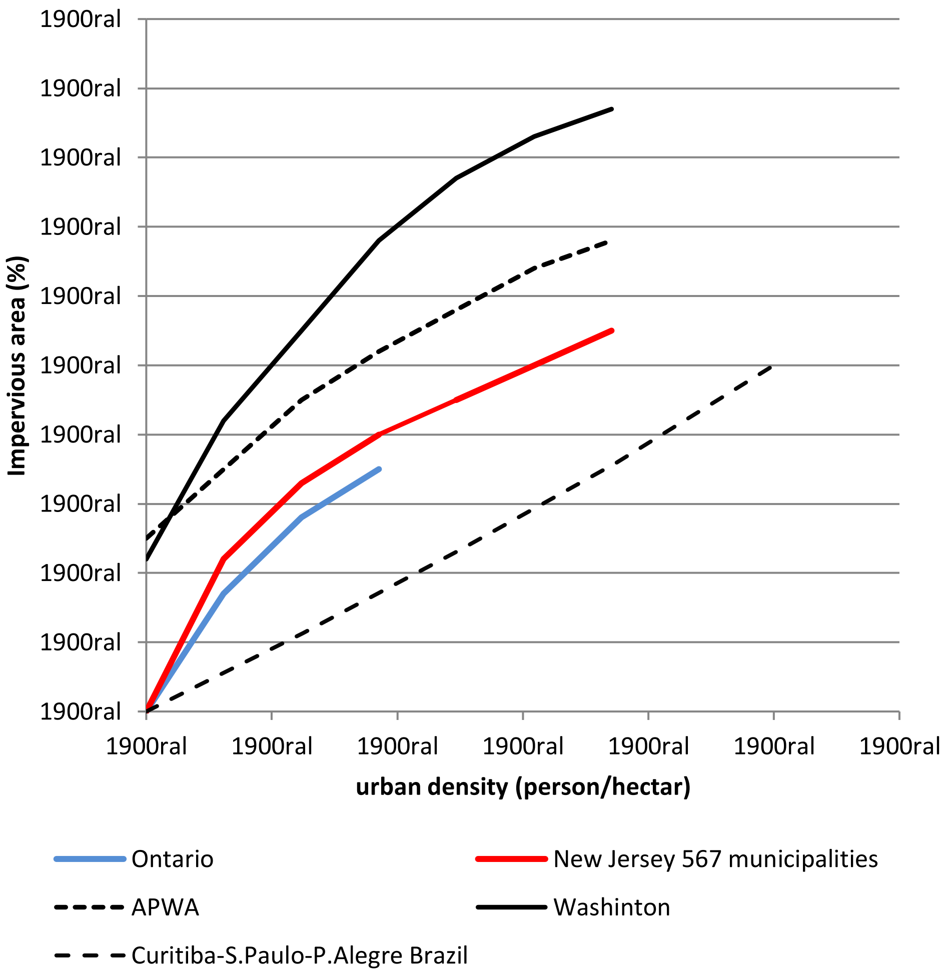

Figure 20. Urban density and impervious areas for USA cities (567 municipalities of New Jersey, and APWA curve (Henley et al. 1977) and a mean of three major Brazilian cities: São Paulo, Porto Alegre and Curitiba (Campana and Tucci, 1994).

This relantionship can change for small areas, when there are parks and other occupations. The relantionship below is mainly used for overall assessment.

C.3.2 Water supply indicators

Water demand

The water demand is calculated by

$$Wd = \frac{P_o}{86400.Wu}$$

Where Wd is de water demand in L/s; Po is the population in persons; Wu is the mean water consume per person in L/person/day. Table 30 presents some data from cities. See indicators.xls sheet water & sanitation for calculations.

Table 34 Shows some values of mean water consume per capita in some cities around the world.

City or country	Year of assessment	Mean unit consume L/person/day	Losses in the network
Canada	1984	431	15
USA	1990	666	12
Costa Rica	1994	197	25
Tokyo	1990	355	15
Santiago	1994	204	28
Bogota	1992	167	40
São Paulo	1992	237	40
Brasília	1989	211	19

Water avaliability

In the main text was presented the equation which allows the estimation of water availability. In this annex is presented the procedure in order to estimate the members of the equation.

Water yield (Qy)

The maximum water yield from a basin it is the mean flow (Qm). But usually the water yield is a proportion of the mean flow β.

When there is not regularization (reservoir) the availability flow is based on the risk of occurrence of natural flow. The flow duration curve is used for that. It relates the flow and its proportion of duration in the time (probability). For instance, Q_{95} is the flow which in 95% of the time the values are greater than this value. Assuming that 95% is an acceptable risk Q_{95} = Qy. In a region is possible to develop a mean relationship of r = Q_{95}/Qm. In this case

$$Qy = Q_{95} = r.\, Qm$$

In this case β = r.

When there is a reservoir and regularization it is possible to regulate a flow as a proportion of the mean flow in the basin (β). For a temperate and tropical climate it could a maximum of 0.40 to 0.7 and for an arid climate is about 0.25. It also is function of the topography in the area.

The mean flow and its relation r mentioned above are usually estimated by data in the region with similar hydrologic conditions or by literature values. There are a few procedures which could be used to estimate these indicators based on the data. The methodology described below is simple and assume some error.

Use the existing flow series in order to estimate the mean flow of the gage with data (see Figure **21**) and estimate the mean specific flow dividing by the basin area. Usually when there is not a large change in the rainfall along the space in the basin the mean specific discharge does not have a large variability.

The mean flow (Q) usually is obtained in m^3/s or L/s and the basin Area is in km^2. The specific discharge is [L/(s.km^2], when the flow is in L/s.

$$q = \frac{Q}{A}$$

For each basin j with flow data will be a specific discharge q_j. Mean of these values would be the regional

$$q_b = \frac{\sum q_j}{n}$$

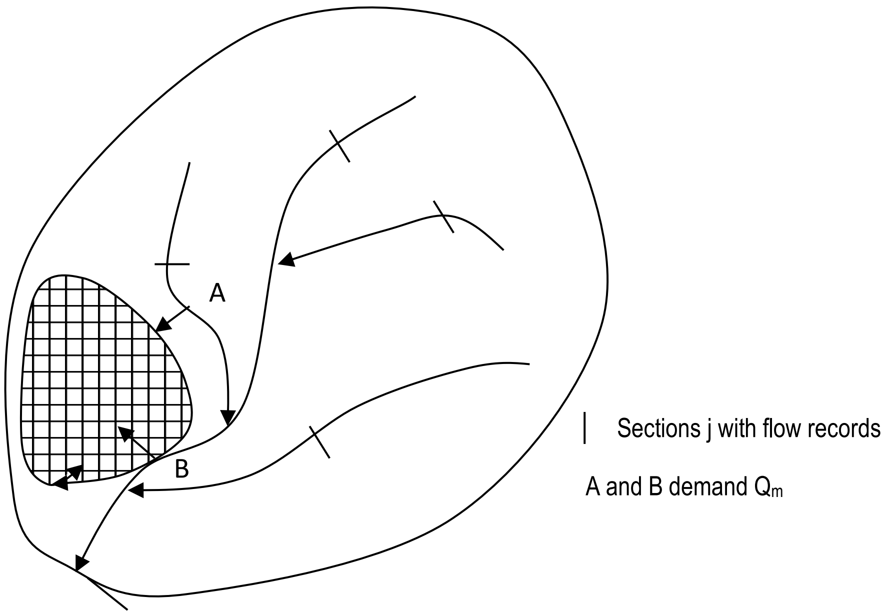

Figure 21 Flow gages and flow demand

The obtained value has to have some compatibility with the mean annual rainfall. The rainfall is usually obtained in mm, transforming the q_b in mm, which is q (mm) = 31,536 q_b (l/s.km^2). Using the rainfall the flow coefficient is

$$C = \frac{q_b}{P}$$

This coefficient usually varies in the range 0.10 – 0.45 (See table 31) from a natural basin in climates such as tropical, temperate and cold. In semi-arid regions this coefficient can be near to zero (~0.04). Since this flow and rainfall are obtained from different sources, if the coefficient is outside of the range and could be result of bad data.

Table 35 Flow coefficients

Type of Basin	Rainfall Mm	Flow coefficient[1]
Tropical	1400 – 2400	0.25 – 0.45
Temperate	600 – 1200	0.20 – 0.35
Dry	400 – 600	0.02 - 0.10

1 – lower limit with high infiltration and evapotranspiration; 2 – upper limit with low infiltration.

The mean flow yield in the section where the demand is required is obtained by multiply the mean specific discharge of the basin by the basin area where it is required (see figure 17).

$$Q_m\,(i) = q_b.\,A(i)$$

where (i) is the required section.

The coefficient r can be obtained by the use of the same procedure described for the specific discharge.

When there are not data in the basin or in other representative basin in the region, from the rainfall is possible to estimate the mean flow and Q by the flow coefficient.

C.3.3 Sewage Loads and indexes

The total sewage flow is a proportion of water supply in the city. It is estimated by

$$Qs = \alpha.\, Wd$$

Where α is the proportion of the water supply which return as sewage. Usually this value varies from 0.8 – 1.

The total load is product of the flow by the concentration of the water quality parameter, which is

$$Sl = 86.4\, C_i.\, Qs$$

Where Sl is in kg/day In the case of Coliform it result in Num; Ci is the concentration of the water quality parameter in mg/L. In the case of coliform it is Num/100mgL and coefficient is change to 8.64; and Qs is the sewage flow in m^3/s.

The main water quality parameters and what it represents, in terms of source and impact, are presented in the table 32 together its concentration from domestic sewage.

Table 36 Values for water quality parameters in the untreated sewage

Parâmetro	Indicator	Untreated[a] Sewage	CSO[b]	Stormwater[c]
BOD – Biochemistry Oxygen Demand (mg/L)	Organic load	160	600-200	10-250 (30)
P – Phosphorus (mg/L)	Nutrient	10	1-11	0.2 – 1.7 (0.6)
N– Nitrogen (mg/L)	Nutrient	35	3-24	3 – 10
Coliformes (Num/100ml))	Biological	10^7-10^9	10^5-10^7	10^3 – 10^8
Suspended solids		225	100-1100	3,000-11,000 (650)

a- Novotny et al, 1989; b – CSO= Combined Sewer Overflow, Novotny (2003); c Novotny and Chesters (1981) and Lager and Smith (1974); (..) mean

The total load may be infiltrating in soil by septic tanks or collected by sewer network or dumped in the drainage. The load in soil is

$$Gl = a.\, Sl$$

Where a is the proportion of load which is sent to soil by septic tank (varies from 0 to 1).

The stream and reservoir loads is calculated by

$$Rl = [(1-k_j).\ b+c)\ Sl$$

where c is the proportion of the total load which is dumped in the streams without any level of treatment. It is the sewage flowing through stormwater pipes, delivered in the streets or directly on the streams; b is the proportion of the sewage which collected by sewer network; and k_j is the proportion of load treated for this type of water quality parameter j.

The coefficients a, b, c and k_j are obtained for each city and they should be a+b+c=1. It also can be obtained from state officials or estimated by interview. In some countries it is part of the statistics on water and sanitation.

The total load for each water quality parameter in groundwater and streams from the city is

$$GL_i = 86.4.a.C_i.Q_s$$

$$Rl_i=86.4.[(1-k)b+c].C_i.Qs$$

The relation of the total Load and the treated load can be estimated as an efficiency index for the city in each water quality parameter. There two indexes:

1. The surface index (without groundwater), called here by ING. This index assesses only water surface contamination;

$$ING_j = \frac{Rl_i}{(1-a)SL} \quad \text{surface índex load}$$

2. Global index, IWG which identify from the total water delivered in the proportion of water left in the environment.

$$IWG_j = \frac{Rl_i}{SL} \quad \text{global index}$$

These are reliable indicators of sanitation of a city, since they assess the amount of the load which is treated from the total deliver from the population. In this scenario is almost impossible to reach 100%, but the goals are to decrease **a** and **c** and increase k, in order to reach levels of at least 20%.

C.3.4 Urban Drainage indicators (stormwater)

The main urban drainage indicators are: *quantitative* which measures the required volume need to decrease the peak flow due to urbanization (Sv) and the increase in the pollution load from urban drainage, which is qualitative indicator (Ls).

Quantitative Indicator

The flow increase in peak and volume in an urban area is dependent of the impervious areas and time of concentration of the basin, which is dependent of the existence of conduits or channels. This increase is dependent also of the basin characteristics and should be estimated by each basin in the city based on the impervious area, basin area and time of concentration for a specific rainfall risk. This parameter should be compared to the channel capacity for that risk in order to find out if there is a flood condition. This analysis has as requirement a few physical information's about the basins which is not available at this level o f assessment.

In the development the solution of stormwater usually the goal is to obtain the volume needed to dump the peak to the conduits capacity. In high urbanization the required volume is greater than less urban area and it is an indicator of impact and of cost.

From our experience of a few cities in South America, the stormwater planning detention volume requirement for flood control is dependent of: impervious areas, existing flow capacity and rainfall risk. Table 33 summarized some of our experience in Brazil. This information allows the assessment of the required volume and area for flood management.

Table 37 Required detention volume for flood management in urban areas

Description	Volume m^3/ha
Urban residential areas with ~ 60% of impervious areas 10 years 25 years	 100-140 200-220
Urban Residential area with ~40% of impervious areas 10 years Downtown with > 60% of impervious areas 10 years	 70 – 100 200

The volume can be estimated also by the equation bellow as

$$vt = \frac{10460.AI^{1,05}}{Qc^{0,94}}$$

Where v_t is the specific volume (m^3/ha); AI is the impervious area (between 0 and 1) and Qc is the existing flow capacity of the main section of the basin in L/(s.km^2). It was developed by a 10 years rainfall for a city in South America with an annual rainfall of 1,400 mm.

Since in stormwater the depth varies from 0.8 to 1.3 m because of the major drainage and using 1.0 m as mean depth the required area for detention in the basin varies from 100 – 200 m^2/ha, which is about 1 – 2 % of the basin area.

Qualitative Indicator

Stormwater is the source of pollution due to washing urban surfaces. The main aspects of this load are:

- The pollution source is the contents deposited in the urban surfaces which are later on washed to the stream after a rain period;
- In the rural areas the loads are related the use such as: agriculture, forest, or other; and in urban areas is dependent of air pollution which is mainly due to industrial emissions and to fossil fuels;
- 95% of the load from stormwater are carried out in the first part of the overland flow representing about 20 to 35 mm of total rainfall

The load from a stormwater can be estimated by the simple method was recommended by Schueller (1987)

$$L = 86{,}4Q.C.$$

Where L is the load in (kg/day); Q is the flow of the storm events (m^3/s); C is the mean concentration in mg/L. The flow can be estimated by

$$Q_u = \frac{r.P_m.C_s A}{31536}$$

Where r is the proportion of rainfall which results in overland flow. There are many events which does not result in overland flow because of its low intensity. In order to take into account this events r is between 0.8 and 0.95. There are 5 to 20% of the daily rainfalls which will not produce overland flow. Usually r is assumed as 0.9; A is the basin drainage in km^2; P_m is the total annual rainfall in mm; C_s is the flow coefficient, which is obtained by (Tucci, 2007) with data of Brazilian and USA urban basins (see Figure **22**.)

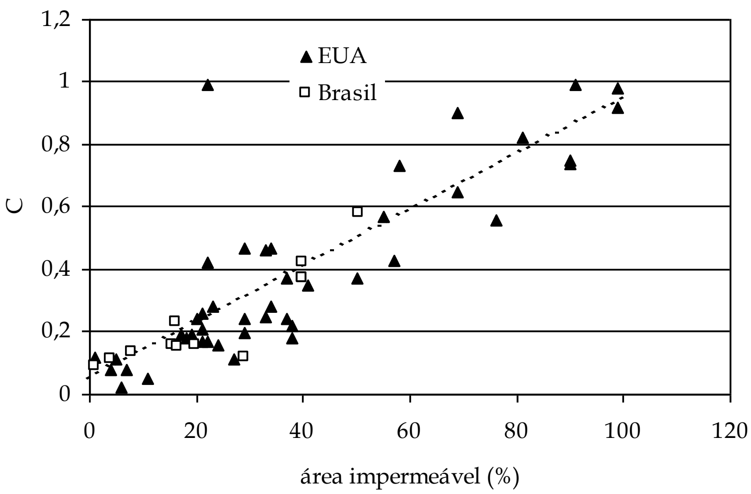

Figure 22 Flow coefficient and impervious area (Tucci,2007).

$$C_s = 0,05 + 0,9.AI$$

Where AI is the proportion of impervious areas (between 0 and 1). The impervious areas can be obtained from urban density as explained above.

The load in kg/year is

$$L = r.P_m.A.(0,05 + 0,9AI).C$$

Concentration of the parameters in stormwater is presented in table 32.

Support capacity (Sc)

The load effluent from the city is disposed in the water system: reservoir, river, ocean or groundwater. Each system has a capacity of dilution of the residual load from the urban development. There are scenarios where the load is too small for the water system capacity and in other the capacity is so small that even with high level of treatment the capacity is not enough to receive the load.

The assessment of assimilation capacity of the water system is dependent of system and load characteristics. Each region has its standard for water quality in water systems and licensing the disposals. In developing countries usually the cities develops without control and the impacts are often found in the rivers and environment enforcement is weak.

In this document it is covered only a basic indicator for river and reservoirs systems in order to have a first indicator between the load and water assimilation capacity. The assessment is different for a river or reservoir, as described below. In the river the main issues related to organic load are related to Dissolved Oxygen and BOD Biochemical Oxygen Demand for river sustainability and in the reservoir the eutrophic conditions are the main important. The eutrophic condition is assessed mainly based on the phosphorus concentration of the reservoir or lake.

For a river:

The Support capacity (SC_i) for each water quality parameter should be greater than the total disposed in the river system for each water quality parameter. This support capacity is estimated by (Figure **23**).

$$Sc_i = Qs.C_i = (Qs+Q_R)CL_i - Q_R CR_i$$

$$Sc_i = Qs\ CL_i - Q_R(CL_i - CR_i)$$

Where Qs is the total discharge from the load (see above) and C_i the load concentration. The total load $Qs.C_i$ should be the sum of the point type of pollution from domestic and industrial system and non-point (diffuse) pollution from agriculture and urban loads; CL_i is the maximum concentration allowed in the river based on the legislation for the i water quality parameter; Q_R the existing upstream discharge in the river (for the assessment is often used a minimum discharge with some frequency, for instance minimum discharge of 10 years and 7 days duration); CR_i is the concentration of the water quality parameter i, upstream of the disposal.

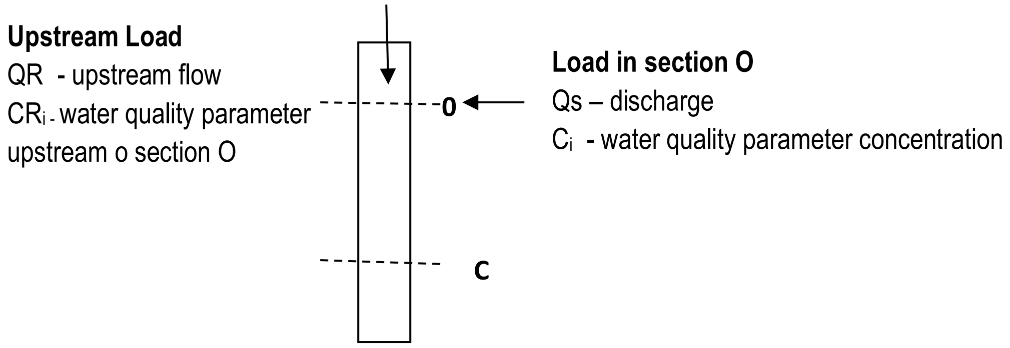

Figure 23 River reach characterization

It can be calculated for the same group of water quality parameters presented in the load estimate. In addition, it is important to assess the DO -Dissolved Oxygen which consequence of the River BOD (Biochemical Oxygen Demand). A minimum DO concentration is required in order to support river fauna. The support capacity of DO is estimated based on DBO and some river characteristics (Streeter Phelps method) by

$$DO_c = D_c + DO_s$$

Where DO_c is the minimum value which usually occur downstream of the load entrance in the river; DO_s is the DO of saturation in the water and D_c is the deficit of DO in the water (Dc=DO – DOs). The estimative o Dc is obtained by

$$Dc = \frac{k_1.L_o}{(k_2 - k_1)}[e^{-k_1 x./v} - e^{-k_{21} x./v}) + D_o e^{-k2x./v}$$

Where D_o is the deficit of OD in the section 0 (mg/L); Lo is the concentration of BOD at section o (mg/L) ; k_1 is BOD decay coefficient (1/day); k_2 is the reparation coefficient (1/day); v is the flow velocity of the river (km/day)and x is the distance from section 0 to critical section C (km), estimated by

$$x = \frac{v}{k_2 - k_1} \ln\{\frac{k_2}{k_1}[1 - \frac{D_o(k_2 - k_1)}{L_o k_1}]\}$$

The coefficients k_1 and k_2 are estimated based in the data from the tables 34 and 35 and

$$DO_s = 14.652 - 0.41022.T + 7.991.10^{-3}.T^2 - 7.774.10^{-5}.T^3$$

For reservoirs:

The support capacity of a reservoir is mainly related to its eutrophic conditions. When a reservoir is poor in nutrients it is oligotrophic and when it is rich in nutrients it is eutrophic, which is an undesirable condition for water bodies, since it can create algae and the contamined the water for water supply.

Table 38 Reaeration coefficient k_2 (Hann e Wiley, 1972)

River	k_2 mg/L	Upper limit mg/L
Pequenos Lagos e remanso	0,12	0,23
Rios Calmos e grandes lagos	0,23	0,34
Grandes rios com pequena velocidade	0,34	0,46
Rios ligeiros	0,69	1,15
Rios rápidos e cascatas	1,15	

Table 39 Decay coefficient k_2 (Hann e Wiley, 1972)

Description	k_1 mg/L	Upper limit mg/L
Load with slower degradation	0,10	0,20
Domestic load	0,20	0,25
Fast degradation load	0,25	0,5

This condition is controlled by the amount of Nutrients, phosphorus and Nitrogen in the reservoir, mainly the first. Table 36 presents the limits and the classification of the reservoir based on this limits.

In order to assess the reservoir conditions the mean phosphorus concentration has to be calculated which are

$$P = \frac{We.}{H/t + 10}$$ for a temperatre reservoir

$$P = \frac{We.tr^{3/4}}{3.H}$$ for a tropical reservoir

Where P is the phosphorus in mg/l; We is total load which enters the reservoir and it is estimated by the sum of point –pollution and non-point pollution as mentioned above [in g/(m^2.year)]; H is the mean depth of the reservoir in m and t is residence time (V/Q) in years, where V is the volume and Q is the mean inflow to the reservoir.

Table 40 Reservoir trophic condition (Vollenweider, 1975 and CEPIS, 1990)

Climate	Eutrophic	Mesotrophic	Oligotrophic
Temperate	➢ 0,02 mg/L	0,01 < P < 0,02 mg/L	< 0,01 mg/L
Tropical	➢ 0,07 mg/L	0,03< P < 0,07 mg/L	< 0,03 mg/L

C.3.5 Total solids

The origins of the solids can be from: (a) Sediment yield from basin eroded by stormwater; and (b) solid waste from population washed by the rain. In the urban environment both contents come together since the waster washes pervious and impervious surface. The main differences are the source of the solids.

The assessment of sediments yield in an urban basin is dependent of the following: (a) stage of development of the basin; (b) soil conservation measures; (c) type of soil. Table 37 shows some sediment yields from urban areas. Usually the upper value occurs when the city is under construction, decreasing after it is developed. In the Washington Manual for stormwater Total solids (Schueller, 1987) is estimated based on rural (28,8 t/mi^2/ano), sub-urban (45 t/mi^2/ano) and urban (71 t/mi^2/ano). In São Paulo Loret Ramos et al (1993) estimated for basin under development the sediment yield of about 10.000 m^3/(km^2.year), which is about 2600 t/mi^2/ano.

Table 41 Sediment yield in some basins (Dawdy,1967)

River and place	Area (mi^2)	Sediment yield (t/mi^2.ano)	Use
Watts Branch, Rock., Md	3.7	516	Rural
Seneca Creek, Daw., Md	101	320	Rural
	21.3	470	Rural
Anacostia River, Col, Md	300	808	rural
Gunpowder, Towson, Md	300	233	Rural
Gunpowder Falls, H., Md	80	913	Rural
	80	500	Rural
Monocacy River, Fr.,Md	817	327	rural
George Cr., Franklin, Md	72.4	207	Rural florestada
Conococheaque Cr., Md\	494	217	Rural
Helton Branch, Ky	0.85	15	Florestada
Oregon Run, Cock., Md	0.236	72000	Industrial
Johns Hopkins Univ, Md	0.0025	140000	In construction – commercial
Minebank Run, Tow, Md	0.031	80000	Residential
Kensington, Md	0.032	121000	Residential
L.Barcroft, Fairfax, Va.	9.5	25000	Residential
Greenbelt Res., Md.	0.83	5600	Urban
Anacostia Riv, Hy., Md	49.4	1200	Urban
Anacostia Riv, Riv, Md	72.8	1000	Urban
Cane Branch, Som, Ky	0.67	1147	Mining
Rock Creek, S. D, W.DC	62.2	1600	Urban
Little Falls Br ,Bet,Md	4.1	2320	Urban
Gwynns Falls, Md	0.094	11300	Residential

When the services are bad the amount left to the drainage can be about 18% of the total volume. In Jakarta was estimated that 4,000 m^3/day was not collected (Berbassi,2008). When the services are better the amount left to drainage is less than 1%, but it maybe still high.

Neves (2006) in a urban basin of Porto Alegre Brazil of 1,9 km^2 of reliable solid waste service estimated the amount that enters the drainage is 11.72 kg ha^{-1} year^{-1} (in mass) and the output is 3.5 kg ha^{-1} year^{-1}. From these numbers it can be seen that 31% of the garbage that enters the drainage system leaves the drainage system. Thus, it appears that 70% of the garbage that enters the drainage remains to block the pipes, but since the amount of paper that stays inside the pipes is about 40%, and it is likely that this will be dissolved; the amount that blocks the pipes is also about 30%.

Table 42 Solids produced by humans, monitored in the period of November 2003 to 30 June, 2004 (Neves, 2005).

	Value in the monitoring period (kg) (in mass)	Value (kg $person^{-1}$ $year^{-1}$) (in mass)	%
Total collected in buildings [Tc])[1]	1,652,000	191,386	98.914
Total from street cleaning [Tl] [1]	16,896.84	1,957	1.0117
Total which enters the drainage [Td][1, 2]	940	108.9	0.056
Total which leaves the drainage	288	33.4	0.0172
Total	1,670,125	193,485.7	100

1 The values are related only to the human-generated solids waste
2 estimated

ANNEX D: INVESTMENTS AND OPERATION AND MAINTENANCE

At this stage the requirement is to assess the require funds needed for the strategy. It is not a complete economical assessment, but only to find the order of magnitude of the investments in the development of the solutions.

In order to develop the cost in the annex is present the unit cost of the urban waters aspects based on the existing information. The costs can be related to three levels (a) Studies and preparation of the plans and projects; (b) Investments or improvement costs; (c) Operation and Maintenance.

D.1 Water Supply and Sanitation

Hutton (2007) presented a table of costs taking into account some different levels of improvements and regions of the word in an overall assessment of water and sanitation requirements. Table 40 reflect this per capita costs and its conditions.

Table 43 Estimates per capita costs, US$ from 2000 (Hutton,2007)

Type of Service	Region	Construction costs US$	Annual total costs per capita US$
Water Supply			
Basic improvement[1]			
	Asia	17 – 64	1.26 - 4.95
	Africa	21 - 49	1.55 - 3.62
	Latin America & Caribe	36 - 55	3.17 - 4.07
Household connections[2]	Asia	92	4.78 - 5.70
	Africa	102	5.30 - 12.75
	Latin America & Caribe	144	7.48 - 15.29
Sanitation			
Basic Improvement[3]	Asia	26 - 50	3.92 - 5.70
	Africa	3 - 91	4.88 - 6.21
	Latin America & Caribe	52 - 60	5.84 - 6.44
Septic Tank	Asia	104	9.10
	Africa	115	9.75
	Latin America & Caribe	160	12.39
Household connections[4]	Asia	154	8.99 – 11.95
	Africa	120	7.01 - 10.03
	Latin America & Caribe	160	9.34 - 13.38

1 – Borehole, stand post, dug well, rainwater harvesting

2 – Lower estimate: piped water, not regulated; higher estimate: piped water

3 – VIP, small pit latrine, and pour flush

4 – Lower estimate: sewer connections; higher estimate: sewer connections, with partial treatment

Whittington (2006) presents the economic costs of providing a household with modern water and sanitation services. It is the sum of seven principal components presented in table 41 with its unit costs. This values change with the scale of projects, available of water, disposal conditions and environment requirements. These costs include investments and operation.

Using this cost with water demand the total cost of investment and operation per person for a range of 150 – 250 L/person/day is US$ 9 – 22 per month/person. In a family of 4 it would represent US$ 36 – 88 per month/person. This value is high for many families in developing countries. There many economic mechanisms which could be use in order to mitigate this cost (see Whittington, 2006)..

Table 44 Cost estimates: improved water and sanitation services (Whittington, 2006)

N.	Component	US$/ m^3
1	Opportunity cost of raw water supply	0.05 – 0.20
2	Storage and Transmission to treatment plant	0.15 - 0.20
3	Treatment of drinking water standards	0.15 - 0.20
4	Distribution of water to households	0.50 - 0.70
5	Collection of wastewater from home and conveyance to wastewater treatment plant	0.80 - 1.00
6	Wastewater treatment	0.30 - 0.50
7	Damages associated with discharge of treated wastewater	0.05 - 0.20
	Total	2.00 - 3.00

D.2 Urban Drainage

In Urban drainage there are many scenarios of investments because the decision along the time and the situation of each city. When the city still did not developed a Plan of BMPs (best management practices) the drainage (mainly in developing countries is developed increasing the flow to downstream and developing floods scenarios in the constrictions sections of the network. Table 42 shows the network cost, which is US$ 105,072/ha. In order to develop flood control for the basin the cost would be about US $ 20,580/ha. The total cost of this scenario is US$ 125,652. But If the development was done using the basic BMPs the cost would be 47,900, representing 38% of the unsustainable cost. This cost may vary from a region to another based on land, labor and material costs.

Cruz (2004) using some detentions designs and basin characteristics obtained for Porto Alegre, Brazil the following equation

$$CT = 0{,}35\ p - 3{,}4.A$$

Cost in millions of US$; pop is the population in thousand of persons and A is the basin Area in km^2.

In developing countries the scenario of investments is a basin of frequent floods needing a flood management control. In that way, some estimative of costs are presented in table 43, taking into account a few projects in Latin America.

Table 45 Unit costs developed for Porto Alegre Assessment (Cruz and Tucci,2008).

Type	Unit cost US$/ha
Stormwater cost using Best management practices[1]	
Stormwater network[1] Diameter =40cm and 30% or rocks Assuming 187 m/ha Detention pond (assuming 200 m^3/ha and 30% of rocks) Total	38,400 9,500 47,900
Stormwater cost using future flood control[3] Detention pond Total	105,072 20,580 125,652

1 – Developed the drainage together with storage; 2 based on assumption of mean diameter and 30% of rocks; 2 - Development of the networks and after some floods the flood control measures is developed.

Table 46 Estimated range for unit cost of urban basin based on the type of combined solution for flood control measures in stormwater[1].

Type of flood measures	Unit cost range US$ 1,000 /ha
Only by channel and conduits	60 - 100
Underground detention, channels and conduits	30 - 50
Open detention , channels and conduits	10 – 25
Only open detention	8 – 12

1 This is not the cost for implementing the stormwater but for control its existing impacts