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Global Change and Ecosystems

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Decontamination and recuperation of water resources in the Municipality of Cali, Colombia

A Strategic Direction

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Sustainable Water Improves Tomorrow's Cities' Health - SWITCH Project

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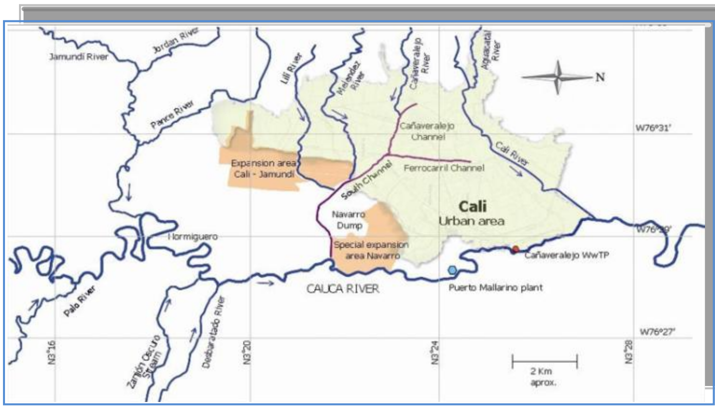
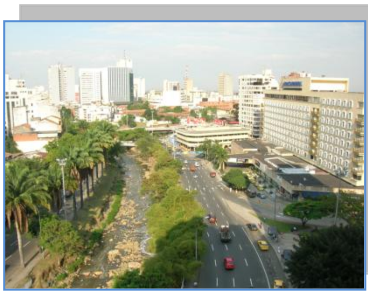
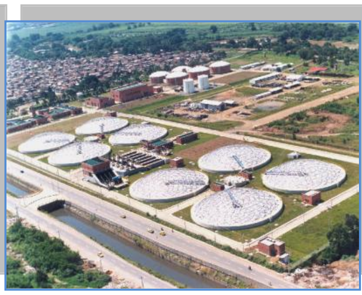
A Strategic Direction







Cali, September, 2010

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The following people from Cinara Institute / Universidad del Valle took part in the development of this report

Alberto Galvis,	Sanitary Engineer MSc, SWITCH Project coordinator in Universidad del Valle
Melissa Herrera,	Sanitary Engineer MSc
Kim Andersson,	Environmental Engineer MSc
Johnny Rojas	Economist MSc
Diana A. Zambrano	Sanitary Engineer, MSc Student
Maria F. Jaramillo	Agricultural Engineer, MSc Student
Luisa Fernanda Calderon	Sanitary Engineer
Efrain Jimenez	Student of Sanitary Engineering
Ricardo L. Martinez	Student of Chemical Engineering
Cristina Echeverry	Student of Social Communication

SUMMARY

Cali, a demonstration City in the SWITCH Project, has a population of 2.1 million of inhabitants approximately. It is located in the southwestern part of Colombia and it is the main administrative center of the southwestern region of Colombia. Cali is known as the "city of seven rivers" which are part of the high Cauca river basin, the second most important river of Colombia. It is the primary source of water for socioeconomic activities in the Colombian southwestern region. Interest in quality of this water source has been increasingly growing, particularly considering that the population is now facing the consequences of deterioration due to mining activities, removal of dragging materials, discharge of domestic and industrial waste water, and leachates from the Navarro waste dump site, among others.

In the context of the SWITCH Project a plan for decontamination and recuperation of water resources of the Cali city was developed. This plan included the participation of different stakeholders working together around the Learning Alliance coordinate by Cinara Institute of Universidad del Valle. This LA gave priority to work on following topics: 1) quality of water on the Cauca River and its impact on Cali's water supply system; 2) the south drainage system of Cali; and 3) the possibility of implementing a paradigm shift in the water and sanitation services in the zone for future expansion in the south of Cali. Subsequently the activities developed were extended to the rest of the city, including the influence area of the WWTP of Cali

The activities around the LA included: performing a diagnosis; review the plans, programs and projects of the local and regional institutions; building a common shared vision; identifying key factors and their trends, building scenarios, identifying alternatives and establishing strategic action lines. In parallel with these activities, the team of the SWITCH project also developed short term projects with the LA members and involved them with relevant participatory processes for the city and the region. Finally for different study areas proposed by LA of the Cali city, study cases were developed. A conventional solution (end of the pipe solution) and the solution with the SWITCH strategies were compared. The SWITCH strategies include: decentralized systems, minimization and prevention, use of natural systems and reuse.

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1. MUNICIPALITY OF CALI – CURRENT SITUATION

1.1 GEOGRAPHIC LOCATION

The city of Cali is the capital of the Valle del Cauca department. It is located to the south-west part of Colombia. Its coordinates of location are: North 92.000N and 116.000N and East 6.000E and 18.000E. Figure 1.1 shows the location of the Valle del Cauca department and the urban area of Cali.

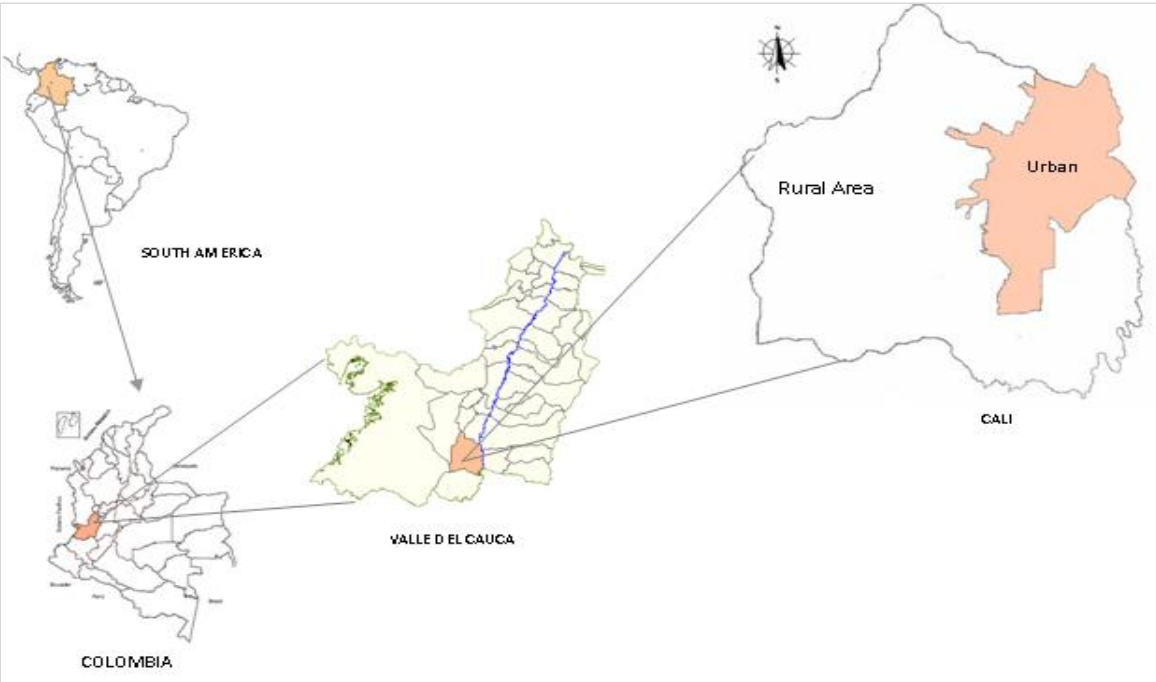


Figure 1.1 Geographic location City of Cali

The urban part of the municipality of Cali is composed by two zones: 1) consolidated area which is the existing urban area and consists of 22 “comunas” or districts and 2) the future development area that is located to the south-east of the city and consists of 2 areas: Navarro and Cali-Jamundí sectors.

1.2 DEMOGRAPHY

According to (DANE, 2005) Cali has a total population of 2075380 inhabitants. Furthermore, according to DANE (2006), in year 2005, 85% of Cali citizens were located in social strata 1, 2 and 3, corresponding to the most economical stressed groups.

Population in the city has increased mainly by immigration from the rural areas, from the south-west part of the country and from other regions in the country. The increase in the migration trends to the city of Cali, especially from the Pacific coastal area and neighboring departments has produced an additional pressure in the demand of land and public services such as water and sanitation. From the census in years 1973 and 1993 it can be seen that Cali used to be a city that welcomed immigrants.

The net migration balance (NMB) was positive during those years. In period 2000-2005, the NMB was negative showing that Cali had reduced its availability of receiving immigrants as it did before. The migration trends towards Cali are mainly caused by violence and internal wars in the country that has caused that people flee their villages looking for more secure dwellings. Between 1985 and 1998, more than 53000 caused-violence immigrants arrived to the city whereas around 16000 caused-violence immigrants arrived between 1999 and 2002. The number of immigrants from the violence that arrive to Cali shows that the city has become one of the preferred migration urban centers. Currently around 70% of the citizens in Cali are immigrants that were born in other departments of Colombia (URL-1).

1.3 CLIMATE

Since Cali is located in a tropical zone, there are not seasons affecting climate. The climate is mostly defined by the mountainous topography and by the elevation above sea level so the weather changes between middle cold and hot temperature (DAPM, 2000). Figure 1.2 shows the temperature and precipitation distribution along the transversal section of the municipality of Cali according to the elevations above sea level.

In the municipality of Cali there are identified four climates based on the air temperature and the spatial distribution of precipitations:

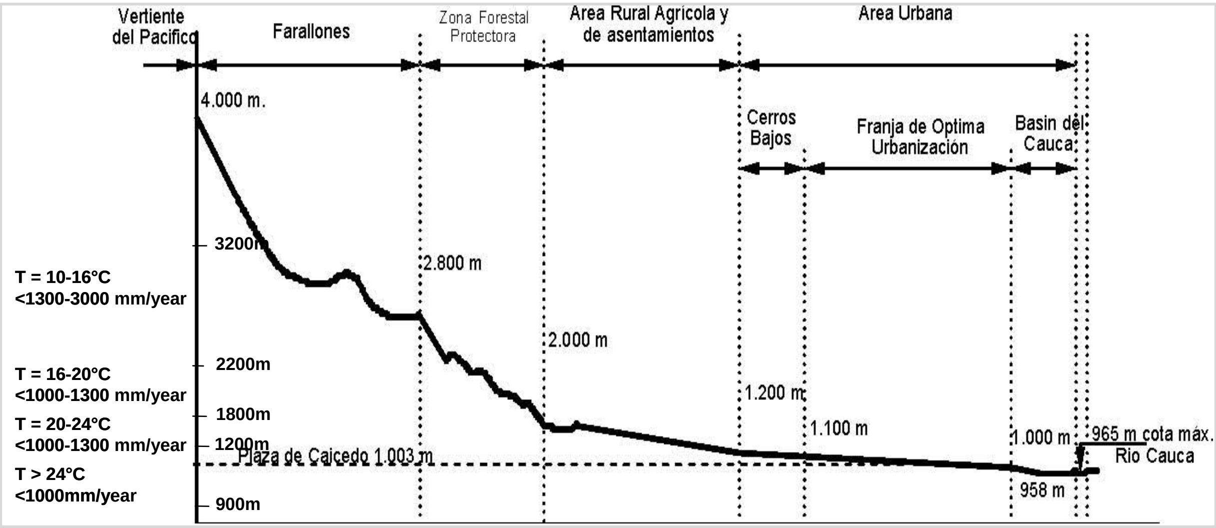


Figure 1.2 Transversal section of the Municipality of Cali and the respective temperatures and precipitations regimes.
Source: (DAPM and Alcaldía de Santiago de Cali, 2002)

<u>Middle humid weather</u>: It is present in the slope of the hill in the west mountain range with altitudes between 1200 and 1800 m above sea level and temperatures between 20 and 24°C.

<u>Cold and moderated humid weather:</u> It is present in altitudes between 1800 and 2200 m above sea level in the east mountain range and presents temperatures between 16 an 20°C.

Humid cold weather: It is present in altitudes between 2000 and 3200 m above sea level and presents temperatures between 10 and 16°C. Precipitations are regular and well distributed.

Precipitations in the city vary between 1300 mm/year in the south and 1000 mm/year in the north increasing in the south-west direction. In the mountain areas, precipitations vary

between 1300 and 3000 mm/year. Rainy periods occur mainly in the months of March, April, May, October and November. Dry periods correspond to the months of January, February, august and September. December and June are the transition periods (URL-2).

1.4 SOCIOCULTURAL CHARACTERISTICS

Education: In year 2006 Cali registered a gross coverage in education of around 87% (URL-3). 94,9% of the population older than five years are able to read and write. On the other hand population older than 18 years register a low school attendance percentage (DANE, 2005). The percentage of illiterate population that lives in Cali is around 4,8%. 30,9% has reached a basic primary education and 38,1 % secondary education. 9,5% has reached university education and 1,5 have achieved specialized education such as masters and PhD.

Health service. Health coverage in the municipality of Cali is around 75,3% with 40,6% access to priority health services in 2003. According to the PAHO, Cali has been assigned a value of 0,3 in the rank of healthy municipalities (in a scale up to 1.0). The goal for year 2007 was to increase such index to 0,7 (Alcaldía de Santiago de Cali, 2004). As stated by DAPM (2004) cited by (DAGMA and ASOCARS, 2005), the health service infrastructure in the municipality of Cali consists of: 2 general hospitals; 2 specialized hospitals; 49 health offices in the urban area; 23 health offices in the rural area; 29 health centers; 28 clinics.

Epidemiologic indicators: According to epidemiologic indicators registered in Table 1.1 it can be seen that in Cali, the birth rate is of 20,2% per 1000 inhabitants and in average there are 1,9 children per female. Additionally, the life expectancy is of 71,9 years for the total population.

Table 1.1 Epidemiologic indicators year 2005

INDICATOR	COLOMBIA	VALLE	CALI
Gross birth rate (TBN) per each 1000 inhabitants	22,0	19,4	20,2
Gross dead rate (TBM) per each 1000 inhabitants	5,0	6,0	6,5
Growth rate (TCV) per each 1000 inhabitants	17,0	13,4	13,7
Gross children dead rate (TMI) per each 1000 live-born babies	26,0	20,1	12,0
Pregnancy mortality rate (TMM) per 100.000 live-born babies	130,0	81,0	59,0
Life spam (years)	72,0	71,5	71,9
Fertility global rate (TGF) Average children per female	2,6	2,2	1,9

Source: URL-4

1.5 SOCIECONOMICAL ASPECTS

Non-fulfill Basic needs index NBI: The indicators that evaluate the coverage of the non-fulfill basic needs index are: inadequate dwellings, overpopulated dwellings, dwellings with inadequate public services, dwellings with high economical dependency, dwellings with school-age children which do not attend school. According to the census in 2005, in the urban area of Cali, 10,9% of the population presented positive non-fulfill basic needs index. At national level the NBI was of 27,6% (DANE, 2005).

Labor market trend: According to DANE (2005), in the period between April 2006 and march (2007), the average of un-employed people at national level was 12,1%. Cali presented in the first semester of 2007, an un-employment rate of 12,5%. The sub-employment rate which refers to non formal-employment activities not related to the person professional level registered a rate of 39,9% in the municipality of Cali and 33,2 at national level (URL-5).

National gross product (NGP): The city of Cali together with the Valle del Cauca department makes part of the main economic sectors in Colombia. Cali is considered as an important economical national and international exchange axis. Its proximity to the principal port of Colombia (Buenaventura) and to the Panama channel makes of it a key market point in Colombia. According to DANE in 1995, the NGP annual growth in the Valle del Cauca region was almost the double of the national NGP. In 1997, the Valle del Cauca NGP was inferior to 1%. Afterwards an economical standby in Colombia happened where the NGP reached -4%and since then the NGP in the region of Valle del Cauca has presented high and low trends.

Economic sectors: In the municipality of Cali there are 4857 production units but only the 9,44% of them is dedicated to the industrial sector. In the period of 1990-1996 there were four main industrial areas in the municipality: Chemical industry (22% of the municipal NGP); Food industry (19% of the municipal NGP); Rubber industry (8% of the municipal NGP); Paper and press industry(9% of the municipal NGP). The small industries are located in the residential areas in low and middle social strata represented mainly by the chemical, paper, rubber and graphic arts industries (DAGMA and ASOCARS, 2005).

Commercial Sector: This sector represents the main economic activity in the municipality with 60,40% of the total market establishments dedicated to commerce. Moreover, this economic sector represent around 36,43% of the employment rate.
Services Sector: According to the economic census, 30,16% of the establishments in Cali are dedicated to the delivery of services. This sector is the main source of employment with 47,01% of the employment rate.

1.6 PUBLIC SERVICES

Water supply system: The water supply system of Cali, operated by EMCALI, is provided by four (4) plants (Table 1.2). Recently, EMCALI started operating La Ribera's plant, with a production of 0,030 m^3/s.

Table 1.2 Inventory of the drinking water treatment systems of Cali.

SOURCE	PLANT	DAILY AVERAGE FLOW (m^3/s)	INSTALLED CAPACITY (m^3/s)	PRODUCTION OF DRINKING WATER (m^3/s)
Cauca River	Puerto Mallarino	264.00	6.60	4.11
	Cauca River	-	2.50	1.77
Río Cali	Río Cali	4.76	1.80	1.23
Río Meléndez	La Reforma	1.23	1.00	0.41

Source: (EMCALI and UNIVALLE, 2006)

The coverage of the drinking water supply system reaches 99.6% in the urban area. However, there are areas of the city where the coverage is low. In the urban districts located at the hillside, such as district 1 (49%), 20 (60%) and 18 (69%); in the district such as 13 (76%) and 15 (77%) in the Aguablanca area in the eastern side of the city, and others, like district 3, 4 and 12, have a coverage between 70% and 79% (Universidad del Valle and CEDETES, 2007). One of the main problems of the Puerto Mallarino water treatment plant is related to the frequent suspensions of water supply service, due to elevated turbidity and high contamination loads in the Cauca River that cannot be treated by the system (Figure 1.3). In order to mitigate this problem, in 2010, an early warning system was developed and a reservoir was built with the objective to create a reserve to supply the drinking water treatment plant of Puerto Mallarino when the Cauca River presents high levels of turbidity.

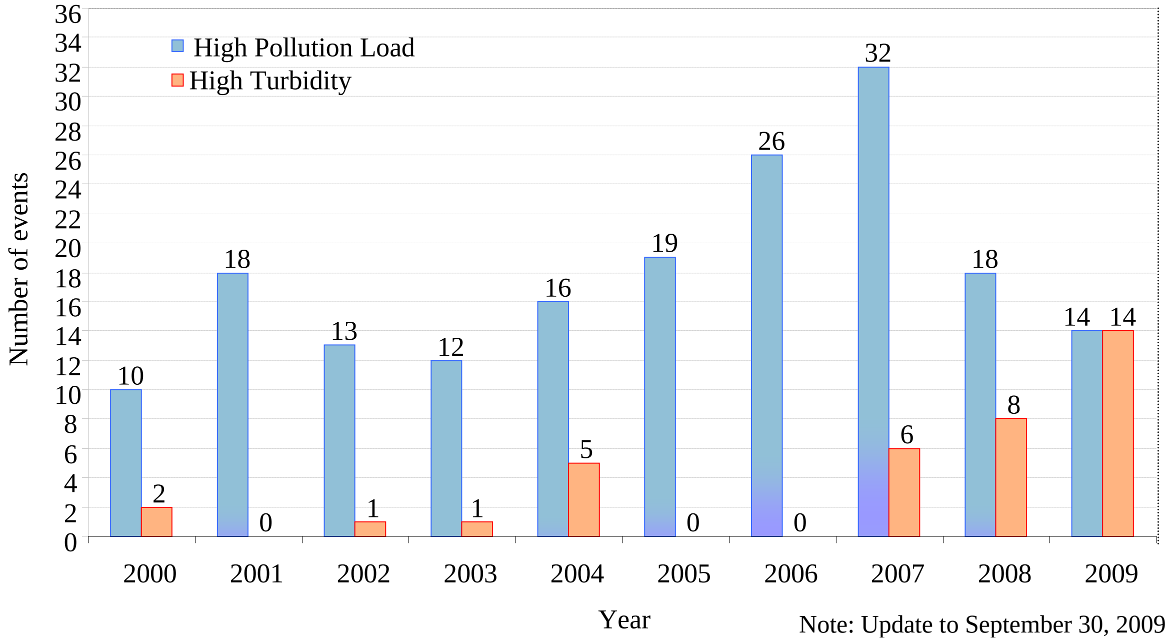


Figure 1.3 Shutdowns of water intake of Puerto Mallarino Drinking Water Plant
Source: EMCALI, 2009

Sewerage system: According to EMCALI, the coverage of the sewerage system to September, 2007 is 94,8%. Following the land topography, the sewage system in Cali is divided in three drainage systems: the South Drainage System (SDS), North-West Drainage system (NWDS) and East Drainage System (EDS). Through these three drainage systems, Cali directly drains its wastewaters and storm waters to Cauca river. The only way of control of wastewater contamination in the city of Cali is made through the use of the wastewater treatment plant of Cañaveralejo (WWTP-C) which receives around 56% of the total wastewater produced in the city.

Solid waste collection and disposal: The management of solid waste in the municipality of Cali is passing through a complicated period over the last decade. The municipal company, EMSIRVA, which was responsible for the collection, transport and disposal of solid waste is in a process of liquidation, hence private companies are now also being contracted to complement the collection service. Navarro, the principal municipal dumpsite located in Cali was closed in 2008, and consequently about 1484 ton/day of the waste produced in the city is currently being transported to the Yotocco landfill, which is situated 56 km north of Cali (Cámara de Comercio de Cali *et al.*, 2008)

Navarro was not considered a proper landfill by the environmental authorities - CVC, since the majority of its extension lacked protection measures for the handling of generated gases and leachate, which has generated a precarious environmental situation in the surroundings with contaminated discharges to water bodies and emissions of gases. Today, Navarro has been sealed with an impervious layer and is revegetated; however, the management of the produced leachate has still not been solved.

The collected leachate is temporarily stored in lagoons, awaiting the implementation of a treatment system. At the moment a proposal for leachate treatment has been elaborated and is under evaluation by the CVC before its approval.

Power generation: EMCALI is the responsible for providing the electric energy service to the municipalities of Cali and Yumbo. The company is the owner of the distribution infrastructure and together with EPSA (Energy Company of the Pacific) own the energy sub-stations which are connected to the electric energy national network (URL-5).

Telecommunications: EMCALI is the main enterprise of the telephony service with 85 % of the local market. The telephone offices and the equipment of transmission are connected by an extensive network of optical fiber. In 2007 EMCALI had approximately 510000 users. Other companies on the market of public telephony are UNITEL, Telecom, and ERT. The city has a disposition of 115400 lines. There are three operators of mobile telephony, all with national coverage and with technology GSM (URL-5).

1.7 WATER RESOURCES

The water network in the municipality of Cali, including Cali city has a sufficient amount of water to satisfy the necessities of the different urban, agricultural, industrial and recreational sectors. As it is shown in Figure 1.4, the dense hydrographic network of the municipality is conformed by the Pance, Meléndez, Lilí, Cañaveralejo, Cali, Aguacatal and Cauca River, which determine the centers of urbanization and economic development of the city of Cali (DAGMA and Universidad del Valle, 2007).The network of drainage of the seven rivers Cali has an overall of 757 km (CVC, 1996 cited by DAPM (2000)).

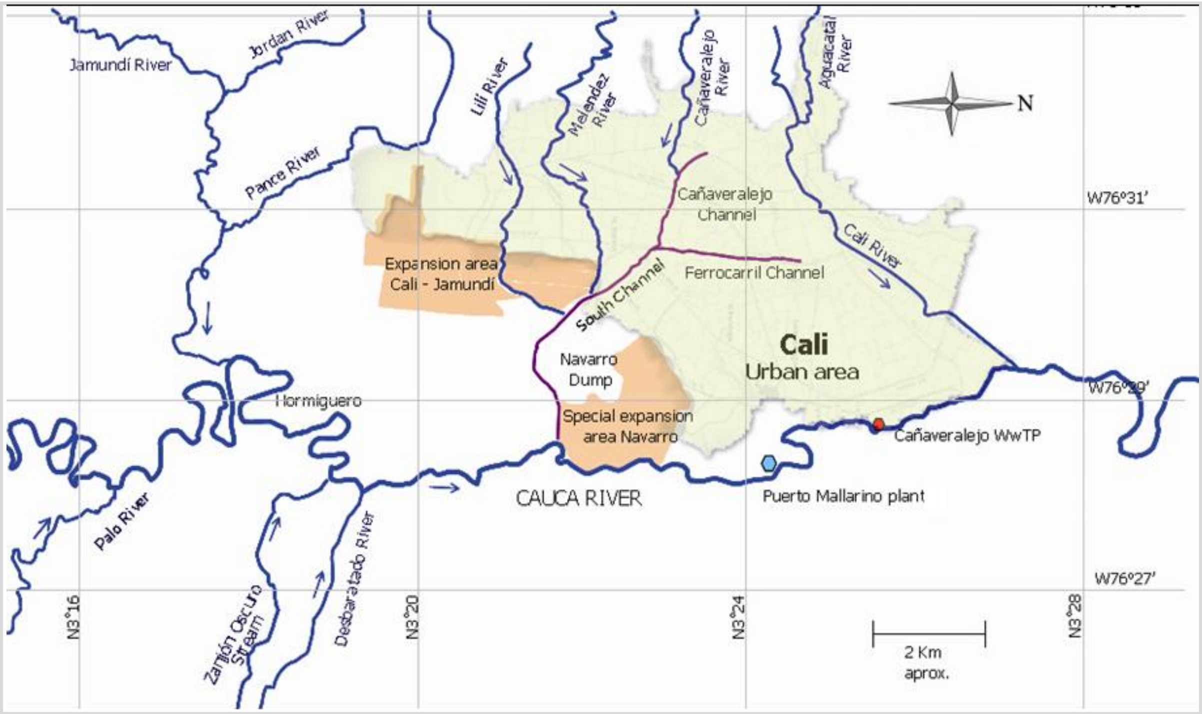


Figure 1.4 Location of existing and future urban areas in the Municipality of Cali.

Cauca River in its Geographical Valley: The Cauca river is the second most important water source in Colombia. It is born in the Colombian mountain range (Macizo Colombiano). It has a length of 1350 km which crosses Colombia from the south to the north until meeting the Magdalena river (Figure 1.5). Cauca's river basin is extended along the Central and Western Mountain ranges with an approximated area of 63300 km^2.

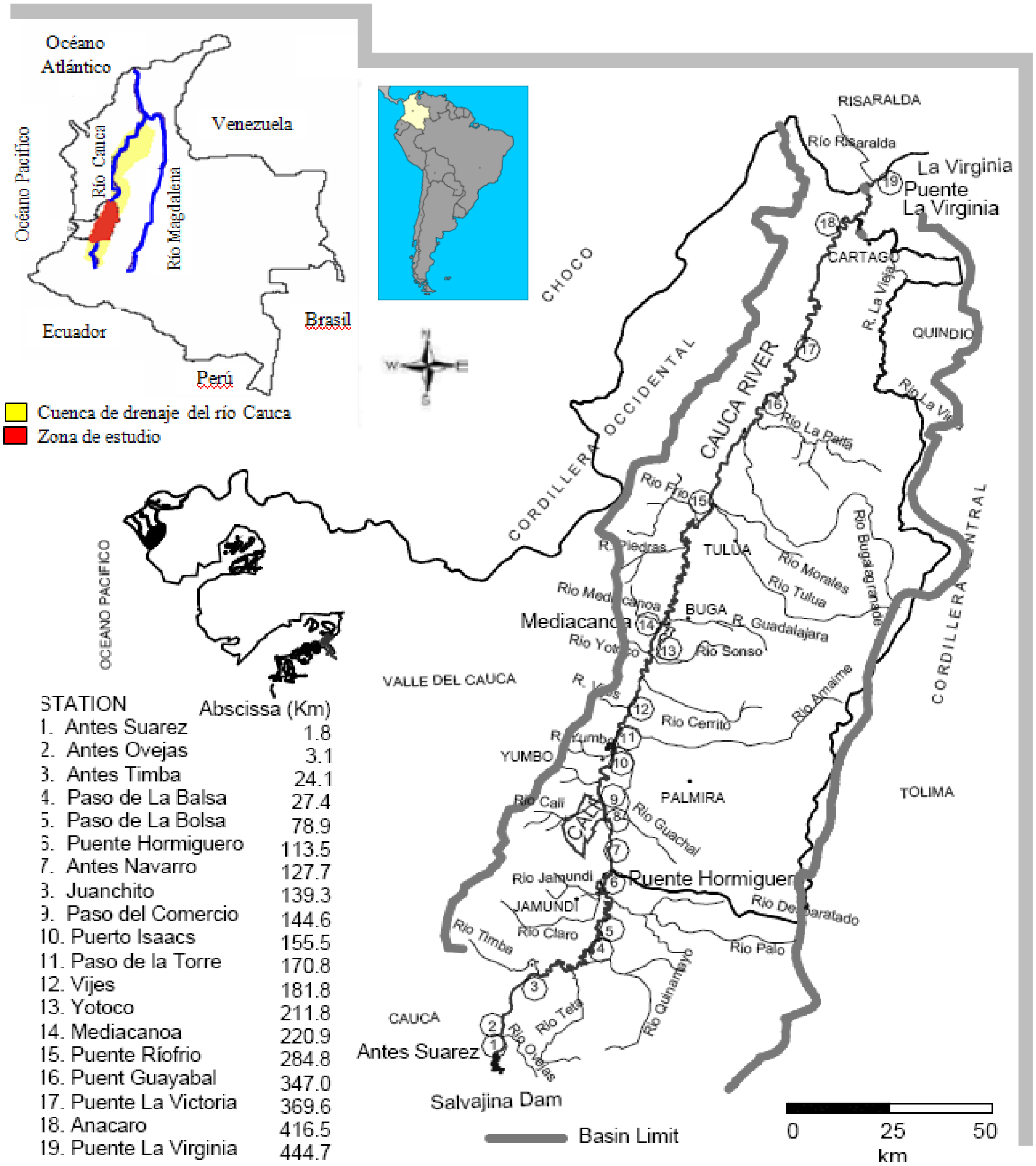


Figure 1.5 Cauca River general location. River basin and geographical drainage valley.

Along its river basin more than 10 million people live, who represent approximately 25 % of the Colombian population. The Cauca's river geographical valley is considered as one of the most fertile areas in Colombia which is the base for an important part of the Colombian economy. Along the valley many important economic industries are located such as coffee, mining, agriculture and sugar cane production (Corporación Autónoma Regional del Valle del Cauca *et al.*, 2007).

The Cauca River has been used for fishing, recreation, energy generation and riverbed matter extraction, and the water is extracted for human consumption, irrigation and industry. It is also used as a receiving source for solid residues and dumping of industrial and domestic residual water, which has caused deterioration in water quality (Figure 1.6)

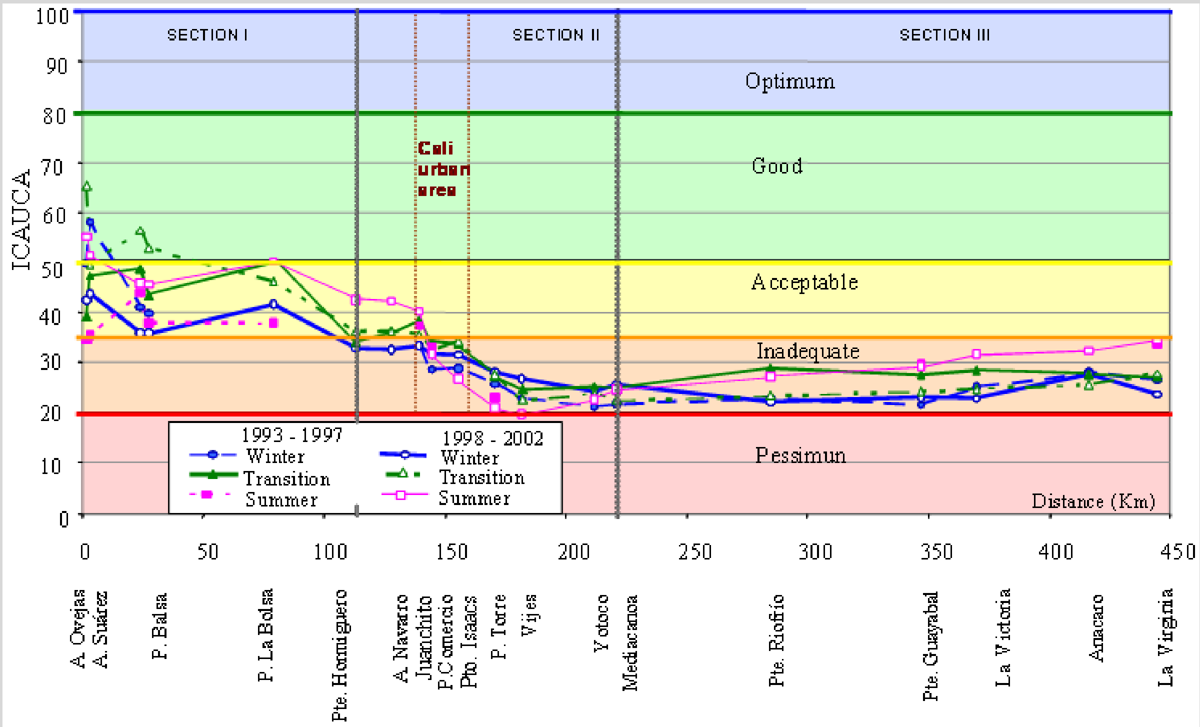


Figure 1.6 Water quality in Cauca River according to ICAUCA index. Period 1993 – 1997 and 1998 – 2002. Winter, transition and summer season.
Source: (Patiño *et al.*, 2005)

The Cauca River flows for 445 km in its geographical valley and descends from a height of 1000 metres to 900 metres above sea level. This stretch of the river has an average width of 105 metres, which at its highest level can fluctuate between 80 metres to 150 metres. The depth at its highest level can vary between 3.5 and 8.0 metres.

Others rivers of Cali City

The other rivers of Cali are: Cañaveralejo, Melendez and Lili (South Drainage System), Pance, Cali and Aguacatal. All the rivers are born in the slope of The Farallones of Cali. The high parts of the river basins are characterized by the presence of forest areas with natural vegetation. The medium river basins have presence of small scale crops, low level of deforestation, cattle breeding activities and uncontrolled urbanization activities.

These rivers haven been affected in their composition and characteristics along its way through the urban area of Cali. The main characteristics affected are: river bank area, margins, route, quality and quantity of water. Some of these rivers have become also part of the drainage system of Cali being receptors of the domestic and industrial wastewater produced in the city.

Wetlands

The expansion zone is the location with the majority of non-intervened wetlands. Due to the specific values of the water resources in the 22nd urban district, the area has a wetland system that is the habitat for a significant number of fauna and flora species; due to the urban development process in the area it is fundamental to conserve and to take under consideration its value in the creation and structuring of public spaces.

Ground water

Three aquifers are identified in the study area: Pance, Cali and Cauca. The recharging zones of the aquifers are related to the depression zones of the Cali, Cañaveralejo, Meléndez and Pance Rivers. All three aquifers are affected by contamination. The Pance aquifer is impacted by contaminated wastewater due to inadequate operation and maintenance of septic tanks and infiltration systems. The Cali aquifer is being affected by wastewater leaks from pipes in deteriorated conditions. The Cauca aquifer is contaminated by leachates from the Navarro landfill, subnormal settlements located on the Cauca river banks, wastewater due to leaks from deteriorated pipes, and the recharge of polluted water from the Cauca River (Gobernación del Valle del Cauca and Cinara, 2009). In the area of expansion, the underground flow moves in two well-defined systems: one coming from the western mountain range, mainly corresponding to the natural drainage of the Melendez, Lili and Pance Rivers, and the other, originated from the Cauca River, mainly recharged during the rainy season.

River protection zones

According to national regulations, a vegetation strip or buffer zone of 30 meters should be left parallel to rivers and creeks, while in the upper area of the river basin, i.e. around the water source this distance increases to 100 meters. Critical sites have been identified in the urban area and the river basin, where there are settlements occupying the protection zones causing damage to the river ecosystem and the water quality.

Natural or green areas

The green areas and parks in the urban zone have an area of 1,000 hectares, including 80 km of channels with protection zones. However, there is a development process in which the urbanization is becoming denser, affecting the vegetation coverage. The reduction of vegetation cover represents a decrease in the natural capacity to retain stormwater, which results in higher runoff peaks and flooding risk (CEDETES, 2007). Presently, every inhabitant in Cali has an average of 4.5 m^2, compared to the 15 m^2/inhabitants of green area prescribed in the municipal Territorial Ordinance Plan (POT) (Camara de Comercio et al, 2008).

1.8 INSTITUTIONAL FRAMEWORK

The main institutions intervening in the study area are the Administrative Department of Municipal Planning (DAPM), EMCALI E.S.P., EMSIRVA E.S.P., the Administrative Department of Environmental Management (DAGMA), and also the urban developers mainly active in the area of expansion. These institutions interact directly in the management of water resources in the city, and their relationship is set as follows: the public services provision (EMCALI E.S.P. and EMSIRVA E.S.P), the urban environmental management (DAGMA) and planning entity (DAPM). However, two other authorities should be added, Regional Environmental Agency in the Cauca Valley and the Colombian National Natural Parks Special Administration Unit (CVC and UAESPNN, respectively, for their acronyms in Spanish) in order to apply an integrated river basin management perspective, recognizing the upper and middle zone of the urban perimeter.

The Administrative Department of Municipal Planning (DAPM) is in charge of formulating short, medium and long term policies and plans, jointly with other entities, in order to reach a municipal development in physical, social, economic, environmental and administrative areas. *EMCALI E.S.P* is the institution in charge of the management of wastewater, stormwater and the water supply system within the urban area and part of the hillside area. The management of solid waste in part of the city, the Navarro landfill and its leachate, has been the responsibility of *EMSIRVA E.S.P.*

The Administrative Department of Environmental Management (DAGMA) is the environmental authority in charge of formulating and implementing the policies under the main framework of environmental standards and making the corresponding follow up and control of companies and individuals that may be contaminating soils, water, air, flora, fauna and community; the jurisdiction of DAGMA is the urban and suburban perimeter.

The Regional Environmental Agency of Valle del Cauca (CVC) is in charge of managing the environment and renewable natural resources, promoting its sustainable development. The jurisdiction area of CVC is the Department of Valle del Cauca, excluding the urban area of Cali, which is covered by DAGMA there is a national entity in charge of the management and administration of the Natural National Park System and the coordination of the National Protected Areas System (SINAP). Other important organisations that interact in the study area are the Local Action Councils (JAL), the Academia, Special interest groups, NGO´s, among others.

One of the most important stakeholder in the expansion zone is the urban developers, which are organizations in charge of developing residential areas, promoting urban project initiatives. This special interest groups of designers and constructors who, through the formulation of partial plans, define the guidelines for the land use in the expansion area, together with the municipal authorities, presenting the allocation of its specific uses, the intensity of its use and basic building norms, as well as the requirements for space and public services. This allows the execution of the specific urban development and construction projects in the terrains included in the planning area, according to guidelines presented in the territorial plan.

There are approximately 15 urban development proposals for the expansion area, of which three are already approved. An inventory of the development plans established by the different authorities in the study area showed that in general, there was a weak component of inter-institutional and public participation.

The legal framework includes decrees, laws, norms, etc., that influence the functions and jurisdiction areas of the institutions. With respect to the territorial planning, this is considered a fundamental instrument for the management, planning, regulation, transformation and occupation of space in a community or a city. These components are fundamental because lack of compliance or clarity of the standards affects the proper management of natural resources, which also is case with territorial planning.

1.9 PROBLEMA IDENTIFICATION

Table 1.1 give a summarized description of the main problems and causes. Although the problems are focused towards the wastewater and stormwater management, problems that are part of the integrated management of water resources are not excluded.

Table 1.1 Identification of key water management problems in Cali Municipality

SUBSYSTEM	COMPONENTS	PROBLEMS	CAUSES
Technological	Rainwater drainage	Presence of wastewater in channels.	▪ Erroneous connections (households and industries) ▪ Discharges from settlements not completely developed. ▪ Inadequate operation of the separation structures.
		Poor operation of the structures due to the presence of solid waste.	▪ Lack of coverage or low frequency in the collection of solid waste and sanitation. ▪ Lack of waste management planning. ▪ Discharges from settlements not completely developed.
		Misuse of the regulation systems, Pondaje Lagoons and Charco Azul	▪ Settlements not completely developed located in the protection area. ▪ Poor systems maintenance. ▪ Disposal of wastewater, solid waste and debris in the lagoons.
		Decrease in the capacity of the channels due to sediment deposits.	▪ Increase of solid dragging caused by deforestation of basins. ▪ Natural systems fusion and urban drainage. ▪ Lack of coverage or low frequency in the collection of solid waste and sanitation. ▪ Inadequate operation of the separation structures. ▪ Poor channel maintenance.
		Phenomenon of the first flush and flow peaks with solid sediments accumulation	▪ Decrease of urban green zones and increase in waterproof areas. ▪ Insufficient infrastructure during Peak flows.
	Wastewater management	Sewage operation is inadequate.	▪ Inadequate disposal of solid waste in the system's pipeline. ▪ Deterioration of the existing collectors. ▪ Existing collectors with insufficient capacity. ▪ Lack of periodical maintenance of the structures. ▪ Obstruction of the relief structures.
		Contamination of the Cauca River due to wastewater discharges from the city of Cali.	▪ Lack of an infrastructure that collects wastewater discharges in the Cauca River and transports it to the Cañaveralejo WWTP. ▪ Low removal efficiency of the Cañaveralejo WWTP ▪ Erroneous selection of technology used for wastewater treatment in Cali. ▪ Low economic support for the implementation of a secondary treatment. ▪ Lack of implementation of a secondary treatment.
		Management of biosolids generated in the Cañaveralejo WWTP.	▪ Use of TPA as primary treatment. ▪ Erroneous selection of technology for the treatment of biosolids.
	Solid waste and sanitation management	▪ Disposal of solid waste and garbage in channels, sewage pipes and public spaces ▪ Poor management of leachates generated by the Navarro landfill.	▪ A waste management and disposal plan is required. ▪ Lack of coverage or low frequency in the collection of solid waste and garbage. ▪ Lack of a management system for the leachates generated in the Navarro dump.
	Water supply	▪ Poor quality of water used in the drinking water treatment Systems. ▪ Increase in service suspensions of drinking water supply from the Puerto Mallarino WWTP.	▪ Poor river basin management. ▪ Low sanitation coverage in the Cali hillside and river basins. ▪ Increase of contaminant load discharge into the Cauca River ▪ Higher turbidity values in the Cauca River.

Table 1.3. Identification of key water management problems in Cali Municipality (cont.)

SUBSYSTEM	COMPONENTS	PROBLEMS	CAUSES
Social	Citizens	▪ High drinking water consumption. ▪ Limited participation and control. ▪ Disposal of waste in vanals, sewage pipelines and public space. ▪ Illegal connections.	▪ Drinking water consumption habits. ▪ Use of domestic Technologies resulting in high water consumption. ▪ Limited knowledge of the efficient water use strategies. ▪ Lack of knowledge of the control and participation mechanisms. ▪ Lack of environmental awareness. ▪ Apathy and loss of credibility in the participative processes.
	Inhabitants of the rural areas	▪ Untreated wastewater discharges into rivers. ▪ Occupation of the river protection areas.	▪ Low sanitation coverage in the rural area of Cali. ▪ Inefficiency in the enforcement of environmental and territorial planning laws.
	Settlements with incomplete development.	Discharge of untreated wastewater, solid waste discharged in channels, rivers and regulation systems.	▪ Lack of efficiency in the application of environmental and territorial planning laws. ▪ Lack of environmental awareness.
Environmental	Water resources	▪ Contamination of rivers and underground water. ▪ Increase of rainwater flows resulting in the re-suspension of accumulated solids and flood risk. ▪ Accumulation of flow obstructing sediments and waste ▪ Increased solid dragging. ▪ Minimum river flows affecting the ecosystem. ▪ Possible lost of the existing wetlands in the expansion zone due to urban development.	▪ Low sanitation coverage in the foothill and rural areas of Cali. ▪ Deteriorated existing collectors increase the percentage of underground contaminated water caused by leaks. ▪ Inadequate management of Navarro dump's leachates. ▪ Deforestation in the upper basin areas. ▪ Settlements in the protected margins of the rivers. ▪ Climatic change (extreme rain and droughts). ▪ Solid waste and sanitation disposition in the Rivers. ▪ Lack of environmental conservation awareness to preserve natural wetlands. This is not a priority.
	Green zones	▪ Loss of urban green zones and increae of waterproof areas. ▪ Occupation of the protecting margins of the rivers. ▪ Lost of forest percentages.	▪ Lack of efficiency in the application of environmental and territorial planning laws. ▪ Poor environmental awareness.
Economic Activities	Urban industry	Discharge of industrial wastewater into the sewage or rainfall drainage.	▪ Lack of industrial discharge control. ▪ Low economic incentives for the implementation of cleaner production strategies and construction of WWTP.
	Mining, agricultural and livestock activities	Specific or difuse discharges that contaminate the rivers.	▪ Informal or illegal businesses. ▪ Lack of strategies for the control of specific or difuse discharges.
Institutional Framework	Institutions	▪ Institutional actions have not solved water management problems in the zone. ▪ Limited vision, end of pipe solutions proposal. ▪ Short or midterm plans and actions. ▪ Non compliance with the proposed projects' execution. ▪ Lack of governability in water management.	▪ Each institution works in an isolated manner. ▪ Short term actions planning. ▪ No interinstitutional cooperation ▪ Lack of training on the new concepts of integrated water management. ▪ Corruption ▪ Plans and actions linked to political terms. ▪ Compliance evaluations of insitutional functions are not made.
	Standards and territorial planning	Deficient regulations and lack of regulatory enforcement.	▪ Compliance evaluations of insitutional functions are not made. ▪ Too many decrees and laws.

2. CREATING A VISION FOR THE FUTURE

2.1 AIMS AND COMPOSITION OF THE CALI LEARNING ALLIANCE

This process begins with the identification of the main stakeholders involved with water management both at the high Cauca river basin and the city of Cali. The Cali LA intends to adjust technical, organisational and legislative solutions (including a review of norms) in light of the local sociopolitical and economic context and put forward approaches revolving around the concept of integrated water resources management (IWRM). The idea is to find local institutions embracing the "paradigm shift" advocated by SWITCH. Table 2.1 lists the main stakeholders who have participated in the activities of the learning alliance of Cali as a demonstration City. Some of them have been especially importants during a specific phase of the learning alliance.

Table 2.1 Main stakeholders of the Learning alliance for Cali

TYPE OF INSTITUTION	NAME OF THE INSTITUTION OR DEPENDENCY
Associations	ACODAL – Asociación Colombiana de Ingeniería Sanitaria y Ambiental AIV Asociación de Ingenieros del Valle CAMACOL Cámara Colombiana de la Construcción
Municipal and Local Administration	Secretaría de Planeación Departamental Secretaría de Planeación Municipal UES Valle Secretaría de Vivienda - Gobernación del Valle UMATA – Unidad Municipal de Asistencia Técnica Agropecuaria
Environmental Authorities	Corporación Autónoma Regional del Valle del Cauca – CVC Corporación Autónoma Regional del Cauca - CRC Departamento Administrativo de Gestión del Medio Ambiente - DAGMA
Public services companies	EMCALI EICE E.S.P (water and sanitation) EMSIRVA E.S.P. (solid wastes)
Foundations	Fundación PROAGUA Fundación Río Cauca
Consultants	Peña & Asociados – consulting firm Independent consultants (Douglas Laing, Luis A. Hurtado, Hugo Salazar)
Ministerio de Ambiente, Vivienda y Desarrollo Territorial - MAVDT	IDEAM - Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia - Planes Departamentales del Agua
Educational institutions	Universidad del Valle - Escuela de Salud Pública Universidad Autónoma de Occidente Universidad Nacional de Colombia, Palmira Pontificia Universidad Javeriana
SWITCH Partner	Universidad del Valle - Instituto Cinara Universidad del Valle – EIDENAR UNESCO – IHE (WP 1.1 and 5.3) IRC - International Water and Sanitation Centre (WP 6.1 and 6.2)

A representative group of these stakeholders (Table 2.1) established the issues to be addressed within the frame of the Learning Alliances in the SWITCH project. These issues are as follows: 1) quality of water on the Cauca River and its impact on Cali's water supply system; 2) the south drainage system of Cali; and 3) the possibility of implement a paradigm shift in the water and sanitation services in the zone for future expansion in the south of Cali. Items (1) and (2) just take a part of the City, item (3) involves the Cauca River catchment upstream of the inlet point including the City of Cali. The vision and the strategic plan included the area of Cañaveralejo WWTP as well as a definition of scenarios and proposals of innovative strategic solutions for the control of the municipal wastewater pollution.

In addressing these three issues, the Learning Alliances conducted 10 workshops, 3 international seminars, and several work meetings with representatives from the institutions, and consulted with experts, independent professionals, and some community representatives from Cali and the region. This process was supported by UNESCO-IHE and IRC experts in the technological component and Learning alliance methodology. Other strategies used in the learning alliance processes include the preparation of brochures, a website (http://switchcali.wordpress.com/) which is updated on a regular basis, dissemination on local and regional circulation newspapers, radio programs, posters, scientific papers, and participation at forums and panels for the discussion of relevant issues of concern to the topics of the Learning Alliances in Cali.

The work during the first 2 years (2007-2008) of the Learning Alliances included the following: i) performing a diagnosis; ii) reviewing the plans, programs, and projects; iii) beginning the process of building a common shared vision; and iv) identifying key factors.

In 2008 a review was conducted of the plans, programs, and projects completed in recent years by the main institutions responsible for water management in the city and the region for the purpose of identifying synergies, gaps, and conflicts. This review revealed that, in the majority of cases, the plans and programs are designed based on the same strategies geared at promoting a paradigm shift as intended in the SWITCH project. These include strategies for integrated water resource management, urban water cycle, and interdisciplinary and intersectorial projects that follow cleaner production guidelines and rely on the participation of the community in the various stages of the projects. Despite these findings, the outcomes of specific projects completed are practically opposite to the initial plans and programs.

In 2009 the Learning Alliances focused on analysing trends, building scenarios, identifying alternatives, and establishing strategic action lines. In parallel with these activities, the team of the SWITCH project also became involved with relevant participatory processes for the city and the region. These processes included: i) preparing a national policy document (CONPES) for the recuperation of the Cauca river, and ii) completing what was called Strategic Diagnosis in the first phase of the project titled Cali Vision 2036 with the Municipality of Cali. In 2010 it has been working scaling up, by extending the LA to new groups of stakeholders, around specific themes and the active participation in formal planning procedures and the dissemination and engagement with decision-makers. Through the SWITCH Project Univalle has been participating in the review of the Territorial Ordinance Plan to the Cali City and in the formulation of the DAGMA action plan (Local Environmental Agency) in which it is pretended to consider the City and its influence or connection with neighbour municipalities.

It is also worth noting that the team of the SWITCH project participated in the development of specific projects together with the members of the Learning Alliances based on short-term strategic action lines. These projects were as follows: 1) “Sentinel of the Cauca river Water Quality for the City of Cali” with the participation of EMCALI and Universidad del Valle, and the assistance of the CVC. The scope of this project also included preparing an early warning system and real-time control strategies that contribute to mitigating the impact of extreme pollution events in the Cauca River on the operation of the Puerto Mallarino and Cauca River drinking water treatment facilities and on the municipal water supply system; 2) “Modelling of Water Quality and Treatment Capacity of the Reservoir Planned for the Puerto Mallarino Plant”, this study was conducted by

EMCALI and Universidad del Valle to model the dynamic water behavior and quality to evaluate alternatives for operating the reservoir built for the storage of pretreated water for the purpose of addressing the critical water quality situations on the Cauca River; 3) "Implementation of Entrepreneurial Environmental Improvement Systems in Santiago de Cali", this project was carried out under the lead of DAGMA and the Regional Center for Cleaner Production with the support of University of Valle, CVC, and the Cali City Mayor's Office.

The strategy of getting involved with recognized important projects on a local and regional level such as Cali Vision 2036 and CONPES document for the recuperation of the Cauca River enable positioning the outcomes and the philosophy of the SWITCH project at the level of decision-making institutions and agencies (Cali Mayor's Office, environmental authorities, Valle del Cauca State Governor's Office, Ministry of the Environment and Territorial Development, and the National Planning Department).

This strategy also allows for incorporation of the concepts of paradigm shift in the water management regulations and policies in urban areas. Meanwhile, the strategy of working on specific projects that have a short-term impact guarantees constant communication with the members of the Learning Alliances and provides an opportunity to show tangible results during the execution of the SWITCH project. Hence, this encourages the continuous participation of these institutions in medium and long-term projects.

2.2 VISION FOR CALI IN 2040

Initially, it was defined a vision for each topic of the learning alliances. After, as the work of the Learning Alliances was consolidated, a deeper characterization of the city problems and the visioning exercise in taken more in depth by the alliance members, being able to define a sole vision for Cali. This vision was adjusted in order to include relevant aspects such as the presence of population, the environment, the water resources, and coexistence principles. The following is the proposal for the city of Cali in 2040:

"Cali is a city where all citizens can enjoy a clean and healthy environment, having vital eco-systems and offering extensive green areas in the urban area. The city's water resources are of good quality, maintain sufficient flow to preserve aquatic life, and are the source for different human uses. There is a safe environment for healthy coexistence in an atmosphere of respect, peace, awareness and environmental culture, where citizens have a decent home and live in areas with low risk for natural disasters".

2.3 SCENARIOS

2.3.1 Identification of key variables

Based on the water resource management problems identified in Cali, there are five sub-systems or components known as TEPAS (for its acronym in spanish – technological, economic, political, environmental and social components) where all problems corresponding to the work areas of the Learning Alliances were located. The components that converted them in problems were extracted, allowing the opportunity to improve, worsen or continue the same, turning into a set of variables (Antioquia, 2008).
Table 2.2 shows key variables identified with the indicators.

Table 2.2 Key variables identified with the indicators

COMPONENT	KEY VARIABLE	INDICATOR
Environmental	Water basin Management	▪ Number of basins with water management committees and plans ▪ Natural protected areas (%) ▪ Number of closedowns in drinking water treatment plants
	Climate change	▪ Change of temperature in Colombia
Social	Environmental culture	▪ Total residential water consumption history in the city of Cali ▪ Per capita water consumption
	Population dynamics	▪ Population growth rate ▪ Accumulated number of persons in displacement situation
Institutional Framework	Inter-institutional coordination	▪ Number of proposals and/or projects implemented in collaboration between various institutions
	Territorial planning	▪ Response to housing deficit ▪ Number of households relocated ▪ Public space in urban zone, area per person (m^2/person)
	Integrated water vision	▪ Number of plans with an integrated water vision ▪ Number of project with an integrated water vision
	Legal and economic instrumentation	▪ Cost of drinking water and sewer consumption ▪ Change of subsidies granted by the municipality ▪ Contributions
Technological	Solid waste management	▪ Coverage of solid waste collection and transport ▪ Produced and collected volume of solid waste ▪ Quantity of construction waste collected by EMSIRVA E.S.P. ▪ Number of illegal dumping sites for domestic and construction solid waste
	Urban water management	▪ Coverage of sewerage ▪ Coverage of water supply system ▪ Number of closedowns in drinking water treatment plant due to contamination
	Implementation or adaptation of alternative technologies	▪ Type of channels ▪ Number of projects with alternative technologies approved by EMCALI E.S.P.
Economic Activities	Cleaner production	▪ Discharge load of BOD from different sectors ▪ Water consumption in industrial activities ▪ Productive establishments with Cleaner Production strategies

2.3.2 Trends

Environmental

River basin management: There has been some progress in relation to the creation of basin committees in charge of the zoning plan development, although some of these processes are in the orientation or diagnosis phase, as is the case of the Líli, Meléndez and Cañaveralejo rivers. In the upper Cauca river basin, 21 out of 35 basins are in the diagnosis process. In the revision of the status of the basins' protected forest areas, a deficiency is found, mainly in the Meléndez, Cañaveralejo and Líli rivers, according to study made by the (Universidad del Tolima and CVC, 2007). Only 45 – 56 % of these areas are covered by forest. Considering the Puerto Mallarino plant suspensions, both due to contamination and water turbidity, it is found that the problem has increased during the last years and that effective actions on the basins upstream the water intake, are not being implemented. Therefore, the trend of the environmental component is classified as "sustained – deficient".

Climatic change: In Colombia, temperature has had an increase of 0.5 °C between 1870 and 1990, and the trend is to continue increasing.

Social

Environmental culture: In terms of water consumption habits of the population in the city, consumption in the 6 socio-economic strata and in the commercial and industrial sector show a decreasing trend, as well as the per-capita water consumption. During the last 7 years, the decrease has been between 16.1% and 26.7%. This is due to the basic consumption water supply and sewage service tariffs (URL-6). However, the trend is "sustained – deficient" considering that there is a lack of awareness for a better use of water resources, instead of being only a result of the increase of public service prices.

Population dynamic: shows a trend to get worse considering that the population increase in Cali is 3.2%, compared to the national average of 1.4%. It also shows that the growing displaced population arriving into Cali settles in the river protection or high risk areas, without having formal public services provision.

Institutional framework

Interinstitutional Coordination: There are some examples of projects implemented by more than 2 institutions in the context of the SWITCH Project. However the activities together on other projects are limited.

Territorial planning: These become indicators of the city's management capacity. In Cali's case, in spite of the fact that programs are implemented to take care of the homeless and at-risk population, the necessary controls are not implemented since the displaced population constantly increases, showing incomplete development settlements.With regards to the available public space per person in the city of Cali, it is noticed that some of the city sectors do not have sufficient public space. Only 3 out of the 22 communes fulfill the standards suggested by WHO (10 m^2/inhabitant). The classification of the territorial planning component is "sustained – deficient".

Integrated water vision: Although all plans and programs show a conceptual base that includes an integrated water vision, in practice, the implemented actions do not include such vision. Institutions develop their projects without considering the inter-dependency of the different water systems. Therefore, this trend is "sustained – deficient" since there is no progress made in its implementation.

The legal instrumentation and economic: This variable is measured in terms of water supply and sewage services cost, where an increase of cost per m^3 has increased. However, the difference between the basic consumption value ($<20m^3$) and the complementary consumption (20 – 40 m^3) is not significant. Therefore, this does not stimulate the rational use of water by the users. Also, analysing the variation of subsidies granted by the municipality it is noticed that these have decreased, causing a tariff increase for the subsidized strata (1, 2 and 3) and those subsidizing the tariffs (5, 6 and the industrial and commercial sectors). Evaluating the contributions of strata 5, 6 and the commercial and industrial sectors, the trend during the last years is to increase, and although the tariffs for strata 1, 2 and 3 have increased, this situation has generated a water consumption reduction, although until now, no other economic or legal tools that incentivise a water consumption decrease have been presented. Therefore, the given classification is also "sustained – deficient".

The technological component

Solid waste management: urban water management and/or the adaptation of alternative technologies. Three indicators were identified for solid waste management: solid waste collection and transportation coverage, the solid waste volume produced and collected and the amount of debris collected. It is noticed that the waste collection activity has been affected by the last years of economic crisis and the intervention of EMSIRVA, the public service enterprise, by the national government and where other enterprises are rendering the service. Comparing domestic solid waste produced vs. the amount of solid waste collected, close to 50,000 ton/month are not collected. As for the collection of produced debris, there are not enough or adequate disposal sites. Additionally, the production of solid waste was increased during 2007 – 2009 due to the civil work made for the Integrated Transportation System of Cali. Considering the above mentioned factors, the trend for this variable is "sustained – deficient".

Urban water management: is a variable with 3 indicators: sewage system coverage, water supply system coverage and the number of suspensions of the Cauca river treatment plants due to water contamination. Sewage coverage in Cali in 2008 was 96.4%. However, 2 communes (18 and 20) from the South Drainage System located in the upper part show 67% and 60%, respectively. The development of these areas is incomplete. In 2008, water supply coverage in Cali was 99.6%. Likewise, communes 18 and 20 which have neighbourhoods located on the hillside, have a coverage of 69% and 60%, respectively. Suspensions at the Puerto Mallarino and Rio Cauca water treatment plants increased from 2000 to 2007. In 2008, these suspensions started decreasing, although it is important to continue working on the deterioration causes of the Cauca river water quality. This includes South Channel wastewater discharges. The classification for the urban water management variable is "progress".

The implementation and/or adaptation of alternative technologies: The indicator used to evaluate the trend is the type of channels implemented for the drainage of stormwater. It can be noticed that 92% of the channels have casing pipes and that other drainage systems, such as green ditches that would allow the stormwater infiltration, are not implemented. In the revision of the technological development implemented by EMCALI for wastewater management, it is observed that the trend is to implement conventional technologies and to use centralized systems. In the Expansion Zone the feasibility studies have focused on the evaluation of the best alternative to conduct wastewater to the Cañaveralejo WWTP. This implies the continuation of the trend to use centralized systems. Control of re-suspension and solid sediments in the South Channel is limited to the construction of sand traps, focusing on just mitigating the problem, without really handling its main causes. The classification of this variable is "sustained – deficient".

Economic activities

Cleaner production in the industrial sector: The key variable used in Cleaner Production and the indicators include the BOD loads discharged by the different productive sectors, the consumption of water for the different industrial activities and the implementation of productive activities using CP strategies. BOD discharges generated by sugar mills, paper companies and the coffee growers have reduced their loads between 80% – 90% in the 1979 – 2003. Other types of industries have reduced their load 70%, so this may be an indicator of the implementation of CP by these industries. Water demand for industrial

activities in Cali has decreased 52% during the last 7 years. However, a large amount of industries in Cali have not formalized their wastewater treatment system, do not apply CP strategies or any kind of environmental control measures to reduce negative environmental impact. The variable is classified according to the large industries applying CP strategies, where progress is shown, and the small and middle sized industries, including mining and agricultural activities, that do not have any kind of environmental control or CP strategies. In this case, the classification is "sustained – deficient". Table 2.3 shows a summary of the trends for the key variables of each component.

Table 2.3 Trends identified for key variables

Component	Key Variables		Trends			
			Worsening	Sustained - deficient	Advanceme nt	Satisfactory
Environmental	Water basin management					
	Climate change					
Social	Environmental culture					
	Population dynamics					
Institutional framework	Inter-institutional coordination					
	Territorial planning					
	Integrated water vision					
	Legal and economic instrumentation					
Technological	Solid waste management					
	Urban water management					
	Implementation or adaptation of alternative technologies					
Economic activities	Cleaner Production	Large/mid-sized industry				
		Small-sized industry, mining and agricultural sector				

2.3.3 The driving forces

The driving forces selected to build scenarios are: population growth, climate change, environmental culture, inter-institutional coordination, municipal economy, policies and norms changes and cleaner production.

Figure 2.1shows the driving forces classified according to its importance and uncertainty.

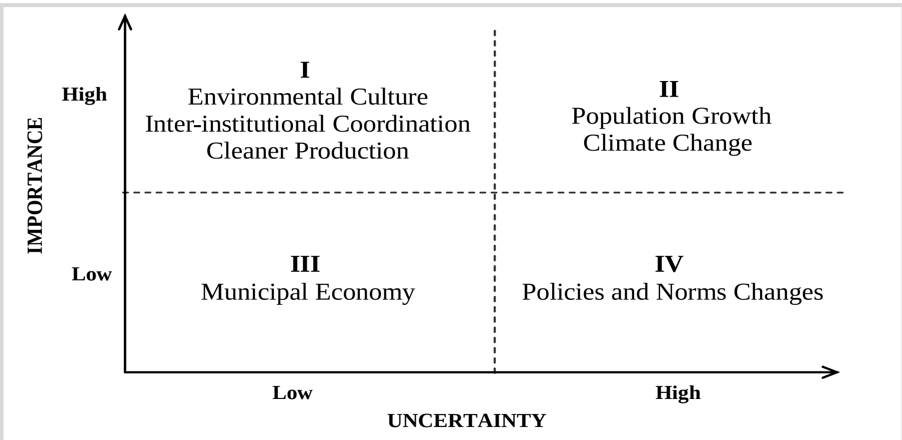


Figure 2.1 Water resources management in Cali.

The key facet of this stage is to determine whether these driving forces are acting to make the Cali's environment with more or less favourability. All the driving forces weren't used,

the scenario environment description was carried out with factors located in Quadrant II, since are the most important (Liu *et al.*, 2007). The driving forces are selected based on their influence of the city's water management and the long term water management decisions taken. An example is the case of climatic change and demographic growths, which may affect actions, implemented at medium and long term, but it represents a high degree of uncertainty with respect to their behaviour.

The two driving forces located in the second quadrant of Figure 2.1 corresponding to climatic change and demographic growth. Information related with temperature and precipitation shows an increase trend in the Project "Effects of Climatic Change and Evaluation of the Vulnerability" (CVC and Lovania, 2008). The increase in temperature ranges between (0.2 – 0.6 °C) and (0.8 - 1.5 °C) for years 2020 and 2050, respectively, and an increase in precipitation between (0 – 4%) and (0 – 10%) for years 2020 and 2050, respectively.

2.3.4 Formulation of sceneries

Scenario 1

<u>*Pessimistic and Critical Development:*</u> Cali's situation with respect to global warming is extremely serious. The increase in temperature in 30 years has been approximately 1.5°C and there has been a precipitation increase of up to 10%. This has significantly affected the city, increasing urban and rural area floodings, impacting agricultural productivity in rural areas due to the higher intensity of the rainfall and drought periods. Violence in the rural areas of Colombia continues. In addition, agricultural productivity problems caused by climatic change and socio-economic problems of the country have increased the displaced population that arrives in Cali, settling in any area of the city. The vulnerable population management program is no longer in effect.

Scenario 2

<u>*Sustained - Following the Actual Trends:*</u> Temperature increases due to climatic change have been approximately 0.8 °C in 30 years. The dry and rainy seasons are intense and affect the operation of the sewage and stormwater drainage infrastructure. The migration of displaced population towards the city of Cali continues. This population settles in any location, including areas having high natural disaster risks, river protection and regulation system areas. Although there is a program for the attention of vulnerable groups, it is very week and has limited services.

Scenario 3

<u>*Optimistic Development:*</u> Thanks to the implementation and compliance of global climatic policies to slow down climatic change, Cali's temperature has increased only 0.6°C in the last 30 years. In spite of the government's great effort to stop the war and violence in the rural areas of Colombia, the displacement phenomenon continues due to the population's socio-economic problems. However, the ratio of displaced people entering the city has decreased. Valle del Cauca, together with the government of the city of Cali, has strengthened the attention system for vulnerable groups by implementing training programs in different areas, including environmental topics, to improve their location within the city and the project to return to their places of origin.

2.4 STRATEGIC LINES

Strategic (action) lines are defined as conceptual statements of the desirable conditions for a specific problem of the city. Although they are qualitative non-quantifiable abstractions, they must be kept realistic (Fernández, 2006). In order to progress in complying with the vision, development objectives and goals are set with their respective strategic lines for the 3 work topics of the Learning Alliances: the South Drainage System, the South Cali Expansion Zone – Cali- Jamundí corridor, and the quality of the Cauca river water, and its impact on the city's water supply.

The actions will be implemented based on these strategic lines in order to achieve the optimum scenario, following strategies aimed towards the mitigation of the effect of climatic change over water resources and the environmental problems generated by demographic growth, including incomplete development settlements, among others. The general objective of the strategic lines is to achieve the sustainability of water resources in Cali.

Table 2.4 shows the strategic lines for the 3 work topics of the Learning Alliances. The Southern Expansion Zone, Cali-Jamundí corridor, is the future development area promoted for the construction of housing ranging between a middle and high socio-economic level. This sector presents different options for water supply and sanitation, combining different actions in order to minimize contamination caused by municipal wastewater

The proposed strategic lines for the recovery of the Cauca River includes some of the strategic lines for the South Drainage System of Cali, considering the direct relationship of the Cauca river contamination with the South Channel discharge upstream the water intake of the Puerto Mallarino and Rio Cauca treatment plants that supply the water to the city of Cali and other strategic lines for the upper Cauca river basin, including domestic and industrial discharges in the Cauca Department, the agricultural and mining activities, and other factors such as the institutional, educational, territorial zoning, citizenship participation topics, among others.

Table 2.4 General strategic lines proposed for 3 studio areas of LAs of Cali

OBJECTIVE	DEVELOPMENT GOALS	STRATEGIC ACTION LINES	INFLUENCE AREA		
			SDS	ZE	CARC
To comply with water quality standards in the rivers in order to use them as sources of water supply for human consumption and recreational purposes.	To reduce residential and industrial contaminant discharges into the rivers	Providing access to wastewater, excreta, and solid waste management services.	X		X
		Optimizing the wastewater management system (sewage, treatment, use of byproducts, reuse of treated water in irrigation, etc.)	X		X
		Promoting decentralized wastewater management systems.	X		X
		Performing proper management of leachates from the waste dump site at Navarro	X		X
		Promoting cleaner production strategies in the manufacturing industry (particularly in small and medium-sized enterprises).	X		X
		Performing proper management of mining exploitation activities	X		X
Proper integrated management of solid waste and debris	To eliminate illegal dump sites	Shutting down unauthorized waste & debris dump sites	X		X
	To achieve total coverage in the solid waste and debris collection services on a residential and industrial level, and at public spaces.	Providing access to solid waste and debris collection services on a residential and industrial level, and at public spaces.	X		X

Table 2.5 General strategic lines proposed for 3 studio areas of LAs of Cali (cont.)

OBJECTIVE	DEVELOPMENT GOALS	STRATEGIC ACTION LINES	INFLUENCE AREA		
			SDS	ZE	CARC
To recuperate and preserve the riverbeds.	To recuperate and preserve the rivers from an environmental and landscaping perspective.	Recuperating the riverbeds and vegetation on the rivers that have undergone human intervention.	X		X
		Relocating human settlements in protected areas of the rivers.	X		X
To minimize the risk of floods which affect the population	The rivers, and the rainwater drainage system have the capacity to retain and evacuate rainwater in rain events without overflowing.	Implementing alternate technologies for rainwater retention (on a lot or neighborhood level)	X		X
		Implementing alternate technologies for retaining the water flow of the rivers.	X		X
		Relocating human settlements in areas at risk of flooding. preserving and recuperating the natural flood areas of the rivers.	X		X
To keep a higher flow rate than ecological flow rate on the rivers all year round.	Anthropogenic water consumption do not exceed the levels to maintain the demand for water from natural ecosystems.	Reforesting the basins of the rivers.	X		X
		Using water in a rational and efficient manner	X	X	X
To optimize the use of natural resources.	Urban water management systems allow optimizing the use of natural resources (i.e. materials and energy).	Minimizing water consumption.	X	X	X
		Using technologies with natural methods that require a lesser consumption of electric power and chemical supplies.	X	X	X
		Using cleaner production strategies for recycling water and substituting environmentally harmful supplies.	X		X
To raise environmental awareness among the population about the importance of water resources and strategies to take care of these resources.	The population takes a responsible attitude towards environmental issues.	Conducting information campaigns and training sessions at all levels and media - Cali's vision is communicated to the population.	X		X
		Tariffs and incentives that encourage a change of habits.	X		X
		Facilities for taking environmental actions are available.	X		X
To increase the coverage of urban green areas in order to preserve natural ecosystems.	The green areas allow for the existence of natural ecosystems and provide opportunities for human recreation.	Recuperation of green areas	X		X
		Preservation of green areas		X	
Take into account and work to improve institutional aspects that interfere the integrated management of the Cauca river and its tributaries located upstream from Cali.	The structure of the institutions of the water and sanitation sector allow the adequate management of water resources in the upper Cauca river basin.	Coordinate interinstitutional work considering the basin as analysis unit.	X	X	X
		Institutions working to overcome limitations, trying to achieve common goals.	X	X	X
		Include diffuse contamination control aspects in the legislation.	X	X	X
		Include innovative Technologies for contamination control in the legislation.	X	X	X
		Promotion campaigns for citizenship participation in water management issues.	X	X	X
		Strengthening of citizen surveillance.	X	X	X
		Science and technology investments in topics related to water and sanitation research for the upper Cauca river basin.	X	X	X
		Inclusion of the environmental subject as a mandatory topic for formal and informal education of the population.	X	X	X
Take into account and work to improve institutional aspects that interfere the integrated management of the Cauca river and its tributaries located upstream from Cali.	The structure of the institutions of the water and sanitation sector allow the adequate management of water resources in the upper Cauca river basin.	Coordinate interinstitutional work considering the basin as analysis unit.	X	X	X
		Institutions working to overcome limitations, trying to achieve common goals.	X	X	X
		Include diffuse contamination control aspects in the legislation.	X	X	X
		Include innovative Technologies for contamination control in the legislation.	X	X	X
		Promotion campaigns for citizenship participation in water management issues.	X	X	X
		Strengthening of citizen surveillance.	X	X	X
		Science and technology investments in topics related to water and sanitation research for the upper Cauca river basin.	X	X	X
		Inclusion of the environmental subject as a mandatory topic for formal and informal education of the population.	X	X	X

SDS: South Drainage System; ZE: Expansion Zone; CARC: Cauca River Water Quality

3. ACTIONS FOR ACCOMPLISHING THE VISION

3.1 SOUTH DRAINAGE SYSTEM

For the SDS in the city of Cali there are three principal geographical areas that can be distinguished in relation to negative impacts on the water resources: the middle and upper parts of the Lili Meléndez and Cañaveralejo river basins with a deficient basin management; the consolidated urban area with contaminated discharges from residential areas, industries and also from inadequate solid waste management; and finally, downstream the urban area - where the Navarro landfill generates contaminated leachate. Considering these geographical areas, their specific characteristics and impacts on the water resources, within the SWITCH project -although focused on the urban water management- alternatives have been developed not only for the South Drainage System but also for the area of influence. An overview of these alternatives is shown in Figure 3.1.

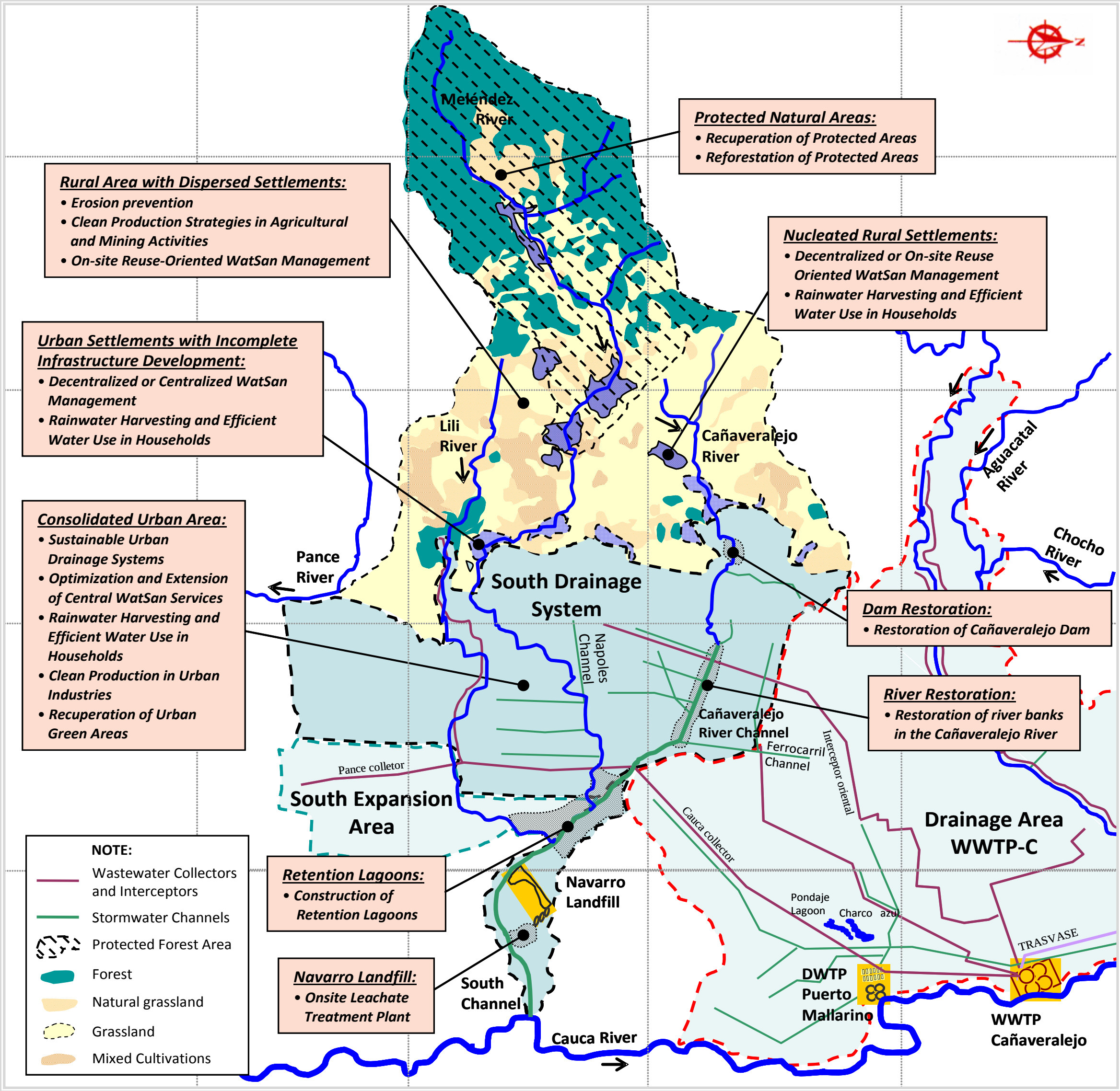


Figure 3.1 Alternatives proposed for SDS

In general, the proposals for the different alternatives have been developed on a conceptual level initially, where their potential and feasibility have been considered. This means that specific implications regarding for example specific sites, area requirements, costs etc.

have not been specified. However, in a few of the proposed alternatives a pre-dimensioning has been conducted to establish the feasibility and main impacts of the alternative. In the case of the South Drainage System, more thorough analyses were made for the leachate treatment of Navarro Landfill, construction of retention lagoons next to South Channel, and for the construction of a wastewater treatment plant for the treatment of the effluent of the South Channel on the other side of Cauca River. The last alternative was however discarded as it was not found to be in agreement with the sustainability objectives of this study.

Furthermore, it is apparent that the proposed alternatives are broad, i.e. they include a set of activities in different areas and on different levels. For the SDS all the alternatives are also compatible, which means there is no either or, instead the alternatives can and are recommended to be implemented in parallel, to generate the most positive impact

A more detailed description of the alternatives is presented in Table 3.1divided according to their geographical belonging, apart from a few alternatives that are considered general for the entire area, which can be found at the end of the table. The description of the alternatives includes the main components, potential impacts, and the estimated time frame of the implementation.

Table 3.1 Alternatives proposed for the SDS and the area of influence

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Nature protection and restoration	Rural (upper/ middle river basins)	▪ Recuperation of protected areas, including both protected forest area and river protection zones (with activities including relocation of illegal settlements) ▪ Reforestation of protected areas ▪ Erosion prevention (e.g. reestablishment of plant cover)	▪ Increased capacity for retention of rain and stormwater ▪ Reduced discharge and resuspension of soils and sediments in the river systems ▪ Reduced peaks in water flow	Short term/ continuous
Cleaner production strategies in mining and agricultural activities	Rural (upper/ middle river basins)	▪ Institutional support through a Cleaner Production program, including capacity building, pilot projects, economic stimulus, etc. ▪ Legalization process ▪ Closedown of mining activities that does not comply with the environmental norms. ▪ Promotion of organic agriculture	▪ Reduced discharge (direct and diffuse) of soils and other contaminants to the river systems, including toxic substances ▪ More self-sufficient farms with implementation of organic production approach	Short term/ continuous
Water and sanitation management in dispersed rural settlements	Rural (upper/ middle micro-basins)	▪ On-site sanitation systems with possible reuse in irrigation ▪ Rainwater harvesting and greywater reuse on household level ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Potential reuse of nutrients in green areas and cultivations	Short term/ continuous
Water and sanitation management in nucleated rural settlements	Rural (upper/ middle micro-basins)	▪ On-site, decentralized or centralized sanitation management with possible reuse in irrigation ▪ Rainwater harvesting and greywater reuse on household level ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Reuse of nutrients in green areas and cultivations	Medium - long term
Water and sanitation management in new urbanization	Urban	▪ Centralized or decentralized WWTP, preferably reuse-oriented ▪ Rainwater harvesting ▪ Local stormwater management ▪ Separate greywater management and reuse ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Reuse of nutrients in green areas and cultivations ▪ Reduced peaks in stormwater flow	Short term/ continuous
Water and sanitation management in urbanization with incomplete development	Urban	▪ Centralized or decentralized WWTP ▪ Stormwater retention in public spaces ▪ Rainwater harvesting and grey-water reuse on household level ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Reduced peaks in stormwater flow	Short - medium term

Table 3.2 Alternatives proposed for the SDS and the area of influence (cont.)

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Water and sanitation management in existing urbanization	Urban	▪ Optimization of drainage and sewage system ▪ Stormwater retention in public spaces ▪ Efficient water use strategies ▪ Rainwater harvesting in individual family residents	▪ Reduced discharge of contaminants ▪ Reduced peaks in water flow	Short - medium term
Sustainable Urban Drainage System (SUDS)	Urban	▪ Construction of SUDS technologies in new or existing urbanization, such as: ▪ Detention systems integrated in public spaces ▪ Swales and infiltration trenches ▪ Vegetated filter strips before channels and rivers ▪ Pervious pavements	▪ Minimize the generation of stormwater runoff ▪ Reduced discharge of contaminants (first-flush phenomenon) ▪ Reduced soil erosion ▪ More space for recreation ▪ Protection and enhancement of wildlife habitat	Short - medium term
Recuperation and protection of urban green areas	Urban	▪ Recuperation of protected river areas, including relocation of illegal settlements ▪ Recuperation of public green areas (where possible remove impermeable surfaces) ▪ Erosion control (e.g. reestablishment of plant cover)	▪ Reduced discharge of solids ▪ Reduced peaks in water flow	Short term - long term
Restoration of the Cañaveralejo Dam	Urban/ Caña-veralejo river	▪ Extraction of solid waste and sediments of regulation lagoons and dam areas ▪ Construction of separation structures (stormwater and wastewater)	▪ Recovered capacity for stormwater regulation and retention ▪ Reduced risk for flooding events	Short term
Restoring natural river system	Urban/ Caña-veralejo river	▪ Restoring the channelized parts of the Cañaveralejo river ▪ Recreate riverbanks and where possible the meander	▪ Restoration of natural sedimentation characteristics ▪ Reduced peaks in water flow ▪ Restoration of river ecosystem ▪ Landscape improvements	Medium term
Cleaner production strategies in urban industries	Urban	▪ Institutional support through a Cleaner Production program, including capacity building, pilot projects, subsidies, etc.	▪ Reduced discharge of contaminants, including toxic substances ▪ Economic benefits in industries due to resource economization	Short term / continuous
Retention lagoons	Peri-urban (next to South Channel)	▪ Construction of lagoons for the retention of river and stormwater flow ▪ Lagoons in the three river subsystem as joining in South Channel	▪ Retention of water flow ▪ Retention of solids, BOD and other contaminating substances, including pollution from non-point sources ▪ New environmental space for human recreation and wildlife	Medium term
On-site leachate treatment in the Navarro Landfill	Rural (Navarro district)	▪ Construction of an on-site treatment plant for the leachate produce from the Navarro Landfill ▪ Combined technological solution, such as UASB with constructed wetland, seems promising for efficient treatment	▪ Reduced discharge of contaminants, including toxic substances	Short - medium term
Solid Waste Management	General	▪ Closure of illegal dumping sites for domestic solid waste and construction waste ▪ Improvement of activities for solid waste collection in public spaces ▪ Implementation of Domestic Solid Waste Management Plan ▪ Formulation and implementation of Construction Waste Management Plan	▪ Reduction of solid waste volumes in public spaces, rivers and stormwater system ▪ Reduction of operational problems of sewer and stormwater systems ▪ Reduced risk for flooding ▪ Improving life quality of residents due to improved environment	Short term
Environmental education	General	▪ Public campaigns focused on environmental consciousness ▪ regarding water and waste management issues ▪ Training of professionals and students in alternative technologies	▪ Reduced water consumption ▪ Reduced generation of wastewater ▪ Implementation of preventive measures	Short term / continuous
Economic instruments	General	▪ Incentives, subsidies, polluter tariffs etc. to achieve a change towards reduced water consumption and solid and liquid waste production.	▪ Reduced water consumption ▪ Reduced generation of wastewater ▪ Implementation of preventive measures	Short - medium term

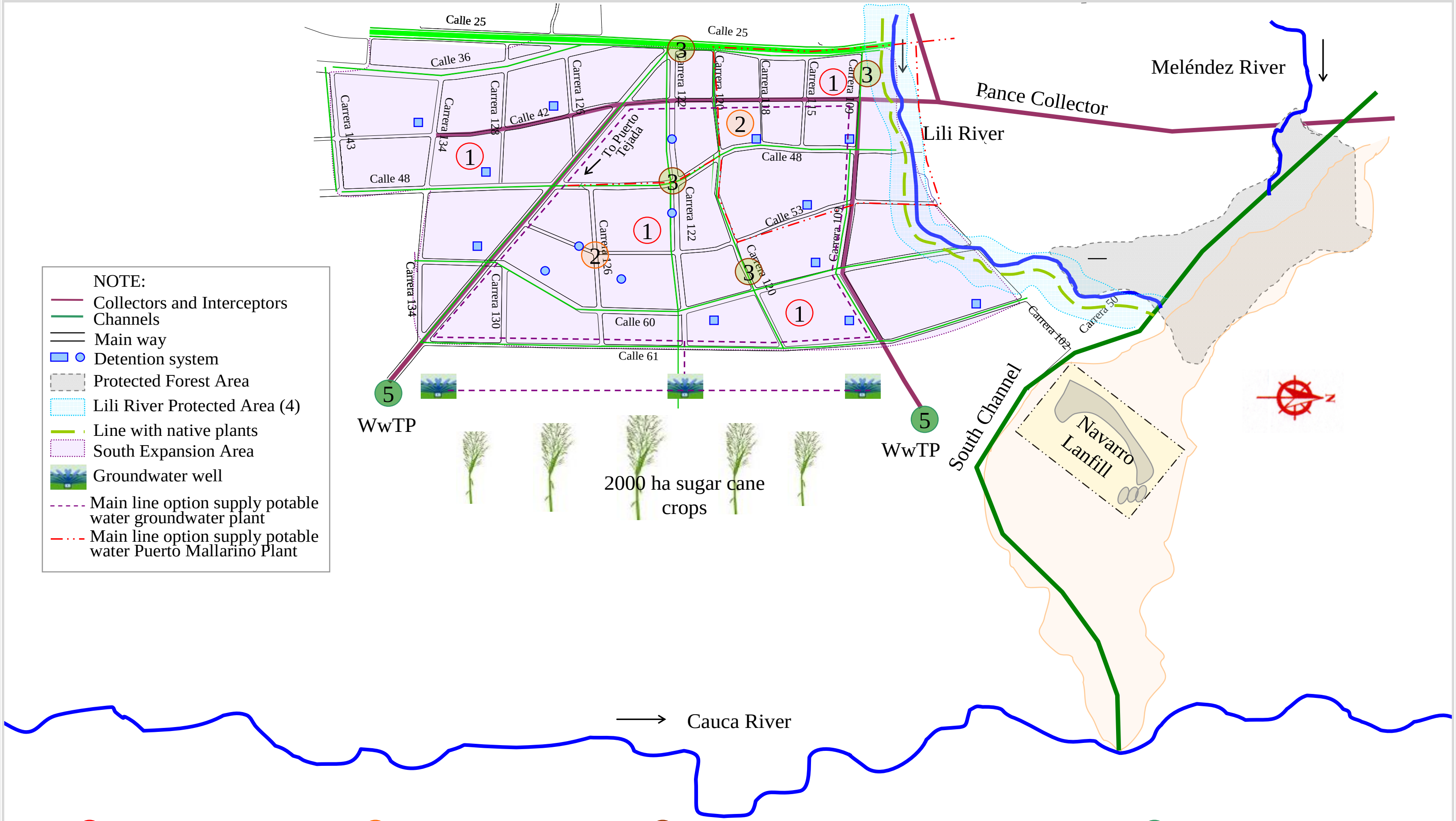
3.2 SOUTH EXPANSION AREA, CALI – JAMUNDI CORRIDOR

For the Expansion Zone along the Cali – Jamundi Corridor, the proposed alternatives focus on various water supply and treatment options, including the implementation of water management strategies in new urban developments that seek to minimize pollution by municipal wastewaters. The options for water supply include greywaters, rainwater, and potable water. Greywaters in particular**,** which come from washing machines, showers, and sinks, constitute a steady source with potential use in flushing toilets and watering gardens, diminishing the total volume of wastewaters to be treated. Rainwater collected from the house roofs is an alternative source of supply for the household, simultaneously diminishing the runoff volume to be discharged. It is used by households for domestic chores such as washing clothes and cleaning the house.

With respect to alternative potable water supply methods, the following two options are being considered: i) an extension of the main Cali network, supplied for by the Puerto Mallarino plant with capture from the Cauca River, and ii) supply from underground water, requiring the startup of three wells and a iron and manganese removal system. This second supply source contributes to the regulation of water table levels, which in turn minimizes seepage into the sewer system.
Figure 3.2 shows the proposed alternatives for the Expansion Zone along the Cali – Jamundí Corridor.

Natural treatment systems offering the possibility of water reuse have been considered as alternatives for wastewater treatment. These alternatives include: i) primary facultative ponds; ii) anaerobic and secondary facultative ponds in series; and iii) anaerobic ponds and subsurface flow constructed wetlands in series. For each of these three alternatives, the additional implementation of rock filters, maturation ponds, and fishponds has also been considered. With respect to its disposal or the possibility of assigning discharge a final use, the management options are disposal into the Cauca River and reuse in irrigation of sugarcane plantations. Figure 3.3 shows the schemes of the different alternatives proposed for the treatment and disposal of the wastewater of the expansion zone.

With respect to the runoff water management, the proposed drainage system extends to include retention and in-situ seepage, capture and transport through underground drainage and the transport of overflow through pipes, using the dividers of main and secondary arterial roadways as ‘green drains’ or wetlands and including the installation of filter drains. Overflow will be carried over to natural irrigation systems and existent water sources in the area. For peak volume and polluting discharge buffer systems, retention systems are suggested for the later distribution of water to the commercial sector for uses such as cleaning facilities, flushing toilets, and washing cars. These systems will be integrated into the landscaping and the roadway system as road features with depressions in them. The flooding zone of the Lili River and associated protected areas will remain unchanged and rainwater retention ponds will be integrated into the local environments. Likewise, it is proposed that vegetation be included on the riverbanks and aquatic plants in the ponds, serving as integral landscaping elements that simultaneously aid in regulating local temperature and purifying and improving water quality. Wetland recovery and conservation programs will also contribute to the management of the rainwater flow. It is important to identify and inventory the local wetland systems and include them in landscaping and conservation projects alongside the urban developments. Table 3.3 provides a summary of these alternatives.



1 Water and sanitation management in new urbanization:
- Low consumption devices
- Greywater recycle
- Rainwater use, water use
- Water loss control in the housing
- Environmental education

2 Stormwater collection:
- Detention system
- Recollection of water captured for the maintenance of institutional and neighbouring zones

3 Drainage management:
- Porous pavement
- Green strips
- Wetland or Infiltration trench

4 Lili River Procteted Area
- Maintenance floodplain
- Line with native plants

5 Wastewater treatment:
- Decentralized
- Implementation of natural systems for the WwTP of the South
- Reuse of the effluent in irrigation sugar of cane

Figure 3.2 Alternatives proposed for South Expansion Zone, Cali – Jamundi Corridor.

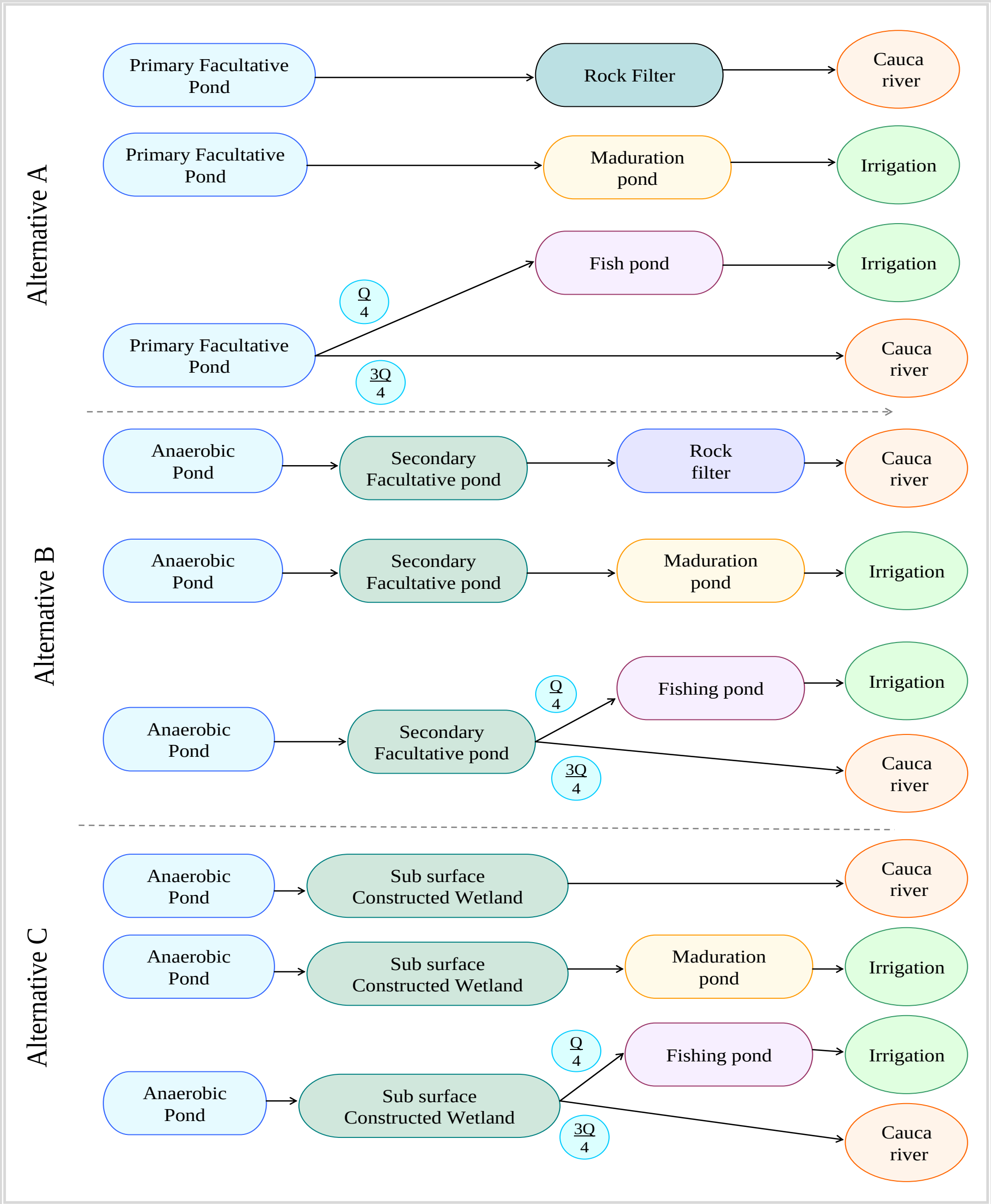


Figure 3.3 Schemes proposed for treatment and disposal of wastewater in South Expansion Zone.

Table 3.3 Alternatives proposed for the South Expansion Zone, Cali – Jamundi Corridor.

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Water and sanitation management in new urbanization.	Urban	▪ Implementation of greywater re-circulation systems storm water collection systems. ▪ Design of hydrosanitary facilities with efficient use concepts that consider: low consumption devices, greywater recycle, rainwater use, water use environmental education. ▪ Water loss control in the housing. ▪ Use of drinking water exclusively for basic needs (consumption, food preparation, personal hygiene). ▪ Separate greywater management and reuse. ▪ Efficient water use strategies. ▪ Rainwater harvesting in individual family residents. - Stormwater retention in public spaces.	-Reduced discharge of contaminants. -Reduced water consumption. -Reuse of nutrients in green areas and cultivations. -Reduced peaks in stormwater flow.	Short term/ continuous.

Table 3.4 Alternatives proposed for the South Expansion Zone, Cali – Jamundi Corridor (cont.)

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Discharge control for WWTP-South	Urban	Decentralized wastewater treatment in the expansion zone through the implementation of two plants which would use natural methods to attain secondary and/or tertiary treatment levels. The technologies proposed for the treatment include the following: -Primary Facultative Pond+ Rock Filter. -Primary Facultative Pond+ MaturationPond. -Primary Facultative Pond (3/4Q) + Fishing Pond (Q/4). -Primary Facultative Pond with baffles+ Rock Filter. -Primary Facultative Pond with baffles (3/4Q) + Fishing Pond (Q/4). -Anaerobic pond+ Secondary facultative pond+ Rock Filter. -Anaerobic pond+ Secondary facultative pond+ Maturation pond. -Anaerobic pond+ Secondary facultative pond+(Q/4) Fishing pond. -Anaerobic pond+ Secondary facultative pond with baffles+ Rock Filter. -Anaerobic pond+ Secondary facultative pond with baffles+(Q/4) Fishing pond. -High rate Anaerobic Pond+ Secondary facultative pond with baffles+ Rock Filter. -High rate Anaerobic Pond+ Secondary facultative pond with baffles+(Q/4) Fishing pond. -Anaerobic pond+Sub surface Constructed Wetland. -Anaerobic pond+Sub surface Constructed Wetland+ Maturation pond. -Anaerobic pond+Sub surface Constructed Wetland+ (3/4Q) Fishing pond. -High rate Anaerobic Pond+Sub surface Constructed Wetland.	-Reduced discharge of contaminants to the Cauca River which can be generated under two scenarios: -Direct discharge into the Cauca River perpendicular to the expansion area, minimizing risks to the population of Cali, taking into account that the purification plant is located downstream. -Discharge into the Cauca River through the Cañaveralejo WWTP, reducing the accumulation of load at the point of discharge and a much greater impact associated with the increase of residues to treat and dispose.	Short term / Medium term.
		-High rate Anaerobic pond+Sub surface Constructed Wetland+ Maturation pond. -High rate Anaerobic pond+Sub surface Constructed Wetland+ (3/4Q) Fishing pond. Among the options for discharge, there is disposal directly to the Cauca River or reuse of the effluent for irrigation of sugarcane plantations.		
Sustainable Urban Drainage System (SUDS).	Urban	Implementation in local streets and public space -Porous pavement -Green strips -Cobblestone sidewalk -Filter drain Implementation in inter-regional roads such as the Cali-Jamundi road and the road to Puerto Tejada and in the principal and secondary arteries -Porous pavement -Green strips -Cobblestone sidewalk -Filter drain -Wetland or Infiltration trend Detention systems integrated into public spaces and into the infrastructure of the roads such as roundabouts associated with each partial plan of urban development. -Vegetated filter strips before channels and rivers	-Minimize the generation of stormwater runoff -Reduced discharge of contaminants (first-flush phenomenon) -Reduced soil erosion -More space for recreation -Protection and enhancement of wildlife habitat.	Short -medium term.
Recuperation and protection of urban green areas.	Urban	--Recuperation of protected Lili River y natural waterways. -Maintenance and promotion of green spaces. -Integration of the network of natural drainage into the urbanization and landscaping. -Erosion control (e.g. reestablishment of plant cover).	-Reduced discharge of solids. -Reduced peaks in water flow.	Short term/continuous

Table 3.5 Alternatives proposed for the South Expansion Zone, Cali – Jamundi Corridor (cont.)

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Retention lagoons.	Peri-urban (next to Lili River)	-Construction of lagoons for the retention of river and stormwater flow. -Implementation of living hedges with native plants on the buffer zones of the Lili river. -Conservation and isolation of floodplain of Lili river.	-Retention of water flow. -Retention of solids, BOD and other contaminating substances, including pollution from non-point sources. -New environmental space for human recreation and wildlife.	Medium term
Solid Waste Management.	General	-Improvement of activities for solid waste collection in public spaces. -Implementation of Domestic Solid Waste Management Plan. -Formulation and implementation of construction waste Management Plan.	-Reduction of solid waste volumes in public spaces, rivers and stormwater system. -Reduction of operational problems of sewer and stormwater systems. -Reduced risk for flooding. -Improving life quality of residents due to improved environment.	Short term
Environmental education.	General	-Public campaigns focused on environmental consciousness. -Regarding water and waste management issues. -Training of professionals and students in alternative technologies.	-Reduced water consumption. -Reduced generation of wastewater. -Implementation of preventive measures.	Short term / continuous
Economic instruments.	General	-- Incentives, subsidies, polluter tariffs etc. to achieve a change towards reduced water consumption and solid and liquid waste production.	--Reduced water consumption. --Reduced generation of wastewater. --Implementation of preventive measures.	Short - medium term

3.3 WWTP-C DRAINAGE AREA

WWTP-C drainage area is composed by drinking water, stormwater and sewer system, where the later includes part of the South Drainage System and South Expansion Area. The main characteristic of this area is the fact that its wastewater is treated in the Cañaveralejo Wastewater Treatment Plant (WWTP-C). The study area is divided in three main zones; upper basin characterized for high coverage of forest; middle basin, where the majority of nucleated and dispersed rural settlements is located; and finally the consolidated area within the city of Cali. Each zone has its particular problems related to water management that affects or interacts with the other zones, all together resulting in major negative impacts on the Cauca River.

The conducted analysis of water management causes and problems in the WWTP-C Drainage Area shows that deforestation, mining industry, agricultural activities, and poor water management in rural and peri-urban settlements, have an important impact on the Cali River. When the Cali River runs through the urban area, its quality is becoming further deteriorated due to problems in sewerage operation and disposal of domestic solid waste and construction waste in channels and in the river. An overview of the proposed alternatives is shown in Figure 3.4.

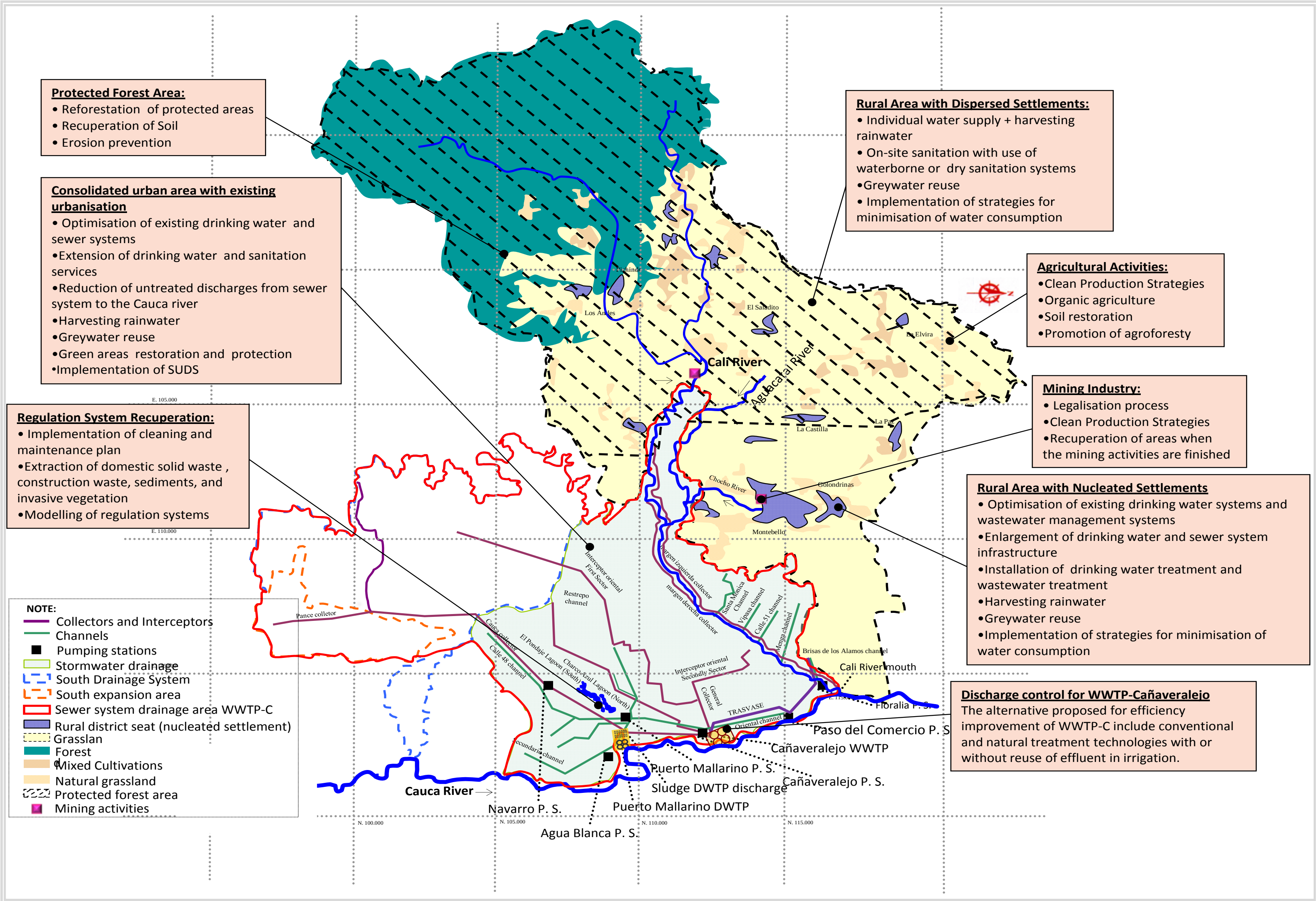


Figure 3.4 Overview of alternatives proposed in the WWTP-C drainage area and their zone of influence.

The alternatives are aiming to improve forest management in upper basin, implement sustainable practices in activities such as mining and agriculture, and solve the water management problems in the rural communities in the middle basin. In the consolidated area the proposals are focused on the improvement of the infrastructure in the drinking water and sewer systems, to improve the efficiency of WWTP-C, with the objective to reduce discharges to the Cauca River. The main components of the alternatives, their positive impacts and estimated time frame for implementation are presented in Table 3.3

Table 3.3 Alternatives proposed for the WWTP-C drainage area and their zone of influence

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Nature protection and restoration	Rural (upper/ middle river basins)	▪ Protection of existing forest in Cali River Basin ▪ Recuperation of protected areas (protected forest and river protection zones). This recuperation includes the relocation of illegal settlements). ▪ Reforestation of protected areas and river protection zones ▪ Erosion prevention through strategies of reestablishment of plant cover	▪ Increased capacity for retention of rain and stormwater ▪ Reduced discharge and resuspension of soils and sediments in the river systems ▪ Reduced peaks in water flow	Short term/ continuous
Cleaner production strategies in mining and agricultural activities	Rural (upper/ middle river basins)	▪ Institutional support through a Cleaner Production program, including capacity building. ▪ Legalization process ▪ Closedown of mining activities that does not comply with the environmental norms. ▪ Recuperation of areas when the mining activities are finished ▪ Promotion of organic agriculture ▪ Soil restoration ▪ Promotion of agroforestry	▪ Reduced discharge (direct and diffuse) of soils and other contaminants to the river systems, including toxic substances ▪ More self-sufficient farms with implementation of organic production approach ▪ Reduction of eroded areas	Short term/ continuous
Water and sanitation management in dispersed rural settlements	Rural (upper/ middle basins)	▪ Individual water supply ▪ On-site sanitation systems with possible reuse in irrigation ▪ Rainwater harvesting and greywater reuse on household level ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Potential reuse of nutrients in green areas and cultivations	Short term/ continuous
Water and sanitation management in nucleated rural settlements	Rural (upper/ middle basins)	▪ Optimisation of existing systems to water supply and sanitation ▪ On-site, decentralized or centralized sanitation management with possible reuse in irrigation ▪ Rainwater harvesting and greywater reuse on household level ▪ Installation of drinking water treatment systems and wastewater treatment systems ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Reuse of nutrients in green areas and cultivations	Medium - long term
Water and sanitation management in new urbanization	Urban	▪ Connection of new urbanisations to existing drinking water systems ▪ Centralized or decentralized WWTP, preferably reuse-oriented ▪ Rainwater harvesting ▪ Local stormwater management ▪ Separate greywater management and reuse ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced water consumption ▪ Reuse of nutrients in green areas and cultivations ▪ Reduced peaks in stormwater flow	Short term/ continuous
Water and sanitation management in existing urbanization	Urban	▪ Optimization of drinking water, storm water and sewer systems ▪ Rainwater harvesting in individual family residents ▪ Efficient water use strategies	▪ Reduced discharge of contaminants ▪ Reduced peaks in water flow ▪ Reduce of water consumption	Short - medium term

Table 3.3 Alternatives proposed for the WWTP-C drainage area and their zone of influence (cont.)

ALTERNATIVES	AREA	MAIN COMPONENTS	POTENTIAL IMPACT OF ALTERNATIVE	TIME FRAME
Discharge control for WWTP-Cañaveralejo	Urban	Implementation of systems for efficiency improvement. The considered alternatives are: ▪ Primary Treatment + Reuse ▪ Primary Treatment + Activated Sludge+Reuse ▪ Primary Treatment + Activated Sludge+Cauca River ▪ Primary Treatment + Falcultative Ponds+Reuse ▪ Primary Treatment + Falcultative Ponds+Cauca River ▪ Primary Treatment + Wetlands+Reuse ▪ Primary Treatment + Wetlands+Cauca River	▪ Reduced discharge of contaminants to the Cauca River	Short – medium term
Sustainable Urban Drainage System (SUDS)	Urban	Construction of SUDS technologies in new or existing urbanization, such as: ▪ Detention systems integrated in public spaces ▪ Swales and infiltration trenches ▪ Vegetated filter strips before channels and rivers ▪ Pervious pavements	▪ Minimize the generation of stormwater runoff ▪ Reduced discharge of contaminants (first-flush phenomenon) ▪ Reduced soil erosion ▪ More space for recreation ▪ Protection and enhancement of wildlife habitat	Short - medium term
Recuperation and protection of urban green areas	Urban	▪ Inventory update on green areas and potential areas to recuperate ▪ Recuperation of protected river areas, including relocation of illegal settlements ▪ Implementation of restoration plan ▪ Changes in POT: increase area per person of public green area (where possible remove impermeable surfaces) ▪ Recuperation of urban green areas invaded ▪ -Erosion control (e.g. reestablishment of plant cover)	▪ Reduced discharge of solids ▪ Reduced peaks in water flow	Short term - long term
Regulation systems recuperation (Pondaje and Charco azul laggons)	Urban	▪ Implementation of cleaning and maintenance plan ▪ Extraction of domestic solid waste , construction waste, sediments, and invasive vegetation ▪ Control of vegetation growth ▪ Monitoring program for water quality ▪ Periodic monitoring of accumulated sediments in the bottom ▪ Modelling of regulation systems ▪ Determine operational and maintenance parameters	▪ Recovered capacity for stormwater regulation and retention ▪ Reduced risk for flooding events	Short term
Cleaner production strategies in urban industries	Urban	▪ Institutional support through a Cleaner Production program, including capacity building, pilot projects, subsidies, etc.	▪ Reduced discharge of contaminants, including toxic substances ▪ Economic benefits in industries due to resource economization	Short term / continuous
Solid Waste Management	General	▪ Closure of illegal dumping sites for domestic solid waste and construction waste ▪ Improvement of activities for solid waste collection in public spaces ▪ Implementation of Domestic Solid Waste Management Plan ▪ Formulation and implementation of Construction Waste Management Plan	▪ Reduction of solid waste volumes in public spaces, rivers and stormwater system ▪ Reduction of operational problems of sewer and stormwater systems ▪ Reduced risk for flooding ▪ Improving life quality of residents due to improved environment	Short term
Environmental education	General	▪ - Public campaigns focused on environmental consciousness ▪ regarding water and waste management issues ▪ Training of professionals and students in alternative technologies ▪ Evaluation of environmental education programs	▪ Reduced water consumption ▪ Reduced generation of wastewater ▪ Implementation of preventive measures	Short term / continuous
Economic and normative instruments	General	▪ Incentives, subsidies, polluter tariffs etc. to achieve a change towards reduced water consumption and solid and liquid waste production. ▪ Development of technical guidelines and standards for alternative technologies and for the construction of environment-friendly buildings, including water efficiency strategies.	▪ Reduced water consumption ▪ Reduced generation of wastewater ▪ Retention of stormwater ▪ Implementation of preventive measures	Short - medium term

3.4 CAUCA RIVER WATER QUALITY AND ITS IMPACT ON THE CALI WATER SUPPLY SYSTEM

For the labours realized by the regional work panel in contributing to the formulation of CONPES for the Cauca River, in the final document issued by the MAVDT and DNP, CONPES document No. 3624, "Program for the Treatment, Management, and Environmental Recovery of the Upper Cauca River Basin", a problem tree was included which was compiled by local sources (Figure 3.5, Figure 3.6, Figure 3.7 y Figure 3.8) .

The document pointed out that the degradation of this body of water is due not only to point-source pollution, but also to diffuse pollution, moreover identifying the structural causes of the situation. The CONPES document was approved in November 20, 2009.

It is worth noting that the work completed by the regional panel on the proposal presented to CONPES is related to three of Cali Learning Alliance's issues, taking into account all actions implemented for the South Drainage System, the South Cali Expansion Zone, and the entire upper Cauca river basin upstream of Cali which will positively or negatively affect the water quality of this body of water and therefore the Cali supply system.

The most relevant actions to be taken for improving the Cauca River water quality upstream of the city of Cali and diminishing the impact on the city water supply system come from the work that is proposed for contributing to the formulation of CONPES. These actions are outlined below:

- Reforestation of the upper parts of the tributary river basins located upstream of Cali, especially the Palo, Desbaratado, and Güengüe River basins, which are partly affected by the sewing of illegal crops.

- Consideration of the mining activities that occur in the Cauca department. These are small-scale operations, using dangerous chemical substances that are dumped into the river, causing erosion of the bottom of the Cauca River and sediment loading. With respect to this issue, it is necessary to coordinate with regional authorities, the environmental authorities from the Ministry of the Environment, and the Ministry of Mines and Energy (entity responsible for regulating mineral extraction and granting operating licenses), aiming to mitigate the negative impact of these activities on the water quality of the Cauca River and its tributaries.

- In addition to the control that must be placed on site-specific domestic and industrial wastewater dumping, as much for tributaries upstream of Cali as for the Cauca River itself, it is necessary to pay attention to the issue of scattered pollution, which, in the case of the upper Cauca river basin, is mainly caused by the following three factors in particular: i) farming activities in which pesticides are used, and erosion is caused by unsuitable cultivation practices; ii) the surface runoff from urban areas where the 'first flush' phenomenon occurs and from rural areas where this runoff is associated with basin deforestation; and iii) pollution caused by improper management of solid wastes and debris in both urban and rural areas, where the problem of leachates occurs, which pollute both surface and underground water sources.

- The South Drainage System is one of the main sources of pollution of the Cauca River. Because it is within the scope of work of the Cali Learning Alliances, it has been

specifically addressed, and all previously mentioned actions proposed for this system directly impact the water quality of this body of water.

- Another issue to take into account is the degradation of Cauca River water quality; the structural causes are related to institutional factors**,** governance, regulatory and legal considerations, the citizenry, scientific and technological development, education, and regional planning. This plan proposes actions aiming at achieving a coordinated institutional work effort, taking the basin as a unit of analysis, strengthening the abilities of professionals from institutions, and including other important stakeholders in the planning and management of water resources at the local, regional, and national levels via the Ministry of Mines and Energy, the Ministry of Agriculture, the Ministry of the Environment, National Planning, professional associations, environmental authorities, public utility companies, user associations, and the industrial sector, among others. Likewise, it is important that the institutional planning processes aim at achieving common objectives and have both medium-term and long-term visions.

- With respect to the issue of governance, it is necessary to achieve a consensus between political sectors (the mining sector, the environmental sector, the agricultural sector, and the energy sector) and strengthen institutional ability to enforce compliance with regulations. Likewise, progress is necessary on the issue of lack of transparency through the creation and operation of citizen's oversight committees and the limitation of political interference in decision-making without technically justified support. In regulatory and control affairs it is indispensable to understand the basin as the unit of analysis and to incorporate scattered pollution and innovative technologies in the regulatory framework with the aim of progressing towards sustainable water resource management. Equally, regulations must shift their focus away from end-of-pipe practices towards actions directed at minimization and cleaner production.

- With respect to citizens' participation in the management of water resources, environmental education is necessary in both formal and informal settings, across all levels and stages of education. To this end it is necessary to develop appropriate educational strategies beginning at the national level and also to facilitate the training of professionals who work in the water and sanitation sectors. Following this track of thoughts, citizens acquire better knowledge of how to participate in environmental and city planning issues. Likewise, education would facilitate the social inclusion process for marginalized groups that do not participate in decision-making and are not included in planning processes.

- The alternatives implemented for contributing to improving Cauca river water quality include the development of projects such as the "Sentinel of the Cauca river Water Quality for the City of Cali", "Modelling of Water Quality and Treatment Capacity of the Reservoir Planned for the Puerto Mallarino Plant", and "Implementation of Entrepreneurial Environmental Improvement Systems in Cali" which constitute short-term actions that will contribute to planning and decision-making in the medium- and long-term.

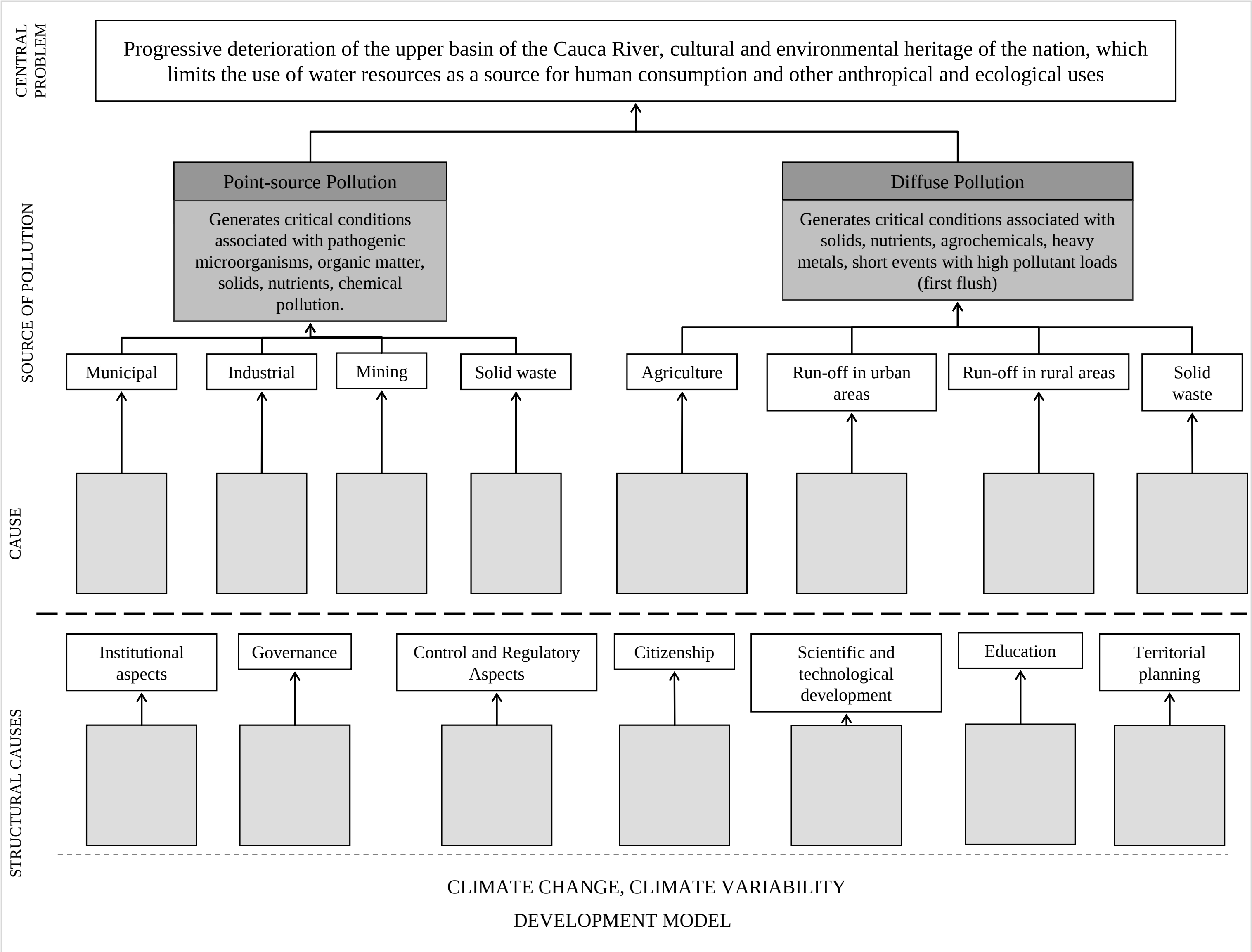


Figure 3.5 Problem tree associated with water quality of Cauca river

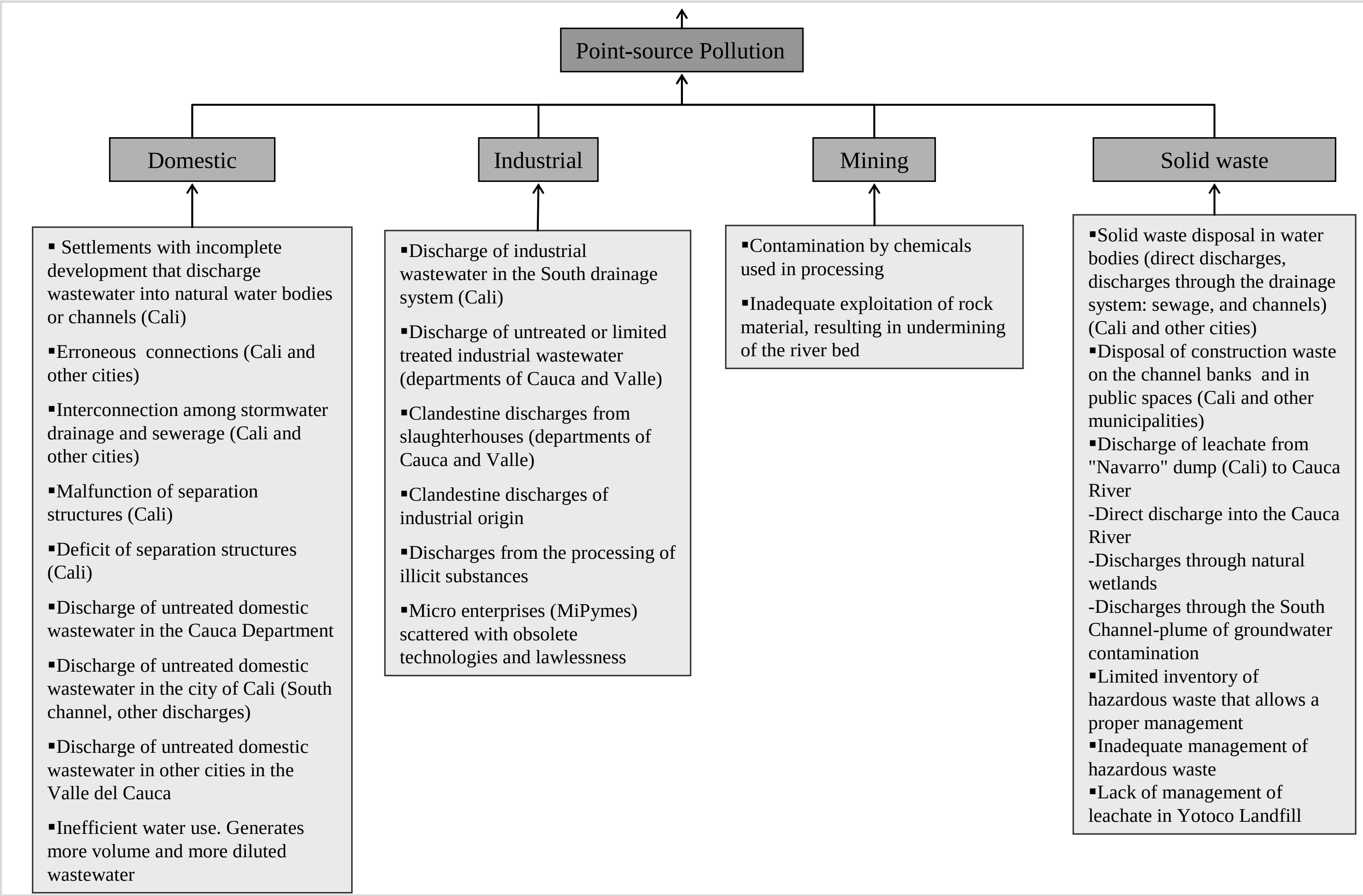


Figure 3.6 Problem tree associated with water quality of Cauca river (Point source Pollution)

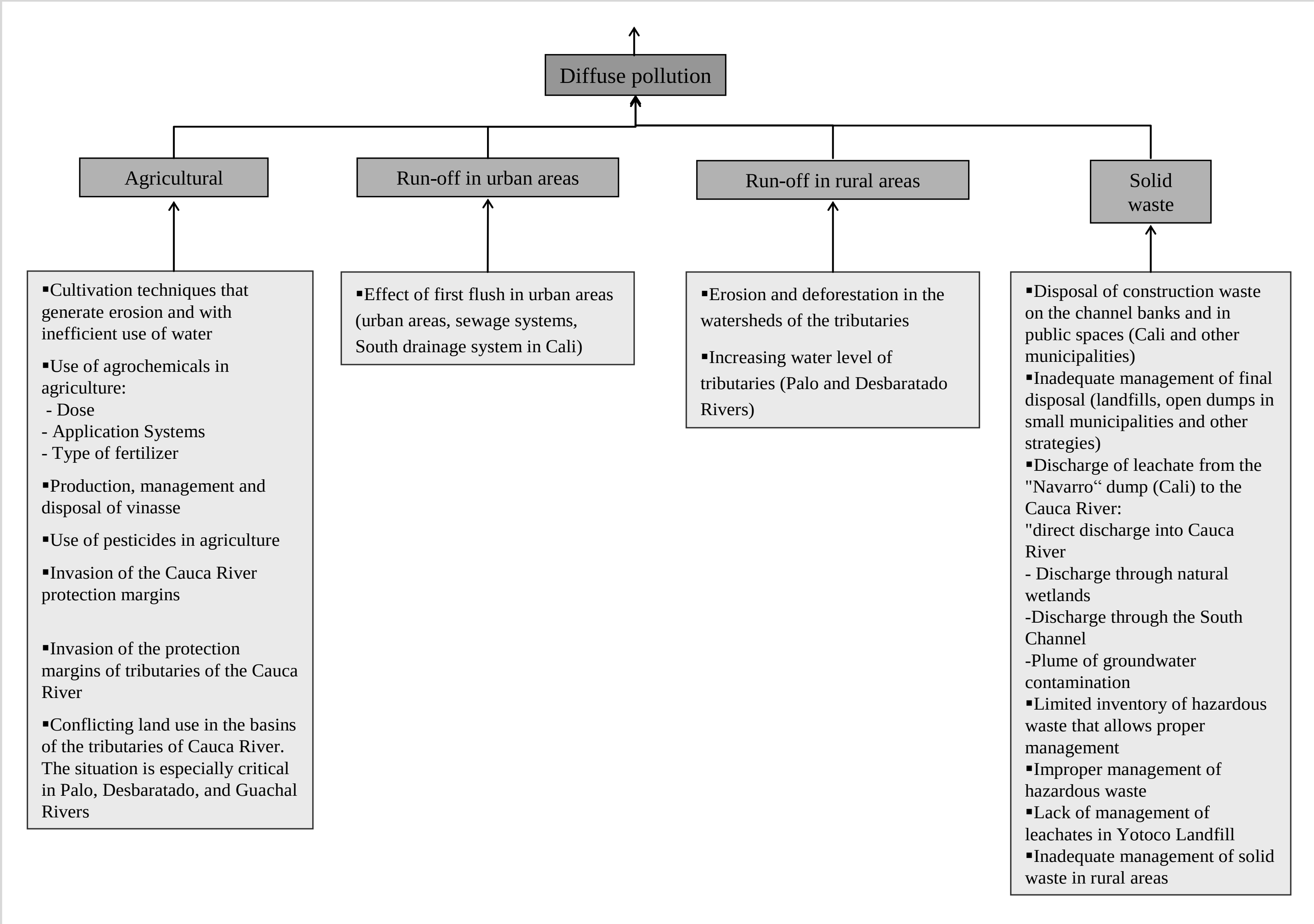


Figure 3.7 Problem tree associated with water quality of Cauca river (diffuse pollution)

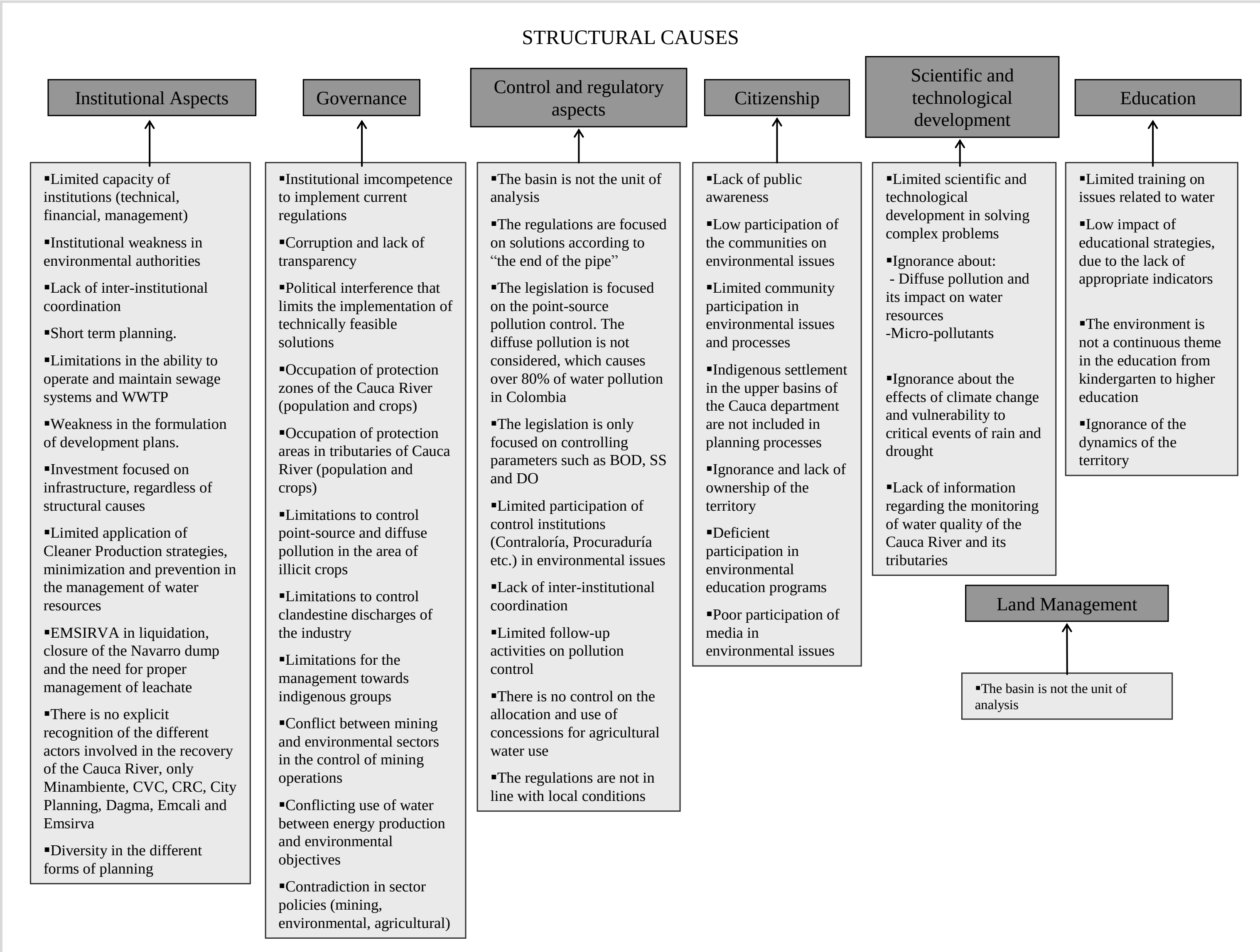


Figure 3.8 Problem tree associated with water quality of Cauca river (Structural Causes)

4. SWITCH APROACH VERSUS CONVENTIONAL SOLUTIONS

4.1 STUDY CASE SOUTH DRAINAGE SYSTEM

4.1.1 Backgraund

The South Drainage System is delimitated by the urban area of the basins of the Cañaveralejo, Meléndez and Lili rivers until the outlet of the South Channel in the Cauca River, see Figure 4.1 Since the three rivers are interconnected with the drainage system and all have been intercepted by the South Channel, the upper and middle water basins of the Cañaveralejo, Meléndez and Lili rivers are influence areas and accordingly, the complete system must be taken into consideration to achieve an integrated management of water resources and to accomplish the objective of decontamination of the South Drainage System.

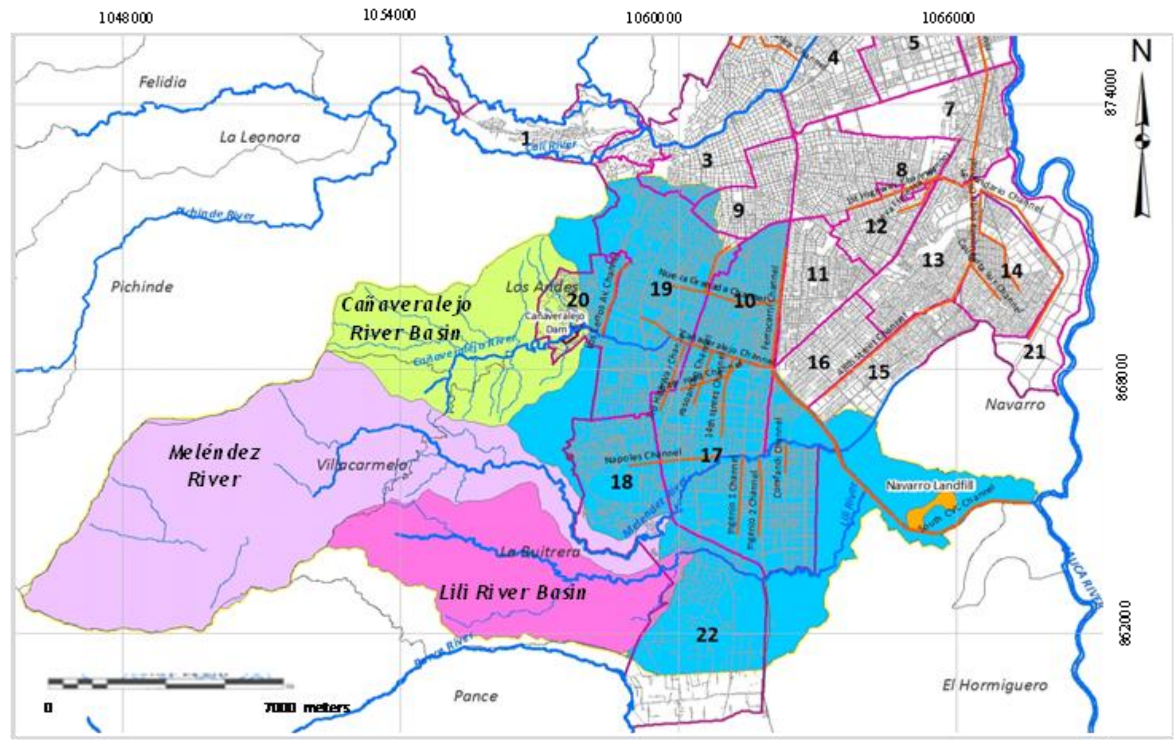


Figure 4.1 Map of the South Drainage System with influence area

The SDS was chosen as one of three priority areas by the SWITCH Learning Alliance, as it has a complex situation regarding urban water management, additionally it is one of the main contributors to the operation problems in the downstream Potable Water Plant - Puerto Mallarino, due to the high levels of turbidity and contaminants in the effluent to Cauca River.

The main problems identified in the South Drainage System (EMCALI *et al.*, 2007; Univalle, 2008) have been presented in chapter 3:

- Wastewater discharges from illegal and erroneous connection, or from informal settlements
- Wastewater discharges from informal industries
- Solid waste in stormwater system

- Untreated leachate discharges from Navarro
- First flush with solids and toxic substances
- Hydraulic deficiencies due to combined river and stormwater systems
- Flooding of streets

In addition to the above mentioned problems it is important to emphasize that the Lili, Meléndez and Cañaveralejo rivers are partly deteriorated as they enter the urban perimeter, which is caused by human activities such as deforestation, agricultural and mining activities and human settlements.

4.1.2 Conventional approach in the SDS

The conventional solutions in the South Drainage Area are in general directed towards end-of-pipe solutions, i.e. solving the problem at the end of the problem chain, instead of working to prevent the problem from occurring in the first place. An example of a conventional solution in the SDS is the implementation of in-stream sand traps for the retention of sedimentation. Another strategy applied within the urban and peri-urban area is trying to conduct all generated wastewater in the city to a single centralized wastewater treatment plant, in this case the WWTP-C. As a result, new wastewater collectors are being built in the margins of the Cañaveralejo, Meléndez and Lili rivers, as a measure to take care of wastewater from settlements that have been discharging directly to rivers and stormwater channels.

The strategies implemented to improve the drainage system within the urban area are seeking to optimize the system by removing erroneous connections, improving combine sewer overflows (CSO), increasing drainage capacity among others. This type of infrastructure development is receiving the main part of the budget, while preventive actions in general have low prioritization

4.1.3 Solutions with SWITCH approach

In the former phase of the SWITCH project in Cali, alternative approaches for the decontamination of the water resources were developed in a conceptual manner in the South Drainage System. In this present phase, the Cañaveralejo water basin was selected as a case study, for the application and feasibility analysis of SWITCH solutions. The following themes were studied within the river basin:

- Strategies for the rural area
- Strategies for informal settlements
- Centralized vs. decentralized sanitation in peri-urban areas
- Urban river restoration
- Sustainable Urban Drainage Systems (SUDS) in the consolidated urban area

In addition of the themes above, the management of leachate from the Navarro landfill is another theme that has been studied further in this present study.

In the following section the different themes are briefly described, including a short description of the problem, the conventional solution, the solution with SWITCH approach, and the result of the comparison, in the case where it applies.

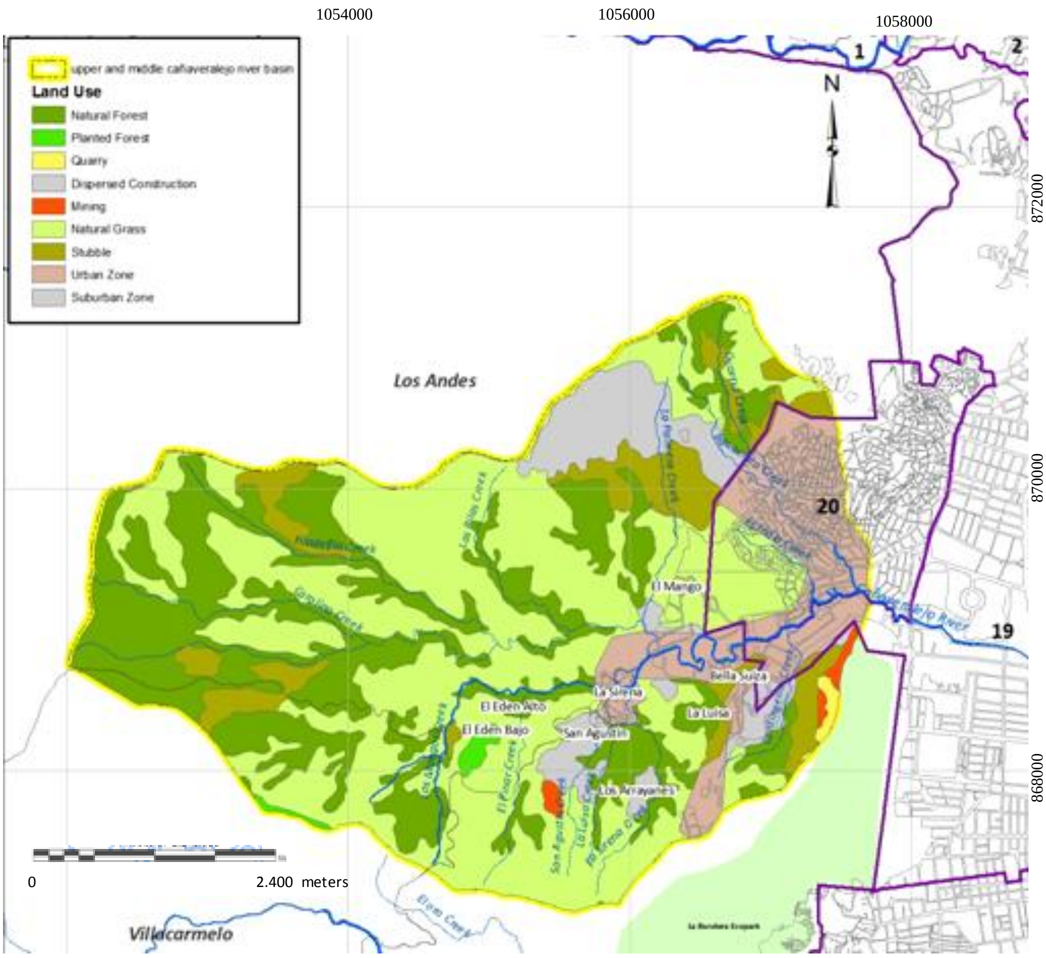
<table>
<tr><td colspan="2">STRATEGIES FOR THE RURAL AREA</td></tr>
<tr><td>Problem description:</td><td>Point and no-point pollutions is generated from human activities, including deforestation, agriculture, mining, and human settlements, generating water pollution with wastewater, agrochemicals, solids, etc. and changes in the hydraulics of the river system.</td></tr>
<tr><td colspan="2">

Figure 4.2 Land use map of the Cañaveralejo River basin</td></tr>
<tr><td>Conventional or actual solution</td><td>• The domestic wastewater is managed with infiltration pits without treatment. The regional environmental authority (CVC) requires the installation of treatment for new housing development.
• The agricultural activities are applying high amounts of agro-chemical. The CVC is promoting a green market program promoting organic cultivations. To protect the streams and reduce the impact of erosion due to cattle grazing the CVC is implementing a project for reforestation and generation of income from forestry, although the budget for the project is very limited.
• The mining authority - INGEOMINAS and the CVC are coordinating actions to close and seal illegal mines in the basin; however new mines are opened simultaneously.</td></tr>
<tr><td>SWITCH approach:</td><td>The strategic lines developed for the rural area are based on the activities being implemented by the authorities working in the area. However, with the aim of complementing and enhance the potential and the long-term sustainability of these activities the following items are considered important to aggregate:
✓ Water and sanitation: Water balance analysis to establish ecological capacity and potential supply capacity. Water and sanitation diagnosis of human settlements. Include alternative W&S alternatives and promote the reuse of wastewater.
✓ Agriculture and forestry: Strengthen the reforestation, organic agriculture and river conservation projects, with the search of new financial opportunities like the new CONPES 3624 (Recuperation of upper Cauca river basin) and the formulation of new projects with a broad inter-institutional cooperation, taking advantage of the shared interest of recuperate the Cañaveralejo River.
✓ Mining activities: Include environmental evaluation for all new mining activities. Integrate mining closure projects with environmental protection plans to ensure follow up and control. Social programs to create new income generating activities as alternatives for the mining activity.</td></tr>
</table>

STRATEGIES FOR INFORMAL SETTLEMENTS	
Problem description:	Informal settlements or settlements with incomplete development, where the users have no legal permits for the housing, are outside the jurisdiction of the majority of institutions. Consequently, no investments regarding water and sanitation supplies can be made, which results in lack of public services and discharge of untreated wastewater and solid waste to water bodies. The Cañaveralejo river basin which is partly situated within a deferred regime area "potential expansion zone", the situation is more complex since these areas are not properly regulated. i.e. it is not rural nor urban, and can therefore not be approved as new settlement as long as this planning status remains. According to a study made in 2010 by the Social Housing Secretariat – Special Housing Fund and the government of the city of Cali, there are 14,024 households in incomplete development settlements, out of which 919 are in rural areas and 13,105 are in urban areas. Particularly in the Cañaveralejo River Basin there are several informal settlements that do not have basic water and sanitation infrastructures; some located near La Sirena, in La Buitrera, called La Sirena- El Edén Upper Section, La Sirena – El Edén Lower Sector, San Agustín, Los Arrayanes, and Bella Suiza, among others, see Figure 4.3.

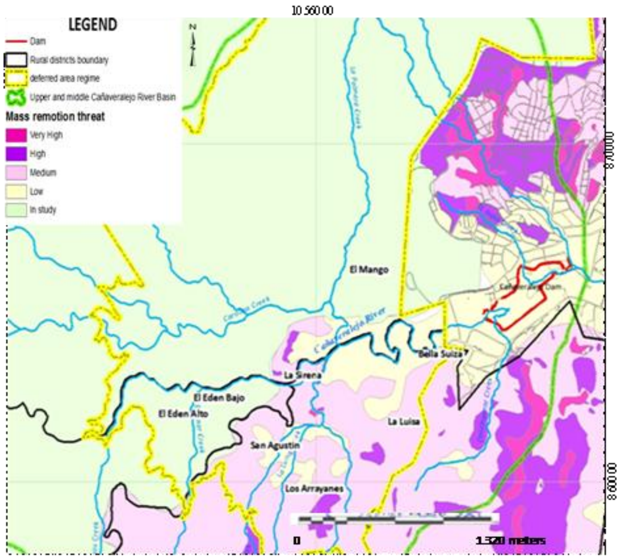


Figure 4.3 Location of the Incomplete Development Settlements of the Cañaveralejo River Basin

Conventional or actual solution	In general, very few actions are being taken to improve the situation, which partly depends on the situation explained in the problem description, but also due to lack of resources to implement actions.
SWITCH solution:	The following strategies are proposed to approach the problems related to informal settlements (see Figure 4.4): - Appropriation of land - Consolidation of Settlements - Re-composition of Settlement - Relocation of Settlements - Environmental Education

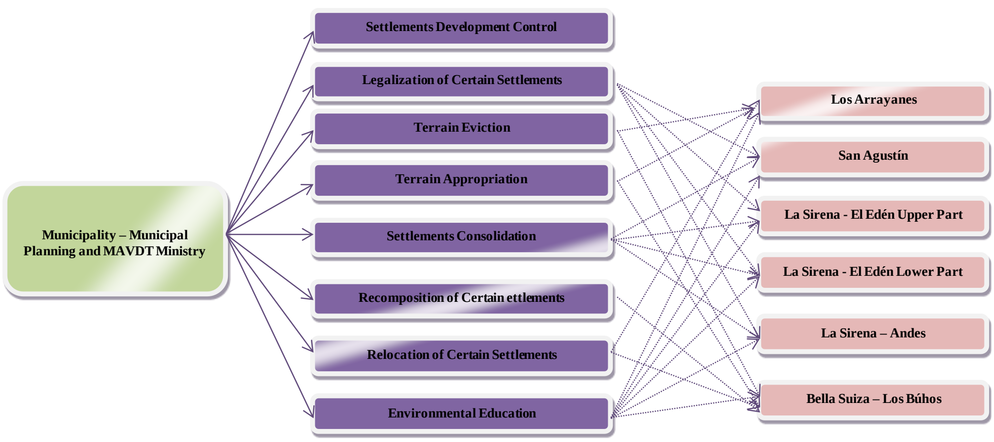


Figure 4.4 Proposed Application of Strategies in Incomplete Development Settlements located in the Cañaveralejo River Basin

<table>
<tr><td colspan="2">CENTRALIZED VS. DECENTRALIZED SANITATION IN PERI-URBAN AREAS</td></tr>
<tr><td>Problem description:</td><td>Cañaveralejo river is the most affected stream of the city, before entering into the urban perimeter, Cañaveralejo River is already deteriorated with diverse contaminants and concentrated domestic wastewater discharges from the rural districts such as La Sirena, El Mango and other surrounding sectors deteriorate the river before coming to Cali urban zone, see Figure 4.5 and Figure 4.6</td></tr>
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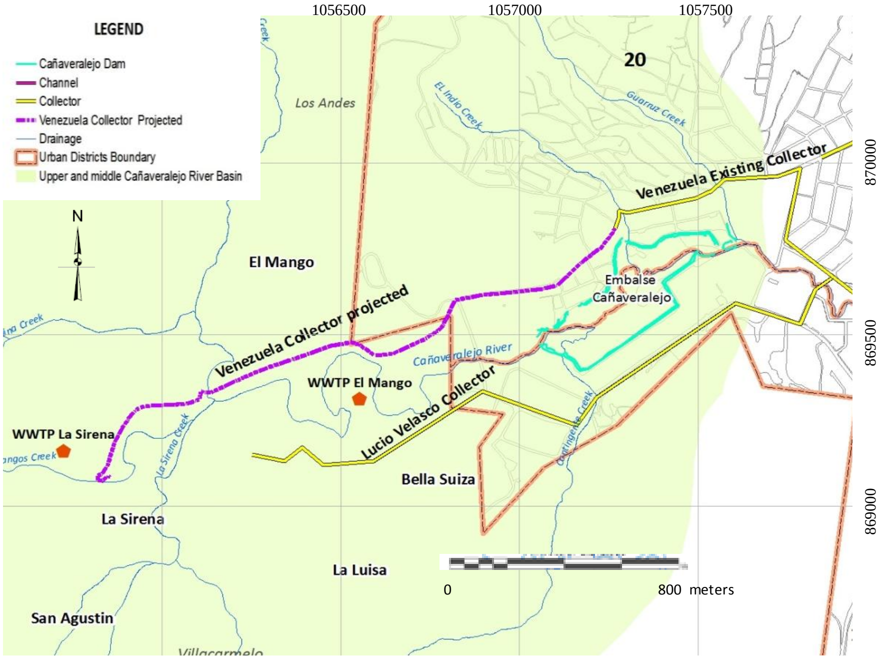


Figure 4.5 Location of Venezuela collector existing and projected (conventional alternative) and decentralized plants of wastewater treatment in La Sirena and El Mango (SWITCH alternative)</td></tr>
<tr><td colspan="2">CENTRALIZED VS. DECENTRALIZED SANITATION IN PERI-URBAN AREAS (cont.)</td></tr>
<tr><td colspan="2">

Figure 4.6 Aereal view of the La Sirena Sector</td></tr>
<tr><td>Conventional or actual solution</td><td>The extension of Venezuela collector is one of the works required for the decontamination of river systems in Cali, according to PSMV 2007 – 2016. Venezuela collector extension will allow that communities like La Sirena, El Mango, surrounding sectors, and a small portion of Siloe district connect to this collector.

Presently, entities such as EMCALI, SSPM and DAGMA are very interested in the recuperation of Cañaveralejo River and currently have carried out a strategic alliance to collect economic resources to execute the Venezuela collector expansion project.</td></tr>
<tr><td>Decentralized Wastewater Treatment Plants:</td><td>The Municipal Public Health Secretariat (SSPM), as the entity is in charge of guaranteeing water and sanitation in rural communities of the city of Santiago de Cali, has the faculty of hiring engineering firms or independent consultants to design water and sanitation options for the communities. SSPM, in the case of La Sirena and El Mango, proposed the design of decentralized plants consisting of the septic tank, anaerobic filter, phytopedologic filter and drying beds.</td></tr>
</table>

CENTRALIZED VS. DECENTRALIZED SANITATION IN PERI-URBAN AREAS (cont.)	
SWITCH solution:	Considering the alternatives that may be developed within the SWITCH Project context, a non-conventional solution for the treatment of waste water in rural areas such as El Mango and La Sirena are proposed. This solution consist of the construction of decentralized treatment plants in the two sectors and the treatment configuration is based according to the proposal made by consulting firms previously hired by SSPM. In addition to the decentralized plants in each of the locations, the innovative proposal with a SWITCH approach, includes the application of prevention and minimization strategies for the control of contamination by the households in both areas.
Comparative analysis	The net present value of initial inversion pland the operation and maintenance costs corresponding to 30 years was calculated. The values were obtained only for conventional solution and decentralized alternative due to the SWITCH approach requires new estimation of costs, which is still to be elaborated. The cost comparison can be seen in Figure 4.7

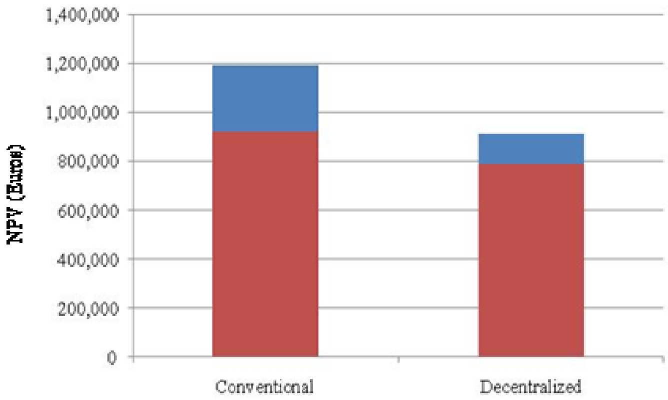


Figure 4.7 Comparison Total costs Between Conventional and Decentralized Alternative (including construction and net present value of O&M)

	The costs of conventional alternative and its operation and maintenance costs are higher than using the alternative of decentralized plants considering a 30 year period. The operation and maintenance for the conventional alternative was obtained taking into account that 28% of the wastewater tariff is designated to operation and maintenance of the wastewater system.

URBAN RIVER RESTORATION	
Problem description:	The Cañaveralejo river is turned into a concrete-lined channel in the urban areas and consequently loses all its natural characteristics, which affects both the aquatic ecosystems and other environmental service that are generated in a river system Figure 4.8

Figure 4.8 Map of the study area with the selected river stretch

URBAN RIVER RESTORATION (cont.)	
Conventional or actual solution	The actual proposals only consider ecological improvements in the area along the river channel, mechanical restoration of channel depth in river stretch without concrete-lining, and removal of sediments in channel system.
SWITCH solution:	Restore "natural" river characteristics by removing the concrete lining and creating a wider river bed with a soil in the bottom. Construct river walls by reused cement blocks and introduce rocks and plants within the river and create a meandering within the river channel, see Figure 4.9

Figure 4.9 Proposed cross section for the Cañaveralejo River-Channel in street "Carrera 50"

Potentials:	River restoration in urban areas is great challenge as it competes with diverse land uses in densely built areas. However, the in-channel actions for restoration that are proposed in the case of Cañaveralejo River are considered feasible, both economically and technically. The proposal generate benefits as it re-establish important river features, including auto purification and also a resistance towards flushing. However it is important to state that a modulation and adjustments in design and estimated budget is still to be conducted, hence these statements are based on preliminary result.

STORMWATER MANAGEMENT - SUDS	
Problem description:	A great part of the wastewater network of Cali is managed with combined sewerage, which means that the system overflow in rain events to the stormwater system, through separation structures, which contribute to a discharge of wastewater to the South Drainage System. Additionally, the major channel system of Cañaveralejo River basin suffers from flooding in heavy rain events (≥ 10 years return period).
Conventional or actual solution	The solutions implemented and projected by the municipal potable water and wastewater company, EMCALI, in the urban area are focused on improving combine sewer overflows (CSO), drainage capacity, recuperate the buffer capacity of the Cañaveralejo dam, among others.
SWITCH solution:	The alternative proposed with SWITCH approach is the Sustainable Urban Drainage Systems (SUDS), which aim to retain and reduce the stormwater flows that discharge in the drainage system and also to remove contamination generated in the runoff. The results of the application are preliminary, and phase of modulation and evaluation of benefits is still to be conducted. The two SUDS technologies that have been studied at present are infiltration basins and pervious pavement.

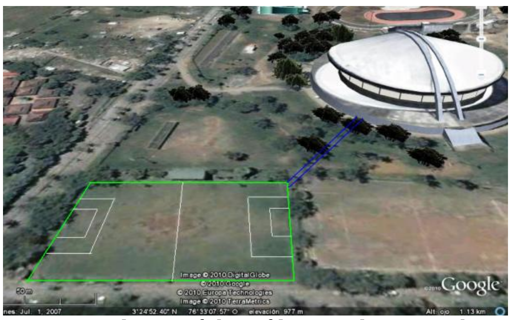


Figure 4.10 Pre-design of the infiltration deposit in the sports complex

Figure 4.11Construction of infiltration basin

Potentials:	The preliminary results show a very high potential for the infiltration basin and the pervious pavement. In the case of the infiltration basin a 30 cm depression of an existing football court is enough to retain a 10 year rain from the rough of the coliseum of the people, and in this manner avoid that this volume (937m^3) is directly discharged to the drainage system. The installation of pervious pavement in a car park also generates the potential to infiltrate all water precipitated over the same area, instead of generating a runoff of 3165 m^3. Another important advantage of the pervious pavement is the investment cost and durability; the cost is 20% less than for the replacement of asphalt, while the durability is 30 years instead of 10-20 years for asphalt.

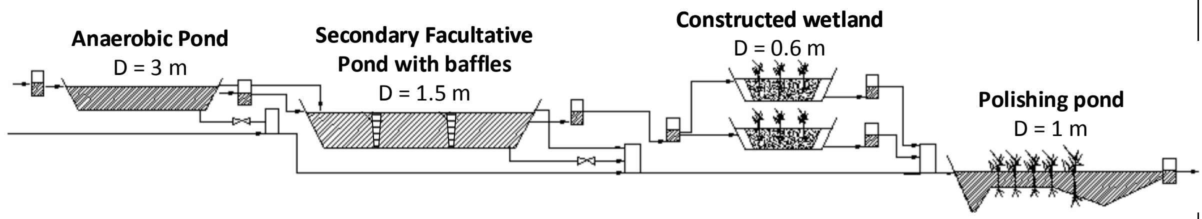
<table>
<tr><th colspan="2">LEACHATE MANAGEMENT IN THE NAVARRO LANDFILL</th></tr>
<tr><td>Problem description:</td><td>Navarro, the principal municipal dumpsite located in Cali was closed in 2008. The landfill was never considered a proper landfill by the environmental authorities, since the majority of its extension lacked protection measures for the handling of generated gases and leachate, which has generated a precarious environmental situation in the surroundings with contaminated discharges to water bodies and emissions of gases. Today, Navarro has been sealed with an impervious layer and is revegetated; however, the management of the produced leachate has still not been solved.</td></tr>
<tr><td>Conventional or actual solution</td><td>At the moment a proposal for leachate treatment has been elaborated and is under evaluation by the CVC before its approval. At the moment, no exact details of this proposal have been shared with the SWITCH Project; however, according to EMSIRVA (in liquidation) an alternative under consideration is conventional treatment methods, such as reverse osmosis. Consequently, the conventional alternative has been constructed without certainty about the options considered by the authorities of Cali.</td></tr>
<tr><td>SWITCH solution:</td><td>The SWITCH alternative was selected through a thorough decision support system, including a multi criteria analyses. Based on the result and the SWITCH approach natural treatment methods where selected, consisting of: anaerobic pond, secondary facultative pond, constructed wetland and polishing pond</td></tr>
<tr><td colspan="2">

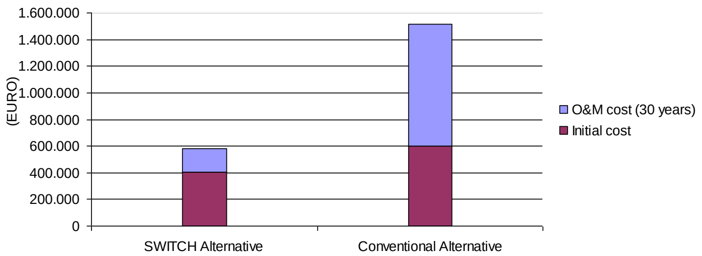
Figure 4.12 Selected leachate treatment scheme.</td></tr>
<tr><td>Comparative analysis</td><td>An analysis of benefits was performed, which among other showed that the to alternatives will achieve similar treatment efficiencies regarding parameters such as BOD, COD, TSS and metals, while the natural treatment generate more technical, social and environmental benefits. The cost analysis showed a clear advantage both regarding initial investments and O&M on a net present value basis considering a 30 years lifespan (see Figure 4.13)


Figure 4.13 Total costs including construction and net present value of O&M</td></tr>
</table>

4.1.4 Concluding remarks

Three different geographic areas can be distinguished in the South Drainage System in relation to the management of negative impacts on the water resources: the middle and upper parts of the Lili-Meléndez-Cañaveralejo river basins with a deficient basin management; the consolidated urban area with contaminated discharges from residential areas, industries and also from inadequate solid waste management; and finally, downstream the urban area - where the Navarro landfill generates contaminated leachate.

Considering these geographical areas, their specific characteristics and impacts on the water resources, within the SWITCH project -although focused on the urban water management- alternatives have been developed not only for the South Drainage System but also for the area of influence. In the middle and upper areas the alternatives are aiming to improve forest and soil management, implement sustainable practices in mining and agricultural activities, or encounter alternative income generating activities to be able to close illegal mining, and promote more sustainable water and sanitation

solutions in the rural communities. In the consolidated area the alternatives are focused on the improvement and installation of complementing infrastructure to improve the natural characteristics of the rivers and to reduce high flow peaks and contaminated discharges to the stormwater systems through. And finally in the area downstream the urban zone the indispensable management of the leachate produced in the Navarro Landfill. The result of the different themes are still preliminary, consequently it is too soon to draw conclusions on the magnitude of impacts and benefits from the implementation of the different strategies on a larger scale in the South Drainage System.

4.2 STUDY CASE SOUTH EXPANSION AREA

4.2.1 Conventional solution

Urban development in the expansion area is viable provided that there is availability of public water supply and basic sanitation services. The conventional proposal in this theme consider conventional water supply (drinking water for all uses) from the Puerto Mallarino Plant, drinking water plant whose source is Cauca River. As far as sanitation is concerned, there is proposal for a separate sewerage system where wastewater is pumped to the Cañaveralejo Wastewater Treatment Plant (WWTP) and rainwater is discharged into the water resources in the area. Figure 4.14 shows the location of the study area and water and sanitation infrastructure in existing and proposed.

In the framework the SWITCH project, were considered alternatives for the pollution control with the implementation the minimization and prevention strategic for the residential sector and decentralized treatment with natural system for reuse in irrigation.

The alternatives the minimization and prevention were designed on three major fronts: low consumption devices, use of rainwater, and use of grey water. Alternate sources were associated with the different uses of water in the household. The formulation of strategies was based on a combination of possibilities of incorporating various low consumption devices (available in the Colombian market) together with the use of potential supply sources, considerer. Taking into account that both single-family and multiple-family housing units will be built in this area, two different types of combinations will be proposed which are related with the possibilities for using water at each kind of housing unit.

For the selection of the alternative, the method used was based on AHP and GRA proposed by Zeng et al, (2007a) .The criteria considered were economic, technical, social and environmental criterion. Also was identified the relative weight of the indicators assigned by the decision-making center. The weights for each criterion are: environmental 32%, economic 19%, technical 24% and social 25%.

The indicator used were capital and O&M cost, level of complexity, institutional support, acceptance social, removal efficiency load BOD & load TSS and decrease water demand. The indicators as costs and levels of removed load BOD and TSS were calculated for each alternative. The social acceptance the alternative sources in each use, were identified throw survey. The institutional support was realized with consulted and participation of learning alliance members and other officers the institutions of water management in Cali.

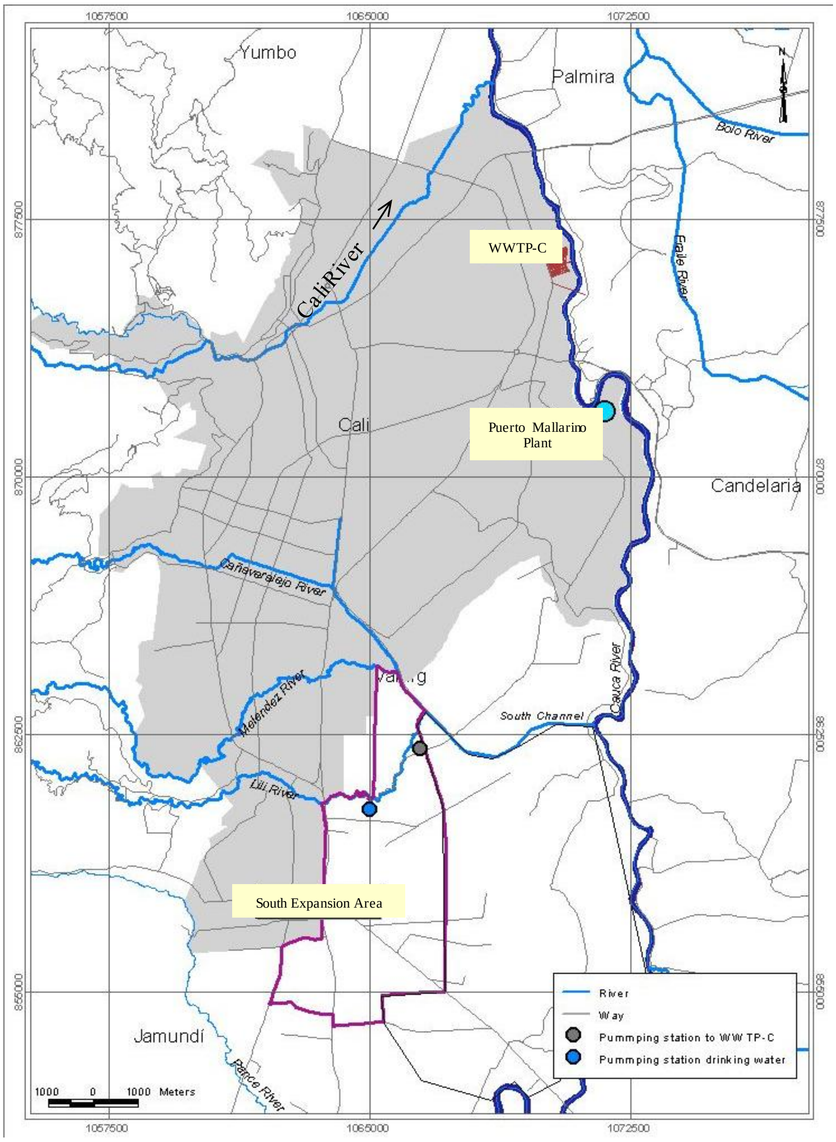


Figure 4.14 Location of study area and infrastructure of conventional proposal for water management in the expansion area

Preference excreta disposal devices, was identified through a social consultation. The most widely accepted is the highest efficiency equipment in water consumption (WC 2.3 L and toilet dual flush). Based on combinations of water uses and the incorporation of gray water and rain harvesting are ten options for the area (see Table 4.1).

Table 4.1 Alternatives to minimization and prevention in expansion area

STRATEGY	DEVICE EXCRETA DISPOSAL	HOUSING OPTION	APARTMENTS OPTION
		▪ Drinking water in kitchen, basin and shower	▪ Drinking water in kitchen, basin, shower and laundry
a	WC dual flush	Drinking water for all uses	
b		▪ Grey water in toilet flush & garden irrigation ▪ Drinking water in laundry	▪ Grey water in toilet flush & garden irrigation ▪ Grey water + rain harvesting in cleaning commune areas
c		▪ Grey water in toilet flush & garden irrigation ▪ Rain harvesting in laundry	
d		▪ Drinking water in toilet flush and laundry ▪ Rain harvesting in garden irrigation	▪ Drinking water in toilet flush ▪ Rain harvesting in garden irrigation and cleaning commune areas
e		▪ Drinking water in toilet flush ▪ Drinking water-rain harvesting in laundry ▪ Rain harvesting in garden irrigation	

Table 4.2 Alternatives to minimization and prevention in expansion area (cont.)

STRATEGY	DEVICE EXCRETA DISPOSAL	HOUSING OPTION	APARTMENTS OPTION
		▪ Drinking water in kitchen, basin and shower	▪ Drinking water in kitchen, basin, shower and laundry
f		Drinking water for all uses	
g	WC 2.3 L	▪ Grey water in toilet flush & garden irrigation ▪ Drinking water in laundry	▪ Grey water in toilet flush & garden irrigation ▪ Grey water + rain harvesting in cleaning commune areas
h		▪ Grey water in toilet flush & garden irrigation ▪ Rain harvesting in laundry	
i		▪ Drinking water in toilet flush and laundry ▪ Rain harvesting in garden irrigation	▪ Drinking water in toilet flush ▪ Rain harvesting in garden irrigation and cleaning commune areas
j		▪ Drinking water in toilet flush ▪ Drinking water-rain harvesting in laundry ▪ Rain harvesting in garden irrigation	

The eligibility order of options is presented in Figure 4.15. The most viable option is strategy h, which involves installing a 2.3 L WC, using grey water for evacuating excreta and irrigating gardens, and using rainwater for washing clothes and cleaning common areas.

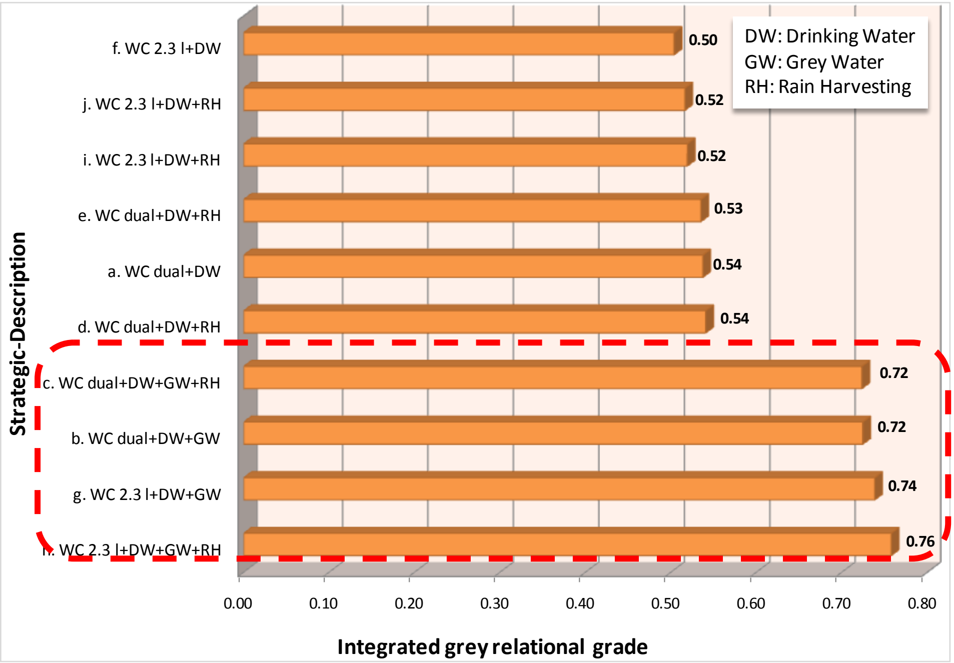


Figure 4.15 The integrated grey relational grade for each optional scheme to minimization and prevention

Figure 1 shows that there is no significant different between the strategy with the highest score (h) and other strategies such as g, b, and c which are highlighted with a dotted line. These alternatives share something in common which is the use of grey water. The use of this water source has not only a remarkable impact on the reduction of environmental indicators which, in the selection model, constitute a major weight criterion, but also a high rate of social acceptance. Rainwater harvesting is another strategy that improves environmental conditions. It is listed among the alternatives of strategies h and c.

For decentralized treatment with natural system, and water re-use, the set of technology options ware characterized based on the reuse of water for agriculture purposes (irrigation of sugar cane fields), it consists of the six following options:

- T1 Primary facultative pond+ Maturation pond
- T2 Anaerobic pond+ Secondary facultative pond+ Maturation pond
- T3 Anaerobic pond+ Secondary facultative pond with baffles+ Rock filter
- T4 High rate Anaerobic pond+ Secondary facultative pond with baffles+ Rock filter
- T5 Anaerobic pond+sub surface Constructed wetland+ Maturation pond
- T6 High rate Anaerobic pond+Sub surface constructed wetland+ Maturation pond

The process of selection was realized with the AHP-GRA, considering the technical criteria, environmental, economic and sociocultural, in consultation with local experts.

The results of this survey yielded the following rates of relative relevance: environmental criteria (43.4%), followed by sociocultural (29.5%), technical (21.2%), and economic criteria (5.9%).

In selection process also characterize the six different wastewater treatment options as a function of the proposed indicators. The technology selected consisting of a high rate anaerobic pond, a facultative pond, and a rock filter as shown in Figure 4.16.

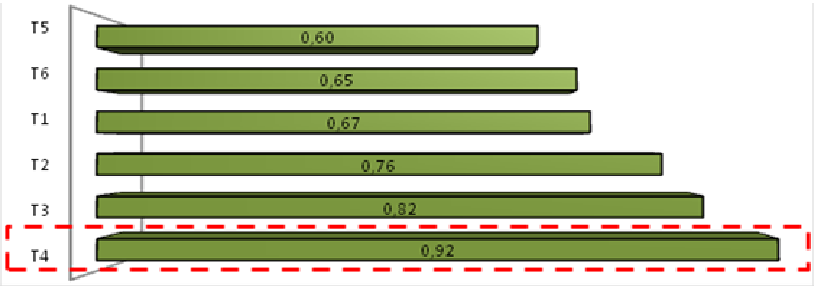


Figure 4.16 The integrated grey relational grade for each optional scheme to WWTP

After selecting the technology of wastewater treatment, agricultural plan was developed, consisting of crop selection, irrigation times and other productive activities in order. For area expansion under the water balance estimates (Sokolov and Chapman, 1981) the period of irrigation will be held in July and August, which will reuse 100% of effluent for irrigation of sugarcane (336 L/s) in 997 ha. In wet months, the wastewater will discharge to Cauca River

4.2.2 Cost-benefit analysis

The implementation of minimization and prevention strategies and the decentralized treatment using natural methods for agricultural re-use were financially evaluated, considering that the cost-benefit estimate of the profile was made.

In summary, the conventional solution consists in conventional water management in households, and pumping waste water to WWTP-C complemented with activated sludge, as secondary treatment, and effluent discharge on Cauca River.

The solution with SWITCH approach consists in the application of pollution prevention and minimisation in 70% expansion area households (Table 4.3), and treatment decentralised (2 WWTP) with natural system (conformed by high rate anaerobic pond+ secondary facultative pond + rock filter) and reuse of 100 % effluent in driest months (July-August) in sugar cane irrigation.

Table 4.3 Characteristics of alternative minimization and prevention in expansion area

DEVICE EXCRETA DISPOSAL	HOUSE OPTION*	APARTMENTS OPTION**
WC 2.3 L	▪ Grey water in toilet flush & garden irrigation ▪ Rain harvesting in laundry	▪ Grey water in toilet flush & garden irrigation ▪ Grey water + rain harvesting in cleaning commune areas

* Drinking water in kitchen, basin and shower
** Drinking water in kitchen, basin, shower and laundry

The location of infrastructure (pumping stations and treatment plants) of the conventional option and the solution with SWITCH approach is presented in Figure 4.17, as well as irrigated areas identified for the reuse of wastewater.

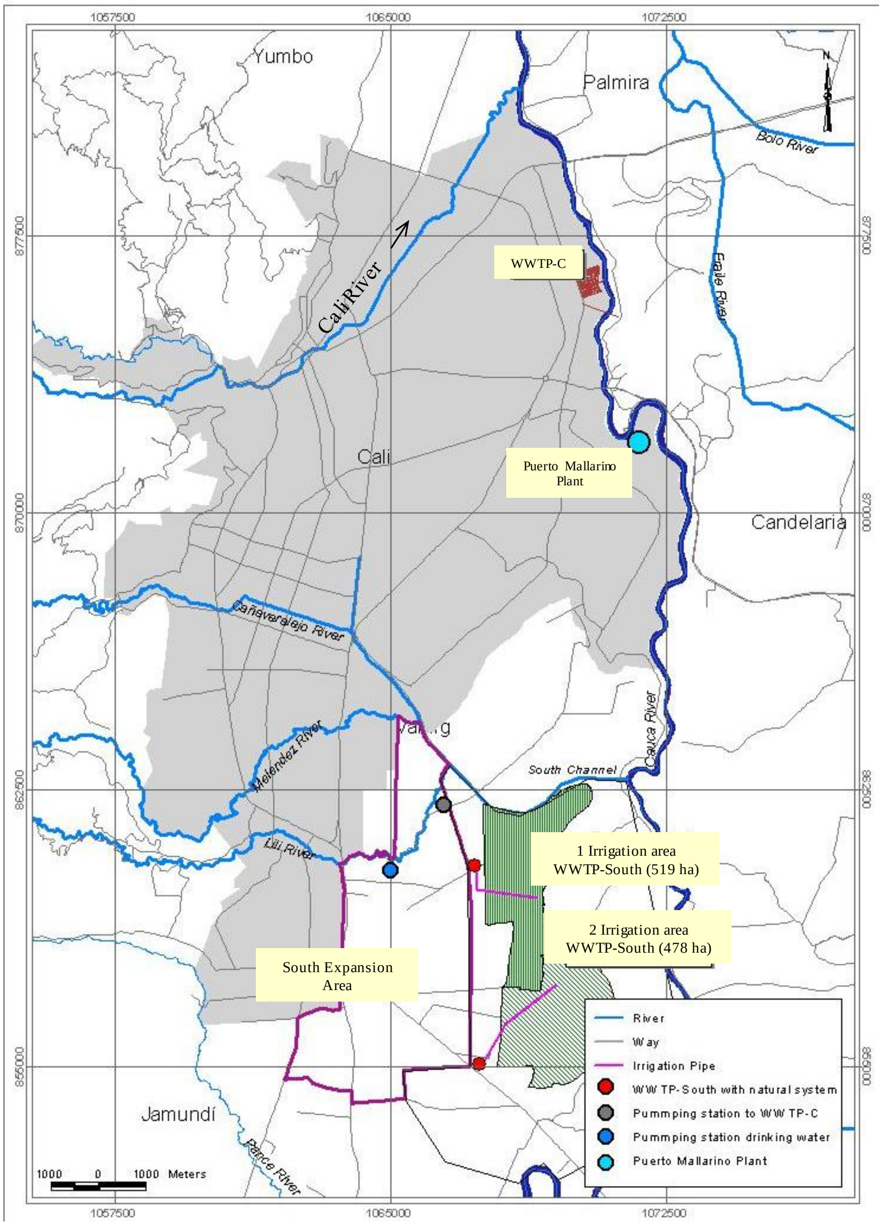


Figure 4.17 Location of water and sanitation infrastructure in the conventional proposal and the alternative with SWITCH approach in the expansion area

The main characteristic of the conventional solution and solution with SWITCH approach are shows in Table 4.4.

Table 4.4 Characteristics of alternatives proposed for expansion area

PARAMETER		UNITS	CONVENTIONAL	SWITCH APPROACH
Drinking water demand		L/s	1067	714
Wastewater production		L/s	854	336
BOD load discharged to Cauca river	Driest months	kg/day	3729	0
	Wet months*	kg/day	3827	1516
TSS load discharged to Cauca river	Driest months	kg/day	2421	0
	Wet months*	kg/day	7213	2934

*Includes load rain harvesting

In each of the options identified costs associated with its implementation. We also identified the benefits of which are listed below:

- B1 Water and sanitation tariff saving
- B2 Acquisition of carbon credits by reduction of greenhouse gases emission
- B3 Avoided cost by use of less amount of fertilizer
- B4 Reduction in payment by use tax of groundwater
- B5 Avoided cost in infrastructure for uptake groundwater
- B6 Saving cost by O&M of groundwater wells
- B7 Saving cost in payment by discharge BOD and TSS
- B8 Saving cost in infrastructure drinking water and sanitation

Table 4.5 shows the summary of the financial evaluation made. The data of costs and benefits analysis are distributed through 30 years, the cash flow is shown in Figure 4.18. Implementing the solution with SWITCH approach is economically feasible because benefits are obtained are more than the costs, representing savings by € 23.601.836. The cost/benefit ratio is 1.70, demonstrating the financial profitability of the proposal.

Table 4.5 Indicators of the economic feasibility of the implementation of a solution with a SWITCH approach in the expansion area

NPV Costs	33.667.946
NPV Benefits	57.269.782
NPV Benefit-NPV costs	23.601.836
NPV Benefit/NPV costs	1.70

Benefits are a result of different variables, being the distribution of investment in external infrastructure, the most relevant. This is a fluctuating variable throughout time, associated to investment planning. Likewise, these benefits are affected by investments saved in groundwater infrastructure, which is considered every four years. A benefit showing constant increase are the savings caused by tariffs, which show growth between year 2 and 21. After that year, savings become constant because the area has reached the maximum possible population. A benefit generating low impact are the carbon credits because the low emission factors estimated are a result of general studies that not necessarily reflect the local situation and the carbon credits purchase does not have a significant impact in the benefit's price.

Considering both the costs and benefits, during the first year the benefits are 78% above the costs required for the implementation of a solution with a SWITCH approach, which are associated with the optimization of the water supply, sewage and treatment systems. The incorporation of minimization and prevention strategies decreases the amount of work and installation costs.

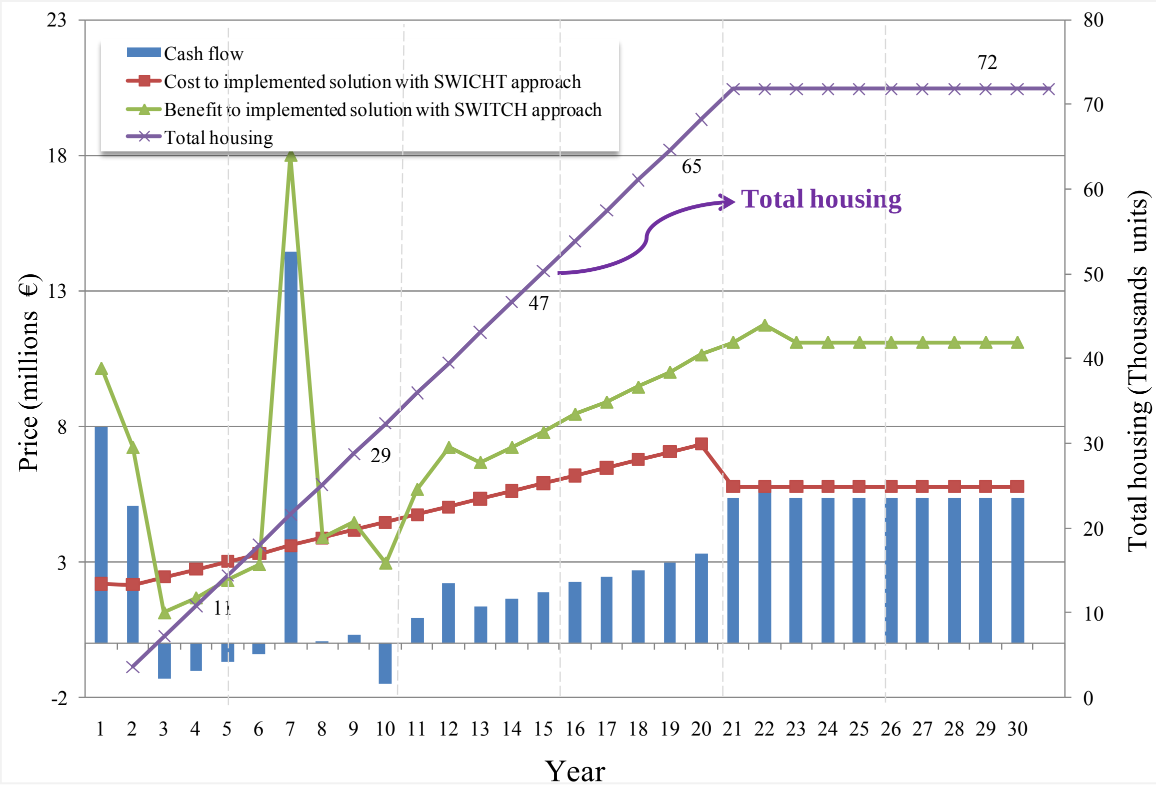


Figure 4.18 Costs, benefits and net cash flow to implementing the solution with SWITCH aproach in the expansion zone

On the other side, the management of lower waste water volumes in a decentralized manner demand smaller sewage and WWTP systems. Added to this, the usage of natural methods generates lower conventional water supply costs and the pumping and treatment of waste water towards the WWTP-C, complemented with activated sludge.

An increase in benefits is shown in year 7, due to savings in water supply and sanitation infrastructure, and explicitly, because during that year the conventional option includes the initial investment made for the implementation of secondary treatment with activated sludge in the PTAR-C, which is a technology with a considerable cost equal to €14.663.724.

After year 23, a constant net flow is shown because the costs of a solution with a SWITCH approach do not represent an initial investment, but are related to O&M costs and the benefits become permanent as a result of water and sanitation tariff savings and savings in fertilizers and economic instruments by the use of waste water for the irrigation of sugar cane crops.
The profile evaluation shows the financial feasibility of considering the minimization and prevention strategies, decentralized treatment with natural system, and water re-use in the expansion area. The implementation of these concepts is feasible in new urban areas due to the great impact in initial investments for hydro-sanitation infrastructure, and in the case of agricultural re-use, infrastructure investment.

It is important to consider that the implementation of a solution with SWITCH approach can represent greater feasibility once the socio-economic analysis is made.

4.3 STUDY CASE WWTP-C DRAINAGE AREA

4.3.1 Conventional solution

The conventional solution for WWTP-C drainage area has an "end-of-pipe" approach, where all the investments are addressed to improving the wastewater treatment plant Cañaveralejo. In this solution is considered a secondary treatment with activated sludge in contact stabilization modality, whose effluent will be discharged into Cauca River. The components of conventional solution are shows in Figure 4.19.

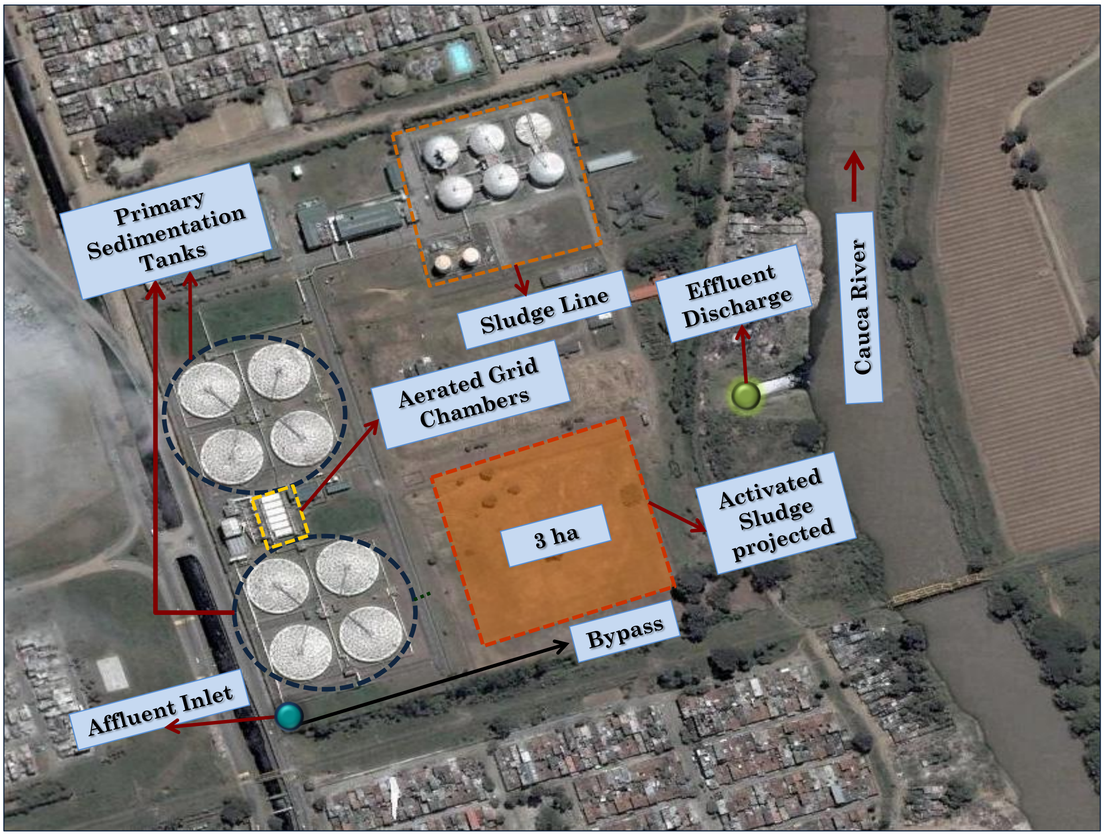


Figure 4.19 Components of conventional solution for WWTP-C drainage area

4.3.2 SWITCH Approach

The solution with SWITCH approach has two main components: a strategy of pollution prevention and minimization, and a secondary treatment with reuse of effluent in agricultural irrigation. The strategy for pollution prevention and minimization was focused for Cali households. Initially, the strategy included the implementation of low consumption devices, specifically flushing toilets with less water consumption, rainwater harvesting systems with treatment, and for last, a greywater reuse system with treatment. Due that the amount of alternatives was very high, a first filtration for reduce alternatives was applied. This first filtration is based in three indicators: market availability, effluent quality requirements, and social acceptation of low consumption devices. The market availability refers to technologies that can be purchase easily in colombian market. The effluent quality requirement depends of uses possible in household. Although the uses proposed (garden irrigation, flushing the toilet, house cleaning, and for wash clothes) do not need effluent of rainwater harvesting and

greywater reuse with high quality, is necessary that comply a minimum quality for domestic use.

The social acceptation of low consumption devices was measured through a survey. Additionally, the purchase intention also was identified to 3 payment options: direct payment, pay by installments or subsidy payment. With application of these three indicators, nine technologies were pre-selected for study. The selection of alternative for pollution prevention was based on the methodology of analytic hierarchy process (AHP) and grey relational analysis (GRA) (Zeng *et al.*, 2007b) for these nine alternatives pre-selected. According with selection process, the alternative for pollution prevention and minimization chosen was high efficiency toilets (flushing toilet of 2.3 L) with a rainwater harvesting system including filtration (see Figure 4.20). Although two alternatives obtained the same scores, the option with filtration was selected because the quality effluent is better.

Figure 4.20 Pollution prevention alternatives ranked for WWTP-C drainage zone

The implementation of pollution prevention and minimisation strategy is proposed for 30% of Cali city households. The zones of Cali city selected for implement the pollution prevention alternative are areas supplied by drinking water plants of La Reforma, Río Cali and Puerto Mallarino. The main objective of location the intervention in this area responds to the impact of river water extraction by drinking water plants, especially in Melendez and Cali rivers. The number of users (near to 618000 Cali citizens) and amount of water saved by area is shows in Table 4.6

Table 4.6 Distribution of the pollution prevention alternative in Cali city

DRINKING WATER PLANT	USERS	WATER CONSUMPTION (m^3/MONTH)	DRINKING WATER SAVED		% APPLICATION BY INCOME LEVEL		
			m^3/month	m^3/s	1-2	3-4	5-6
Cali River	82.400	824000	824000	0,32	5%	5%	10%
La Reforma	20.600	206000	206000	0,08		5%	
Puerto Mallarino	20.600	206000	206000	0,08		5%	
Total	123.600	1236000	1236000	0,48	30%		

The second component of solution with SWITCH approach is the secondary treatment with reuse of effluent in sugar cane irrigation. Three options are proposed for secondary treatment: activated sludge in the contact stabilization modality, facultative ponds, and horizontal sub-surface constructed wetland. These technologies are combined with reuse of WWTP-C effluent in sugar cane irrigation. The wastewater technology selection process with reuse was carried-out with the AHP-GRA, considering the technical criteria, environmental, economic and socio-cultural, in consultation with experts. The results of this survey yielded the following rates of relative relevance: environmental criteria (43.4%), followed by sociocultural (29.5%), technical (21.2%), and economic criteria (5.9%). The result of technology selection process was activated sludge of the contact stabilization modality.

The definition of the agricultural plan for implementation of wastewater reuse at WWTP-C was carried out. From the water balance results at the study zone, it is observed that the treated wastewater reuse shows a potential of 365 days per year, where there are deficit or a negative water balance. The estimated potential irrigation area was 3080,43 ha (see Figure 4.21), with which 43% is reused (3,32 m^3/s) of the wastewater flow generated by Cali municipality (during the year 2015). A summary of main characteristics of solutions proposed to WWTP-C drainage area are shows in Table 4.7.

Table 4.7 Technical performance of alternatives proposed for WWTP-C drainage area

PARAMETER	UNITS	CONVENTIONAL	SWITCH APPROACH
Flow affluent to WWTP-C	m^3/s	7.6	7.5
BOD load discharged to Cauca river	kg/day	31850.8	15869.3[a]
TSS load discharged to Cauca river	kg/day	43022.1	21435.3[a]

The solutions proposed for WWTP-C drainage area were financially evaluated, using cost-benefit analysis to profile level. For the future, is recommended to make a socio-economic evaluation including eco-systemic benefits and services. In the first step of cost-benefit analysis, the benefits and the costs were identified and calculated. The benefits are:

- Water and sanitation tariff saving by implementation of solution with SWITCH approach
- Acquisition of carbon credits by reduction of greenhouse gases emission
- Avoided cost by use of less amount of fertilizer
- Reduction in payment by use tax of ground water
- Avoided cost in infrastructure for uptake groundwater
- Saving cost by O&M of ground water wells

4.3.3 Cost-Benefit Analysis

The cost-benefit analysis was carried-out using two evaluation criteria: economic efficiency or the difference between benefits and costs, the relation of Net Present Value ($NPV_{benefits}/NPV_{costs}$) (Brent, 2006). The data of costs and benefits distributed through 30 years for analysis is shows in Figure 4.22.

In Figure 4.22 the cash flow (difference among the benefits and costs) between year 1 and 12 is negative, the reason of this behaviour is because the costs are highest than benefits, on the contrary, between year 13 and 30 the cash flow is positive because benefits are highest than costs.

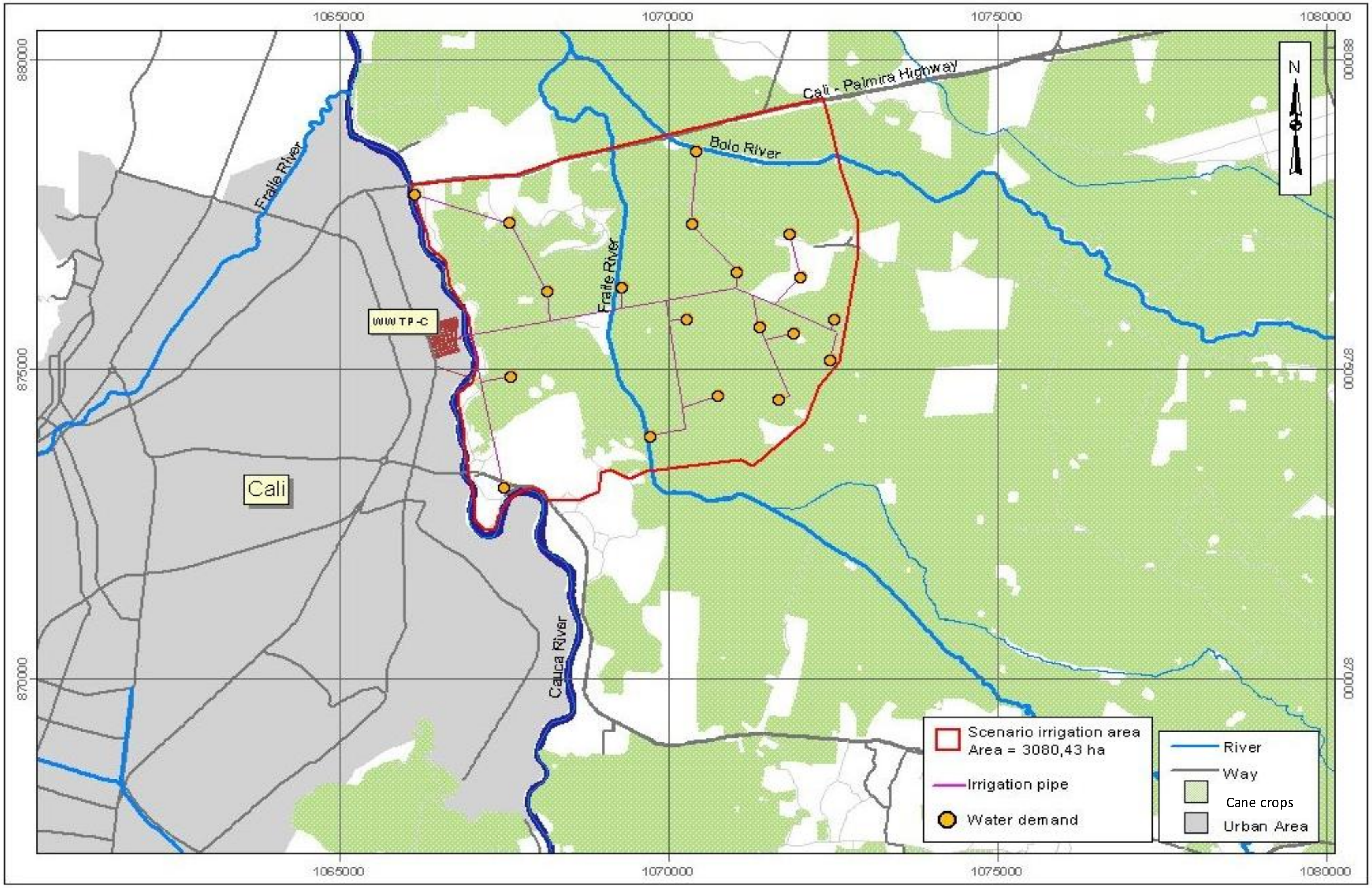


Figure 4.21 Components of solution with SWITCH approach for WWTP-C drainage area

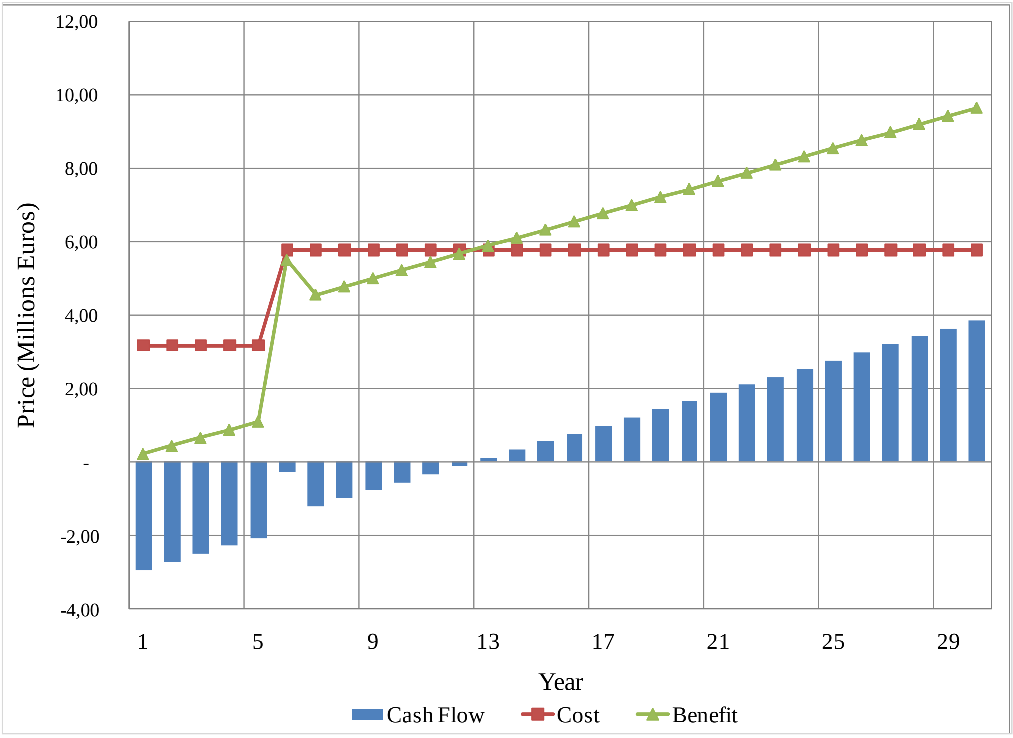


Figure 4.22 Behaviour of cost and benefits of alternatives for WWTP-C drainage area during analysis period

This behaviour is expected, since in this year the line of costs and benefits is crossed, is to say, are the same. This point is also called the breakeven.

Regards to trend of benefits, between the years 1 and 5 has a growing trend directly related with the implementation of pollution prevention and minimisation in Cali households. This crescent trend increases in the year 7 because in this point, the project start receiving the benefits related with reuse. Also is identified a peak in year 6, relates the cost saving by the wells that not be build for irrigation, since irrigation will be carried-out with WWTP-C effluent.

The trend of costs shows a stable behaviour among years 1 – 5, and 6 – 30. Between years 1 and 5 the costs correspond to the application of pollution prevention and minimisation strategy (initial investment and O&M), subsequently, there are a peak related with the initial investment of infrastructure for reuse, and there are other breakeven. The costs among years 6 and 30 are highest because was added O&M of reuse system.

The economic efficiency indicator in SWITCH solution is negative. This means that costs estimated are highest than benefits. Regarding to cost-benefit relation, the solution with SWITCH approach has a value of 0.8, is to say, in financial terms the SWITCH project is not feasible or cost effective (see Table 4.8).

Table 4.8 Indictors of economical feasibility for solution with SWITCH approach in WWTP-C drainage area

NPV Costs (Euros)	40.592.236
NPV Benefits (Euros)	32.422.400
NPV Benefit-NPV costs (Euros)	- 8.169.836
NPV Benefit/NPV costs	0,80

Although financially the solution with SWITCH approach is not feasible or cost-effective, is necessary apply socio-economical analysis for include the positive impacts of the project about society and environmentally.

4.4 LEARNING ALLIANCES IN THE FORMULATION E IMPLEMENTATION OF POLICY OF RECOVERY OF CAUCA RIVER

4.4.1 Background

The continued process of deterioration of the water quality in the high basin of the Cauca River (HBCR) has been notorious, especially in the last decades. As a result, different stakeholders such as environmental authorities, professional associations, academic sector and civil society organizations from Valle del Cauca, and its capital city Cali, have been promoting different initiatives oriented towards solving the main causes of water pollution in the HBCR. For example, in 2004, more than 400 people from nearly 202 institutions participated in the design of the Integrated Cauca River Management Plan while in 2005 the First Consensus Building Table among the key Cauca basin stakeholders was created. The main outputs of this table were the formulation of a common vision for the Cauca Basin but also that for the first time it was suggested that facing the problems of the Cauca River will require the formulation of a CONPES[1] document oriented to the Strategic Management of this Basin. Even the former Ministry of Environment Juan Lozano pointed out around 2007 that the formulation of a Cauca River CONPES was imminent. In spite of these initiatives, there were not concrete outputs for solving Cauca River situation.

While these initiatives were taking too long to become a reality, the problems with water quality in the HBCR worsen. As a result, the main water treatment plan of Cali, which serves nearly the 76% of the population of the city (1.7 million), was forced to stop for an unusual amount of times (see figure 1.3 below). The claims of the local and regional institutions pointing out that short term action and long term planning were required to overcome this situation, finally produced the political will needed to formulate the Rio Cauca CONPES. In May 2009, the Ministry of Environment, Housing and Territorial Development (MEHTD) was made responsible for conducting the process of formulating the CONPES, to which only a few months were assigned. In November 2009, the National Planning Department and the MEHTD approved the CONPES 3624 oriented to the sanitation, management and environmental recovery of the HBCR.

The process of formulating the CONPES was not absent from suffering difficulties. Local actors have been involved in the discussion but the participatory process implemented by the MEHTD included isolated consultations with each institution, mainly CVC, CRC, EMCALI, DAGMA and municipal and regional administrative authorities, leaving behind key stakeholders such as communities, private sector, academic sector and others. Furthermore, the actions incorporated in the CONPES did not arise from a structural analysis of causes and effects for the contamination of HBCR. Additionally, the approach is markedly oriented to constructing urban wastewater treatment plants, giving less priority to actions related to reduce wastewater contamination produced by mining activities and agricultural runoff.

[1] A CONPES is a document that the National Council for Social and Economic Policy prepares in order to set up the main courses of action, including strategies, programs, projects, activities, actors, goals and resources which are needed to solve different kind of development problems including environment, health, education, economic activities, etc. The process of formulation of a CONPES should ideally involve local actor's participation.

Despite of this, the CONPES has opened a good opportunity to promote alternative solutions to water problems, SWITCH type solutions.
In parallel to the process of formulating the CONPES, a Regional Working Panel was created by local institutions, including CVC, DAGMA, EMCALI, CINARA, ACODAL, private sector, professional associations and some other organizations. The creation of this working panel was led by Cinara/Universidad del Valle, within the context of the SWITCH Project, in which Cali is a demonstration city, and through the strategy of the learning alliances established to discuss issues related to water problems in this city. The main objectives of this working panel were: a) to analyze the HBCR problems from an integral perspective and b) to support this process by providing comments and suggestions to the team in charge of it. In two workshops carried out by the working panel, as part of the SWITCH project, in July and August 2009, more than 15 institutions produced very relevant outcomes for the CONPES: i) using the logical framework methodology, the problem of the HBCR was characterized and its main causes and consequences were identified (the problem tree was built up); and, ii) a thorough review of the formulation process was conducted and the main results were presented to the Conpes leading team. It was of high importance that both the problem analysis (problem tree) and some issues of the reviewed process were incorporated in the final CONPES Document. There was also a meeting with the senators and representatives that belongs to Valle del Cauca, in order to socialize and discuss the main outputs generated by the working panel.

Although the CONPES was issued at November of 2009, the regional working panel has continued operating very dynamically during 2010. In the present year the working panel has had around 12 meetings and it has produced a technical document aimed at providing support to the action plan and its 5 components[2] proposed in the CONPES. For this, the technical document is developing a base line analysis and it has defined the priorities for each component, in terms of interventions to be implemented with its costs and sources of funding. For the regional panel, it has been of tremendous relevance to have incorporated the Cauca Department Regional Environmental Authority (CRC) in the process, due to the main water quality problems of HBCR are born in its jurisdiction. Moreover, the CONPES has considered actions in Cauca Department from the beginning. The total projected budget for the development of the CONPES reaches the sum of EU 664.041.207.

The SWITCH project contribution to the development of the CONPES has been outstanding. it is worth noting that the proposals made by the regional panel to the CONPES are related to three of Cali Learning Alliance's issues, taking into account all actions designed and projected for the South Drainage System, the South Cali Expansion Zone, and the entire upper Cauca river basin upstream of Cali. But most importantly, the project team has been able to establish a dialogue with institutions which has started to create a very slow process of paradigm change among institutional staff; additionally, they have demonstrated that alternative and creative solutions are feasible, in contrast with the conventional end of pipe alternatives.

The rest of this document is devoted to present the prioritized interventions identified by the regional panel to each one of the 5 components, which are part of the Conpes action plan. There was also a change that the regional panel decided to make: due to the study of the non-point source pollution is not the only one topic that needs to be researched, the fourth

[2] The five components of the action plan are: 1) River Environmental Management in Cauca Department; 2) Reduction of pollution produced by the main water courses in Cali; 3) River Environmental Management in Valle del Cauca Department; 4) Study of the non-point source pollution and land use conflicts in the UCRB; and 5) Institutional Strengthening.

component was directed to identify the whole research needs for the sustained development of the HBCR.

4.4.2 River Environmental Management in Cauca Department

The Conpes document has identified three major initiatives for the Cauca region, including:

- Wastewater treatment
- Reforestation and erosion control
- Land acquisition

There is an on-going process carried out by the working panel oriented to define a list of priorities for these interventions and the costs associated to each one of them.

4.4.3 Reduction of Pollution produced by the main water courses of Cali

The CONPES has included 5 strategies oriented to achieve the goal of reducing the pollution produced by the main water courses of Cali, among them: wastewater control, closure of Navarro Landfill, implementation of a debris plant, reforestation, and acquisition of land. However, the working panel has decided to group these strategies in four new components: conservation and recovery of natural cover (Table 4.9), management of wastewater dumped into rivers and canals, maintenance of sewage systems in relation to debris and sludge and Navarro landfill closure.

Conservation and recovery of natural cover

Table 4.9 interventions and priority level for the conservation and recovery of natural cover

INTERVENTION	PRIORITY
Forest fire control	High
Soil recovery and stabilization	Medium
Reforestation and maintenance of forest	Medium
Agro-forestry sustainable systems	High
Control in the marketing of timber	High
Control of human settlements with incomplete development	High
Soil remediation and recovery (in relation to mining activities)	High

Management of wastewater dumped into rivers and canals

For this subcomponent some interventions have been identified without specifying the level of priority and costs.

- Control of the discharges to the sewage system generated by productive processes which dump into the south canal and that produce substances of sanitary relevance, including the mining sector
- Evaluation of the non-point source pollution in the area of influence of the south canal
- Construction of collectors, optimization of combined sewer overflows (CSO) and actions to control fraud connections

The specific interventions, priorities and costs within the components *Maintenance of sewage systems in relation to debris and sludge* and *Navarro landfill closure* are still under discussion by the working panel.

4.4.4 River Environmental Management in Valle del Cauca Department

In the case of the environmental management in Valle del Cauca, the working panel has decided to work on the basis of what has been proposed in the Conpes document in order to have more time to discuss the specific interventions that need to be implemented. Until now, the following interventions have been considered:

- Erosion processes control
- Industrial wastewater control
- Control of excessive open mining and sediment exploitation
- Formulation and implementation of Sanitation and Wastewater Management Plans (SWMP)

4.4.5 Research needs for the sustained development of the HBCR

Research is a basic aspect for the sustained development of the HBCR due to:

- It allows the production of new knowledge and information which is needed to understand the processes and problems taking place at the basin level
- The new knowledge and information can be used to make decisions based on solid ground
- Research findings are useful for the design of new laws, regulations and integrated water resources frameworks at the basin
- New research topics comes out from research findings

The prioritized research needs are presented in Table 4.10.

Table 4.10 Prioritized research needs

RESEARCH TOPIC	PRIORITY
Assessment of non-point source contamination produced by agricultural runoff	High
Assessment of non-point source contamination produced by humid and dry deposition of atmospheric contamination	High
Determination of the impacts of urban non-point source pollution in Cauca River water quality	High
Determination of impacts of different types of mining in the HBCR	Medium
Determination of the effects of Cali´s Industry on the water contamination of Cauca River	Medium
Implementation of a water basin committee in a pilot sub-basin of the HBCR in order to research its functioning, structure, resources, methods, and feasibility	High
Formulation of a dynamic model to relate economic activities and land uses in the HBCR with water quality and quantity	Medium
Epidemiological study to establish health risks produced by the HBCR´ water quality	High
Identification of strategies for in situ remediation and recovery of natural degraded wetlands	High
Assessment of buffer zones for non-point source contamination management	Medium
Implementation of environmental education strategies to different key stakeholders (producers, civil society, institutions, agricultural sector, etc.)	High
Multi-criteria Social Evaluation of ecosystem services provided by water producer ecosystems (paramos)	High
Characterization and resolution of environmental and water use conflicts	High
Implementation of three learning projects on community management of strategic aquatic ecosystems	Medium
Characterization and strengthening of water governance processes in the HBCR	High
Characterization of processes of water intake using river bank filtration and its impact in the clean water quality in Cali	High
Characterization of the potential of community based water and sanitation providers to carry out integrate water resources management processes for different uses	High

4.4.6 Capacity Building

Although the CONPES 3624 included institutional strengthening as one its five components, this approach seems to be very restricted to the implementation of strategies aimed to strengthen the internal processes of organisations. Knowing that overcome the difficulties associated with institutional issues in the HBCR would require a different approach, the

working panel adopted the one of capacity building. This approach has three main elements: i) the creation of an enabling environment, including the design of appropriate legal and regulatory frameworks (Table 4.11); ii) institutional development, involving community participation especially of women (Table 4.12); and iii) development of human resources and strengthening of management and information systems (Table 4.13). Under this approach, the following interventions have been identified:

Table 4.11 Interventions and priorities to create an enabling environment

INTERVENTION	PRIORITY
Re-design and implementation of a participatory institutional framework for the environmental management of the HBCR	High
Creation of the Upper Cauca River Basin Committee	High
Creation of a regional project bank for consolidating all the HBCR projects and initiatives	High
Inventory of users, communities and productive activities settle down in the HBCR in order to identify water uses (quantity) and wastewater produced	High
Characterization of contaminant sectors and actors, identifying who are affecting, who are affected, impacts level, and short, medium and long term actions to be implemented in order to control and reduce contamination	High

Table 4.12 Interventions and priorities to institutional development

INTERVENTION	PRIORITY
Evaluation and organizational redesign of institutions and actors responsible for the environmental management of the HBCR to facilitate the adoption of the new institutional framework	High
Creation of 3 community centers for monitoring and control of water uses and for the follow up of the CONPES implementation	High
Institutional coordination for the adjustments of the Land Use Plans	Medium
Strengthening of environmental education schemes and strategies from a perspective of human development	High

Table 4.13 Interventions and priorities for the development of human resources and strengthening of management and information systems

INTERVENTION	PRIORITY
Creation and implementation of the GIS for the HBCR, including: Sediments monitoring stations Modeling of soils loss Strengthening of Cauca River GIS	High
Formulation of a research plan prioritizing relevant topics for the integrated water resources management and contamination control of the HBCR	High
Implementation of a postgraduate scholarship program for institutional staff	Medium
Implementation of a capacity building program to community members, especially women	Medium
Design and implementation of a dissemination program for all the actions taken in the HBCR (charts, leaflets, seminars, radio and media campaigns, etc)	Medium
Plan for equipment replacement and provision of technology for information management and production to institutions and research bodies related to the environmental management of the HBCR	High

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