Strategy for the implementation of DEWATS* for industrial effluents in León (Nicaragua)

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(*) Decentralised Wastewater Treatment Systems

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Declaration of authorship

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I hereby declare that I have written this thesis with the title:

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Without any help from others and without the use of documents and aids other than those stated above and that I have mentioned all used sources and that I have cited them correctly according to established academic citation rules.

Place and date

Signature

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List of abbreviations

ABR	anaerobic baffled reactor
AECID	Agencia Española de Cooperación Internacional para el Desarrollo
AF	anaerobic filters
AFP	advanced facultative pond
BOD_5	Biochemical oxygen demand at five days
BORDA	Bremen Overseas Research and Development Association
CAM	Comisión Ambiental Municipal / Municipal Environmental Commission
CIMAC	Centro de iniciativa Medioambiental
COD	Chemical oxygen demand
CPML-N	Centro de producción más Limpia - Nicaragua
CWs	constructed wetlands
DEWATS	decentralised wastewater system
DGA	Dirección de Gestión Ambiental Municipal / Environmental management direction
ECODES	Ecología y Desarrollo
ENACAL	Empresa Nicaragüense de Acueductos y Alcantarillados
INAFOR	Instituto Nacional Forestal
INETER	Instituto Nicaragüense de Estudios Territoriales
mamsl	meter above sea level
MARENA	Ministerio del Ambiente y Recursos Naturales
MINSA	Ministerio de Salud
MP	maturation pond
NGO	nongovernmental organization
PISASH	Integral Sectoring of Water and Human Sanitation Programme in Nicaragua
SBR	Sequencing Batch Reactor
SIWQ	simplify index of water quality
SFP	secondary facultative pond
TDS	Total dissolved solids
TSS	Total suspended solids
UASB	Upflow Anaerobic Sludge Blanket
ULSA	Universidad Tecnológica La Salle
UNAN	Universidad Nacional Autonómica de Nicaragua
WWTP	Waste water treatment plant

Abstract

This thesis seeks to understand the dynamics of environmental project planning, execution and key factors to assure long term operation. The development of a decentralized wastewater treatment plant for the effluent generated in the slaughterhouse of León in Nicaragua serves as base project for understanding the process and actions behind. Factors such as institutional strength and communication, general public involvement, legislation, funding or corruption have a greater impact on the overall outcome of a project. These factors are analyzed to finally reach to the conclusion that resources needed to accomplish certain project such as water, budget, workforce, knowledge or information can be readjusted to achieve a better outcome. It is the effort invested in the “readjustment” which increases the difficulty of reaching a good result thus provoking a small positive impact on the environment.

1. Purpose, methodology and structure of the paper

1.1. Purpose of the study

This thesis intends to identify factors that may affect the transferability of a wastewater management project in the municipal slaughterhouse of León in Nicaragua. The holistic overview of this paper helps to build a detailed scenario where all major factors interact. The experience and knowledge gained during the development of this pilot intervention are analysed to help solving comparable issues along the river. The pilot project is being broken down to isolate tangible factors such as materials, budget or workforce as well as intangible factors such as communication, information or awareness to build a strategy that may be followed in future proposals.

This thesis is an assignment received from the NGO BORDA (Germany). The Municipality of León is the main counterpart in the pilot project. This project meets one of the objectives of the mechanism for protecting the Chiquito River, driven by the municipality. The local government intends to protect the river and its watershed from industrial effluents. Other aspects included on the Chiquito River basin protection project are reforestation, waste management and the implementation of better agricultural practices.

“Although the nature and severity of water problems are different from country to country, one aspect is common to most countries: water scarcity – whether quantitative, qualitative, or both – originates more from inefficient use and poor management than from any real physical supply limitation” (Saleth & Dinar, 2004).

One could assume that water scarcity should not be a problem in the city of León. Rainfall and fresh water are abundant. It is nevertheless becoming an issue due to poor management and the rapid urbanization of the area which has caused an increase of pollution.

León and in particular Chiquito River have been the objective to numerous development projects in the past. Several measures have been carried out where outcomes have not always resulted as desired. The aim of this paper is to understand connections between actors, their duties and way to proceed, so that improvements can be detected and better planning processes and outcomes can be achieved.

The environmental situation in the river basin is dreadful. The core of the reason is that citizens and their representatives allow it to be that way. In a society which struggles with basic developmental aspects, the protection of the environment plays a secondary role. It is of vital importance to change behaviour patterns and enhance awareness regarding environmental issues. General public must assimilate that economic growth and environmental protection should walk hand-in-hand. When this occurs, the notion would reach legislators and governors. In fact, citizens are the actual driving force behind governors.

In León, a great part of the infrastructure ought to be mended or upgraded. Citizens and institutions have the capacity to choose the strategy to follow. There are parts of society and experts who understand that economical growth should follow different criteria. Although there are professionals in León who work hard to shift the pattern, the change of mind-set of a society implies huge effort, time and the inclusion of the

vast majority. Why results from this work are barely visible and efforts made so far do not suffice are the overarching elements of this paper.

A chapter of this paper deals closely with the pilot project studied and considers technical components. The considerations on economical, sociological and technical factors compose the outcome of this thesis.

1.2. Methodology

The core of this research intends to clarify which factors are crucial for success in the transferability of an environmental project in León. The efforts were initially focused on exploring the local situation and obtaining as much information as possible from primary sources. It became important to comprehend the social reality in Nicaragua, to uncover the regional human behaviour and their individual experiences. The interpretive method was chosen to analytically illustrate the why, how, or by what means people do what they do, while showing how those behavioural patterns intermingle so that this method can be used to generate observable outcomes (USC, 2015). This approach was used for gaining an understanding of the particular situation in the city of León; the involvement of institutions and actors, their actions and how these affect the management of the river and development of the city. This paper seeks to create some understanding for the role of society and to identify factors which have created the current situation in the area over the past 40 years. The research was conducted aiming to gain a holistic comprehension of the problem for later developing a strategy which can be put into practice to address existing environmental issues in an efficient way.

The first action was to discover the details of the pilot project developed by BORDA in the slaughterhouse. The sparks of the project, its development and key technical and human components were found out through conversations with the people in charge of its execution.

A literature review during the two month period previous to my stay in Nicaragua was conducted. Firstly, the research was conducted on wastewater management projects in tropical climate. The type of industries in the area was detected and their effluents studied. The third topic studied was the theory behind environmental project development.

Once in Nicaragua interviews were conducted to become familiar with the situation. Institutions which participate in the management of the river were contacted. Initially interviews were conducted in institutions of different profile; Table 1 shows the list of institutions and what was expected to obtain from their consultation.

A member of the municipality, who works in the department of project development, was involved in the pilot project team. She put me in contact with personnel of the municipality who worked close to the river management as well as workers of other institutions. Firstly, the departments of biology, urban planning and geographic information systems and the water laboratory in UNAN (Universidad Nacional Autonómica de Nicaragua) were visited. They facilitated the access to theses written in their departments and shared information about current researches. The Hamburg twin town office is involved as well in the pilot project and

has put into practice several projects on the river . Information about these projects was received.

These first interviews augmented my local network of institutions and people. More interviews were conducted thus, the insight into the situation in Chiquito River was deepened.

Interviews and information that was gathered created an overview of the development through time and the current state of the Chiquito River. Prior to visiting the river and its adjacent industries, information about previous projects and the volume and sort of industrial activity in the area was collected.

It was necessary to identify the actual number of industrial objects dumping their wastewater into the river. The tanneries were the first target. An expert accompanied me to approach the first contacts. This fact eased the task enormously. A questionnaire (see annex C) was designed to find out about the volume of water used, amount and origin of the chemicals involved and the general characteristics of each individual industrial site. Identifying similarities and differences (between them and between them and the pilot project) will help to design the strategy to address the problems caused by their pollution. The outcome from these questionnaires can be found in chapter 6.

In a different stage pig farms and soap-oil industries were approached and questionnaires were completed. The city wastewater plant, which treats domestic wastewater from a great part of the households on the river side, was also visited at this point. This last visit helped to further understand the complexity of the problem created by the contamination of the Chiquito River.

At the same time two excursions to the river basin, with different purposes, were scheduled. An expert guide from the municipality lead the first one. There, the infrastructure of previous projects realised in the river was visited. Objects of this excursion were, among others, finding out what issues mattered at the time the first development projects were executed, what had been done and what aspects still remain active despite the time that has passed. Local students guided the second visit trough the partly dry river bed. In this visit, the immediate effects of the water pollution, the deficiencies in the maintenance of the wastewater network and other sources of pollution were observed. The intended route was disrupted due to safety problems.

An important facet was to understand and highlight the significance of the pressure exerted by the local institutions on polluters. It was possible to accompany an inspector from the environmental Ministry to audit two tanneries and to witness the repercussions following the infractions committed by the polluters.

The city is rather small, everyone knows one another, therefore establish a network was moderately easy. Occasionally this characteristic caused people to hold back information fearing consequences. The diverse opinions personnel from different institutions hold on the same issue can be difficult to analyse. The material used for the analysis is composed of their respective personal point of view and experiences rather than proved quantitative data. However, enough data has been gathered through questionnaires completed by the protagonists to evaluate the situation.

Frequently, family businesses perform outside the legal framework to avoid taxes. When the turnover, e.g. the total number of pigs in a pig farm, is not important their activities passed unnoticed by the authorities. This fact obviously complicated the creation of a complete inventory.

A major effort was directed at reviewing the previous works written on the topic of river protection. The University library comprised a number of master theses and term papers with the river and its industries as their main subject. The theses were written by Biology and Chemistry students. The twin town of Utrecht contributed with the documentation that was available from a project executed 20 years ago in the river, partly in Dutch. More information about this project can be found in chapter five.

Chapter six intends to suggest proper solutions and best suitable approaches for future actuations. What technical aspects of the pilot project can be easily implemented and what aspects need further modifications based on literature review.

1.3. Structure of the paper

Firstly some brief general information about Nicaragua and its history is given. Chapter three then directs the focus on expounding the situation on the basin of the Chiquito River. Physical data and sociological aspects narrate the development of the area through history up to its present state. Chapter four deals with the legal framework and gives an overview of the legislation that applies to water protection and industrial activities. This chapter also specifies the institutions involved in the legislation, management and control of this resource. In addition a short discussion about the progress of environmental legislation in Nicaragua is included in this chapter.

Chapter five analyses the causes and effects of the pollution of Chiquito River. It also deals with the protagonists of river and water issue management in León, their responsibilities and

Institution	Expected
UNAN	
Water laboratory	Water analysis, previous works on the river, collaboration
Urban planning	Previous works on the river, collaboration
Municipality	
Project management and development department	Information about previous projects in the river, future strategy
Environmental management and natural resources department	Information about previous projects in the river, future strategy
Cadastre	Geographic data, current register of properties
Sisterhood cities	
Hamburg	Information about previous projects in the river
Utrecht	Information about previous projects in the river
Zaragoza (ECODES)	Information about previous projects in the river
ENACAL	Competences, functions, future strategy, water river analysis
MARENA	Competences, functions, future strategy

Table 1. Main institution in León where interviews were conducted and information sought (Own elaboration, 2014)

future development plans for the city. The following chapter describes the pilot project in the slaughterhouse and the previous cooperation projects carried out within the area. Chapter six also collects opinions from experts who at that time were evaluating the level of success of afore mentioned projects.

The subsequent chapter deals with the operations of the industries on the riverside, how the pollutants originate from their activities and the repercussions of their effluents on the environment to finally explain measures that need to be taken to minimise their effects on the river.

Chapter eight analyses how the pilot project can be transferred to other polluters of the river. Firstly, the shortcomings found in the pilot project are described. After that, factors which affect transferability are analysed. Opinions and suggestions from the protagonists are used to write this chapter. Finally a suggested strategy to approach a new project and a system of points to detect which industrial site is more suitable is shown. The paper concludes with a discussion of the suggested solutions and possible adaptations and extensions.

In the annexes, a text referring to a similar case in Colombia, a chapter dealing with corruption and material used for the interviews can be found.

2. Facts and history of Nicaragua and Leon

The Republic of Nicaragua is the largest country in Central America, bordering Honduras to the north and Costa Rica to the South. The country is situated in the Northern Hemisphere within the tropics. The Pacific Ocean lies to the west, and the Caribbean Sea to the east (See Figure 1).

Figure 1. Location of Nicaragua and León. Modified from Wikimedia Commons

Nicaragua became officially independent from Spain in 1821 but experienced several dictatorships and foreign rule. Between 1909 and 1933 the US army invaded on several occasions under the pretext of assisting its citizens and their properties. The reason behind this was the construction of the first interoceanic canal. These foreign interventions favoured the formation of a guerrilla offensive led by the patriot Cesar Augusto Sandino, which expelled the US army from the country in 1933. Shortly after, the General in charge of the National Force, Anastasio Somoza, had Sandino assassinated, overthrew the existing president and began a brutal dictatorship that passed to his son, and his brother, and lasted 43 years in total. During this period (1937-1979) the economical system hindered the access to basic services and opportunities for the large majority of people, especially in rural areas. The increment of exports and unequal land distribution favored environmental degradation.

Somoza was overthrown by a rebel group, the Sandinista guerillas (named after Sandino) in 1979, who formed a new government. The Sandinistas began redistributing property and made huge progress in the health and education sectors, but their pro-Cuban orientation alarmed the United States, which launched a sustained campaign that included embargo and armed subversion (BBC, 2014).

In 1981, the United States, among other countries, authorized and financed the training of anti-Sandinista guerillas, also called counter-revolutionaries, shortened to the term “contras” (Cooper & Ingram, 2014). Guerilla warfare began, known as the Contra War, which damaged the economy and the foundations of the country enormously. Human rights violations were committed across the country. These acts generated international pressure and foreign-funding was cut off. As a consequence the Contras were forced to retreat and eventually disperse by the late 1980s. Nicaragua limped through the 1980s and 1990s as various politicians tried to put the country on its feet. By 1990, when the Sandinistas were defeated in elections held as part of a peace agreement, Nicaragua's per capita income had fallen dramatically, inflation was out of control and the infrastructure was in bad conditions (Press Reference, 2002).

Peace brought some economic growth, lower inflation and lower unemployment. But this was counter-balanced by the devastation caused by Hurricane Mitch in 1998, which killed thousands, left 20% of the population homeless and caused billions of dollars worth of damage.

León is the second largest city in Nicaragua after the capital Managua measuring 19.09 Km^2. The city had an estimated population of 201,100 in 2012 (INIDE, 2012). León is located along the Chiquito River, 90 kilometres northwest of Managua, and 18 km east of the Pacific coast. It has been the political and intellectual centre of the nation thanks to its university (UNAN), the second oldest university in Central America, founded in 1813. León is also an important industrial, agricultural (sugar cane, cattle, peanut, plantain, sorghum) and commercial centre for Nicaragua.

The first city named León in Nicaragua was founded in 1524 by the Spaniards about 30 kilometers east of the present site. The city was abandoned in 1610 after a series of earthquakes and an eruption of the volcano Momotombo.

León had been the capital of Nicaragua since colonial times, so naturally when Nicaragua withdrew from the United Provinces of Central America in 1839, León became the capital of the new nation. For some years the capital shifted back and forth between León and Granada, with Liberal regimes preferring León and Conservative ones Granada, until as a compromise Managua was agreed upon to be the permanent capital in 1858.

Prior to the earthquake in Haiti (2010), Nicaragua surpassed Haiti as the poorest nation in Central America (Burrell & Moodie, 2012). Unemployment nowadays is 7,8% (Economy Watch, 2013), although reliable labour statistics are difficult to obtain and nearly half of Nicaragua's work force is estimated to be underemployed (not enough work to provide for one’s self or a family) (The giving lens, 2013). The main source of work remains agriculture and sweat-shop style labour.

3. Background and relevant aspects of the Chiquito River basin

The Chiquito River is 21 kilometres long, it starts 300 metres away from the limits of the city. It flows into the Pacific ocean at the Las Peñitas estuary, situated behind the protected area of Juan Venado Island. This paper deals with a stretch of 4 kilometres which flows through the city of León (See Figure 3). The river has six tributaries, the most important being the Ojoche River.

Until the 1970's the river was used as a recreational area, hosting diverse and abundant vegetation. From 1970 on, the riverside has been indiscriminately used for housing and industrial purposes. The discharge of both wastewater streams directly into the river and the disposal of solid waste have caused its current polluted state. Wastewater from households is nowadays collected and driven to the waste water treatment plants of the city. Most of the industrial wastewater still does not receive any treatment. The river has become the most polluted area of the city during the past years caused by an intense misuse allowed by the lack of regulations or weak application of those. According to studies realised by the Ministry of Health (MINSA, by its initials in Spanish) the riverside is the area with the highest rate of premature mortality and deforestation in the city (Lezama Cortes, Galo, Hernández, Zapata, Martínes, Laguna, 2007) as the inhabitants deplete the natural resources irrationally, which becomes a threat for the preservation of the area.

3.1. Physical aspects

Unless a reference is shown, the data gathered

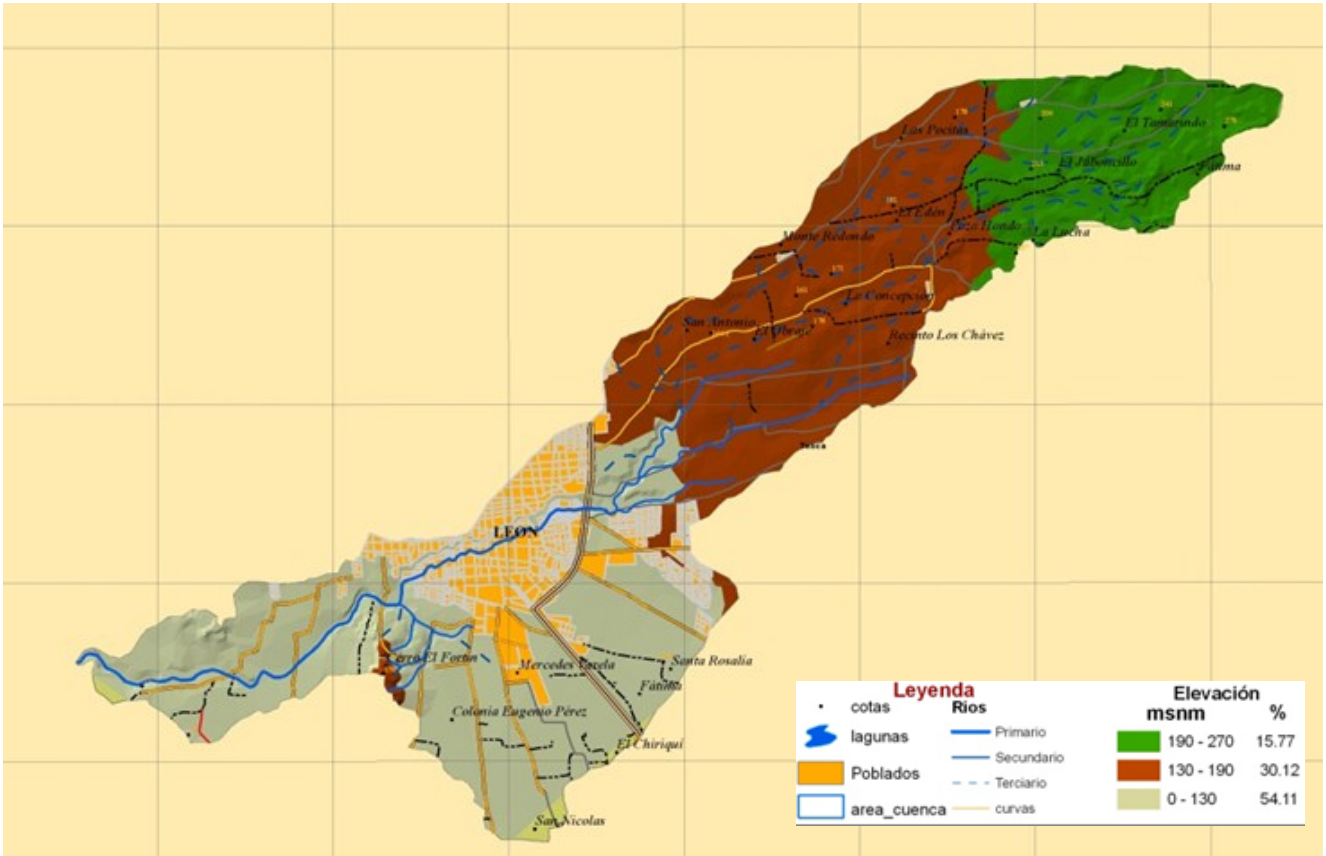


Figure 2. Rio Chiquito watershed. Altitude map. Source: Municipality of León

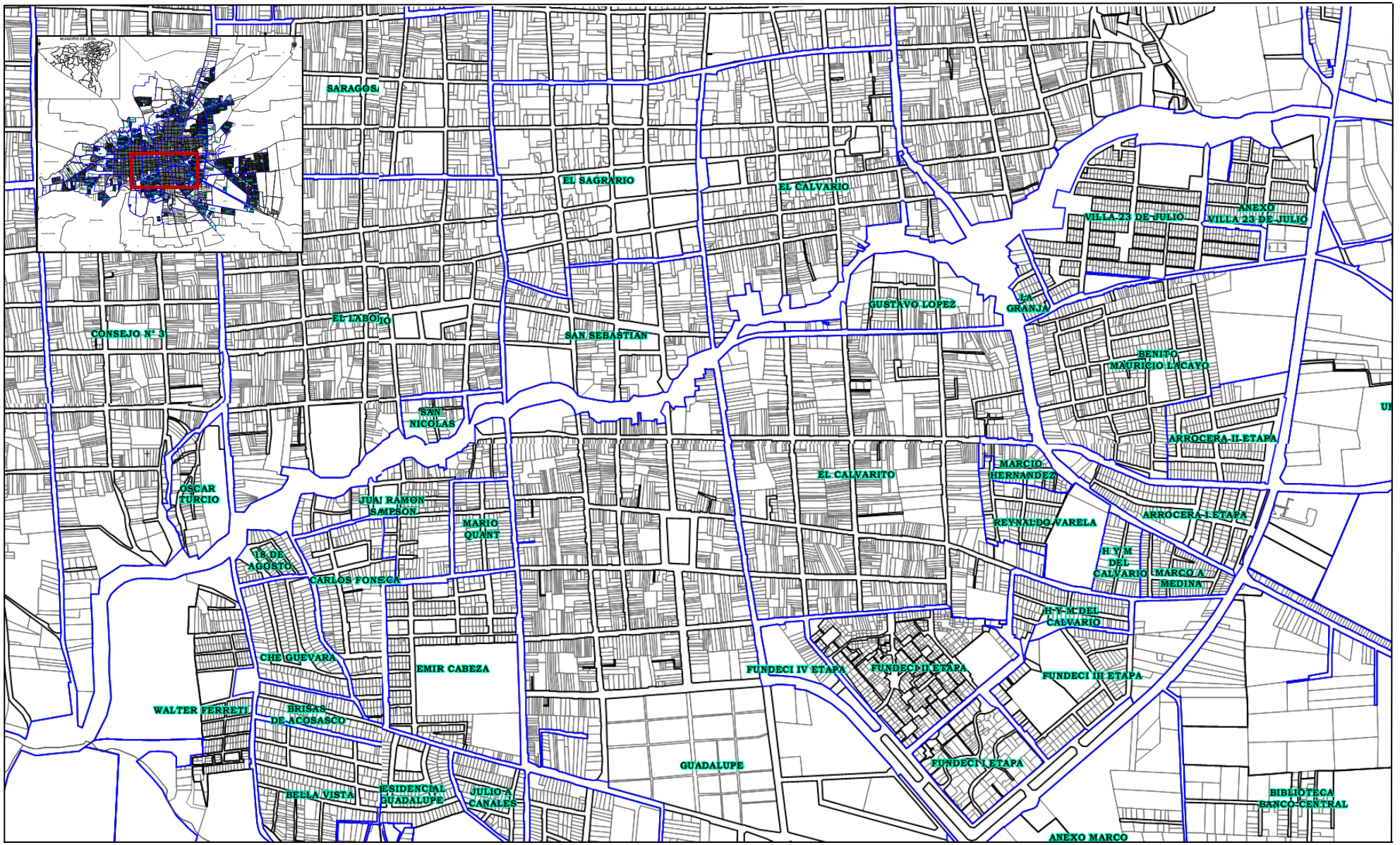


Figure 3. Area of León which Chiquito River flows through. Source: Municipality of León

for this point comes from a study the municipality assigned to an expert from the UNAN. The documents the municipality provided had no date or author.

The altitude of the watershed goes from 1 meter above sea level (mamsl) to 276 mamsl on the highest point. As it can be seen in Figure 2 the area is divided into three parts regarding their altitude: low, medium and high. The stretch of the river to be studied is situated in the low part which has a surface of 30.72 km^2. The watershed has a long shape with a perimeter of 55.49 kilometres. The main riverbed has a length of 26.44 kilometres. The tributaries together reach a length of 26.44 Kilometres disposed making an angle of 45° with the Chiquito River.

The humidity is determined by the content of water in the atmosphere which is transported by the intertropical convergence zone, tropical waves[1] from the east and the marine breeze from the Pacific Ocean. Observing the annual distribution of rainfalls in Figure 4, there are two

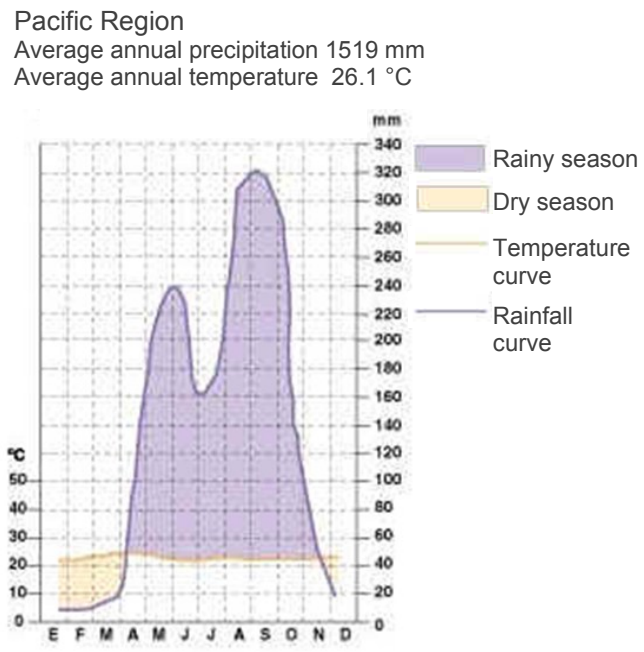


Figure 4. Temperature and precipitation chart (INETER, 2005)

well defined periods of six months each. The rainy season lasts from May to October when 99.5% of the annual rainfall occurs and the remaining 0.5% occur during the dry season from November to April. The annual precipitation varies from less than 800 millimetres in the drier areas of Nicaragua to 5,000 mm.

Leon is located in the Pacific area with an annual rainfall oscillating between 1,000 mm and 2,000 mm (INETER, 2005).

The annual average temperature does not oscillate immensely, however differences between diurnal values are important. In León as in other zones located on the flatlands next to the lakes (Cocibolca and Xolotlán) days are very warm, with an average of 34°C whereas in higher lands, above 800 mamsl average daily temperatures are not higher than 26°C.

The solar radiation is highest from February to the beginning of May coinciding with the final months of the dry season. July and August are also among the warmest months.

The area is vulnerable to volcano eruptions, landslides and floods. The volcano Cerro Negro, sited 25 km to the east of the city of Leon, has had several violent eruptions in recent years, the last one in 1999.

3.2. Sociological aspects

This point meets the needs of the inhabitants, their problems and the conflict generated by the interaction with the subwatershed.

[1] Tropical waves are a type of atmospheric trough, an elongated area of relatively low air pressure, oriented north to south which moves from east to west across the tropics causing areas of cloudiness and thunder-storms

León underwent an accelerated growth in the late 1950s, when cotton was introduced as a crop. It generated a massive rural immigration to the city and the settlement of poor people to areas devoid of services. At that time the area of the river was formed by 17 low income settlements and was inhabited by 25,000 people.

A. Urban development process

(Somarriba, 1993)

The urban development processes in Leon have been influenced by the political changes, the trial of different economic development models, natural population growth, and natural phenomena occurring in the city and the country, which altogether have caused the instability of the rural population.

There are three different outstanding historical periods:

From 1950 to 1971 deep changes in the economic model of the municipality of León occurred. Before 1950 Leon was a producer of basic crops, and agriculture was mainly aimed at the internal market. In this period, however, Leon opened its activities to the international market. The Somoza government implemented an agricultural model based on cash crops, cotton being the main crop. Therefore the Somoza government put into practice several measures in order to promote a rapid adjustment to the agricultural model.

The first measure taken was the expropriation of peasants' agricultural lands and the surrounding lands near to the city for cultivation of cotton. Other measures implemented included the concentration of services and housing programmes in the urban area of the city. This common phenomenon in developing countries, called "urbanization", reduced the chances for the development of the rural area. This caused a lack of stimulation of rural growth and the emigration of the rural population to urban areas.

In this period Leon was a producer of migrants, whereby poverty levels and unemployment were not alarming in the municipality. The urban population in Leon reached 62% of the total. In the rural areas settlements and employment were generated around the cotton and sugar cane cultivation areas. Most of these settlements were temporary only and likewise employment was insecure and irregular.

During the second period, from 1972 to 1980 urban population in Leon reached 82% of the total. The main reason of this migration was a severe earthquake in 1972, killing 10,000 people and producing a relocation of 23,000 people of which 96% were relocated to the urban area of Leon. Somoza carried out programmes for the new rural settlements which did not reach the low income people provoking a further deterioration of the rural area.

The third period covers the Sandinista revolutionary regime (1981 – 1990) which inherited the previous situation. The strategy of this government was trying to counterbalance this pattern and to decentralize productive investments and political responsibilities. The purpose was to bring services to all people regardless of the place of their residence and at the same time reducing the environmental damage caused by transportation. However several factors made it difficult to gain control over migration and the previous tendency

remained the same. Among these factors are the floods in 1982 and 1986 caused by the hurricanes “Alleta” and “Joan” respectively. Other factors were the international drop in prices of cotton and coffee, the warfare in the countryside and the trade embargo imposed on the country.

From 1990 peace brought more stability to León.

Table 2. Relation of houses and population in Chiquito Riverside (Own Elaboration. Source: Alcaldía de León, 2012)

Neighbourhood	Number houses	Inhabit-ants	Area (ha)
Rogelio Santana	104	443	52.33
El Coyolar	1701	5884	70.19
El Calvario	705	4038	26.31
San Sebastián	273	916	13.24
El Laborío	1159	4678	41.67
San Nicolás	42	184	0.25
Oscar Turcio	67	285	3.54
Walter Ferreti	247	1115	19.11
18 Agosto	69	397	1.48
Che Guevara	176	616	4.43
Carlos Fonseca	211	1268	6.45
Juan Ramón Sampson	242	789	7.32
Mario Quant	105	749	2.86
Guadalupe	1192	4928	119.21
Gustavo López	110	627	5.9
La Granja	34	118	0.99
Villa 23 de Julio	589	3422	12.96
Anexo Villa 23 de Julio	193	6665	18.22

Although there has been a steady growth of the population, compare to the country’s population Leon’s total share is drecreasing. Nowadays around 190,000 inhabitants live in the subwatershed of the Chiquito River. They are located on the middle and lower part of the subwatershed, existing a total of 231,264 houses, of those 96.78% are located on the low part with an average of 5 to 8 people per house. There are around 49,000 inhabitants on the riverside, representing 26% of the total population (Lezama Cortes, et al. 2007). In Figure 5 the sector of the river studied in this paper is shown. The map shows the current distribution of usages and urban density.

Table 2 displays a relation of the neighbourhoods in León surrounding the Chiquito River. The number of inhabitants who are narrowly related to the river influence within the urban area is 37,122.

During the 80’s, there was an organisation in charge of dealing with housing related issues. After it disappeared, the tasks were divided among different institutions. From this moment on, a void in the competences regarding urban planning and sectoring was created. As a result, illegal settlements appeared which worsened the problem. Because of the lack of action and communication between the institutions, the municipality assumed the responsibilities. Although the municipality of León has been implementing a Master plan since 1999, there are still areas which do not obey to any orders. These areas are shown in Figure 5 highlighted in brown.

B. Water and sanitation

The city has an important reserve of

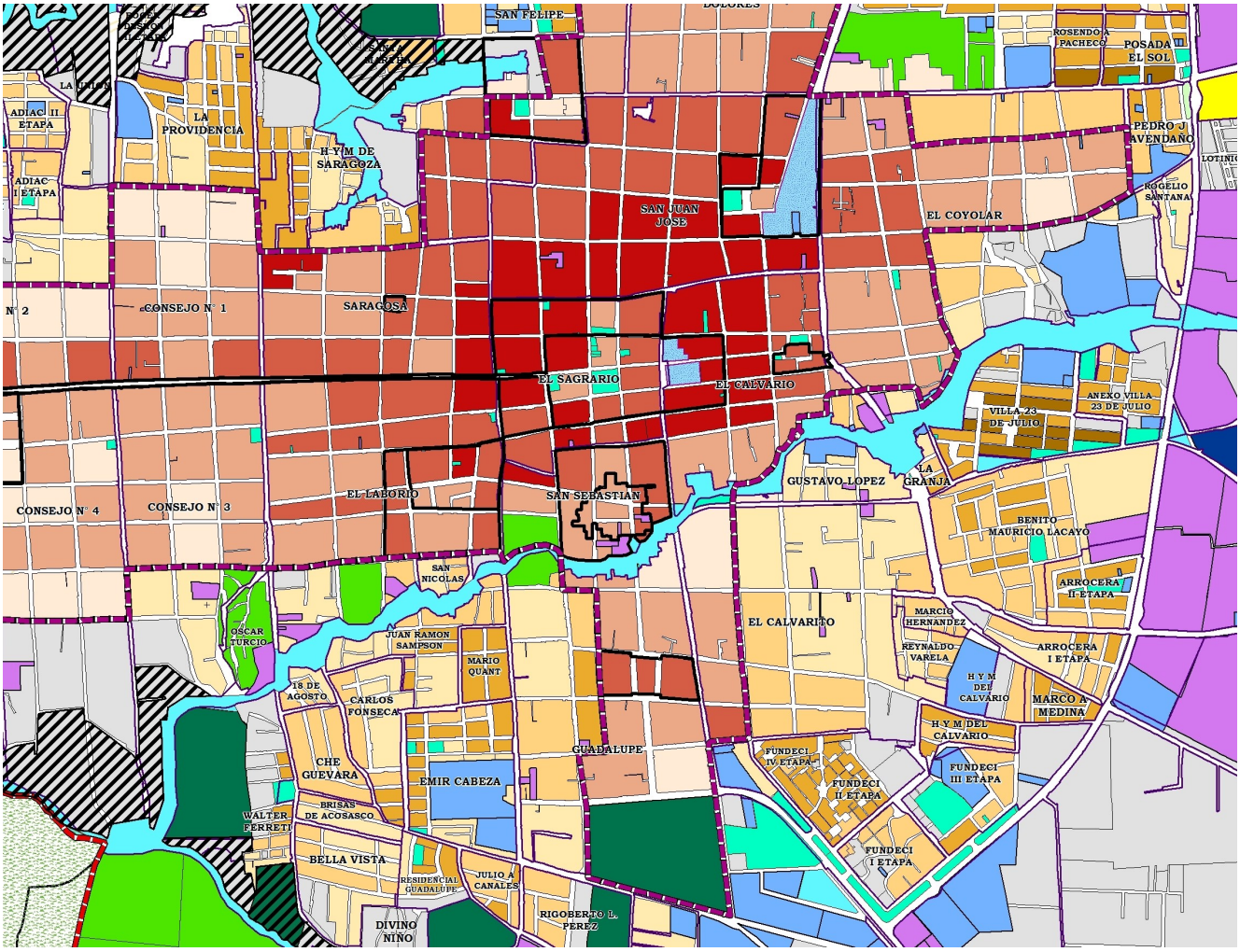


Figure 5. Distribution of urban usages in Rio Chiquito's Riverside. Cropped from original plan of Alcaldía de León (2013)

Zone elements

- Foundational core limit
- Cultural heritage limit
- Urban limit
- Neighbourhood limit
- Urban expansion area
- Area for urban border protection

Cultural heritage housing area

- Saturate patrimonial area
- Consolidated patrimonial area
- Semi - consolidated patrimonial area
- Semi - consolidated patrimonial area

Occupied urban area

- Saturate suburban area, (*)ρ= 0.8 - 1
- Consolidated suburban area, ρ= 0.6 - 0.8
- Semi - consolidated suburban area(1) ρ= 0.4 - 0.6
- Semi - consolidated suburban area(2) ρ= 0.2 - 0.4
- Future consolidated suburban area, ρ= 0 - 0.4

Industrial area

- Heavy industry area
- Light industry area

Green areas

- Recreational area
- Natural Protection area

Area of urban equipment

- Current area of urban equipment
- Future area of urban equipment

Commercial area

- Urban commercial area

Special use equipment area

- Current special use equipment area

Concerted action area

- Concerted action area

areas that due their size and potential are considered under a special regime regarding their transformation

- Flood risk areas

(*)ρ= Urban density

groundwater covering an area of 2,565 Km^2 (Lezama Cortes, et al. 2007), bigger than half of its territory, which is the main source of drinking water of the city. There are ten wells supplying drinking water, the supplying network is more than 40 years old and is affected by problems with leakages and cracks (Abarca & Valladares, 2011). The company in charge of the water supply and the sanitation network, (ENACAL, by the initials in Spanish) destines 95% of the water production to supply households (Munguía, Munguía, Hernández & Funes, 2007); rural areas and small industries are provided for water by private and public wells. Of the 76% of households (7,789) that have access to drinking water, 46% are connected to the network by pipes and 30% obtain water from private and public wells (Abarca & Valladares, 2011).

It is estimated that one out of four houses (about 7,000 households) are connected illegally to the distribution network. In 2010, just 44% of the production was invoiced (Hansol EME, 2010), this figure is worsening the financial situation of ENACAL. Despite being a public entity it is mainly externally financed. ENACAL plans to invest 430,000$ between 2014 and 2018, 43.29% will be financed by loans; 40.13% of it will be financed by foreign donors, 15.31% by the government and just 1.27% will be self-financed by the company (Gobierno de Nicaragua, 2014). Just the 7% of the budget the municipality of León receives from the central government is intended for water and sanitation (L.Escorcia [ENACAL], personal communication, November 20, 2014).

Figure 6. Discharge from Sutiava wastewater plant into Chiquito River (Own image)

In the urban area of Leon around 73% of the population has access to proper sanitation facilities; this figure drops to 16% in rural areas affecting around 8587 households. These figures are from 2010, it is expected to reach 86% and 58% respectively in 2015. There is presently no up to date data available (Abarca & Valladares, 2011).

Leon has four wastewater treatment plants, Sutiava (Figure 6), El Cocal, San Isidro and San Carlos. Only the first one dumps its effluent into the Chiquito River. Although the Sutiava plant is capable to treat 6,400 m^3/day, it receives 15,516 m^3/day and treats 8,000 m^3/day (Lezama Cortes, et al. 2007). The difference of around 7,516 m^3/ day contributes to the negative performance of the system. This plant has four ponds, two for primary treatment and two for the secondary treatment. Its design does not address the treatment of fat and solid elements (Munguía et al., 2007).

There are different aspects influencing the

actual performance of the wastewater plant. The local government cannot afford proper maintenance. In addition, there are safety problems. Some of the technologies scattered through the plant, donated by the twin town of Luxembourg, are not working any longer. The robbery of metallic pieces is the main reason. There are installations out of use for this reason. The sand removal and the crematorium had their lids stolen. A hydraulic turbine stopped producing electricity because of the disappearance of elements and the lack of maintenance. The plant is easily accessible, there are not proper fences to protect the site. Thefts are committed by inhabitants who occupied the land (property of ENACAL) surrounding the plant years ago. Workers of the treatment plant accuse them of throwing waste to the stabilization ponds, such as tires, causing operational problems. They also become a threat for the workers (R. Mercado, personal communication, September 30, 2014).

Leon faces serious problems regarding sanitation and the environment. The insufficient treatment of the municipal and industrial waste and wastewater are the main causes. A particular case is the pollution of the Chiquito River, the causes of this issue are explained in detail in chapter five.

C. Roads

The paved roads in León are in acceptable condition. However they lack proper maintenance. The municipality is in charge of development and maintenance of the streets. The main problem occurs during the rainy season when the drainage system collapses with the waste and the streets flood. The urban storm water runoff ends up in the river, drawing not only the waste from the streets, but also the pollutants from traffic. In the periphery there are still many roads without paving, many improvements have occurred in recent years, however the unpaved roads amount to 54% of the total number. Some rural areas lose their means of communication during the winter which impedes the commercialization of the agricultural production.

D. Migration

Migration is associated with different causes - natural disasters, epidemics, seeking a better quality of life and searching for more productive land are among them. Nowadays the leading causes of migration in León are looking for alternative job opportunities and for more fertile agricultural soil. Unemployment plays a crucial role even in rural settlements. The lack of alternatives of work during the disruption in the agricultural cycle provokes the exodus of the community. This happens regularly during the first months of the summer (November to January). The few available options influence the mind-set of the inhabitants who are forced to await the next productive cycle or to migrate to the city.

Commonly, the major part of the rural population does not own land. Inhabitants borrow land from the few owners in the area to produce self-subsisting crops. During the rest period, farmers habitually migrate to the city; women seek to work as domestic help and men in carpenter and bricklayer jobs. Residents with more possibilities travel to Costa Rica or the United States with the same aim. The rest of the year migration reaches low levels.

E. Land tenancy

In the past, families obtained rural titles trough cooperatives, those titles proved the registration and legal character of a certain land . When the cooperatives disappeared the rights on the land became individual and private property rights instead of being under the cooperative registration. Just 50% it is recorded on the Land Registry. Most of the families are not able to legalize their land because of economic reasons. Only the families with severe economic problems sell their rural properties, causing a permanent migration from the rural areas to the city. There are still many conflicts, of difficult solution, when it comes to trade the properties such as boundaries issues, double ownership, verbal contracts or invasion of land.

Urban areas are regulated by two laws; Law 85 and Law 86. The Law 85 establishes housing properties in favour of who was occupying them until February 26 of 1990. The Law 86 deals with plots destined to the construction of buildings. The basin is compounded by approximately an area of 130,000 m^2 (88,3%) which are property of the central government, 11,000 m^2 (7,4%) that count for the municipality and 6,250 m^2 (4,2%) of private property, all these areas are legally registered in the Register of the Property (Lezama Cortes, et al. 2007).

F. Economical productive activities

The watershed is characterized by a low productive potential. The soil has suffered from intensive use during the last decades. In addition volcanoes produce an accumulation of sand on the land and the forests have been enormously depleted. These factors have caused an imbalanced environment.

The main part of the watershed's rural soil is dedicated to cultivate peanuts, a high mechanisation crop. Small and medium producers cultivate corn, sesame seeds and yucca. Families cultivate vegetables and citrus for their own subsistence at first, nevertheless surplus is commercialised.

This activity generates low incomes and has plenty of limitations such as the lack of water in summer, the proliferation of plagues, lack of financial support for the producers, difficult access to loans and little technical assistance. Even though some farmers make use of improved seeds and implement techniques for the conservation of soil and water, the use of chemical fertilisers is widespread. The production in either case is still low as the soil is already very damaged. During the droughts the crop yields become drastically affected.

The commercialisation of crops represents the main income for the producers. However, the means invested by the producers are hardly recovered. The commercialisation lacks safe channels and market prices fluctuate readily. This situation does not allow farmers to improve their standard of living. Hardly ever producers contract day labourers for working on the field, the workforce is usually composed by family members.

Animal husbandry is not widely practiced. The main intent is to milk production. Cattle graze on the fields owned by the farmers. It is common to own small animals and horses for using as animal traction.

In recent years unemployed people have found a source of income in the lumbering of wood. This circumstance has accelerated the deterioration of the environment. The pace of

deforestation is such that the few remained forested areas are under threat and the natural regeneration is impeded. In addition, illegal forest activities with commercial purposes are carried out using aggressive techniques. The economic activities carried out in the urban area are mainly commercial activities followed by services and finally industry.

Industry on the riverside of Chiquito River has decreased in the past years. Effluents from tanneries have been pointed out as the mayor problem for the river (Abarca, personal communication, August 19, 2014). Therefore the next chapter analyses the legal framework for waterbody conservation and the legislation regulating industrial activity in tanneries.

4. Local and national legal framework

Industry must fulfil standard values regarding the quality of effluents (Decree 33-95). Tanneries do not have a Technic Norm which regulates their activity as it occurs with the slaughterhouses (Technic Norm No. 05 001-99). Setting up, expansion, retrofitting or relocation of a new tannery must follow the Decree 79-06.

The rest of activities are normed trough other laws of a more general scope. The following section is an analysis of the legal framework affecting industrial activities on the riverside.

4.1. Legal framework

a. General application

- General Law on Environment and Natural Resources of Nicaragua No. 217 (1988)

This is the environmental law with national validity. It establishes norms for the conservation, protection, improvement and restoration of the environment and natural resources. Chapter II, from article 72 to 94, is dedicated to water usage, consumption and protection.

- Penal code, Title XV, Crimes against nature and environment. Published in the official gazette No. 86, May 8, 2008.

The penal code includes crimes defined in the special Law against the environment and natural resources (Law 559).

- Decree system of Environmental evaluation, Decree No. 76-2006. Published in the official gazette No. 248, Dec 22, 2006.

This decree establishes the procedures that the environmental and natural resources Ministry (MARENA) uses to grant environmental permits, which are part of an environmental impact study. Tanneries processing more than 50 hides per day are included in category two and must conduct an environmental impact study, whereas tanneries processing less than 50 hides per day are included in category three and are obliged to realise an environmental valuation through MARENA.

b. Generation and disposal of residues

- Basic law for the regulation and control of pesticides and hazardous substances. No 274. Published in the official gazette No. 30, Feb 13, 1998.

This law regulates the use of hazardous substances, establishes institutional competences and assures the protection of agricultural production, human health, natural resources, safety and hygiene at work to avoid

harm deriving from an improper use or selection of these substances.

- Technical Norm on the use treatment and final disposal of non-hazardous solid waste. NTON 05 014-01.

This norm came into force in May 2002 and establishes the technical and environmental criteria to be fulfilled executing projects regarding the usage, treatment and final disposal of non-hazardous waste to protect the environment. It applies nationwide.

- Technical Norm on the use, treatment and elimination of hazardous solid waste. NTON 05 015-01.

This norm establishes the criteria for storing, handling, transporting, treating and finally disposing hazardous solid waste generated from industrial activities among others.

c. Use of water and effluent generation

- General Law of national water. No. 620. Published in the official gazette No. 169, Sep 4, 2007.

This law constitutes the legal framework to administrate, conserve, develop and to sustainably use all the hydrological resources of the country. It aims to protect (volume and quality) of water resources of any kind.

- Maximum levels of pollution in domestic, industrial and agricultural effluents. Decree 33-95. Published in the official gazette No. 118, Jun 26, 1995. Article 41.

The values established in this decree show the maximum levels of certain pollutants allowed in domestic, industrial or agricultural effluents collected in the sewerage or dumped into waterbodies. Following Table 3 shows the parameters allowed in the effluents of tanneries, before they are discharged into waterbodies.

4.2. Competences of main institutions

The Ministry of environment and natural resources (MARENA) establishes the regulation of environmental management. Its action frame is based on the law 217 and the law of organization, competences and procedures of the executive branch.

Law 40 and 261 set the competences for the Municipality. Article 6 states that “municipalities have competences in all branches regarding socio-economic development, environmental and natural resource preservation on its territory.” Article 7 section 8 establishes, that it is a local government task, to “develop, conserve and control the rational use of the environment and the natural resources as a base for a sustainable development of the territory and the country, encouraging local initiatives in these

Table 3. Maximum values of Physical-chemical parameters in effluents in tanneries (Decree 33-95)

Physical-chemical parameters	Max. limits or ranges
pH	6-9
Total Suspended solids (mg/l)	150
Sedimentable solids (mg/l)	5,0
Biological oxygen demand (BOD) (mg/l)	120
Chemical oxygen demand (COD) (mg/l)	250
Total Chromium (mg/l)	10
Sulphurs (mg/l)	0,2
Phenols (mg/l)	0,1
Oils and fats (mg/l)	30

areas and to promote their monitoring, surveillance and control in coordination with the national entities". Section 5 of the article 28 delegates the creation and approval of ordinances and municipal resolutions to guarantee the hygienic and sanitary conditions in the community to the Municipalities. The local government must also formulate ordinances for the protection of the environment, with special focus on drinkable water sources, soil, forests and the elimination of waste.

In the law 217, articles 16, 25 and 27, the competences of the municipalities regarding environmental impact assessments are mentioned. Activities which can potentially deteriorate the environment such as construction works or industrial activities must obtain an environmental permit granted by MARENA.

As it is set in the law 217 , articles 34 to 36, the Ministry of education culture and sports should promote environmental awareness by including this topic in educational programmes.

Section VII of the same law explains the incentives offered to people or institutions who achieve special merits towards the protection of the environment and natural resources, for instance exoneration of taxes.

The law 228 on the National Police establishes in the article 3 section 6 the obligation of cooperation and coordination with other institutions such as MARENA, Municipality and regional governments in the protection of the environment. Military forces must also help in this matter (law 281, article 2 section 7).

Table 4 lists the institutions together with their area of competences within the laws and regulations of Nicaragua.

4.3. Why the environmental laws do not take affect in Nicaragua

The reality shows that the law's potential for solving water conflicts has given little results. The transaction cost of the coordination between institutions, the difficulties on gathering information or the weak protection of property rights are some of the principal drawbacks. Besides, agricultural lobbies exert pressure on the legislative authority and block the appointment of strategic vacancies in the newly created institutions. Nevertheless, the root of the problems lies on the inconsistency of setting advanced water related objectives on weak institutions (Novo & Garrido, 2010).

The difficulty of achieving environmental justice in Nicaragua resides in the difficulty of finding

Table 4. Localization of institution's competences in the Nicaraguan laws (Own elaboration. Source: Abarca, Valladares, 2011)

Institution	Regulations - competences
MARENA	General law 217 of the environment and the natural resources. Articles 21 and 22
Municipality	Law 40 and 261 of the municipalities. Articles 6, 7(8), 16, 25, 27, 28(5)
Ministry of education, culture and sports	General law 217 of the environment and the natural resources. Articles 34 to 36
MIFIN	General law 217 of the environment and the natural resources. Section VII
National police	Law 228 on the national police corps Article 3 (6)
Nicaraguan Army	Law 181 of the Code of military Organization, Jurisdiction and Social prevision Article 2(7)

complete solutions to environmental problems. There are several factors which negatively affect achieving these solutions. For instance, financial resources are insufficient to ensure the evidence. The laws are complex and these are subject to broad interpretation (Burhenne-Guilmin & Nazrul, 2002).

Municipalities began to obtain more competences in the late 1980s. Local governments are more aware of the needs and problems than national governments (Larson, 2004). Although the law 40 and its modifications show that municipalities play the main role in the management of natural resources, the water law has still not been implemented completely at municipal level. The central government intervenes in the competences of the municipalities, controlling and making important decisions for them (Somarriba, 1993). Despite taking into consideration the difficulties to face, it is more feasible that advances in the implementation of water laws follow a bottom-up approach rather than a top-down one (Novo & Garrido, 2010).

Local governments need three key elements to manage their resources in a successful way; capacity (technical, financial and legal), incentives and interest (Larson, 2002). The weak incentives to develop infrastructure and projects in developing countries make the services delivered to the population falling far short of what could be achieved. Corruption, imperfect monitoring (if existing) and administrative blockages are just more factors to add to this equation (World Bank, 2002).

Society also plays a crucial role in environmental and resource conservation processes (Larson, 2002). Involving poor people in the service delivery has shown good results in order to invert this pattern (World Bank, 2002).

The new law represents a serious attempt to clarify and reorganize the roles of government branches, independent agencies, users' organizations, and territorial administrative agencies (Novo & Garrido, 2010). 'Without better policies and institutions, social and environmental traces of the society and its institutions may impede developmental progress, leading to higher poverty levels and a decline in the quality of life for everybody' (World Bank, 2002).

5. Analysis of causes and effects of the pollution of Chiquito River

5.1. Problem tree

The next page shows the problem tree (see Figure 7). The box in the centre represents the problem, in this case the pollution of the water of the Chiquito River. The boxes below show the causes of this problem and the ones above its effects.

This paper focuses on the causes represented in the third column of the diagram, the industrial wastewater dumped into the river without previous treatment. As it can be seen, the overall problem is very complex and the origin of its causes very broad.

The industrial effluents content a high volume of toxics. These effluents are considered to be one of the major causes of the pollution. In addition to this source of pollution, the volume of solid waste ending up in the river basin, the sewage filtrations coming from the failures in the sewage network and the runoff of the city wastewater

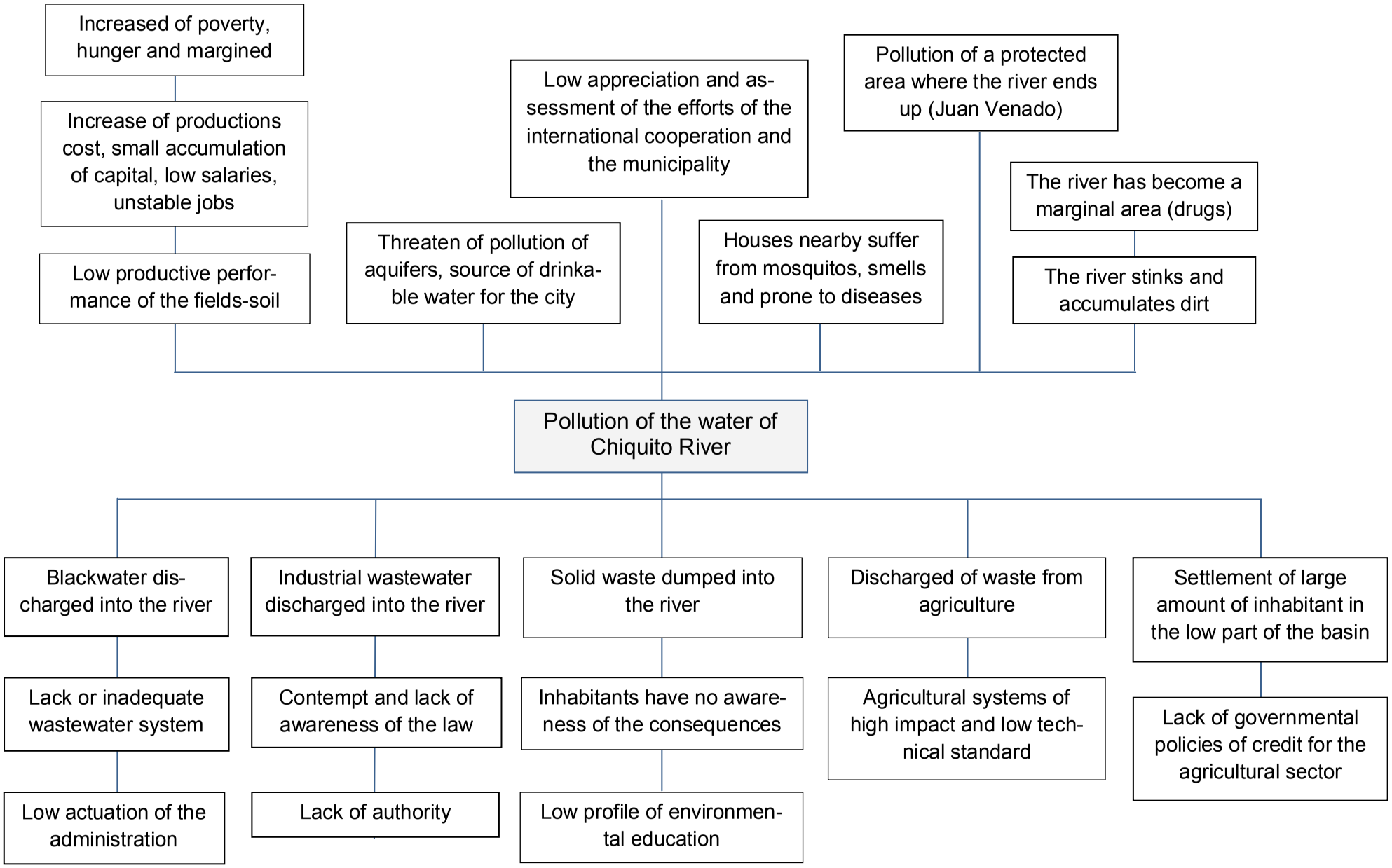


Figure 7. Problem tree. Own elaboration (Munguía et al. 2007) & (Own compilation)

plant are also considered important polluting factors (see Figure 8). The weak institutional frame favours these situations to be sustained over time. Institutions have little capacity to provide proper service and to reverse the situation.

The pollution in Chiquito River produces obvious environmental issues as well as health threats derived from the dirt and the filtration of toxics into the groundwater reserves. Social concerns about the pollution of the area have also risen since the river has turned into a marginal space where drugs and delinquency coexist. The river is never frequented by the majority of the citizens of León (Jährling, 2014).

5.2. Stakeholders' presentation

The management of water resources in Nicaragua has traditionally been very fragmented among different institutions. Given this scenario, obligations frequently overlap and remain unclear (IWRM, 2012). Institutions are viewed as instruments for interpreting and transforming information into knowledge. This is a challenge in most countries with obsolete and poorly functioning water institutions (Saleth & Dinar, 2004).

The crisis in the water sector has revealed the limitations of institutions dealing properly with problems regarding natural resource allocation and management. In the case of Nicaragua, the allocation and conflict-resolution mechanisms have to be strengthened or in most cases created, in both legal and policy areas. Water institutions, which define the rules of water development, allocation and utilization, have to be reoriented to respond to current realities in terms of supply/demand and quantity/quality balance. The water administration and decision makers have to learn how to involve the strong role from independent groups (user organizations, nongovernmental agencies…) as well as to open processes to ease the use of emerging water technologies and new information tools (Saleth & Dinar, 2004).

Environmentally focused institutions lead the efforts to both understand the causes of environmental problems and to formulate responses to these problems that have a reasonable chance to succeed. At the same

Figure 8. (From the left) A tannery's pipe discharging on the river. A blocked manhole on the riverbank. Solid waste accumulated on the river's edge (Own images, 2014)

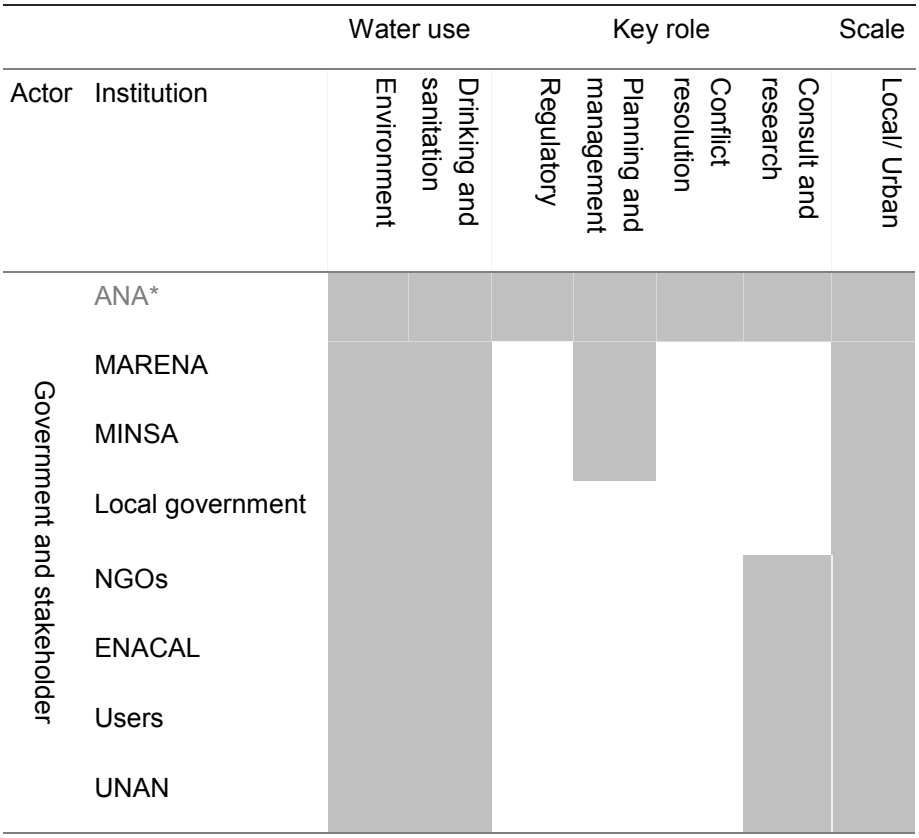


Figure 9. Institutional mapping (modified from Novo & Garrido, 2010)

time the role of inefficient regulatory systems is pointed out as the cause for major environmental problems. In these cases institutions are seen as the sources of such problems. It seems logical to respond to these problems with institutional reforms (Young, 2003).

The environmental municipal plan of León 2008-2018 (Lezama, 2008) analyses the local capacities to achieve a proper environmental management in León. It distinguishes and assesses two commissions or organizations. Firstly the Municipal Environmental Commission (CAM) comprised of nine institutions including local and central government, organizations of cooperation, councilmen and community leaders. This commission oversees the planning and monitoring of environmental activities with the technical and administrative support from the Environmental management direction (DGA). The DGA should be composed by nine people. It guarantees the coordination among national institutions, such as MARENA, whose activity, if of local relevance, relates to the conservation of the environment. In the same document, Lezama credits both commissions with an overall good performance, but he also shows that the DGA is composed of one member. However, it was difficult to find information to corroborate the real scope and activities of these organizations.

Novo and Garrido (2010) generated a table to show the protagonist who take part in the regulation, planning, management, financing and research on water issues in Nicaragua. This table has been modified to fit the case of León, and the scope of this paper which is looking at a local scale and only taking into consideration the institutions which have their head office in León

and have participated in generating the outcome of this paper (See figure 9).

During the interviews conducted for this research, institutions and their workers have pointed out the difficulties that they often face in order to accomplish their duties. These are not only economic reasons, such as a lack of resources, but also privation of freedom in order to put laws and regulations into effect.

5.3. Future strategies regarding wastewater management of the main Institutions in León. Municipality, MARENA and ENACAL

This section shows and analyses what actions are to be undertaken in the river basin by the main institutions in relation to the sanitation of the city.

A. The municipality

The Municipality has elaborated a strategic plan (Plan estratégico 2011-2020) summing up the goals to be achieved by 2020 regarding water supply and sanitation.

After a very detailed analysis of the situation, the plan shows the goals to accomplish. As initial and essential point, it states the need to strengthen institutions, organizations and stakeholders. The second topic in importance is the access to drinkable water. The plans seek a change in the behaviour of the society regarding the use and payment of water and water saving.

The plan also aims an integral access to sanitation, relying once more on the change of peoples' behaviour to achieve this goal. In the following points objectives are the improvement of rainfall drainage and the protection of the fluvial basins. It also calls for increasing the environmental education and the recurrent change of the current mentality in the society.

One of the goals of the municipality is to treat the totality of industrial wastewater before this is dumped into a waterbody. To protect the environment, the standard values established in the law must be fulfilled. The project devised by the municipality in this plan targets mainly the discharge from the tanneries.

B. ENACAL

ENACAL presented a study in 2010 called "Feasibility study of the wastewater network in León Nicaragua" (Hansol EME, 2010). The afore mentioned strategic plan drafted by the municipality, made use of information from this study.

This study presents an analysis of the situation regarding water supply and wastewater generation and treatment in León. It estimates the volume of wastewater that is expected by 2030, distinguishing between its origins; industrial, commercial, governmental and residential.

Hansol (2010) estimates the volume of industrial wastewater in relation to the volume of domestic wastewater. The domestic wastewater volume data is taken from a previous report. For a population of 166,454 in 2030 the study determines as unitary volume of domestic wastewater 160 litres per capita per day (Lpcd) (Feasibility study of the wastewater network in León, 1996). Hansol (2010) assumes that 2% of this volume will amount to the industrial wastewater generated by the city of León in 2030.

This rule (assuming the 2% of domestic wastewater) is used to estimate the volume of wastewater for the population targeted in this paper (37,122 inhabitants, estimation in page 11 line 19). It results in around 20,000 litres of industrial wastewater per day.

The future strategy compiles the expansion of the wastewater network to the areas without connection to the sewage system and the expansion and new construction of wastewater treatment plants. It is explained that, considering the increase of population, the actual network will not be able to treat the volume of wastewater generated.

However, ENACAL, after estimating the volume of the wastewater of all sort, does not differentiate in its strategy among different ways of treatment. It suggests (due to omission) that all effluents will receive treatment in the same plant. In plants of the present technological level, industrial effluents may not receive appropriate treatment (analiza calidad, n.d.).

The approach of the municipality, together with BORDA and the other participants in the pilot project, is to decentralize the treatment of the effluents from polluters such as tanneries.

There are three possibilities in order to treat industrial effluents. The first is the one chosen by ENACAL, treating industrial effluents together with black-water from households. The second option is the treatment by the industry directly, a decentralized technology, chosen to feature in the pilot project of the slaughterhouse. And the third option is constructing a plant only for treating industrial wastewater. The characteristics of the effluents of individual industries, legal restrictions, the cost of the disposal of the wastewater and the cost of the actual treatment will lean the decision towards one option or another (analiza calidad, n.d.).

This report and strategy from ENACAL has been in the drawer for five years (personal communication). Neither initiative nor activity has taken this information or plan into action.

Municipality and ENACAL hold two completely different approaches regarding wastewater treatment. The two institutions should be working together in developing the infrastructure of León. This in my opinion shows the lack of understanding and insight.

Since León is still starting to build the environmental strategy for its future development, institutions should make use of modern tools, according to their financial possibilities, for stopping the abuse of natural resources and to find a solution for the problem of environmental sanitation and urban water management. Frequently, it has been found that preventing the problem is easier and more economically feasible than solving the effects once they are generated (Giraldo Gómez, n.d.). Decreasing the volume of water in contact with industrial effluents is understood to be a better approach.

C. MARENA

The ministry of the environment is currently involved in a project with a deadline in February 2016. This programme is called "Sustainable management of water and soil resources in priority areas of the basin 64, departments of León and Chinandega".

The plan aims to strengthen local capacity for facilitating the adaptation to climate change repercussions and to mitigate its effects. It targets soil and water management through the implementation of sustainable production systems. The strong educational component translates into the implementation of training programs and an increase of awareness about environmental issues in the society. MARENA intends to involve the private sector (large producers) for the rational use of water. It also aims to improve access to drinking water in rural communities affected by drought implementing actions to manage and restore areas of groundwater recharge.

The reality observed in León one year before this programme is coming to an end does not meet the expectations described above. Industries on the riverside receive ineffective pressure from the institution. The application of regulations contained in the environmental laws is far from being a reality. Workers from the institution find it difficult to carry out their work.

Even though little progress has been achieved, the institution follows an annual operative plan which obliges to carry out regular inspections to the tanneries. Those interventions must be conducted with the presence of members from the police, military force, municipality and MINSA (Díaz, personal communication, September 19, 2014). In practice, only a technic from MARENA and a municipal official carry out these inspections which consist of a series of questions regarding machinery and volume of production that in the end have no short term repercussion (see Figure 10).

Figure 10. An inspector from MARENA during the inspection of a tannery in León (Own image, 2014)

6. Presentation of the pilot project and previous cooperation projects in the area

6.1. Pilot project: A model project for sustainable management of residues in the municipal slaughterhouse

The Senate of Hamburg, Engagement Global (Bonn), BORDA/Bremen and the technological university La Salle (ULSA) supported the partnership between Hamburg and the city of León in Nicaragua in the planning and implementation of a sustainable sanitation system for the municipal slaughterhouse in León.

The project aims to be a model example. The knowledge gained during its planning and construction is intended to be useful for developing future projects of similar characteristics in the Chiquito River as well as other industrial areas in Nicaragua.

This master thesis materializes the strong bond between this project and educational institutions. The facility is aimed to be used by local

educational institutions for researching and internships. Using a real example will benefit both sides, students learn from dealing with a real project, while also generating a valuable set of data (see figure 11).

Figure 11. Students visiting the installations of the slaughterhouse with BORDA and the renewable project coordinator form La Salle. (BORDA, 2014)

Previous to the start of the pilot project, the working process in the slaughterhouse was rather alarming and the facility lacked a sanitation concept. Fifteen years ago, a decentralised wastewater system was constructed in the slaughterhouse. This system failed for many reasons, mainly due to a bad concept and a lack of maintenance. It was designed with two electrical pumps. The shortages of electricity were numerous at that time stopping the pumps and harming the smooth running of the plant. The system also lacked a proper filtration device. As a result, solids entered the digester damaging the pumps. Lastly, the covering of the digester was a textile which was easily damaged and not repaired. In addition neighbours complained about odours released from uncovered ponds and basins. The system stopped working after only one year of operation (see Figure 12).

An inspection was carried out in the slaughterhouse in January 2013. This was the starting point of the current pilot project. An illegal connection conducted the wastewater from the slaughterhouse to the domestic sewage system. This connection provoked blockages in the domestic network which caused overflows in manholes. The inhabitants living in the area were exposed to odours and diseases. The extra volume of wastewater together with its high content of biological matter was affecting the wastewater plant of Sutiava which was not designed for treating this kind of effluents.

The slaughterhouse is a public institution, however, its operation resembles more a private industry since the municipality does not control the activity in it. Private stockmen hire slaughters who work independently. The local government's duty consists of renting the facility and security matters. At that time the slaughterhouse self-supplied the water needed for the process through a private well. This implied that neither a fee for the water used nor for the wastewater disposal was paid.

After the inspection the municipality was in

Figure 12. Infrastructure of the previous DEWATS in the slaughterhouse (BORDA, 2013)

charge of bringing the decentralised system back in use. They contacted the office of sustainable projects in La Salle. Its coordinator contacted an expert in biological treatments for bio-waste working in the university of Managua (UNI) who at the same time approached BORDA seeking support. BORDA finally drafted the project. The project was presented in the city of Hamburg who consequently sought for further financial support.

After taking into consideration the initial budget, the project focused mainly on the creation of a wastewater treatment plant for the slaughterhouse. Later the objective was expanded to achieve improvements in the slaughter process, which will be explained in detail in the next chapter. At present, the utilisation of the treated water in urban gardening and the increase of participation from educational institutions are important objectives of the project .

Since the beginning there was an interest in reusing the infrastructure from the previous project. As a result, the concrete structure with baffles, the biogas tanks and a third concrete basin were modified to be included in the new design. In Figure 13 the schemes of both systems are shown and the reused components highlighted.

The water coming from the slaughter process contains solids that must be separated before arriving to the first stage of the DEWATS. For these purpose the installation has gratings to cover the drains, these gratings must have proper maintenance and regular cleaning.

The actual treatment consists of three phases during which the wastewater generated in the slaughtering process is treated (see Figure 14). As a result, the output can be used for irrigation or disposed in a waterbody with no risk.

Firstly the effluent is pre-treated in a biodigester settle. There, the suspended solids sink by sedimentation to the lower part and are digested

Figure 14. Pilot project, from the left horizontal filter, Filter reactor and tank for slurry (BORDA, 2013)

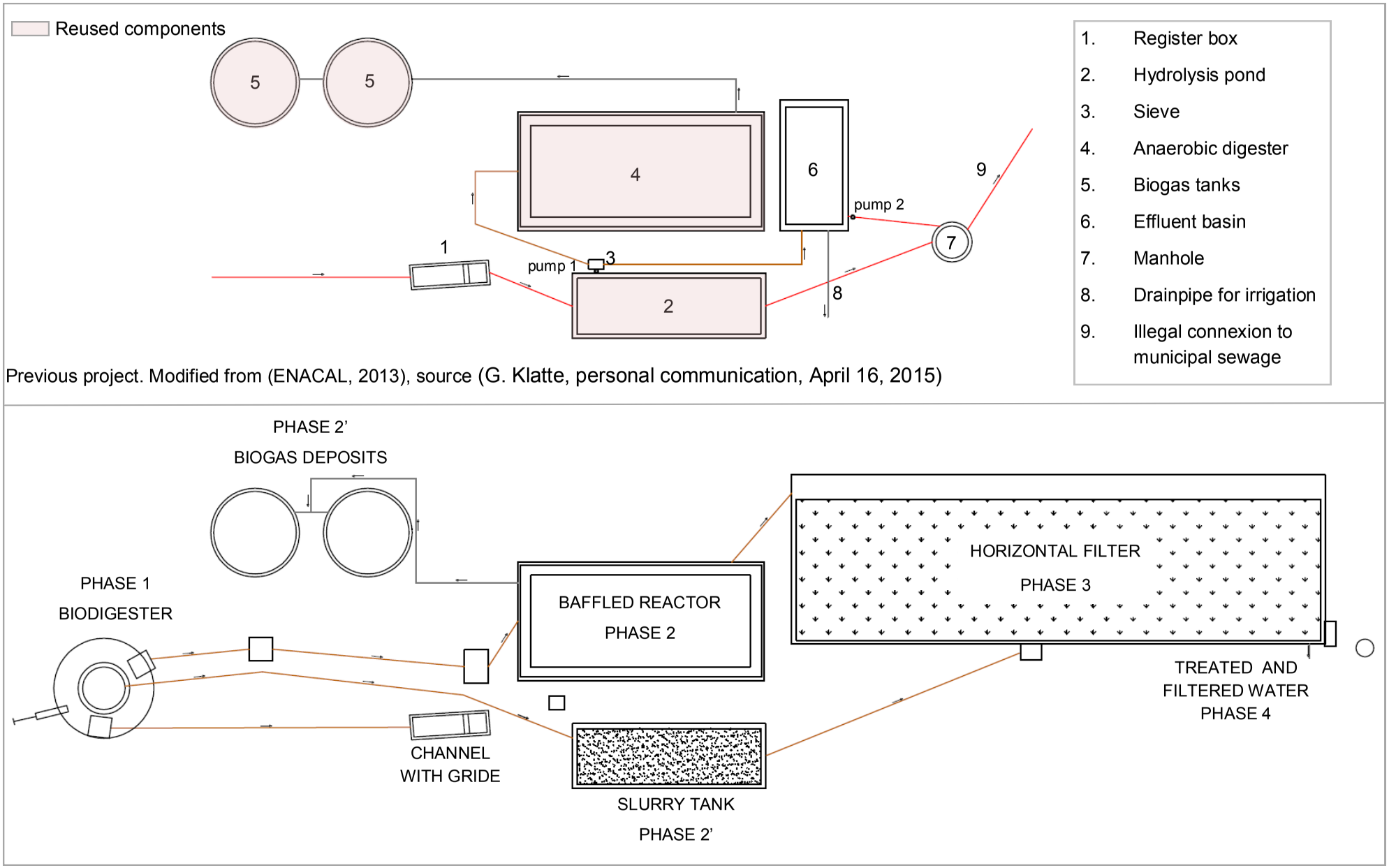


Figure 13. Schemes of the previous and actual wastewater projects in the slaughterhouse of León (ENACAL, 2013 & BORDA 2014)

in an anaerobic process. From here the liquid phase is conducted to the anaerobic filter with eight filtration chambers in series where the wastewater is filtered and the organic matter further degraded by active biomass that is attached to the surface of the filter material. This degradation is also anaerobic, consequently biogas is produced and collected in two tanks for being used as fuel during some phases of the slaughter process. The slurry produced in the biodigester is conducted to a tank where heavier matter drowns. From there the liquid phase pass to the gravel horizontal filter to receive further treatment.

Once the water leaves the horizontal filter will be used to irrigate urban gardens in the surrounding area and the surplus will be properly discharged into the Chiquito River.

For the calculations of the volume of the system, an important reduction of the water consumption has been taken into consideration after the installation of three pressure washers. The use of these washers instead of normal hoses has decreased the water consumption in the slaughter process from 30 (CPmL-N, 2008a) to 25 m^3 per day (V. Luchmanova [BORDA], personal communication, November 20, 2014). However, the decrease of water usage for washing the tripe it is still pending. The overall water consumption is expected to be lower.

6.2. Previous projects in the area of Río Chiquito

During the last 30 years different twinned cities have promoted numerous projects in León to improve the situation in many areas. There have been various initiatives regarding access to sanitation and reconditioning the river, some of them large-scale.

The structural Master plan for the municipality of León developed in the early 90's, promoted by the cooperation agency of Holland, targeted the topic of territorial planning (See Figure 15). This plan has been the technical guideline for further plans such as the "Municipal development plan 2002-2006". As a result of this first Master plan 14 strategic projects were defined, the "Integral development of Río Chiquito" was one of them (Flores, 2006). The following points explain activities funded and supported by different institutions that belong to this overall project, managed by the municipality.

Figure 15. Dutch delegation visiting Chiquito River in the 90s (van Dongen, 2011)

A. Project for the integral development of the Chiquito River sector

This project was promoted by the links between the municipality, Zaragoza and Ecology and Development Foundation (ECODES by its initials in Spanish). It aimed to end up with the proliferation of diseases on the riverside, the extended pollution and social marginalisation to convert the river into a space to be used by the community, integrating the north and south of the city (Lezama, n.d.).

B. The twin city of Hamburg has been focusing on the development of domestic sewerage in several neighbourhoods on the river side. It has constructed 3,700 connections between houses and the sewerage (Lezama, n.d.).

C. The twin city of Basque Country built septic tanks in four areas of the southeast of León where the collectors were unable to reach.

D. Twin city of Utrecht has developed big scale projects in the area: "Treatment of industrial waste (of tanneries) and relocation of polluting (tanning) industries" starting in 1994 and the subproject for recovering the chromium used in the industrial process of the biggest tannery in León "La Batán", currently out of service.

Within the project about treating industrial waste from the tanning industry and relocating the small scattered tanners, major emphasis was put on the technical and mental preparation of the tanners and feasibility from a socioeconomic point of view. The situation of the industry at that time was really different to the present one, mainly regarding the volume of production, the relocation was planned for 18 small tanneries, 5 bigger ones remained in the same location (Ortiz & Sarría, 1995). A study by CONAPI (Chamber of Commerce for medium and small industries) counted 29 small tanneries at that time, 7 of which were out of production (as cited in Lezama, n.d.).

At that time the industrial pollution had the following profile; 15% was caused by the small tanneries, 48% was caused by the 5 bigger ones and the remaining 37% was caused by the slaughterhouse. The pollution of the big tanneries was less visible because the effluents were canalised before entering the river but they were the bigger source of pollution (Lezama, n.d.).

At the same time an Austrian delegation was involved in the construction of the collectors (See Figure 16) for collecting domestic wastewater. Good coordination between them was needed in order to plan the connection of the big tanneries which were not to be relocated.

The decisions made and actions to be taken were the following:

a. The bigger tanneries, not suitable for the relocation, would be technically updated and better equipped in order to prevent clogging up and corrosion of the concrete sewerage pipes. The chromium would held back in the sediment, that would be removed regularly. The oxidation processes would take place at the end of the collectors in the oxidation ponds, still to be constructed at that time. Although a pilot project

Figure 16. Wastewater collectors by the river financed by Austrian cooperation in the 90's (Own image, 2014)

in the biggest tannery (Bataan) was accomplished the treatment plant was just around four years in use. It was planned that this big tannery coordinated and co-financed the replication of this pilot project in other smaller ones. The project was not followed up by the local administration and the duplication never took place (S. Velasquez [Engineer in the municipality], personal communication, April 2, 2015).

b. The smaller tanneries would be relocated to an area in the south western part of León, with collective homogenisation/sedimentation basins and an oxidation pond (the collectors were planned too far from the new location). The relocation aimed to improve the tanning techniques used by the small tanners at that time.

The relocation actually happened. The process faced difficulties (Somarriba, 2014). Those facilities are still in use by six small tanners. Some still maintain the previous location making use of both facilities even though the tanning pits which were no longer in use were destroyed to prevent this situation (see Figure 17).

Nowadays the effluent treatment system in the new location is not in use. It failed due to lack of maintenance several years ago and was never fixed. As a result, all the effluents reach the river without treatment (A. Canales [worker at the Carlos Alvarado cooperative of small tanners], personal communication, September 30, 2014).

During and after their relocation, the small tanners received technical and financial support. All the small tanners, which belonged to a certain cooperative, were invited to participate in the whole process. They had a representative committee. The committee agreed with one of

Figure 17. Old destroyed tanning pits (Own image, 2014)

the proposed sites for relocation and participated in the decisions about the facilities and the equipment. The design of a first demonstration and training tannery was made using the experience and knowledge of one of the best small tanners. There, the small tanners received a small training before moving into the new facilities.

After this experience the remaining small tanners who did not belonged to the initial cooperative got together and set up a new cooperative. They required the same privileges than the others but the reality regarding the international cooperation was very different and this was finally not possible (Somarriba, 2014).

At that time the slaughterhouse was involved in the possibility of being relocated with funds of the Spanish International Cooperation Agency AECI/ICI, but it was not included in this project. More aspects about this situation are explained in point 7.1. of this paper.

Somarriba (1993), an engineer from the municipality and director of the development of the Rio Chiquito project, wrote a review about it leading to the following conclusions:

- Programmes related to training municipal and institutional staffs at local level must be implemented, with the aim of improving the project's results.

- The comprehensive settlements development strategies must consider income generating activities. Somarriba observed that progress was made regarding the role and the importance given to communities in that project. However, real community participation was lacking since the community's right of decision-making had limitations.

The municipality was lacking proper experience. The failures occurred in the local economic development programmes executed were caused by the municipality's decision of self-managing such programmes. Therefore, Somarriba recommends that these programmes must be conducted by NGOs, which have sufficient expertise to handle them.

These conclusions come from the analysis of the following key variables. In most cases these factors are repeated in the present situation. The variables should be considered if the current pilot project in the slaughterhouse turns into a larger project.

a. Lack of community involvement

Community participation in the project was weak. The decision-making role allowed to the community in the process was minimal. Its proposals and suggestions were not taken into consideration. Of course, this caused delay in the implementation stage.

b. Low affordability levels / high unemployment rates

In the area a high proportion of the population was unemployed, so even though the connection to basic services have been made, many householders could not afford to pay taxes for infrastructure use and/or the monthly fees for services.

c. Coordination and communication among institutions, NGO's and local government.

There was no communication or coordination among institutions, NGOs and local government, so all responsibilities for the project were faced by the local government. Clearly the local government was not prepared to take the responsibility so that in the implementation stage, this meant a series of shortcomings and failures.

The causes for this miscommunication were a series of changes in the organizational framework and personnel changes in the institutions. Besides, the government withdrew its support for the NGOs and consequently, NGOs had to reduce their operations due to the lack of funds.

d. Technical and executive capacity of the local government.

No technical procedures were used to define proper planning and programming. The project was not monitored during its implementation. In addition no feasibility studies were made prior to the investment which is why in the execution phase many activities did not have proper budget allocation.

e. Fund allocation

The local government was not able to accomplish the allocation of resources according to the programming due to the decrease of the revenues in the municipality caused by the

sharpening of the economic crisis.

f. Political context

The project was formulated during the former Sandinista government, defining responsibilities for the different protagonists involved in the project, however, the change of government and the frictions among the political groups at all levels did not permit coordinated actions.

The experiences gained in the first phase of the Chiquito River project allow us to learn some lessons:

a. There is a need of developing income generating activities.

Comprehensive development projects do not only imply emphasizing on the development of urban structure, but also on the fact that they must feature the generation of employment and thus an increase of income for the population. Otherwise no cost-recovery criterion can be applied.

b. Strengthening of the technical staff

There is a need for strengthening the staff of the municipality, both in number as well as their capacity and capabilities.

c. Contact with the population

The weak connection between population and personnel in charge of the project and the minimum level of the community's involvement in decision-making should be dealt with as crucial factors to achieve the project's objective.

d. Community representation

In order to overcome controversy among different party supporters at community level, it was necessary to consider the establishment of new organizational forms or neighbourhood committees without any political connection.

e. Sustainability of project activities

The minimum role given to the communities to decide on the direction of their own development and their concern for meeting other priority needs such as food, health care, etc. affected the right selection of the project objectives and performance. Besides there were difficulties in maintaining the facilities provided.

In Table 5 the analysis of the implementation of the first phase of the project of Chiquito River in the early 90's is shown. The variables for the analysis are taken in consideration as well as the conclusions which lead us to the actions that

Table 5. Analysis of the implementation of the Chiquito river project (Own elaboration. Source: Somarriba, 1993)

Variables	COMMUNITY INVOLVEMENT	COORDINATION/COMMUNICATION AMONG INSTITUTIONS, NGOs AND LOCAL GOVERNMENT	TECHNICAL AND EXECUTIVE CAPACITY OF THE LOCAL GOVERNMENT	FUND ALLOCATION, CONSIDER ECONOMIC SITUATION	POLITICAL CONTEXT
Conclusions	Lack of real community participation	Municipality was not ready to manage the programme		The strategies must consider income generating activities	
			Training for municipal and institutional staff is needed		
Lessons learnt	Increase contact with population		strengthening of the technical staff	Need of developing income generating activities	
	organize apolitical community representation				

need to be improved in future developments.

7. Production of pollutants, repercussions on the environment and measures that need to be taken

7.1. Detection of wastewater streams from the main polluters

The information obtained from the institutions in León and the literature analysed pointed at five main streams of pollution of industrial origin into the Chiquito River. In the last years, due to the financial crisis, the industrial volume has decreased drastically. The main sources of pollution are:

1. Sutiava wastewater treatment plant

As pointed out in chapter two the performance of this plant is not optimal. The discharge of its effluents represents the major threat in terms of volume for the river with an effluent of 19,008 m^3 per day (Hansol EME, 2010) . Table 6 shows the analysis of its discharge by Hansol (2010) (whose original source is ENACAL), the analysis executed by ENACAL in 2014 and the maximum values set by the Decree 33-95 for a urban settlement with more than 75,000 inhabitants. It can be seen that, regardless of missing variables such as suspended solids and COD, the values are higher than those allowed by the decree 33-95.

2. Municipal slaughterhouse of León.

This is also located in Sutiava and was founded

Table 6. Water quality effluent of Sutiava wastewater plant and values established in Decree 33-95 (Own elaboration)

	Decree 33-95	Hansol (2010)	ENACAL (2014)
pH	6-9	7,36	7
Electrical Conductivity (uS/cm)		-	665
Dilute oxygen (mg/l)		4,9	1,6
total solids (mg/l)		-	550
Suspended solids (mg/l)	80	-	125
Total oils and fat (mg/l)	10	14	9,2
Sedimentable solids (mg/l)	1	-	
Biological oxygen demand (BOD) (mg/l)	90	90,4	54
Chemical oxygen demand (COD) (mg/l)	180	279	219
total coliforms (MPN/100mL)*		1,10E+06	1,90E+06
faecal coliforms (MPN/100mL)*			1,90E+06
total phosphorus			3,27
Methylene Blue Active Substance (MBAS)	3		

(*) MPN/100mL most probable number in 100ml

in 1964. Currently, 750 cows and 450 pigs are butchered in this installation per month (Y. Velasquez [Municipality], personal communication, October 20, 2014). The amount of water used in the process was 1,671 m^3 per month, 1.85 and 0.63 m^3 per cow and pig respectively (CPmL-N, 2008a). Changes made on the facility have reduced the volume of wastewater to 750 m^3 per month. The effluent will be treated by the forthcoming pilot project and will not represent a future threat for the river any longer.

3. Tanneries

Tanneries are currently the most polluting industries in the area (Figure 18). They use a high amount of chemicals in the tanning process and will be the main focus of this work. Their relevance lies in the volume of discharge generated, 55 m^3 per day (CPmL-N, 2008b), the components of its effluent, the potential for improvement and the possibility of approaching a step-by-step solution. The total volume is generated by eleven different tanneries. Each producer has certain characteristics that do not allow the possibility of applying a unique solution to all of them. This factor might make implementation implementation, however the transfer of the project is intended to be staggered, this way, improvements and corrections can be done in further stages. The number of tanneries and their exact activity changed from one source to another. Compiling all of them and gathering relevant information was the strategy followed to determine the final list. Eleven locations where industrial effluents are being generated were detected.

4. Pig farms

Figure 18. Tannery Bravo, hides drying, on the foreground effluent flowing to the river (Own image, 2014)

Pig farms happen to be a well-known threat for superficial and ground water. The estimated volume of wastewater produced daily by pig farms that is dumped into the river, amounts to 12.15 m^3 (de Victorica Almeida & Galván García, 2006). There was only one pig farm detected, with approximately 800 animals, which dumps its wastewater into the river (Figure 19).

It is worth mentioning that two other medium size farms used to operate in the area during the last decade. They have stopped their production and nowadays their facilities are not registered as industries any longer. The attempt of getting to know about their actual volume of production only yielded elusive answers. Both owners claimed that their activities just covered their families' needs. The real number of animals held in these farms could not be proved.

Figure 19. Pig farm San Pedro (Own image, 2014)

Nevertheless, the owners answered three and nine animals in response to the questions regarding their respective volume. These figures seemed rather implausible in the eyes of my companions who knew the area and neighbours well. They explained that these farms are rather small and keeping themselves out of the official register is well worthwhile when it comes to pay fees and taxes.

5. Oil-soap industries

Oil-soap industries were in production at the end of the 90s. The sites visited were closed. A member of the municipality corroborated this situation (E. Palma [CIMAC], personal communication, October 31, 2014).

In conclusion a possible transfer of the pilot project is more likely to be aimed at the tanneries and ultimately to the pig farm.

The following map (Figure 20) shows the location of the aforementioned industries. More detailed maps of the different sites are shown in Figure 21 to 27. Tables by their side (Table 7 to 14) display the most important features regarding those industries and their production. This data has been gathered through the questionnaires realized to the tanners and the owner of the pig farm.

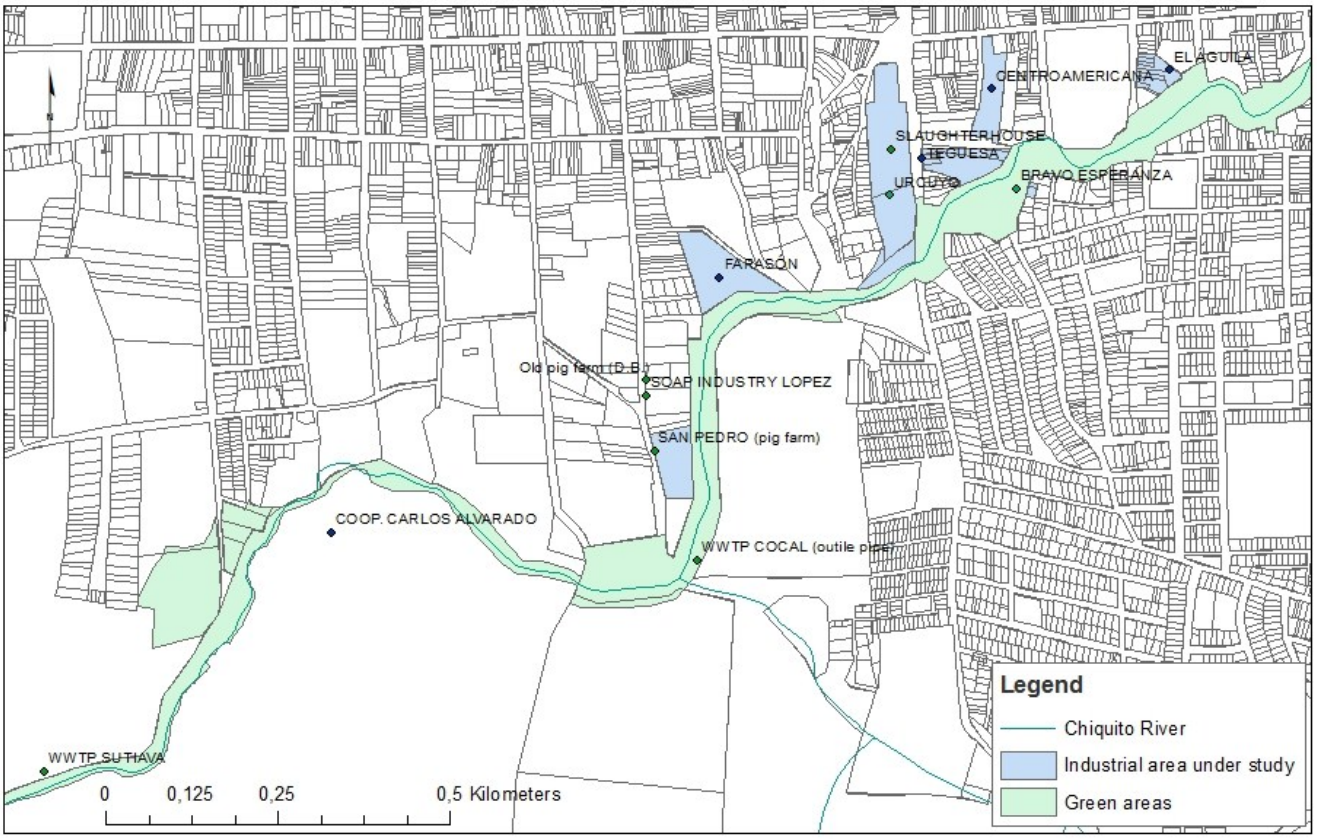


Figure 20. Location of industrial activity in Chiquito River (Own elaboration)

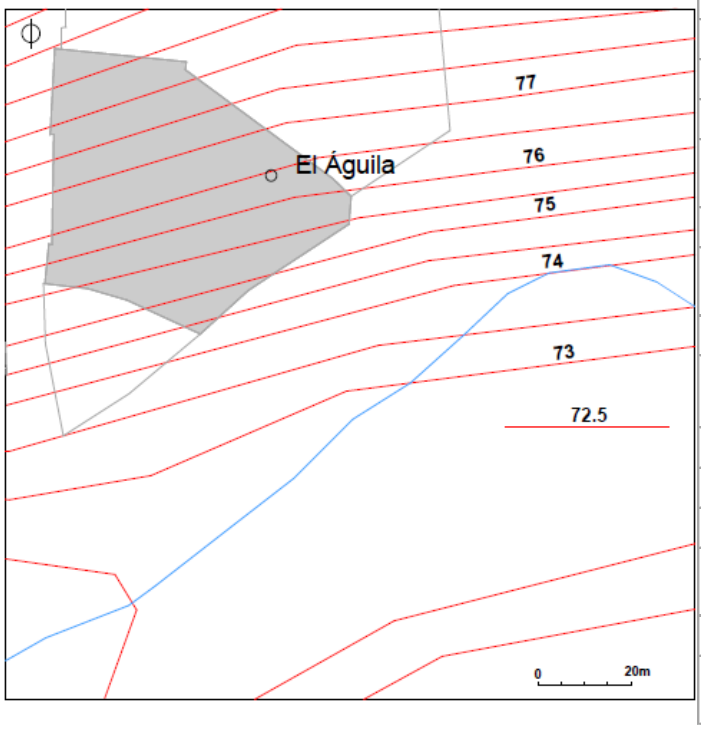


Figure 21. Tannery El Águila plan (Own elaboration, Source: Municipality 2014)

Type	Tannery
Name	El Águila
Coordinates	12.42955°, - 086.88440°
Owner	Jose Antonio Gávila
Person interviewed / position	Alma Nidia Carballa/ Services
Type of hide	cattle
number of hides per month	400
Water supply	well
estimated water consumption [m^3/d]	2,27
Connection to sewage	No
Total area [m^2]	2642
Constructed area [m^2]	1088
Space for DEWATS	Reorganization of the facility needed
Distance to the river [m]	36
Notes	Installation rented to 5 small tanners

Table 7. Tannery El Águila data (Own elaboration, Source: A. N. Carballa [El Águila], personal communication, September 4, 2014)

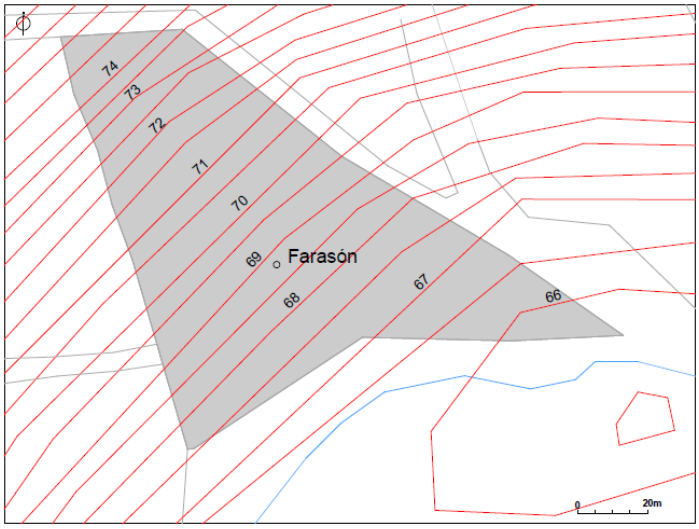


Figure 22. Tannery Farasón plan (Own elaboration, Source: Municipality 2014)

Type	Tannery
Name	Farasón
Coordinates	12.427472,-86.890119
Owner	Ramón Macías Lunas
Person interviewed / position	-
Type of hide	cattle
number of hides per month	-
Water supply	well
estimated water consumption [m^3/d]	-
Connection to sewage	No
Total area [m^2]	8000
Constructed area [m^2]	1000
Space for DEWATS	Yes
Distance to the river [m]	12
Notes	No visited

Table 8. Tannery Farasón data (Own elaboration, 2014)

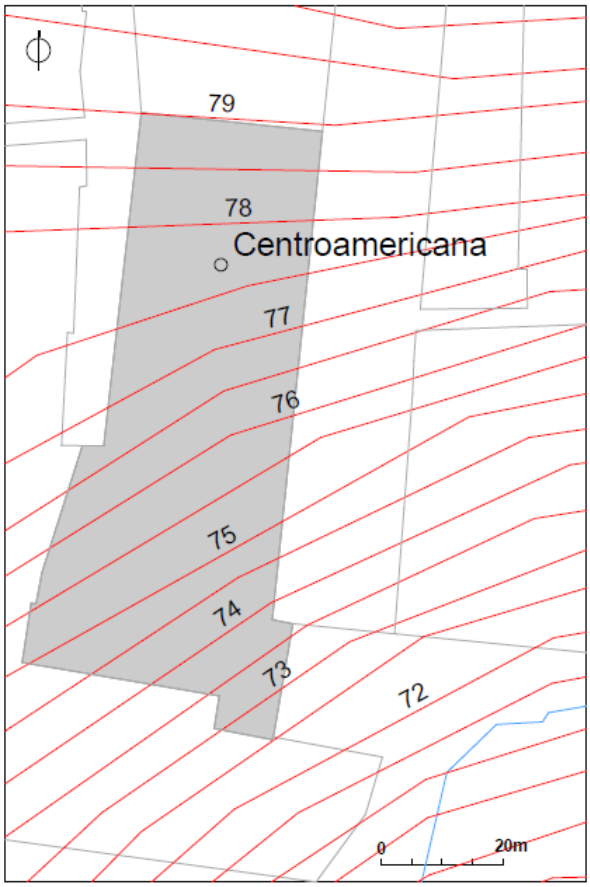


Figure 23. Tannery Centroamericana plan and data (Own elaboration Source: Municipality 2014)

Type	Tannery
Name	Centroamericana
Coordinates	12.42949°, - 086.88680°
Owner	Silvio Salinas
Person interviewed / position	Silvio Salinas / Owner
Type of hide	cattle
number of hides per month	1800
Water supply	well
estimated water consumption [m^3/d]	10,24
Connection to sewage	No
Total area [m^2]	3260
Constructed area [m^2]	812
Space for DEWATS	Yes
Distance to the river [m]	26
Notes	Sustitution of chemicals

Table 9. Tannery Centroamericana data (Own elaboration, Source: S. Salinas [Centroamericana], personal communication, September 4, 2014)

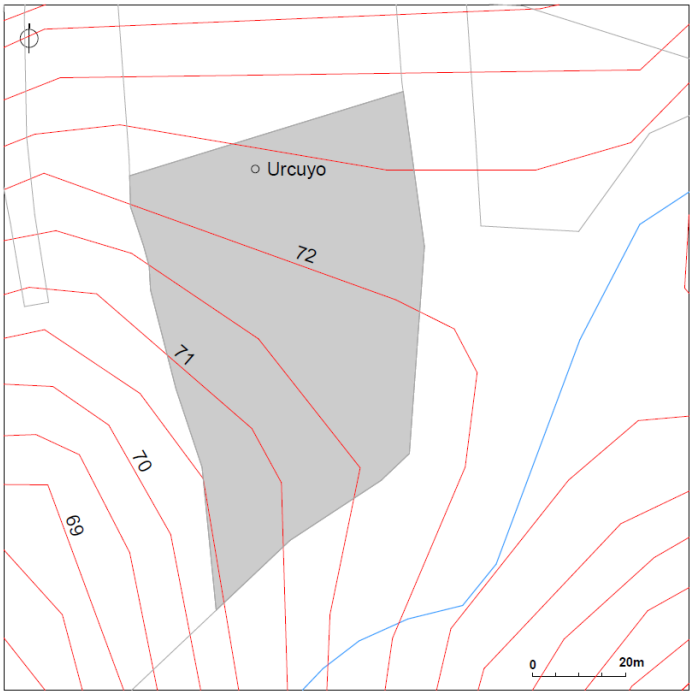


Figure 24. Tannery Urcuyo plan (Own elaboration, Source: Municipality 2014)

Type	Tannery
Name	Urcuyo
Coordinates	12.42811°, - 086.88783°
Owner	Clemence Urcuyo
Person interviewed / position	Juan Antonio Abarco / Manager
Type of hide	cattle
number of hides per month	60
Water supply	well
estimated water consumption [m^3/d]	0,34
Connection to sewage	No
Total area [m^2]	5418
Constructed area [m^2]	1330
Space for DEWATS	Yes
Distance to the river [m]	36

Table 10. Tannery Urcuyo data (Own elaboration, Source: J.A. Abarco [Urcuyo], personal communication, September 4, 2014)

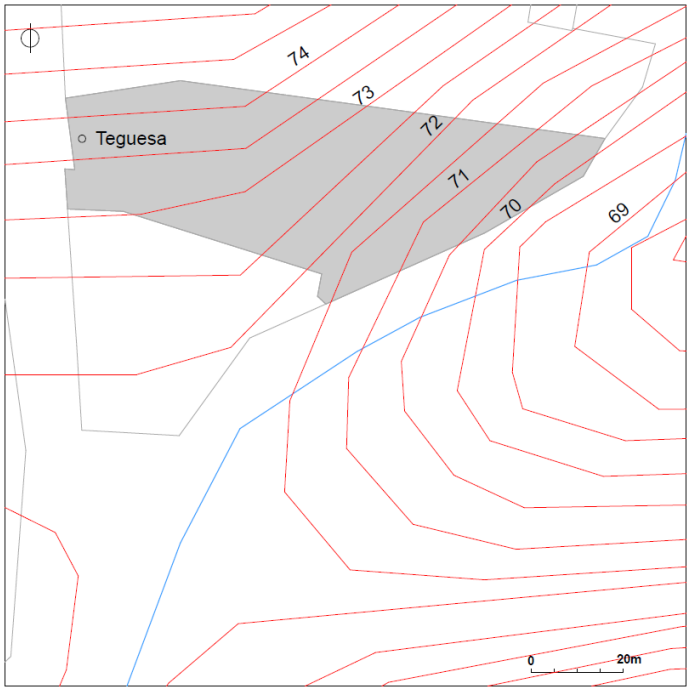


Figure 25. Tannery Teguesa plan (Own elaboration, Source: Municipality 2014)

Type	Tannery
Name	Teguesa
Coordinates	12.42835°, - 086.88777°
Owner	Marcial Guerrero
Person interviewed / position	Santo Rivas / Production manager
Type of hide	cattle
number of hides per month	1200
Water supply	well
estimated water consumption [m^3/d]	6,82
Connection to sewage	No
Total area [m^2]	2730
Constructed area [m^2]	1363
Space for DEWATS	Not enough (draying area)
Distance to the river [m]	15
Notes	Reuse of water in liming and tanning phases

Table 11. Tannery Teguesa data (Own elaboration, Source: S. Rivas [Teguesa], personal communication, September 4, 2014)

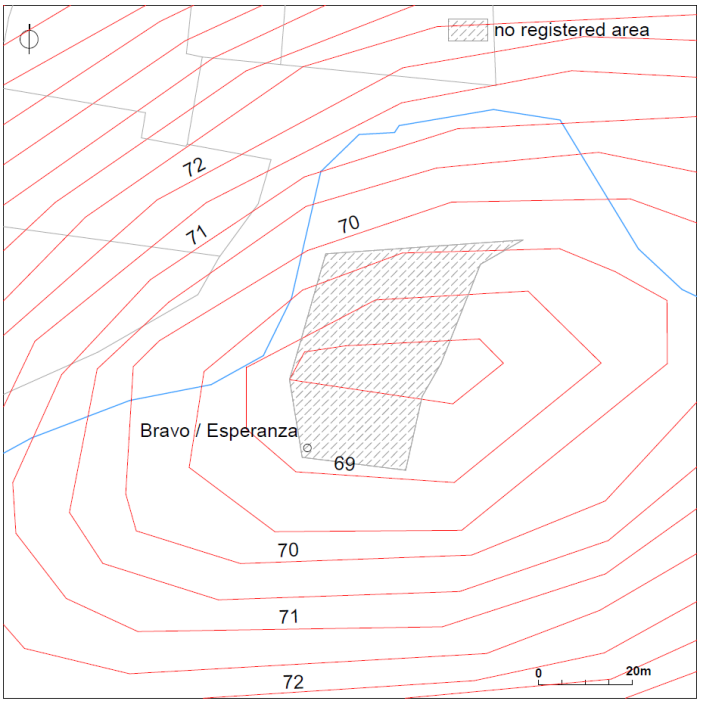


Figure 26. Tannery Bravo/Esperanza plan (Own elaboration, Source: Municipality 2014)

Type	Tannery
Name	Bravo/Esperanza
Coordinates	12.428000,-86.886440°
Owner	Francisco Salgado
Person interviewed / position	Francisco Salgado / Owner
Type of hide	cattle
number of hides per month	150
Water supply	well
estimated water consumption [m^3/d]	0,34
Connection to sewage	No
Total area [m^2]	1520
Constructed area [m^2]	128
Space for DEWATS	Not enough (draying area)
Distance to the river [m]	24
Notes	Very primitive facility

Table 12. Tannery Bravo/Esperanza data (Own elaboration, Source: F. Salgado [Bravo/ Esperanza], personal communication, October 2, 2014)

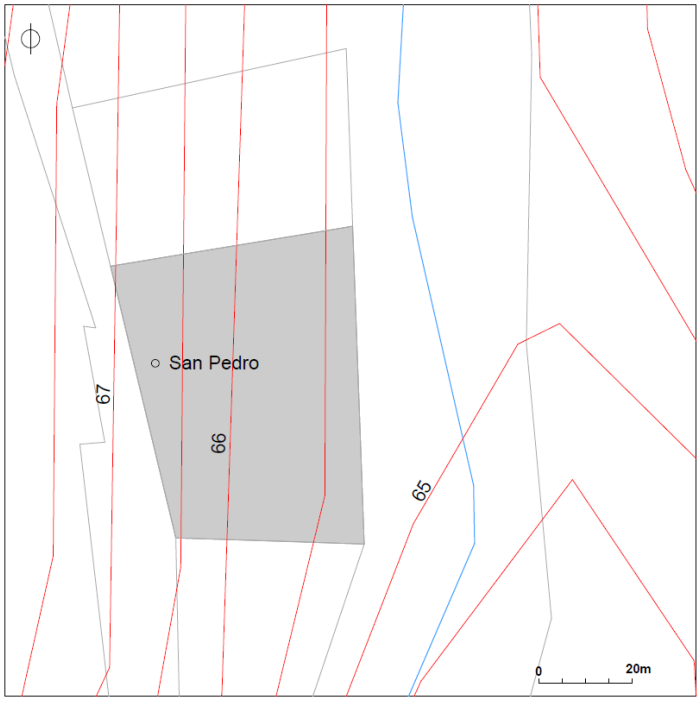


Figure 27. Pig farm San Pedro plan (Own elaboration, Source: Municipality 2014)

Type	Pig farm
Name	San Pedro
Coordinates	12.424544°,-86.891290°
Owner	Rosalpina Galo
Person interviewed / position	Oscar Rivera / Foof processor
number of pigs	800
Water supply	well
estimated water consumption [m^3/d]	12,15
Connection to sewage	No
Total area [m^2]	2835
Constructed area [m^2]	1690
Space for DEWATS	Maybe
Distance to the river [m]	15

Table 13. Pig farm San Pedro data (Own elaboration, Source: R. Galo [San Pedro], personal communication, September 30, 2014)

Type	Tannery
Name	Coop. Carlos Alvarado
Coordinates	12.423484º,-86.895591º
President	Evenor de Jesús Blanco Darce
Person interviewed / position	Alonso Canales / Production manager
Type of hide	cattle
number of hides per month	6000
Water supply	well
estimated water consumption [m^3/d]	34,08
Connection to sewage	No
Total area [m^2]	16000
Constructed area [m^2]	3000
Space for DEWATS	Yes
Distance to the river [m]	60
Notes	There is a broken chromium recovery system

Table 14. Cooperative Carlo Alvarado data (Own elaboration, Source: A. Canales [Coop. Carlos Alvarado], personal communication, September 4, 2014)

7.2. Origins, characteristics and composition of wastewaters associated with industrial activities around the Chiquito River

Pollutants have been categorized into organic and inorganic pollutants on the basis of their nature and origin.

An organic water pollutant is the waste which can include oxygen-demanding substances such as fat and grease. Agents that degrade water quality and are organic in nature become big threats to healthy human existence and aquatic life.

Inorganic chemical pollutants are naturally found in the environment. Due to human development, these pollutants are often concentrated and released into the environment. An example of this are chromium compounds produced in tanneries. Chemicals are used in every aspect of human activity and are often highly toxic to humans and the environment.

The following section explains the processes from which the effluents originate in the different industries that were examined and shows their characteristics and composition.

A. Slaughterhouse

As mentioned before, the slaughterhouse of León slaughters 1,200 animals per month. The process is performed the same way it has traditionally been done, mostly on the floor. The slaughtermen work independently and bring their own tools. The site has two different facilities to differentiate between cows and pigs.

In the following paragraphs, the stages of the slaughtering process for cows in the slaughterhouse of León is described (Figure 28). This section will help to understand the possibilities to reduce the generation of wastewater from changes in the process and the facilities.

- Admission, inspection and washing of cattle

Owners must two fees pay for each animal to be butchered in order to be admitted onto the site. Then a pre-mortem inspection is carried out where some animals are already being discarded. Following that, animals are washed to keep as much mud outside the facility as possible, this first wash does not always take place. During the waiting period manure and urine are produced. A cow produces 15 to 35 kg of dung and 25 litres of urine per day. The concentration of biochemical oxygen demand at five days (BOD_5) of the mixture of these components can reach values of 10 to 20 g/L

(ATV, 1988).

- Stunning and exsanguination

Suitable cattle is taken from the holding area to the slaughter hall during the afternoon. Slaughtermen proceed with cutting the throat without previous stunning, which causes stress to the animals and lowers the quality of the meat. The animal bleeds to death and collapses on the floor. The blood on the floor is removed with buckets of water. Blood has a relatively high BOD_5 more than 140 g/L which greatly contributes to the pollution of the water (ATV, 1988).

- Butchering and skinning

This process is carried out on the floor. The first step is removing the skin, the tail and the legs. These parts are not immediately thrown away, instead they are used to settle the body on the floor during the butchering.

- Evisceration

In this stage the thorax of the animal is opened and butchers obtain the meat without removing the viscera placed in pelvis, abdomen and thorax. The stomach of the animal is taken to a separate area away from the butcher hall. There, manure is removed from the organs and the guts are washed to be commercialised. The weight of the content of the stomach can vary between 35 to 50 kg, with a 60-65% content of water. Washing the guts produces not only faeces but also fats (1.2—1.4 kg per cow and 0.04 to 0.6 kg per pig) which pollute the water being used. The intestinal mucosa is also extracted (0.75 kg per pig and 1.8 kg per cow) and becomes part of the effluent (ATV, 1988).

- Boning

This phase consists of separating the meat from the bones which is cut into in pieces and commercialised. The brain is a sub-product from this stage.

- Processing of sub-products

Several sub-products are obtained from the slaughter of an animal. Some of them are edible (viscera) and some are not (hides). In León, most of the non-edible sub-products are not traded. In the slaughterhouse of León blood is being disposed and ends up in the river when it could be used for the preparation of fodder for animals. Horns and hooves are transported to the municipal landfill of León, those are rich in non-proteinaceous nitrogen and could be used to produce fertilizers. León benefits from just 52% of the animal's weight, 42% of the remaining 48% could be used to generate further income, but instead, it ends up in landfill (CPML-N, 2008b).

- Veterinarian inspection postmortem

The veterinarian arrives to check whether the meat is suitable for human consumption, supervising all the products and sub-products from the process.

The slaughter process for pigs in the slaughterhouse of León has some similarities with the process described for cattle. Reception, inspection and washing of pigs are done in a similar way.

- Stunning and exsanguination

Stunning is carried out by several blows on the animal's head with a metallic tube. This method generates distress to the animals. Afterwards, the animal is being bled to death. Each slaughterer collects the blood of the killed

animals in a bucket. Then, the animal is lifted from its back legs and butchered.

Although the slaughterhouse of León can make use of proper installations to slaughter pigs, but due to several technical drawbacks, the process is done in rudimentary boxes and none of the new technologies available are being used.

- Blanching, flaying and trotters removal

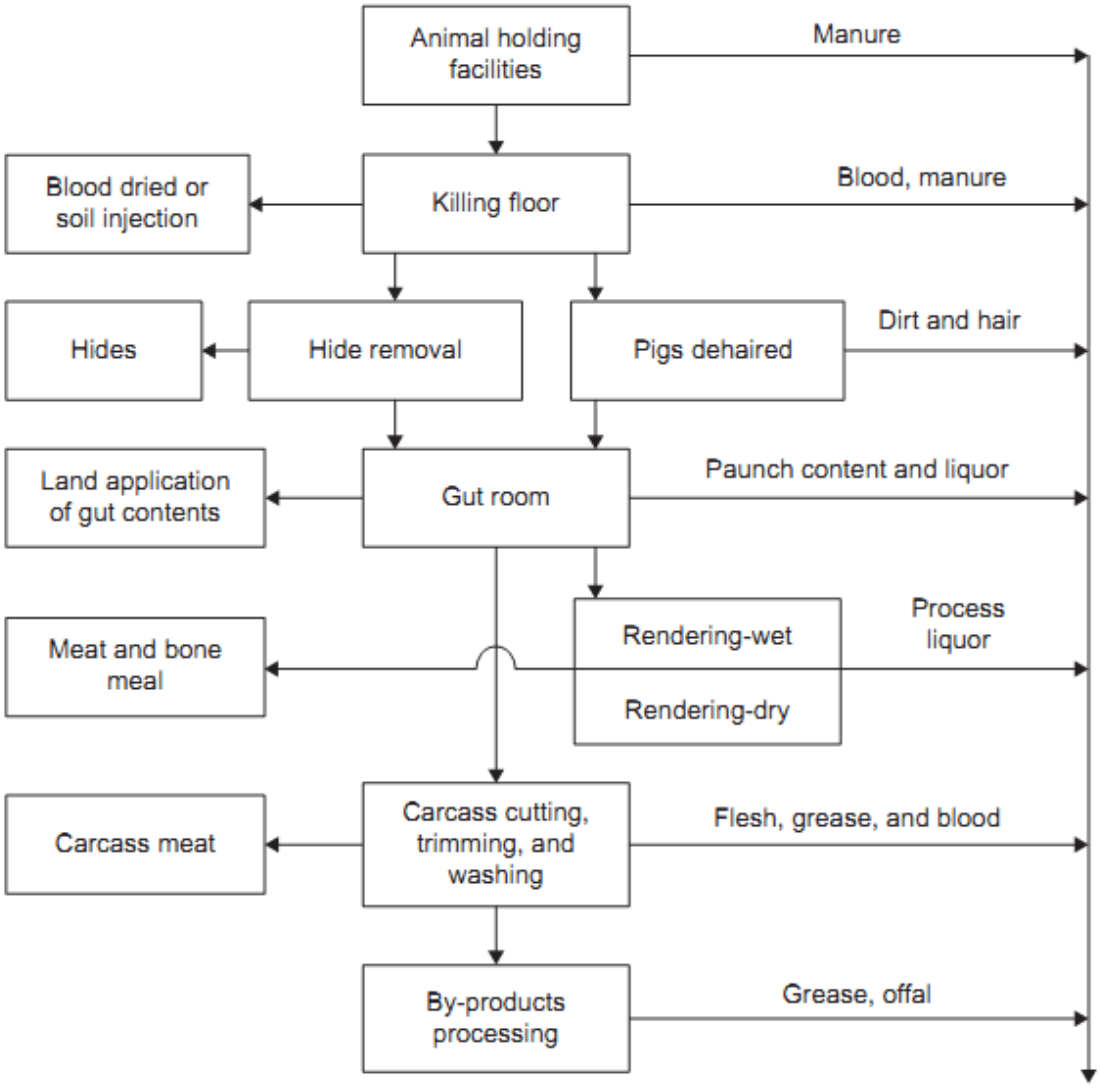
The hair of the pigs is removed by blanching, i.e. immersing the animal in hot water.

After this explanation of the slaughtering process carried out in León, a comparison with the specific legislation applied to slaughterhouses is presented. This norm is called the 'Technical norm for environmental control in slaughterhouses Nº 05 001-99'.

This norm collects compulsory practices in relation to the conservation of water:

1. Separation of wastewater streams with different concentration of pollutants, so that they can be treated applying different solutions.
2. Cleaning of the stables without water and proper disposal of faeces.

Figure 28. Flow diagram indicating the products and sources of waste from a slaughterhouse. Source: Banks and Wang (2006) (Kosseva & Webb, 2013)



3. The water used for washing the animals must be reused for cleaning the holding areas.

At present only practice number two is adhered to the slaughterhouse. In the pilot project it is planned to dispose faeces properly. There is no plan for a future implementation of the other two practices. Number one would not be necessary for the new treatment system and animal washing is still not a common practice in the slaughterhouse of León.

The practices to follow in relation to solid and liquid waste listed in the norm are:

1. Sub-products that are not suitable for human consumption must be processed for animal consumption.
2. Blood must be recovered to produce sub-products or has to be properly treated for final disposal.

These practices are not planned for the pilot project, the chosen approach is to give them proper treatment on the site.

The main consumption of water during the slaughtering process comes from cleaning the floors from the spilled blood . As it was pointed out in chapter five section one, this volume has already been reduced by 16.6%.

The resultant wastewater contains faeces, urine, blood, hair, residues of meat and viscera, undigested food and fat. The final composition depends enormously on the practices carried out in the facility, the presence of collecting channels and the initial cleaning of the facilities without water (Veall, 1993). It is essential that the treatment of the wastewater is initiated inside the facility. Achieving an efficient recovery of the sub-products and introducing a cleaning process without the use of water are key aspects. In Table 15 the typical parameters for the effluent of a slaughterhouse are shown.

Table 15. Characteristics of slaughterhouse wastewater (Nakhla et al., 2003)

Parameter (g/L)	Range	Average
TSS	17.3-61.7	36.9
VSS	15.2-59.8	34.4
TCOD	74.9-154.1	96.7
SCOD	13.1-18.5	16.8
NH_4^+-N	0.2-0.4	0.3
PO_3^{3-}	0.5-0.8	0.7
Oil & Grease	38.8	38.8

B. Tanneries

The common processes in tanneries are explained in this section showing the relationship between the different production phases and the volume of wastewater generated and the levels of pollution. The processes might differ from the ones carried out in other countries with a more developed technological approach. The information was gained from the interviews with tanners and CMPL-N (2008).

Hides produced in the slaughterhouse go to the tanneries along the river. Preparing the animal skins begins by curing them with salt to prevent decay of the animal protein (collagen) due to bacterial growth.

The first steps executed before tanning occur in the so called beamhouse operations. 60 to 70% of the total wastewater is produced during this phase (CPML-N & MIFIC, 2008). This stage

comprises the following steps:

- Soak

The hides are soaked in clean water to remove the salt from curing and to increase the level of moisture so that the hide can be further treated. The composition of the effluent depends on the state the hides, in which state they are received and how they were stored. They may contain soil, blood, manure, fat and other organic components of the skin. This operation generates effluents with a high content of salt.

- Liming

The hides are treated with limewater (a basic agent) and sodiumsulphide for a period of 24 hours to four days depending on the level of mechanization. The main objective of this operation is to remove hair, nails and other keratinous matter (Figure 29).

This step causes the largest consumption of water. The wastewater from this phase is the most concentrated of all. It is composed of proteins, fat and hair. It has a high content of sulphur and lime and ammoniacal nitrogen with a pH between 11 and 12. It represents 80% of total pollution generated in the wastewater (CPML-N, MIFIC, 2008).

Table 17 shows the analysis of the effluents produced in 2008 by the "Carlos Alvarado Cooperative" (the cooperative resulted from the relocation of the small tanners in Río Chiquito) including the effluents produced by liming, chrome tanning and dyeing together with the limits for the same values set in the Decree 33-95. In the produced effluent from the process of liming, the presence of organic matter, sulphurs and lime raise the values of COD (1,351.00 mg/L) and BOD_5 (605.00 mg/L). Its relation (BOD_5/COD) shows the high biodegradability of the effluent. This leads to a deoxygenation of the river. The high value of sulphurs (284.20 mg/L) results in the formation of hydrogen sulphide which generates odour and threats to human health. The high pH levels and the high TDS (22,565.00 mg/L) and TSS (4,159.00 ml/L) are due to the high amount of chemicals used, which are diluted in the wastewater. This concentration can inhibit conventional biological treatment. Next chapter shows different biological solutions for the treatment of the wastewater of the tanneries.

Figure 29. Tannery Teguesa, hides during liming (Own image, 2014)

- Tissue removal

This includes the removal of adipose, subcutaneous and muscular tissue as well as tallow from the inside of the skin. Although this is done by means of mechanical work the

residues contain a high percentage of water.

- Splitting

This operation consists of dividing the two layers of the skin, the exterior and the one in contact with the muscles . Although splitting is a mechanical process, water is used to facilitate the procedure.

Afterwards, the phase of tanning starts. This phase produces 30 to 40% of the total wastewater (CPML-N, MIFIC, 2008) and consists of deliming, pickling, chrome tanning and basification.

- Deliming

In this process the pH of the collagen is brought down to a lower level so that enzymes may act on it. The skin is soaked in water together with ammonium sulphate, which favours the release of lime and sodiumsulphide. By doing so, hides can easily absorb chemicals during the next phases. The effluent from deliming contains ammonium and sulphurs.

- Pickling

The hides are treated in a rotating drum with a mixture of common salt and sulphuric acid to bring down the pH of collagen to a very low level to facilitate the penetration by mineral tanning agent into the substance. The wastewater produced is acidic (pH 2.5 - 3) and contains high levels of salt.

- Chrome tanning

The pH of the hides must be very acidic when the chromium is introduced into the rotating drum where the pickling was performed just before. The hides rotate in these drums for seven hours, then they remain in the drums with the chemicals for another twelve hours, afterwards the hides are allowed to rest for 24 hours outside the drum (Figure30). This process takes up to five days when natural agents for tanning are used. In the raw state, chrome-tanned skins are blue and therefore referred to as "wet blue." The effluents of this phase are potentially polluting due to their content of chromium salts and acids. The effluent resulting from tanning (See Table 17) presents a low organic pollution but the BOD_5/COD relation of 0.47 indicates high biodegradability. The values for sulphurs are high (8.50 mg/L) leading to the production of hydrogen sulphide. The pH of 3.8 - 4 is not adequate for an ordinary biological treatment. The content of solids (TDS and TSS) is high due to the significant use of chemicals in the process.

Figure 30. Tannery Teguesa, hides (wet blue) coming out of the drum after tanning (Own image, 2014)

- Basification

Once the desired level of penetration of chrome into the substance is achieved, the pH of the material is raised again to aid the further process. For this, hides are soaked in water with sodium bicarbonate for 40 to 60 minutes. After this, the hides are washed.

Finally, the finishing phase consists of dyeing, oiling and drying. The wastewater produced in this phase is amounts to 5 to 10% of the total volume (CPML-N, MIFIC, 2008).

- Dyeing and oiling

Tanners in León use different techniques for dyeing the hides. When wet techniques are used, the skins soak in water with dye. The water consumption for this procedure is the lowest compared to the other steps because there is no need for rinsing the hides afterwards. This effluent (see Table 17) is also characterised by a low organic load (COD of 1,351.00 mg/L and BOD_5 of 605.00 mg/L) but a high biodegradability. The content of sulphurs is again high. The acidic pH of 5.69 makes this effluent not suitable for ordinary biological treatment. This effluent contains also chromium that is left in the hides from the tanning process. Dry methods, like spray painting, are also used (Figure 31). Oiling gives flexibility and resistance to the leather. It is performed in the same drums as tanning, mixing a small amount of water and fat.

Figure 31. Tannery Teguesa, dyeing (Own image, 2014)

- Drying

The leather is stretched and fixed on wooden frames and exposed to the sun for six to twelve hours.

Industrial processes in León are largely performed based on traditional knowledge. The use of chemicals is not subject to control. The amount added is based on the workers' subjective experience instead of being related to the objective weight of the hides. To be on the "safe side", a large amount of chemicals is used, often more than needed, which are then not completely absorbed by the hides. In Table 16 the percentage of chemicals used in relation to the weight of the hides in the "Carlos Alvarado Cooperative" is compared to the normal values. The difference between those gives an idea of the amount of chemical waste that flows into the river and filtrates into the soil.

Table 18 explains the addition of water per phase in relation to the weight of the processed hides. This data is based on the experience of tanners in Nicaragua where processes and technologies are similar to the ones used in the facilities of the Río Chiquito area.

C. Pig farms

Pig farms have a very important negative impact

Table 16. Chemical consumption in Carlos Alvarado tannery and limitation in the norm (CPML-N, MIFIC, 2008)

Intake	Process	Tannery (%)	Norm (%)	Diference (%)
sodiumsulphide	Liming	5.7	1.7	4.0
Lime		37.3	1.5	35.8
Sulfuric acid	Pickling	1.6	0.8-1.0	0.6
Salt		16.5		
Sodium formate		1.6	1.0 - 1.5	0.1
Chromium salts	Chrome tanning	11.3	7.0 - 10.0	1.3
Sodium formate	Basification	1.6	1.0 - 1.5	0.1
Sodium Bicarbonate		1.4	0.5 - 2.0	- 0.6
Formic acid	Dyeing and oiling	1.4	0,5 - 0.7	0.7
Fat		4.1		
Phenylamine		2.2	0.4 - 0.6	-3.8

Table 17. Chemical analysis of Carlos Alvarado tannery effluents and values in Decree 33-95 (CPML-N & MIFIC, 2008)

Process	pH	TDS (mg/l)	TSS (mg/l)	Sedimentable solids (mL/l)	BOD (mg/L)
Liming	11.60	22,656.00	4,159.00	15.00	605.00
Chrome tanning	5.69	7,974.40	198.1	60.00	142.00
Dyeing	5.69	1,964.80	585.00	7.00	170.00
Limits Decree 33-95	6 - 9		150.00	5.00	120.00

Process	COD (mg/L)	Chromium (mg/L)	Sulphur (mg/L)	Phenol (mg/L)	Fat and oils (mg/L)
Liming	1,351.00	0.05	284.20	34.10	38.00
Chrome tanning	300.60	604.22	8.50	3.70	37.20
Dyeing	347.00	20.52	6.50	10.60	33.00
Limits Decree 33-95	250.00	10.00	0.20	0.10	30.00

Table 18. Water addition on the different stages of the tanning process (CPML-N & MIFIC, 2008)

Process	% by weight of cattlehide
1st rinsing	200%
Soaking	130%
Liming	300%
2nd rinsing	600%
Basification	250%
Pickling and Chrome tanning	100%

on the environment, especially on the water. Pig farms require large amounts of water for their production process. The resulting wastewaters are turbid and contain high concentrations of organic matter, dissolved, suspended solids. and pathogenic microorganisms. The wastewater should be disposed so as to not harm human or domestic animal's health and without polluting final disposal sites such as soil, rivers, lakes and reservoirs (de Victoria, Galván & Ayala, 2008). Table 19 shows the characteristics of typical effluent resulting from low-tech profile activities in medium sized pig farms and the benchmarks of

these values as defined in the Decree 33-95.

Table 19. Biological parameters of wastewater from pig farms (de Victoria, Galván & Ayala, 2008) and value limits previous disposal on Decree 33-95

Parameter	Typical value	Decree 33-95
pH	8.3	6.9
TCOD (mg/L)	2,997.33	250.00
BOD_5 (mg/L)	1,694.66	100.00
TSS (mg/L)	975.2	150.0

The farm of this study, called San Pedro, was once on the outskirts of León. Nowadays there are houses close to it. It disposes liquid and solid waste without any treatment into the river. The owner blames the situation on the weak economy and the lack of guidance and support from the administration (R. Galo [San Pedro pig farm], personal communication, September 30, 2014).

7.3. Effects on the river

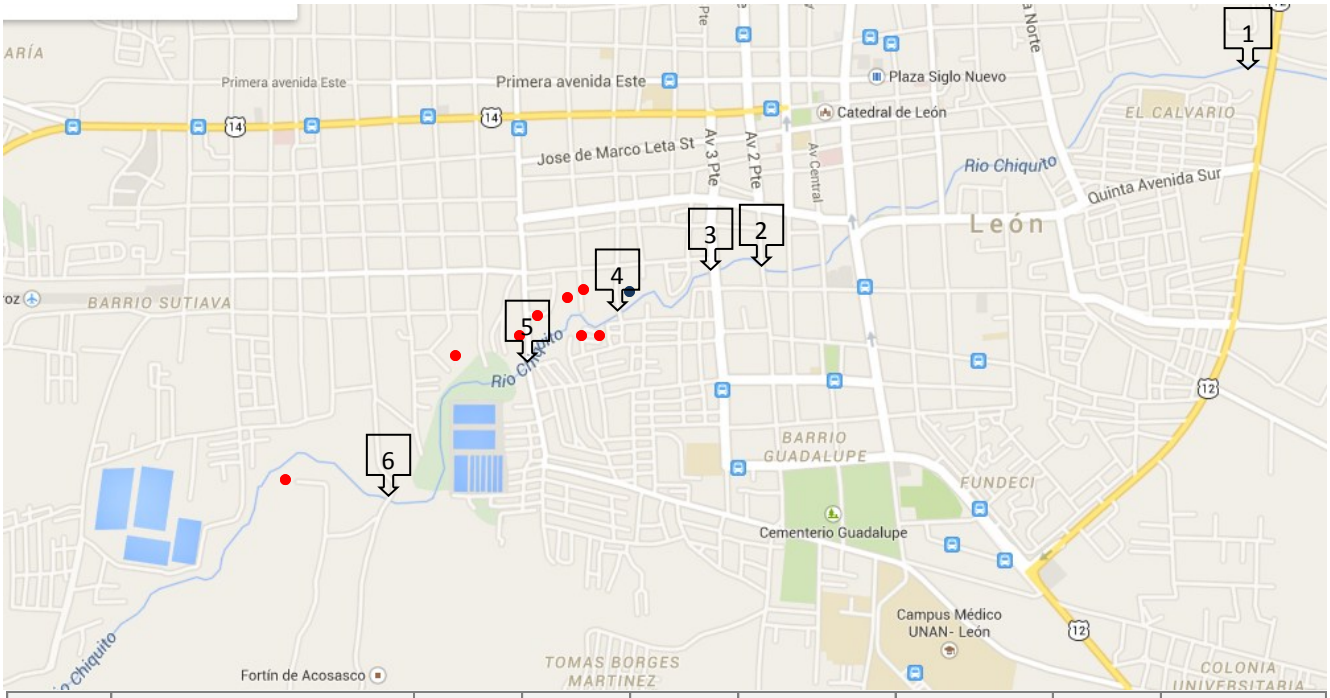
How all these effluents affect the river is analysed in this section. As the industrial effluent is not the only source of pollution for the river re, it is not possible to asses accurately to what extent the quality of the water is affected by industrial polluters with the information collected. However, even a rough analysis suggests that effluents from tanneries have a significant impact.

The simplify index of water quality (SIWQ), gives an idea of water quality for human consumption. It goes from 0 to 100, the higher the index the better water quality. It needs to be combined with other indexes to obtain a proper interpretation. It is calculated using a formula which combines temperature, oxidation to permanganate, TSS, dissolved oxygen and conductivity. The drawbacks of this index are that it does not take toxics nor nutrients (N-P) into account.

SIWQ was the index chosen to analyse the quality of Chiquito River by Palacios Prado and Zapata Vallejos (2011) for their Master dissertation for the Faculty of science and technology of UNAN (See Table 20). In Figure 32 some of the points studied in their paper are included. As it can be seen in sample 1, right after the urban core of León starts, the quality of the water is useful. The main volume of domestic and industrial discharges starts after sample 1. Samples 2 and 3 are taken previous the area of concentration of tanneries, which are marked with red points. The index shows Bad quality in sample 2 but improves to Useful in just 500 metres in sample 3. This might be due to the increment of wastewater volume (Cortes Lezama, 2013). Sample 4 was taken right after the first tannery (blue point, no longer in operation) was discharging its effluent into the river and the quality of the water decreased substantially. The same pattern emerges downstream where most of the small tanneries' effluents are released into (sample 5). In less than 400 metres, between sample 4 and 5 the weight of suspended solids is multiplied times 8 and the index score goes down 20 points, from 58.94 to 39.72. Within this stretch there are 3 manholes which are part of the domestic wastewater network (Cortes Lezama, 2013), of those, two are in bad condition being unable to contain the sewage within the system; the third one was not visited.

Although the situation regarding domestic wastewater infrastructure is similar

Figure 32. & Table 20. Chiquito River SIWQ values and location of strategic points (Palacios Prado and Zapata Vallejos, 2011 & own elaboration)



Sample	critical point	Temp. °C	*DQO-$KMNO_4$ mg/L	TSS mg/L	dissolved O_2 mg/L	Conductivity µS/Cm	SIWQ	Interpretation
1	By-pass Río Chiquito	27	5.58	24.00	4.51	465.00	65.20	Useful
2	Bridge Toledo	25	8.07	60.00	1.06	609.00	49.81	Bad
3	Bridge Vallesca	24	3.33	18.00	1.73	730.00	63.22	Useful
4	Bridge Bataan	25	8.82	19.00	2.79	684.00	58.94	Dreadful
5	Bridge El limón	27	10.52	154.00	1.54	574.00	39.63	Dreadful
6	Before septic tank (bridge fortín. El cocal)	27	14.81	115.00	0.58	941.00	32.72	Dreadful

(*) method to analyse the COD through tritation with perganmanate KMnO4 for small concentrations of organic matter in water

between the two points where samples 5 and 6 were taken, the quality of the water does not worsen drastically (SIWQ 39.72 and 32.72 respectively), reaching the worst quality of the samples analysed. This is partly because there is not new addition of effluents coming from tanneries and also the water of Aposento River joins the Chiquito's River. In conclusion, the addition of the industrial effluents to the river makes a difference concerning its overall pollution.

This case is still presented as a traditional environmental damage (Sierfele, 1988), chromium has a local impact in comparison to other heavy metals. This fact concentrates the problem. The effects of this pollution remain local and can be easily perceived by the human senses (Förstner, 1998). Although the index does not give an accurate scenario for a proper analysis it is clearly visible the damage suffered by the water whilst passing by the tanneries.

7.4. Identification of common basis and similarities among industries to draft an efficient approach in order to establish DEWATS

This point analyses all the factors affecting production and consumption of water. Changes in these factors will lead to a better management of water in the installation and ultimately decrease the production of wastewater.

7.4.1. Reduction of water consumption

The main consumption of water in the slaughterhouse is created by while cleaning the facility and the tripe of the cattle. What devices are chosen for cleaning has a big impact. The reduction of water consumption for washing the facility has already been achieved. A water reduction concept on the area designated for washing the tripe is still in process. It is necessary to enhance awareness among the workers to make good use of this resource.

A big part of the water consumption in pig farms comes from cleaning the installations as in the slaughterhouse . Using pressure washers can reduce the consumption by 25 to 40% (MAGRAMA, 2010). In this case the distribution of drinking water for the animals is also important using systems that decrease waste. Using drinking bowls instead of nipple drinkers can reduce consumption by 24% which, in turn results in a 5 to 14% reduction of liquid manure.

In both slaughterhouse and pig farm, proper management of the water network, i.e. detecting and repairing leakages may divide water consumption by 3. This is a measure that can be applied to any type of industry. This also applies to the control of the water supply. All industries in Leon set their water supply from wells; the volume consumed is not measured. Having some control over water consumption would ease the detection of problems concerning the usage of water for industrial processes as well as the management of the facility. Controlling water, energy and material consumption give a better understanding of the resources used in an industry. This practice improves the performance of a facility and allows to know the economic and productive situation of a certain company at any moment in time.

For tanneries the addition of water during each production phase should be standardised. Tanneries in León do not control their use of water. They overuse water and the proportion of dissolved chemicals in the water is affected.

The instruction of the workers is an important factor regarding all the measures explained above, when dealing with a reduction of water consumption. The implementation of a new technique, way of management or control measurements should involve the personnel in the process and should consider their opinions and suggestions to guarantee a proper reaction to the new challenges.

7.4.2. Water consumption reduction related to changes applied to industrial processes in tanneries

This section focuses on the industrial process of the tanneries and how not very complex changes can make a difference on the total volume of wastewater. These proposals originate from CPML-N (2008b). Subsequently, practices that require low or no investment to be apply to the industrial process are explained, thus enhancing the reduction of wastewater production. These actions are presented following the order of the phases in the process of tanning.

1. Buying a scale to weight the hides

This measurement allows for an accurate

administration of chemicals as the correct amount correlates to the weight of the hides. As a result the concentration of chemicals in the wastewater would decrease.

2. Salt recovery before rinsing

Salt is used to conserve the hides. If the salt would be recovered before hides are rehydrated the content of chlorides in the effluents would decrease. This could be done by shaking the hides over a clean area. This salt could then be reused in the subsequent stage of pickling.

3. Standardised usage of chemicals according to the following the international norm

Since the addition of chemical affects the quality of the hide it is suggested to adjust gradually the amount to the values given in the norm (See Table 16).

4. Performing tissue removal before liming

Usually a lot of tissue is removed after the addition of lime. When this order is reversed the hides would weigh less and less lime would be needed. The savings in chemicals can amount to 15% and the chemicals also act more directly on the skin. When tissue is removed first, the resulting solid residues are non-toxic and can be used to feed animals.

5. Substitution of sodiumsulphide (Na_2S) by sodium hydrosulfide (NaHS) in liming.

When sodiumsulphide is used, the hair is not completely removed and the skin is not very smooth as a result. The effluent generated has a high organic concentration due to the amount of hair suspended and dissolved in the water. When Sodium hydrosulfide is used, the hair is completely removed and is therefore not dissolved in the water, reducing the organic load of the effluent.

6. Reuse of liquids from the liming process

This option requires making an investment. The process of liming produces effluents rich in sulphides and lime. Reusing these effluents would bring a reduction of chemicals and water consumption. This could be done directly or after the filtration of residues from the first cycle. For this an analysis of the concentration of chemicals contained in the fluid is necessary in order to determine the amount of chemicals needed for a new cycle. Elements from Figure 33, which do not already exist have to be purchased and installed. Before acquiring the pump and choosing a pipe the characteristics of the effluent (such as like pH or viscosity) must be taken into consideration.

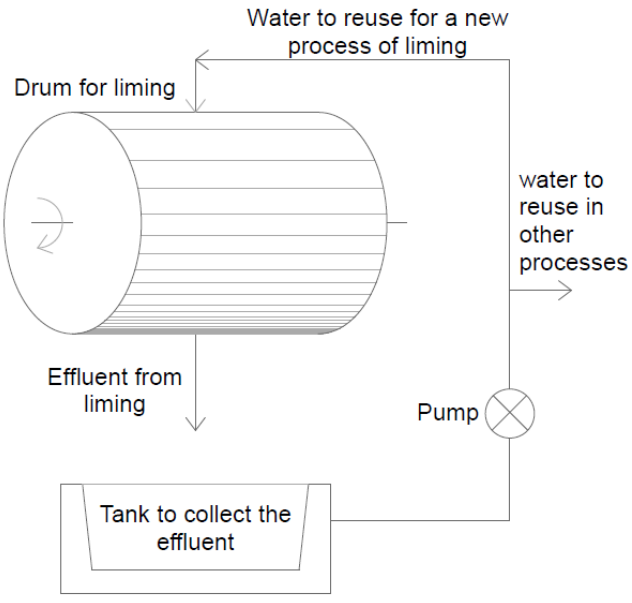


Figure 33. Diagram of the installation for reusing the water from liming. Modified from (CPML &MIFIC, 2008)

7. Reusing the water used for rinsing the hides after liming

The resulting water from rinsing after the phase

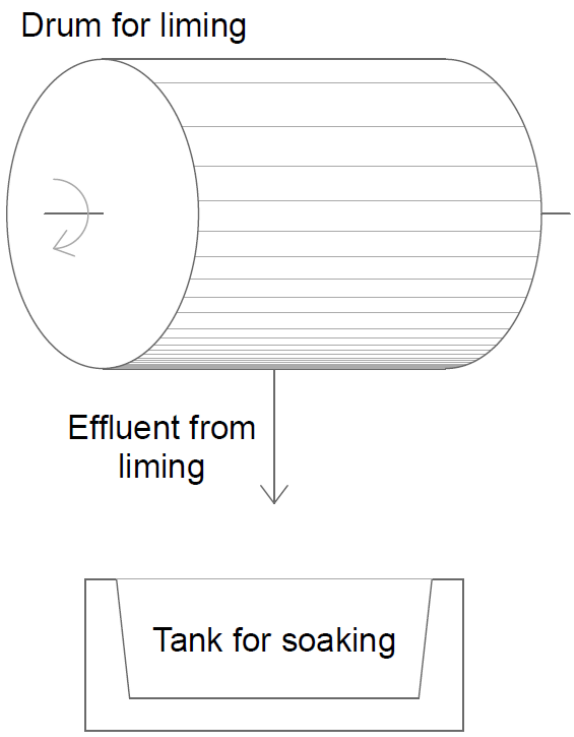


Figure 34 Scheme to reuse the water used to rinse the hides after liming. Modified from (CPML & MIFIC, 2008)

of liming has a low content of solids. It is suggested to directly reuse the water used for the last two rinsing cycles for soaking the hides after their arrival. The investment needed is little if the tanks are on a lower level, so that the water can be transported by gravity (Figure 34). In this case it is just necessary to install the pipes to carry the water to the initial tanks. Reusing this water can reduce the amount of the water needed in the beamhouse operations by up to 50%.

8. Splitting the hides after liming

In the regular process, the hides are split after tanning using chrome. The solid waste that is generated in this process is highly polluting. When the total weight of the hides is lower the demand for chemicals is also lower and the permeation of the hides during deliming, pickling and tanning is greater. This results in better quality leather. Just by changing the order of the processes, chemicals are saved, the quality of the leather is improved and the generation of solid residues containing chromium decreases.

9. Chromium recovery by precipitation

Chromium recovery has a great impact on the cost of production and on the wastewater treatment. A percentage of 30 to 40% of the total chromium used in the tanning process is discharged remains in the wastewater (Viñas Sendic, 1995). Precipitating the chromium in an alkaline environment is the most common method to recover chromium for reusing it in a new tanning cycle (See Figure 35). The process consists of mobile trays collecting the water from tanning. This liquid passes through a sieve, which traps big particles and flows into a tank. Here, a pump transports the liquid to the treatment tank where the chromium is recovered. In this tank an alkali is added and the mixture is stirred until a pH of 8 is reached. At this high pH trivalent chromium sulphate is almost insoluble. The use of magnesium oxide (MgO), available in the Nicaraguan market, for chromium recovery is the most convenient (Haskoning, 1995). A settle pipe extracts the water separated from the sediment of chromium. Afterwards, the chromium hydroxide settled on the bottom is dissolved with sulphuric acid inside the tank once the water is removed. The solution is stirred in the tank for 15 minutes until a pH of 2.5 is reached. During the next stage the dissolved chromium is pumped out to a storage tank where it will wait for a new use.

By applying this method, up to 99% of the total chromium used in the tanning process can be recovered (Haskoning, 1995), reducing its total

amount in the effluent. Investment is required to analyse fluids and to design and to construct the system. As part of the process the process employees have to receive proper instructions. A cost-benefit analysis should be done to analyse each individual case.

7.3.3. Feasibility of implementing biological treatment

The question discussed in this point is whether is possible to treat effluents from tanneries using DEWATS. These effluents have a high content of chromium and other chemicals. Streams of very different characteristics join in this effluent complicating the task. The short answer is that it is not possible to treat such complex effluents while relying on a low technological biological approach.

To achieve biological treatment, it is necessary to previously remove particulate material and chromium from the effluent. The literature reviewed about tanneries' wastewater treatment shows either processes that focus on alkaline salty effluents or solutions to treat acidic effluents with a high content of chromium. Treating the effluents of each phase together results in many difficulties. Basically, the application of the approach to segregate waste streams is the most important step in tannery pollution prevention. However, it is rarely applied (Lofrano, Meric, Zengin, Orhon, 2013).

Lofrano et al. (2013) conducted an extensive review of the available literature, current stage of the research and advances regarding this issue. Firstly aerobic processes are targeted. They state that a high concentration of tannins and other poorly biodegradable compounds as well as metals can impede biological treatment. They quote Murat et al. (2006) saying that a Sequencing Batch Reactor (SBR) is a reliable treatment option for tannery wastewater and

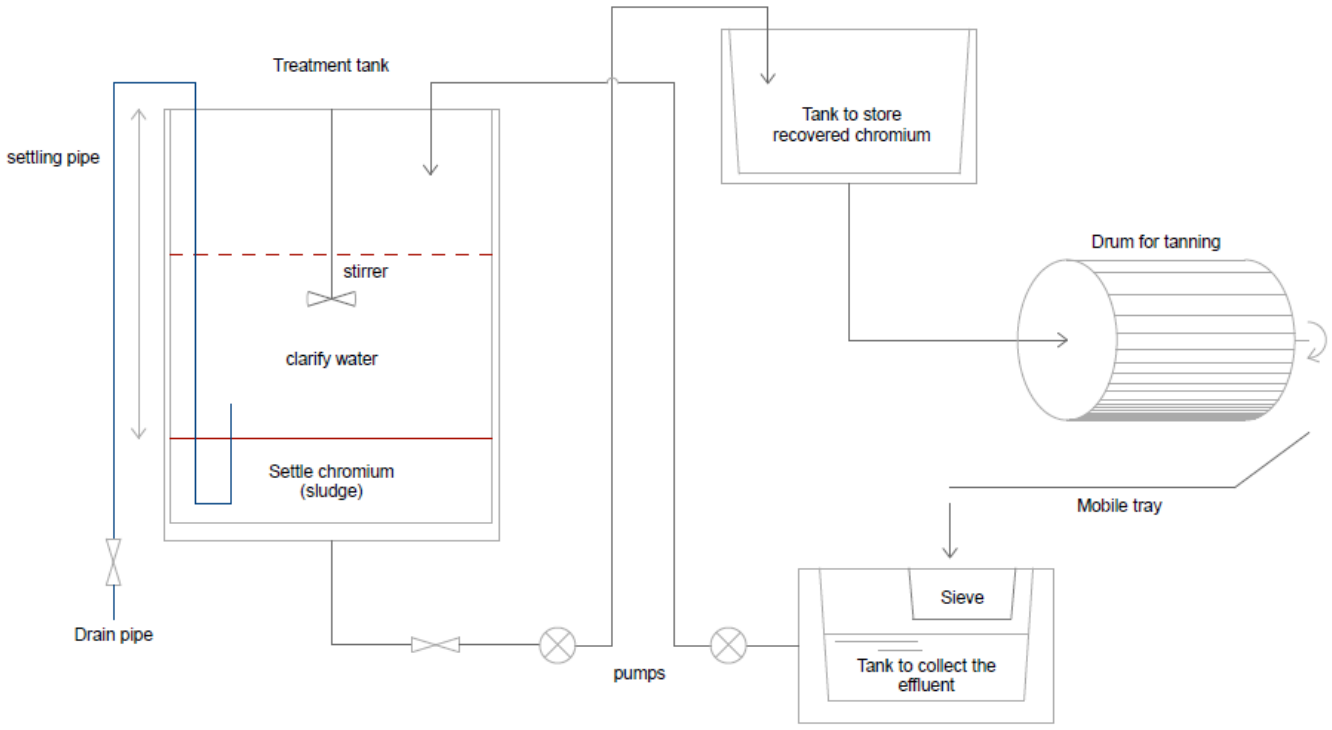


Figure 35. Diagram of installation to chromium recovery by precipitation. Modified from (CPML &MIFIC, 2008)

Farabegoli et al. (2004) who states that the SBR technology has been proved to be more capable of carrying out biological processes in the presence of inhibiting substances such as chromium. Song and Burns (2005) isolated certain salt-tolerant bacteria from tannery activated sludge, which means that they are able to survive in this environment and digest the pollutants. The same applies to Senthilkuma et al. (2008), they isolated a bacteria capable of removing 80% of COD.

Lofrano et al. (2013) concludes that "anaerobic processes present some drawbacks: 1) the implementation of adequate technology for H_2S desorption and treatment is required due to the consistent production of sulphide as a result of the reduction of sulphate which occurs in the absence of alternative electron acceptors such as oxygen and nitrate; 2) high protein component affects selection of biomass, slow kinetics of hydrolysis and inhibits granular sludge formation"

Anaerobic treatment of tannery wastewater is mainly performed by anaerobic filters (AF) and Upflow Anaerobic Sludge Blanket (UASB) reactors (Lefebvre, Vasudevan, Thanasekaran, Moletta, Godon, 2006). Only few research has been done on anaerobic baffled reactor (ABR) (Zupančič & Jemec, 2010).

Tadesse, Green and Puhakka (2004) arranged an advanced facultative pond (AFP) a secondary facultative pond (SFP) and a maturation pond (MP)I n series. They were preceded by simple pretreatment and could adequately treat raw combined tannery wastewater.

Constructed wetlands (CWs) may be an interesting treatment option for leather tannery wastewater. Studies have focused on selecting plant species that are tolerant to this particular type of wastewater. Mant et al. (2004) found species that were able to achieve removal efficiencies of 97-99.6% within 24 hours.

CWs are a suitable main secondary or tertiary stage of treatment. They require accurate wastewater characterization and effective wastewater pretreatment before reaching the CW. Selected plants can adapt to these special conditions and a proper substrate (Calheiros, Rangel & Castro, 2014). Even though high removal rates for chromium, COD and TSS can be achieved, this system may require bigger

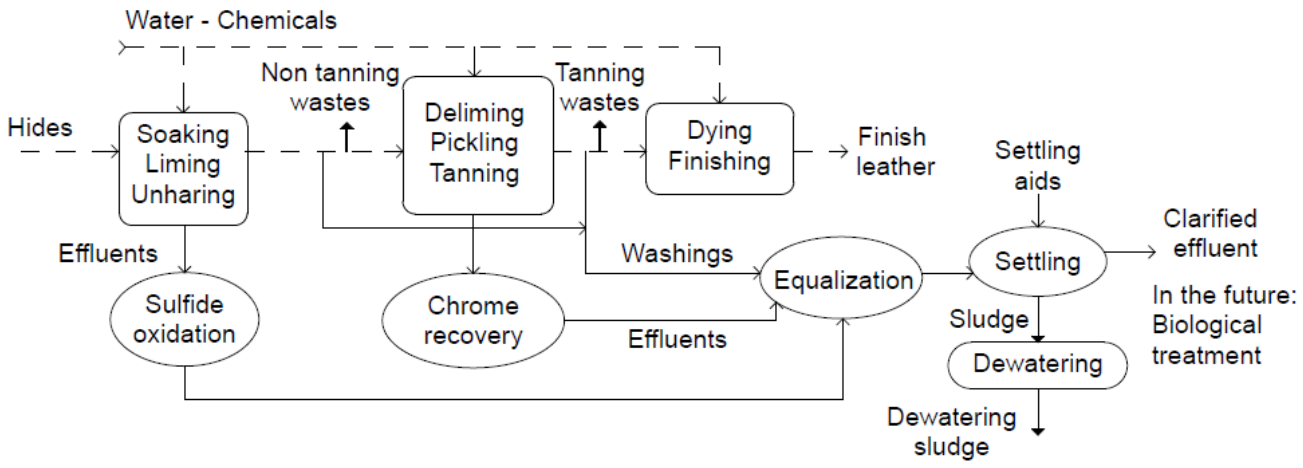


Figure 36. Treatment process in tannery (Viñas Sendic, 1995)

areas than areas suggested in literature (Dotro, Castro, Tujchneider, Piovano, Paris & Faggi, 2012).

Viñas Sendic (1995) propose a treatment process to reach the actual regulations on pollution control. By applying separation of effluents, recycling the washers, oxidation of sulphides, recovery of chromium and equalization and settling with flocculant aids (see Figure 36).

In conclusion, biological treatment can be applied effectively when good control of industrial processes and their effluents already is in place. Standardising the processes in the tanneries of León may be an important aspect in order to succeed.

8. Transferability of the measures taken in the pilot project to other discharges on the same watershed

The notion that environmental problems could be addressed strictly based on scientific and engineering knowledge has been shown not to be a realistic approach. There are arguments implying that environmental standards can only be set when taking into consideration the socio-cultural dimensions of a certain problem. Addressing environmental problems should include fundamental questions about the intention of a certain intervention, however. very often these are diluted within the economic and technological framework rather than being a main part of the discussion (Förstner, 1998, p. 6).

The way Nicaraguans have coped with recent environmental concerns is analysed in order to understand Nicaragua's environmental strategy. For instance, water quality analyses are carried out regularly by the responsible institution (ENACAL), in the drinking water wells spread all over the city. If a negative result is obtained, the well is closed by ENACAL and a new is be drilled instead. The causes or origin of the pollutants remain unknown.

The following analysis is based on the study made by Huber (1995) on environmental actions. This analysis intends to relate the current local environmental strategy to the protection programme to be developed on the river's watershed. Environmental politics in Nicaragua consist mainly of regulations, bans, laws and technical standards. The government could act as an enforcer of its ecological proposal, however, under the shadow of an austere economy the application of environmental laws is not carried out. By contrast, countries with a more established environmental approach use social and market oriented instruments, like liability (financial obligations) or mediation. Their strategy is based on strengthening partnerships between state, producers, retailers and consumers.

In Nicaragua, the main approaches for addressing environmental issues are retaining or treating the emissions and contaminants, also called end-of-pipe measures. The observed industries in Leon do not carry out schemes for increasing the optimization of products or production processes. Although several tanneries in León, looking for an economic benefit, substitute chemical toxic substances with biological substances in certain processes,

innovation regarding materials and production processes are still hard to reach.

8.1. Shortcomings of the pilot project

The modifications devised for the slaughterhouse of León, as explained in chapter 6, is the model to follow and replicate in order to create a future environmental programme for the Chiquito River area. This section differentiates between aspects which can be easily transferred and those which need to be improved for future stages. It is important to mention that during the writing process of this thesis, the pilot project is under construction (expected deadline September 2015). The difficulty of this analysis lies in the fact that the outcome of the project is somewhat uncertain; it will not work out exactly the way it was planned in the beginning. External conditions and assumptions made at the start have changed. Circumstances may, most likely, still change. One of the deviations, for example, was the amplification of the initially defined goals after a rise in funding. Since the project cannot be analysed at its operational phase, criticisms and opinions focus mostly on the planning process. Some assumptions have been made on its future performance though. The project elements considered and omitted during the planning process are being analysed. Aspects which were considered and pushed aside due to particular conditions and external factors affecting the project are also looked at.

Fourteen years ago, the local administration became aware of the problem generated by the management in the municipal slaughterhouse. The effluents produced by the slaughterhouse were damaging the river tremendously and were affecting the municipal treatment plant. The project executed at that time aimed to treat the wastewater. It had a strong technological focus and was in operation for only one year. Reasons for its failure are explained in chapter 6.

Aiming to reduce the generation of effluent is an essential concept that is part of the current approach. The first attempt to treat the slaughterhouse wastewater consisted of a conventional technological problem solving approach. The current project is developed as an integrated approach. The slaughter process is of primary importance.

The initial objective of the current project was to provide the slaughterhouse with a wastewater treatment plant for the effluents it produces. The integration of the other components, such as changes on the slaughtering process, improvement of the facilities, students' participation and urban gardening were included subsequently after an increase in funding. Special circumstances are making the modification of the management and the organisation of the slaughtering process difficult to accomplish. The entity should be working as a public institution, under consistent management and defined set of rules. In reality, processes within the slaughterhouse escape public control and any kind of regulation. The total activity in the slaughterhouse is the sum of independent work from individual slaughterers. Cattle owners contact and hire particular slaughterers who carry out the work. The pilot project board work to maintain a close relationship with the municipality so that the desired changes in the slaughterhouse's organization are put into practice. An improved performance in the facility would back the technical aspect of the project and a better outcome could be achieved.

Due to the short distance from the slaughterhouse to peoples' homes, the municipality aimed to change its location in 2004, however, the relocation did not finally take place due to the impossibility of acquiring the necessary land (Lezama, n.d.). The ,mandatory distance between a slaughterhouse and residential areas differs from 1 to 5 kilometres (García, 2001) and is defined by how far flies and other vectors can reach. Slaughterhouses must also be located a minimum of 5 kilometres away from airports, runways and airfields (Norma técnica N° 05 001-99, 1998). The small airport "Fanor Urroz" is located only 1,2 kilometres away from the slaughterhouse of León. The slaughterhouse which was opened in 1964 does not fulfil the emplacement requirements set by the current norm.

Another point of concern is the growth of the population. The demand for the slaughterhouse is partially increasing. In 2008, 500 cows per month were slaughtered (CPmL-N, 2008a), nowadays this number amounts to 750 cows (Y. Velasquez [Municipality], personal communication, November 21, 2014). The amount of slaughtered pigs has decreased from 1000 pigs to 450 per month respectively. Even if the number of inhabitants increases at the same rate as in the last fifteen years, from 143,878 in 2000 (INIFOM, 2000) to 161,530 nowadays (Oficina de información diplomática, 2014) the facility is big enough accommodate future demands. With a population of more than 20,000 inhabitants full capacity is reached (constructed area of 300m^2 plus 2,500m^2 of land) (García, 2001), the municipal slaughterhouse of León consist of a constructed area of 300 m^2 and property of around 5,400m^2.

The previous two paragraphs analysed some technical and legal aspects of the pilot project, partially suggesting that the relocation of the facility, as it was intended in the first instance, would be a sensible decision. The chances that in the medium term the actual location might change are realistic. The pilot project is attacking the sources which cause ecological damage, however, legal and health issues remain untouched. The reasons for a relocation of the slaughterhouse could return soon or later and will probably lead to the same conclusion.

There are still further aspects which present some drawbacks in the current project. Although improvements on the slaughtering process in León have been implemented, the situation is still quite precarious. To retrofit the inner-slaughterhouse, a plan of action is needed. Interventions such as changing materials on walls and floors would be difficult to accomplish since operations are carried out nightly. The activity in the slaughterhouse will have to stop while these measures need to be taken. However this issue is beyond the scope of this paper. To avoid encountering similar situations in future projects, a minimal quality standard in industrial procedures should be a priority. The development of a wastewater treatment system should take place when a correct process management is achieved.

The assignment from the municipality was to retrofit the previous decentralised wastewater plant. From my point of view, dealing with the infrastructure of the previous project is another difficulty. Fitting together the existing infrastructure with the new concept has created complications that could have been avoided if the construction had been made from scratch.

Nevertheless, taking advantage of the existing construction also had a positive side; it can be analysed afterwards if the savings in workforce and material created a positive balance. In any case, it is unlikely to find in future a similar situation.

An important problem that has to be faced, is that it is not determined who or which institution is going to be in charge of the maintenance of the system once this starts working, or how this is going to be financed. In my opinion a project of this extent should anticipate these aspects and involve whichever suitable entity or person from the beginning of the project so that its functioning and technical characteristics can be fully understood for the future.

The last comment refers to information and participation. On one hand, workers of the slaughterhouse have been asked to participate in workshops where experiences carried out in other facilities were shared. To witness real results increases the awareness for necessary changes among the workers. At the same time, other facilities could learn from the experience of León developing a wastewater treatment system. Neighbours were informed about the project, its effects and importance and agreed on the measures taken. On the other hand, a project of this magnitude must be advertised in an open way. Citizens should be aware of the efforts made to improve the situation and how these efforts can affect their daily life in a positive way. In addition, due to the existence of adjacent houses, taking into consideration their concerns would have been a wise choice. Questionnaires assessing the impact of living close to the slaughterhouse were distributed one year after the project had started.

8.2. Factors that affect transferability

The previous point analysed planning aspects of the pilot project. Planning aspects together with the factors explained in this section will help to lay the foundations to systematically transfer the experiences gained in the slaughterhouse. These factors will relate to the overall situation, including all the protagonists involved, as well as to a particular case of a possible “next project”. The main institutions participating in the environmental development of León have contributed to this overview with their view on the different factors. The manager of operations of ENACAL, the director of environmental management in CIMAC, an engineer who worked for the municipality managing the projects in the Chiquito River and a fourth one who wish to remain anonymous have answered a questionnaire designed for this part of the paper. It must be mentioned that their opinions do not necessarily represent the views of the institutions they work for. The content of this section combine both first-hand information and

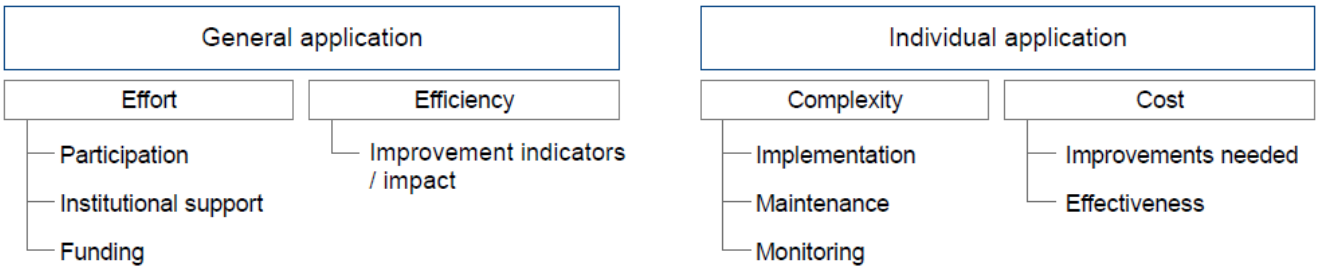


Figure 37. Factors affecting environmental project transferability (Own elaboration)

a more theoretical approach. These factors are shown in Figure 37.

EFFORT

The word effort is understood in this section as the amount of work needed to achieve essential aspects necessary for starting-up an environmental project. These findamental aspects are: citizens' participation, support and communication between institutions and funding.

Participation

Stakeholder participation plays an important role in achieving proper urban environmental management. Environmental management requires the efforts of a wide range of institutions, organizations and individuals. Changing the way society works is a difficult goal to achieve - isolated actions do not suffice. The lack of synergistic action between different stakeholders and protagonists is a bottleneck in the existing urban development scenario. Overcoming this obstacle requires working together to achieve common goals, thus making the overall result of the effort greater than the sum of its parts (Williams, 2000).

In the past, the participation of the inhabitants of León was concentrated on those who were directly affected by environmental issues. The manager of operations from ENACAL states that nowadays the participation of citizens is rather high due to the effort the government has invested in improving the law and encouraging the set-up of social organisations. Workshops are organised on a regular basis in order to underline the importance of community involvement regarding environmental issues.

In the view of CIMAC the participation of the general public in environmental conflicts is very good, however, it is necessary to foster citizen motivation. It is fundamental to grow confidence among the general public and to stress the good features León has to offer.

By contrast, the anonymous interviewee points out that although the involvement is good, it is deteriorating due to the lack of political and institutional interest. This point of view is also shared by the engineer of the municipality, who worked in the cooperation projects on the river. In addition, he states that the structure and organisational cohesion created for the projects two decades ago has already been lost.

ENACAL enhances participation and constant communication with the citizens by the organisation of conferences in schools and universities, the existence of a hotline and physical offices to attend to users' complaints and communication via the media to respond to users' technical questions. To improve the involvement of the citizens, ENACAL suggests the inclusion of topics related to the importance of basic services and natural resource conservation at all levels of the educational system.

CIMAC is an institution with a strong focus on education thus close contact with the general public is a basic feature. The environmental manager points out that even though communication is essential, it does not occur openly and information is not easily spread. The CIMAC reaches its targets by word of mouth and communication between schools, however, there is no marketing strategy which allows the CIMAC to continuously and reliably reach remote and heterogeneous targets. The director states that it is necessary to develop a strategy

which allows the general public to get to know the institution, its function, its activities and projects it has developed. To enhance this aspect, students from the UNAN are currently developing a 3D simulation of the centre so that it can be visited online.

At this point, the engineer from the municipality stated that plans developed by CIMAC, to improve environmental sensitization among citizens, lack financial resources to be put into action. Despite no systematic programme to enhance communication is being applied, the municipality intends to establish one.

The anonymous source considers that despite having a programme which enhance communication between the institution and the general public, this is not materialised due to the lack of resources.

Support and communication between institutions

ENACAL highlights as a positive factor the economic support it receives from the government. They obtain 7% of the total budget transferred from the central to the local government. There are also collaboration agreements between ENACAL and the municipality, twin towns and citizens. The institution points out the positive significance of policies promoting cohesion between institutions established by the central government. Although ENACAL just receives economic support from the local government, the institution feels that support of any kind is easily obtained from the other institutions if needed. The institution works very seldomly with NGO's, however, ENACAL collaborates with ECODES in León.

The CIMAC affirmed that it continually converses with INAFOR and MARENA and more sporadically with ENACAL and MINSA. In addition CIMAC contacts tour-operators to advertised the facility among tourists which is its only financing mean. Citizens, associations and NGO's approach the CIMAC looking for support. Even though it would be desirable to fully meet the demands for support, the reality is that there are not enough human resources to accomplish it She points out as a weakness that interaction between institutions only occurs when there is a need for it and that it does not happen in a systematic way. There are obviously existing communication channels but interesting and beneficial projects are not properly divulged. The municipality agrees on these deficiencies.

From the municipality's point of view, protocols to assure and reinforce inter-communication are missing. There are round-table discussions where national institutions participate, however, the effects on a local level are very limited. In these meetings national plans are given more importance. The project development office in the municipality relies regularly on economic and technical support from NGO's.

Judging from the conversations with the technicians in the institutions it is quite clear that they know each other's work and field of expertise. This is enhanced by the moderate size of the city and the limited number of experts regarding water issues. This is also the opinion of the anonymous source who thinks that the scarce promotion of communication is the weakest feature of the relationship between institutions with the existing protocols being the strongest one.

Funding

In chapter 5 the ENACAL means of financing are already explained. The institution ensures that its budget increases every year. The reason for this is that improving the water infrastructure in Nicaragua is a priority for the government. An example for this is the programme PISASH (Integral Sectoring of Water and Human Sanitation Programme in Nicaragua (2013-32016)), which is financed by AECID and the European Union with a budget exceeding $322 million. However, the reality is that the actual funding does not cover the needs of the country as the infrastructure requires annually a big amount of money for its running operations and maintenance.

The budgetary situation concerning CIMAC is different. For four years, the institution tried to maintain its income to preserve the facility. Lately, economic resources have been decreasing. The institution is self-financed and does not receive public funds. Difficulties are mainly due to the lack of specialised personnel who can interpret the material the centre disposed (plants, birds, butterflies…) Trying to lower costs, the centre is planning on producing electricity using photovoltaic solar panels for its own consumption. Engineering students will participate in this project.

The institutions the anonymous interviewee belongs to suffers from the current allocation of the national budget. The institution, as a national organization, obtains an economical allocation. The interviewee states that the scarce funding is the main factor that obstructs proper functioning of the institution.

The municipal engineer ignores the budget directed to the municipality; in fact it is allocated in a regional way (León and Chinandega together).

EFFICIENCY

This part analyses the repercussions and impact of the pilot project in relation to the overall situation.

ENACAL thinks that the river might probably not experience an important change after the pilot project is accomplished. The important outcome is, in his opinion, that the local government is investing resources and putting effort into fighting the problem, thus serving as an example for citizens. Neighbours cannot take an administration seriously which is asking for better behaviour of the inhabitants, while not leading by example.

The technician from the CIMAC agrees with the view expressed by ENACAL but stresses the fact that the project must be advertised more and that it should not be forgotten. She thinks that neighbours must know what has been accomplished by this project, the same way the administration must know about its progress and difficulties. The engineer working for the municipality and the anonymous interviewee also share the same opinion.

COMPLEXITY

This factor examines the technical level of the technology chosen to deal with the effluents from the tanneries.

ENACAL knows that the applied solutions must be simple and effective and highlights that future maintenance must be guaranteed from the beginning. Staff education and involvement of the administration should also be present from an early stage. Previous projects have, in his opinion, not lasted long due to a lack of interest.

Water conservation projects have to become an issue of major importance and political interest. The local government should make a call to community and institutions to work together for the river. Supporting educational programmes is vital so that this effort does not have to be repeated in future generations.

CIMAC is committed to involve all parts of the project from the beginning in order to ensure the necessary maintenance to sustain the project in the long term. It is BORDA's duty to explain the content of the project, its components and maintenance required in the studied case. Empowerment is essential and must be done properly, recording and editing memories and protocols form the beginning for further consulting and to assure the projects' continuity once the initiator is gone. Educational programmes should address the workers of the facility as well as the person or team in charge of maintenance. The general cause and precursor of "sub-causes" of failure in cooperation projects is a faulty planning stage characterised by low commitment of all parts, leading to improper maintenance due to a lack of knowledge and/or technical resources.

The engineer in the municipality shares the same opinion regarding involvement but also adds an important aspect, which is to carry out proper control of the industrial process. He highlights the lack of follow-up by the local administration as the most important factor affecting the failure of previous projects.

From the point of view of the anonymous interviewee, the involvement of whoever will be in charge of the maintenance in the early stages of the project could be enough to ensure proper maintenance and continuity. He believes that, on previous projects carried out in the river, the most important factor affecting their result was the lack of knowledge which impeded proper maintenance. He also considers the scarce technical resources to be an important factor, as well as inadequate initial planning and the lack of follow-up by the local administration.

COST

Cost is understood as the financial effort made in order to achieve a bigger positive impact on the protection of the river taking into consideration which issues should be targeted initially to obtain a better result.

The technician from ENACAL thinks that the main factor to end the causes of pollution in Chiquito River is to give serious consideration to the issue, including institutions and society and to strictly apply existing laws. From his point of view industrial effluents and solid waste are the first problems to address.

The manager in CIMAC considers that even though environmental awareness is increasing among politicians, there is a need for technicians who can promote the projects in an attractive and interesting way to make politicians understand the meaning and the importance of them. Although all sources of contamination are important, tanneries specially cause great damage. It is worth mentioning that the environmental manager from CIMAC was not informed about the weak performance of the wastewater treatment plant. CIMAC is in charge of unclogging the collectors of domestic wastewater but the vactor truck used for this matter has not received the proper necessary maintenance and it is currently not in use. CIMAC also works on the reforestation of the

watershed, organizes community clean-ups and educational projects.

The municipality regards the most important issue the lack of political interest and conflict of interests, with the effluent from tanneries in second place. This source of pollution is followed in importance by the other sources (domestic wastewater, the WWTP and solid waste). At last, the lack of investment is understood to be the less relevant cause.

The anonymous interviewee estates that the institutional structural deficiencies have a moderate impact on the river. From his point of view, the leakages in the domestic sewerage urgently require a solution. This is followed in importance by solid waste and the WWTP. Tanneries have a rather moderate impact within the scope of the general issue.

Even though this point was focused on detecting the environmental problems of major concern the result shows that what should be improved first is the structural organizational strategic basis rather than what actually happens in the industries.

8.3. The strategy to approach a project

All the information gathered in previous sections indicates that lots of improvements have to be made in order to achieve a solid foundation for the sustainable development of environmental projects. However, changes in mentality, enforcement of institutions and the creation of a powerful network of participants for a responsible development might take decades. What can be done in the meantime? Small specific actions should be taken straight away since there is no time to lose to improve the situation. The important factor is that each of these isolated actions embodies a further step towards the final goal. These actions must be interconnected thus the protagonists are also interrelated. Society will face an ideal scenario when a fully developed institutional framework meets the actions already taken.

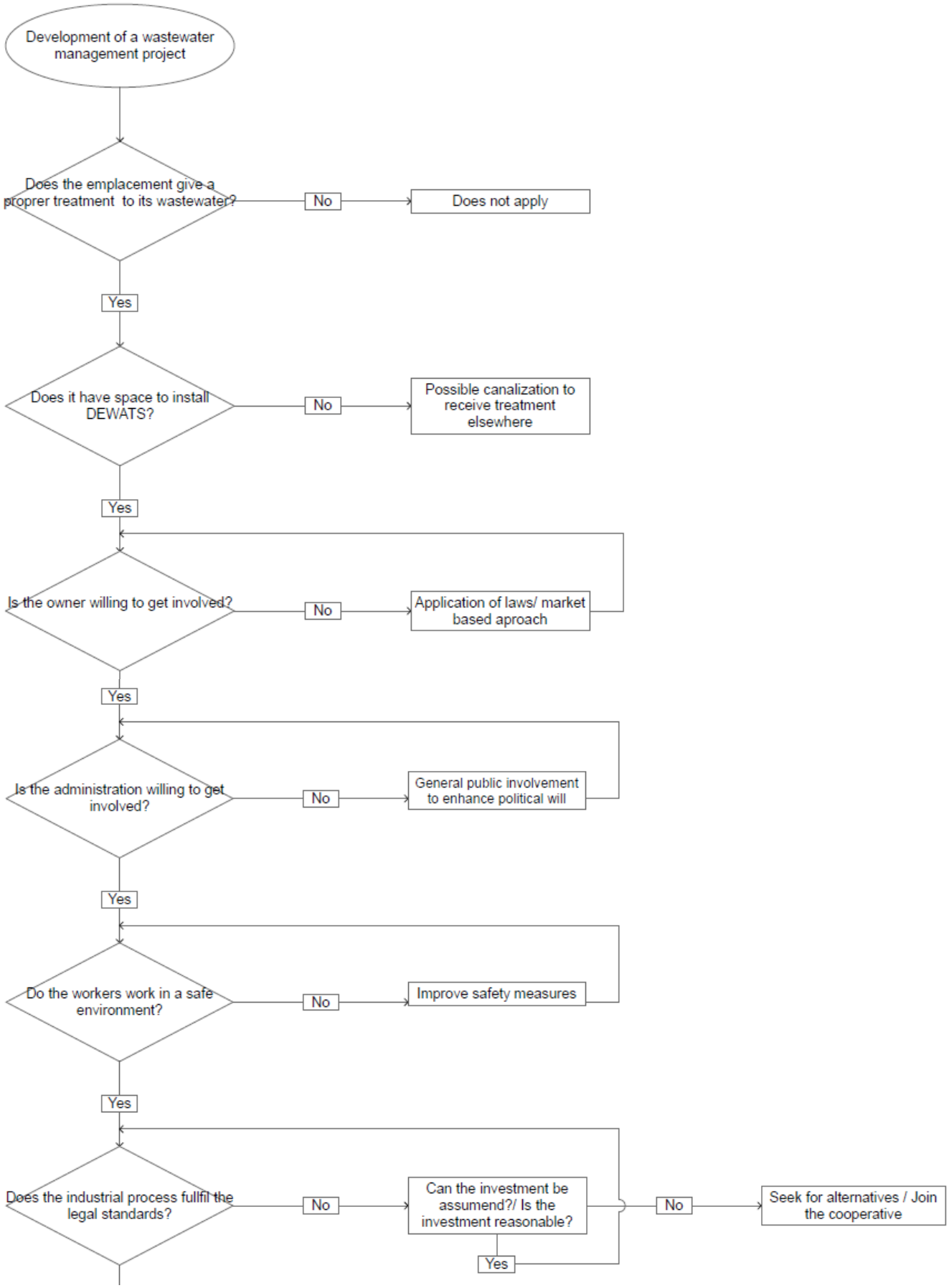
Next page shows a flowchart (see Figure 38) showing the ideal approach to a hypothetic next project in order to overcome the still weak foundations while at the same time reinforcing them.

8.4. Rating system compiling factors for a systematic application of the programme

In order to ease choosing a target to expand the project, a system of points has been created. In Table 21 possible targets are placed in the first column while the features to be graded are placed in the second row. Each feature receives two grades for two different categories. The first one indicates the need for this project to be developed, a major need is represented by a higher grade. The second grade represents the difficulty of application, a higher grade indicates easier feasibility.

The points given are based on my experiences and a more accurate investigation is needed regarding some aspects in order to achieve a better overview. For example, although leakages were witnessed while visiting the facilities, an exhaustive inventory was not conducted, thus the exact amount of water wasted through leakages is unknown.

Figure 39 is the graphic representation of Table 21. “Need for the project” is represented on the X axis of the graph while “Difficulty of application” is on the Y axis. The size of the


Development of a wastewater management project
Does the emplacement give a proprer treatment to its wastewater?
No
Does not apply
Yes
Does it have space to install DEWATS?
No
Possible canalization to receive treatment elsewhere
Yes
Is the owner willing to get involved?
No
Application of laws/ market based aproach
Yes
Is the administration willing to get involved?
No
General public involvement to enhance political will
Yes
Do the workers work in a safe environment?
No
Improve safety measures
Yes
Does the industrial process fullfil the legal standards?
No
Can the investment be assumend?/ Is the investment reasonable?
No
Seek for alternatives / Join the cooperative
Yes

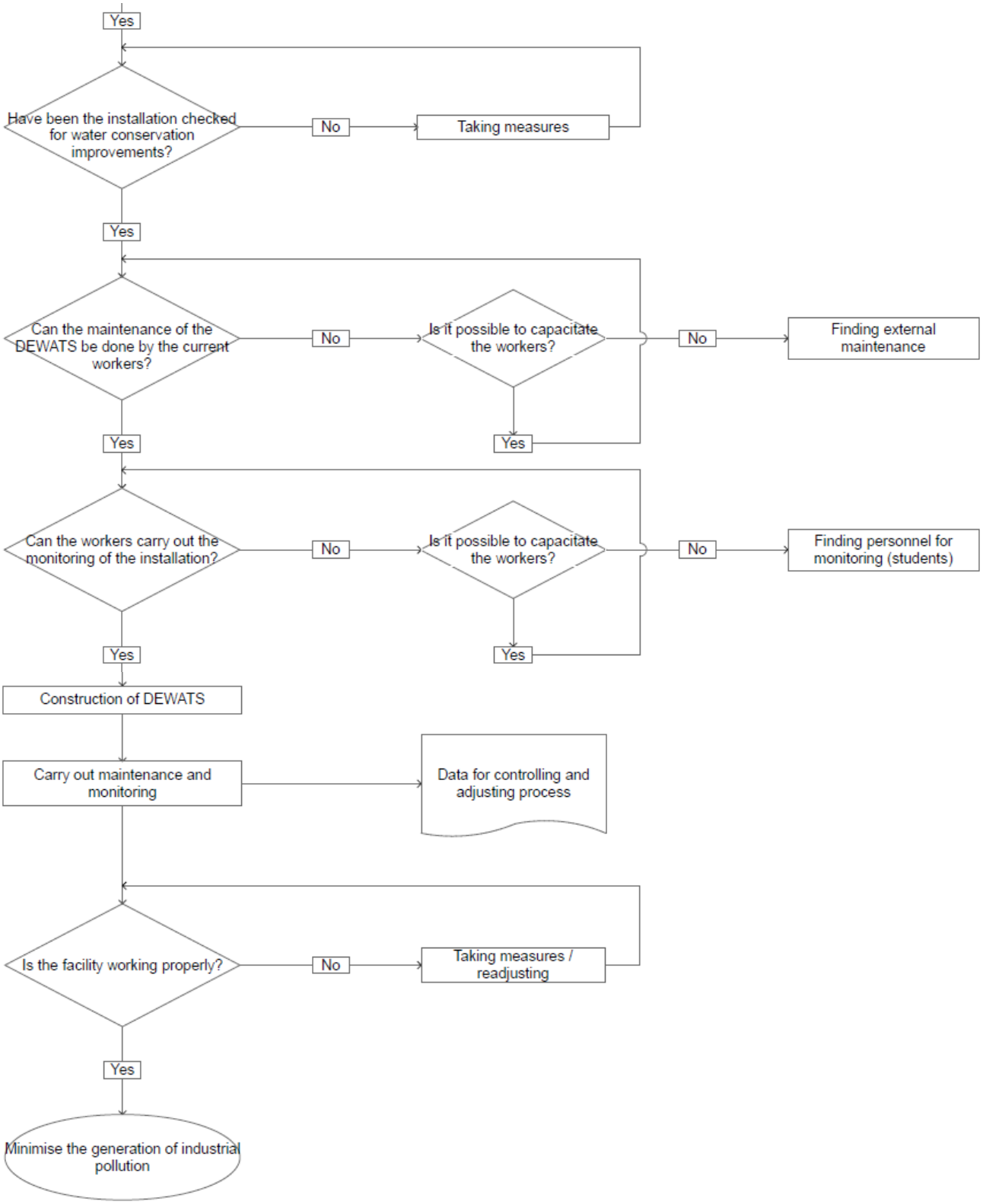


Figure 38. Chart flow indicating process to approach a wastewater management project in a tannery (Own elaboration)

	Water reduction				Feasibility for DEWATS						Changes in process				Total	
	Leakages		Machinery		Room		Targeting the effluent		Maintenance		Control		Machinery /facilities		Need	Difficulty of application
Slaughterhouse	2	3	2	1	0	3	1	3	3	1	3	1	3	1	14	13
Coop. Carlos Alvarado	3	3	3	2	0	3	3	2	3	1	3	1	2	2	17	14
Teguesa	3	3	3	1	0	3	3	3	3	1	3	1	3	1	18	13
Urcullo	3	3	3	1	0	1	3	3	3	1	3	1	3	1	18	11
Centroamericana	1	3	2	2	0	1	3	3	3	1	3	2	3	1	15	13
El Águila	2	3	3	2	0	1	3	3	3	1	3	1	3	1	17	12
Bravo-Esperanza	3	3	3	1	0	3	3	3	3	1	3	1	3	1	18	13
Farasón	2	3	2	2	0	3	3	3	3	1	3	1	3	1	16	14
Pig farm S. Pedro	3	3	2	3	0	2	3	3	2	2	2	2	2	3	14	18

points	Need	Difficulty of application
0	Does not apply	Does not apply
1	It is not needed	Difficult to accomplish
2	Moderately needed	Can be achieved
3	Really needed	Easy to achieved

Slauterhouse
Tannery
Pig Farm

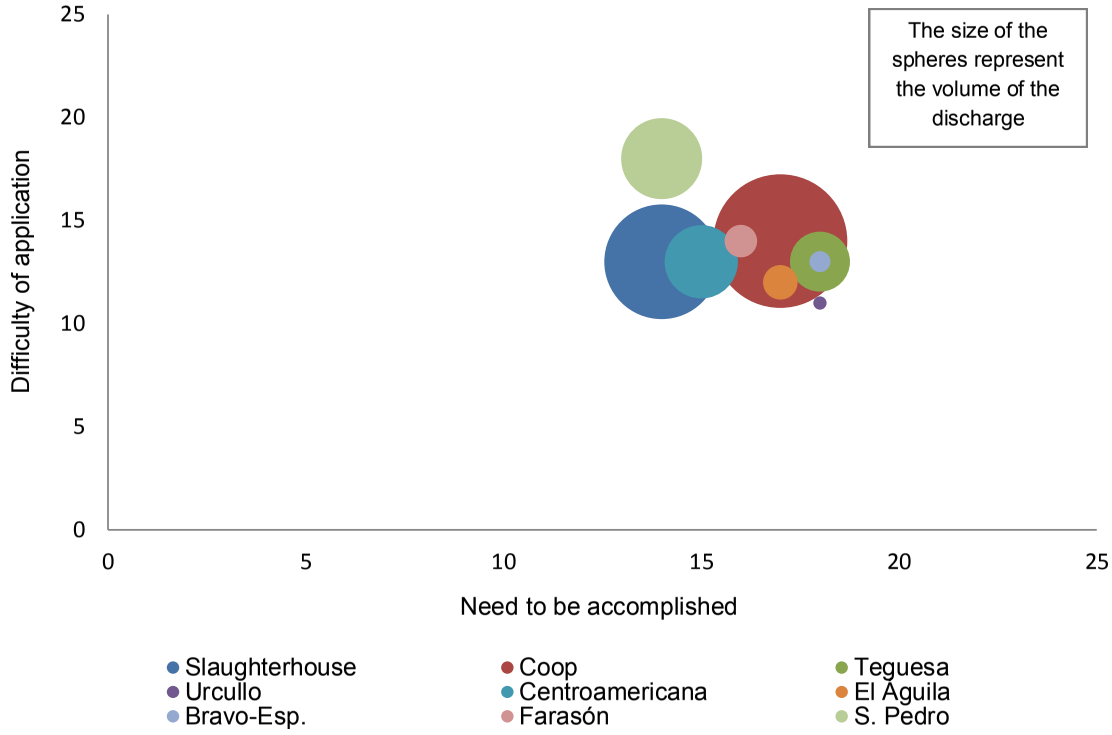


Table 21. System of points (Own elaboration)

Figure 39. Graphic representation of the system of points (Own elaboration)

spheres represents the volume of wastewater produced by each single industry. As a result the spheres sited on a higher level and more to the right of the graph are the facilities than need more urgent intervention while at the same time this intervention might be easier to accomplish.

9. Conclusion

Cooperation projects usually face a multitude of difficulties. Under any circumstances project work is challenging. Effective communication is vital to overcome difficulties. Communication affects participation, commitment and success. Communication encompasses talking, explaining but also asking and listening. International development projects imply understanding different cultural values thus difficulties that might occur within project work accentuate.

Throughout this paper factors that may affect the development of environmental projects have been analyzed. This study is based on the construction of a decentralized wastewater treatment plant in the slaughterhouse of León (Nicaragua). Firstly, the development of the area and its current situation are illustrated. Afterwards, the applicable legislation and institutional framework are outlined. Following, the problem of untreated industrial effluents in the river is assessed. This technical section shows the detailed characteristics of the effluents and states how a better management and treatment could be achieved. The final chapter returns to a more comprehensive view. Here, the factors needed for a well-founded institutional network are addressed. It is endorsed that environmental problems should be based on a strong institutional foundation.

In this thesis a comprehensive analysis of the current situation in León has been made. Institutions, their responsibilities, interactions and opinions regarding the development of León are shown. The results show a demand for improving open access to information and a need to reinforce communication channels. The need for strengthening institutions' capacities is another important outcome.

Although the development of a solid institutional network may take long, actions for environmental protection and conservation cannot wait. Actions must be planned in order to be not only sustainable but also transferable. For that reason a simple point system, based on need for action and the difficulty of implantation, has been created to identify which polluter should be approached in further developments. Once the polluter is identified, a strategy to develop a wastewater treatment project and how to assure its continuity is shown.

Although it is possible to apply biological treatment to effluents generated by tanneries, the technical approach from the pilot project cannot be directly transferred.

As developers and planners it is our responsibility to consequently promote what we know is best practice. It cannot be expected to obtain better results when same strategies are used. Although León has been the site of several environmental projects which have failed, valuable lessons have been learnt. The environmental situation in León, as in many places of the world, is not the result of its circumstances, it is the result of human actions. Despite the need for technology the real engine for change is people. People must demand change so that a different result can be

achieved. The future environmental scenario will be the result of a new chain of actions. These actions will pursue an environment citizens want to live in.

There is a need for changing the way cities develop. This need is unknown to a large part of the general public. Citizens believe there is no other possible approach. Changing the thinking and behavior of the people is the real challenge.

It is demonstrated in this paper that actions can be taken. It is no longer a matter of economic resources or knowledge; it is a matter of motivation.

ANNEX A

Local negotiations balance interests and commit parties to clean up Colombia's rivers

"In Colombia, as in many countries, most wastewater is released untreated into waterways. With little enforcement, limits on pollution emissions have long been ignored. In 1997, the environment ministry implemented a new water pollution charge system that is cost-effective and enforceable. Facilitated under Colombia's decentralized structure, the system is implemented by regional environmental agencies. It brings together municipal authorities, polluting industries, and affected communities to negotiate local pollution reduction targets and charges. Polluters are charged per unit of effluent, and the parties agree to timetables for increasing the charges if targets are not met. All the parties have received extensive capacity building from the national ministry, and the system holds together impressively:

In the nation's 135 river basins, biochemical oxygen demand is already down by 31.5 percent, and suspended solids by 34.2 percent. Nationally the program has generated $9.7 million in revenues, funding pollution reduction projects and regional environmental agencies.

Lessons include the following:

Use national commitment to facilitate locally negotiated solutions. Regulated sectors participate because authorities have signaled their intent to enforce the program. But each region is allowed to set goals and timetables to reflect local conditions and aspirations. Firms can choose emission reductions—and method—in light of per unit charges.

Devise innovative approaches to program administration. A well-respected private bank collects the charges and administers the funds in return for a percentage of the revenues, reducing the burden of collection but not of auditing by government agencies.

Enhance the community benefits of market-based regulatory tools. Local business leaders were initially skeptical, perceiving the program as a new generalized tax burden. When it was agreed that revenues would fund monitorable benefits, such as local pollution reduction, this appealed to businesses and communities alike, and helped generate commitment to implementation.

Future progress will require greater compliance from recalcitrant sectors, such as municipal water companies, who use various pretexts to avoid paying and investing. If those who do not comply are seen to gain, it could threaten the more general commitment among polluters, a commitment that has proven to be a strength of negotiated approaches."

Sources: World Bank 2000d; Andean Center 2001. Citation in (World Bank, 2002)

ANNEX B

The nature of Corruption

“Corruption is the abuse of entrusted power for private gain. It hurts everyone who depends on the integrity of people in a position of authority (International transparency, 2015)”.

This ANNEX tries to understand the nature of the corruption so that, it can be put in place barriers, controls and preventive strategies. This text is based on the conference professor Adam Graicar (2014) gave for the World Bank in November 20th 2014 where he discussed his most recent book, *Understanding and Preventing Corruption*. Firstly, some numbers which give an idea of the dimension of corruption in Nicaragua are shown.

Corruption measurement tools

The Corruption Perceptions Index ranks countries or territories based on how corrupt a country’s public sector is perceived to be. It is a composite index, drawing on corruption-related data from expert and business surveys carried out by a variety of independent and reputable institutions. Scores range from 0 (highly corrupt) to 100 (very clean).

CORRUPTION PERCEPTIONS INDEX FOR NICARAGUA (2014)	
Rank 133/175	Score 28/100

Source: Transparency International (2015)

Control of corruption reflects perceptions of the extent to which public power is exercised for private gain. This includes both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Control of corruption is one of the six dimensions of the Worldwide Governance Indicators. Point estimates range from about -2.5 to 2.5. Higher values correspond to better governance outcomes.

CONTROL OF CORRUPTION FOR NICARAGUA (2010)	
Percentile Rank 23%	Score -0.782690627

Source: Transparency International (2015)

Part 1. Describing corruption

Corruption has many impacts in a society. Corruption hampers economic growth, discourages investment, distorts natural resource development, damages the environment, reduces tax revenue, distorts services, harms the performance of the public administration, weakens judicial integrity and the rule of law and diminishes the quality of life.

G20 (16, November 2014) pointed out specific components of corruption: beneficial ownership, bribery, high risk sectors, public sector transparency and integrity, international co-operation and private sector transparency and integrity.

In order to face corruption the nature of the target has to be distinguished. The target may be corrupted individuals, groups, organizations or societies. In contrast, a better control can be achieved when the focus is on corrupted events, thus this control can reach any of the aforementioned groups.

In order to make a diagnostic of a certain situation, boundaries must be set. Corruption, misconduct and maladministration or inefficiency are different concepts. Corruption can be described as doing wrong things, failing to do

something one should do or doing something permissible but purposely doing it in an improper manner. Corruption within an organization is materialised as the breach of trust. The unauthorized trading of entrusted authority is also characteristic.

At this point, to go deeply into the diagnosis of an experience or a particular case, the extent of what is happening has to be identified. It is necessary to look at the big picture to determine whether the harm done is negligible. In this case, investing resources in solving a minor problem might be not worthy.

Cultural issues play also an important role. For instance, gift giving can turn into rent seeking (expending resources on political activity to increase one's share of existing wealth without creating wealth).

A framework is created when the aforementioned concepts (target, specific boundaries, extent of the problem and cultural issues) are brought together. Through this framework the dynamics of corruption can be understood. Type, Activities, Sectors and Places can be established within this framework.

There are different *types* of corruption: bribery, extortion, misappropriation, self-dealing, patronage, abuse of discretion, misuse of information, creating or exploiting a conflict of interest and nepotism among others.

These types take place in different *activities* such as: appointing personnel, buying things (Procurement), delivering programs or services, managing disasters, making things (Construction / manufacturing), controlling activities (Licensing / regulation/ issuing of permits) and administering (justice).

These types take place in different *sectors* such as: construction, health, tax administration, energy, environment and water or legal system. And at the same time they take in *places,* such countries, regions, localities, corporations or work places.

As example of diagnosis, during the research of this paper, bribery while controlling activities, in the environment and water sector in the city of León was detected. Once the case is broken down this way, the most appropriate source of control can easily be found.

To reach a final diagnosis it is necessary to look at:

-The context: in some cases, corruption is structural and embedded, everybody knows about it and it is therefore tolerated. In other cases, corruption is situational; this happens, for example, when an individual finds a good opportunity and takes advantage of it.

- The participants: likewise, it is important to pay attention to the participants. To stop corruption becomes a difficult task when participants are willing to take part in it. To the contrary, blocking corruption when participants are extortionate becomes easier.

- The benefit: It is important to identify whether the behaviour benefits an individual or an organization.

- The cause: it is necessary to know if what is happening is provoked by a need or greed or whether this behaviour exhibits patronage (nepotism, crony, love...). There might be activities involved in the promotion of an ideology, trying to change values or relocate resources.

Finally It is necessary to distinguish what is being corrupted such as an event or process - for example the way natural resources are exploited - or a culture - when the bribery is the rule-. Corruption can happen in the making of policy and its implantation, when this happens the agency loses the governance capacity.

Corruption can be measured to have an impression of the amount of it affecting certain process. The possibility of grading corruption brings results which may draw public attention towards an issue. Another positive effect is the promotion of the need to take action, so that the best intervention to apply can be identified.

Thanks to the evaluation of corruption it is possible to evaluate the success of corruption minimization strategies and to measure the performance of anticorruption agencies. Perceptions, extent, risks and costs of corruption can be measured through surveys, focus groups, case studies, desk reviews and professional assessments among others.

There are two different types of indicators. Input-based corruption indicators are indicators measuring the existence and quality of anti-corruption or governance institutions, rules and procedures and output-based corruption indicators are indicators that measure the impact of corruption on quality of life and public service delivery such as water, education or human rights, outputs of justice system, electoral fairness, proceeds of crime confiscations or protection of whistleblowers.

Part 2: The Architecture of corruption prevention and control

Corruption can be seen in the context of the big picture such in treaties, global indicators and global partnerships. A closer approach is for example the work made to change systems and implement legislation. A third even closer perspective appears when work is done directly, such as managing processes and dealing with real issues.

There are strategies to further solve the diagnosis. For understanding those strategies paying attention to the individuals is needed. Situations may be encountered where people get involved in corrupted activities due to personal problems which become risk factors, at the same time, there are people who take part or initiate a situation for economic reasons. It can be also differentiated between institutional factors (internal) such as lacking management structure and weak goal setting dynamic in a institution and environmental factors, external to the agency, such us climate change, government budget reduction or reorganization of institutions (Mills & Cooper, 2007).

Prevention and Control

The opportunity structure has to be understood to execute prevention and control over the scenarios. Corruption essentially follows the opportunity and each opportunity follows three components: a motivated offender, a target and the absence of a capable guardian. The absence of political leadership, corrupted behaviours that are accepted within a culture, loose ethics, the lack of an anti-corruption or an audit agency, absence of education and absence of laws are understood as absence of a capable guardian. The existence of a good government and a good management minimizes the appearance of an opportunity. In contrast, poor public policy creates opportunity.

Situational responses (Cornish& Clarke, 2003)

Opportunities must be responded to increase the effort needed to behave corruptly. Strategies such as rotating the stuff, rewriting position statements and rewriting prescriptions may reduce the number of opportunities. Behaving corruptly should not be easy. Being corrupted can become more risky when activities such as monitoring contracts, tracking the movement of people and money, doing random integrity tests, better supervision and criminal penalties are applied. Reducing the rewards of corrupt behaviour is possible when activities such as firing or suspending people, recovering assets and cutting down pensions are put into action. Excuses for corrupt behaviour have to be removed and best practices should be rewarded. This can be achieved towards enhancing leadership, capacity building exercises, reviewing job's specifications (to make sure that they reflect reality) and reviewing benefits and salaries (to make sure that the benefit structure is understood and transparent).

Part 3: Building and Maintaining Integrity

Integrity public servants' behaviour has to be in line with public purposes. Workers must be reliable, resources should not be wasted, users must be treated impartially and decision making processes must be transparent to general public. Education and building integrity are crucial. To enhance education and achieve good integrity building standards communication must be clear and suffer of a continuous supervision.

Strategies for overcoming problems compound guidance, management and control. Guidance is provided by strong commitment from political leadership. Statements of values such as codes of conduct should be established. Professional socialisation activities such as education and training become essential. Management of activities to prevent corruption can be realised through management policies and practices, co-ordination by a special body or an existing

Systemic opportunities	Localized opportunities
lack of integrity among leaders (in both the public and private sectors),	supervision and oversight is not taken seriously
lack of culture of integrity	specialized knowledge/ high discretion
ethical codes do not exist or are not enforced,	decisions affect costs and benefits of activities
patronage and nepotism are accepted	activity remote from supervision
complexity of regulations/ complexity of systems	no capable guardian
where factionalism, regionalism or ethnic differences matter	low decision monitoring
weak legal regimes	silencing of whistleblowers
weak financial controls	low salaries
weak institutions of governance	low risk of being caught
very weak state (or very strong state)	conflict of interest disregarded
	demand exceeds supply

Table 22. Opportunities that might trigger corruption (Graycar, 2014)

central management agency and through proper public service conditions. Control is assured primarily through a legal framework enabling independent investigation and prosecution; Secondly through effective accountability and control mechanisms and finally through transparency, public involvement and scrutiny (OECD, 1998).

Opportunities are situations where corruption may be easily take place. Opportunities can arise in many ways and can be classified as systemic opportunities and localized opportunities. These are listed in Table 22.

To minimise the appearance of opportunities an extended control must be applied. This can be categorized as well as systemic controls and localised controls and are listed in Table 23.

Prevention is essential to overcome corruption. Education, both in government agencies and community based education is important and can be achieved by training programmes, outreach, workforce capacity building and integrity building. Other strategies would be to improve governance to develop positive, transparent workplace cultures, publication of guidelines, frameworks and other resources as well as to communicate audit findings to the public sector in their regular newsletters and bulletins. It might be very useful publishing better practice guides for governance in a range of areas including procurement, performance reporting, and record keeping. It can turn effective to advice small businesses about exploring the ethical dimensions of offering gifts and other benefits to police officers.

In the end corruption control may include, but is more than ethics training, performance management, process re-engineering and criminalization. It is important to keep in mind that all corruption is not the same, that some places are more corrupt than others and also do not confuse personal integrity with the agency's integrity.

Systemic Controls	Localised Controls
Increasing the moral cost of corruption	Appropriate oversight of discretionary decision making
Creating a culture of integrity	Establishing effective internal and external reporting procedures
Civil society oversight	Setting and enforcement of procurement guidelines
Criminalization and penalties	Penalties for procurement breaches
Modification of conflicts of interest guidelines	Decision making process transparent + regular and random audits
External auditing for party finances and campaigns	Random integrity testing
Simplifying regulatory framework	Creating a code of ethics
Workplace performance indicators	CCTV surveillance where appropriate

Table 23. Control actions to mitigate corruption (Graycar, 2014)

ANNEX C **Questionnaires**

INICIO

Mi nombre es Clara Rodríguez, soy estudiante de la Universidad de Hamburgo. ¿Está el dueño o responsable?

Estoy estudiando la posibilidad de implementar tratamientos descentralizados de aguas residuales en las industrias de la sub-cuenca del Río Chiquito. A la vez estoy analizando los proyectos que se han llevado a cabo en el Río durante los últimos 20 años y las causas de falla de estos.

Este estudio es la base de mi trabajo de Maestría. ¿Me dedicaría unos minutos para contestarme a estas unas preguntas?

Trabajo de fin de Master: Posibilidad de implementar tratamientos de agua residual en las industrias de la sub-cuenca del Río Chiquito

Fecha:

Nombre

Edad

Originario de/ vive en

Tipo industria / Nombre

¿Cuánto tiempo lleva trabajando aquí?

¿Qué puesto desempeña?

Descríbame la actividad del complejo (tipo de pieles tratadas, número de pieles tratadas,)
□ RES
□ CERDO

¿Tiene suministro de agua potable?

¿Sabe cuánta agua consume la tenería/industria?

Si no, ¿sabría decirme cuanto paga mensualmente?

¿Tiene conexión con aguas negras/servidas?

Si no, ¿Se recibe alguna presión por parte de la Alcaldía o ENACAL por el vertido de las aguas al río sin tratamiento previo?

Qué sabe usted de los proyectos anteriormente realizados en el Río para disminuir la contaminación y mejoras las condiciones de la cuenca.

(si procede) Participó activamente en ellos (toma de decisiones, diseño, periodo de prueba…)

En una escala del 1 al 10, cuánto consideraría que el vertido de su industria daña el río. ¿Por qué?

¿Participaría en la financiación de medios para disminuir la contaminación de su efluente?

¿Qué parte de sus beneficios dedicaría (%) a financiar medios que disminuyeran la contaminación de los vertidos?

FINAL

Esta es mi información de contacto (e-mail), es posible que necesite ponerme en contacto con usted en un futuro para aclarar información, para hacer alguna pregunta adicional o para hacer algún tipo de comprobación, ¿me facilitaría su e-mail o teléfono?

Muchas gracias por su colaboración.

HOJA DE INFORMACIÓN DE FÓRMULAS USADAS EN TENERÍAS

ETAPA	FASE	X	PRODUCTO QUÍMICO	X	CONCENTRACIÓN (%)	CANTIDAD/mes	NOMBRE PRODUCTO
CURADO	Curado		Sal				
			(plaguicidas) pyrethrum				
			permetrin				
			p-dicloro- benceno				
			silicofluoruro de sodio				
			borax				
			Otros:				
ETAPA DE RIBERA	Remojo		Hidróxido de sodio				
			Hipoclorito de sodio				
			Agentes tensoactivos				
			preparaciones enzimáticas				
			Otros:				
	Pelambre		Cal				
			Sulfuro de sodio				
			Otros:				
	Desencalado		Ácido sulfúrico				
			Ácido clorhídrico				
			Ácido láctico				
			Ácido fórmico				
			Ácido bórico				
			Sal de amonio				
			Bisulfito de sodio				
			Agua oxigenada				
			Azucares/Melazas				
			Ácido sulfoftálico				
			Otros:				
	Descamado						
	Desengrase		Queroseno				
			monoclorobenceno				
			percloroetileno				
			Otros:				
	Purga enzimática		Tripsina				
			Cloruro de Amonio				
			Otros:				
PIQUELADO	Piquelado		Ácido fórmico				
			Acido sulfúrico				
			Sal				
			Otros:				
CURTIDO	Curtido		Cromo trivalente				
			Taninos				
			(Sintano) sulfonados del fenol				
			(Sintano) sulfonados de cresol				
			(Sintano) sulfonados del naftaleno				
			(Sintano) resinas derivadas de ácidos poliacrílicos				
			Otros:				

POSTCURTIDO (mecánico)	Desaguado mecánico						
	Dividido o partido						
	Raspado						
	Recortes						
POSTCURTIDO (húmedo)	Reprocesamiento del colágeno		Cromo trivalente				
			Otros:				
	Neutralizado		Sales al cromo				
			sintanos				
			Otros:				
	Recurtido		Sales al cromo				
			sintanos				
			Otros:				
	Teñido		anilina				
			Otros:				
	Engrasado						
SECADO	Secado						
TERMINACIÓN	(aplicación) binder		anilinas				
	felpa, pistola o rodillo		caseína				
			polímeros acrílicos				
			polímeros poliuretánicos				
	solvetes orgánicos		lacas nitrocelulósicas				
			lacas uretánicas				
			Otros:				

Factores para transferir proyectos medioambientales

Pensando en un escenario futuro, donde se desea transferir la experiencia llevada a cabo en el proyecto de el Rastro Municipal (tratando las aguas residuales) he pensado en los factores que podrían afectar la expansión del proyecto a otros sectores y sobre ellos he formulado unas preguntas que me gustaría que contestara desde su experiencia y perspectiva como trabajadora del CIMAC y así poder construir un escenario con carga real y no sólo teórica.

Cómo definiría el nivel de participación de los ciudadanos en los conflictos medio-ambientales que afectan a la ciudad de León?

- ○ Muy bueno, poco se puede hacer para mejorarlo
- ○ Bueno, políticas y acciones sociales han mejorado mucho la participación ciudadana en los últimos años
- ○ Bueno pero está en deterioro por falta de interés político e institucional
- ○ Malo, no existen políticas ni acciones para propuldar la participación ciudadana
- ○ Otro: _____

Materialización de la comunicación entre los ciudadanos y el CIMAC (Consultas talleres, charlas) Existe un programa que se aplique?

- ○ Sí, y se llava a cabo
- ○ Sí, pero no se lleva a cabo por falta de recursos
- ○ No, pero se quiere realizar uno
- ○ Otro: _____

¿Existe contacto directo y regular con otras instituciones de León?

- ○ Sí, todas las instituciones están mutuamente informadas de las acciones locales en materia de sostenibilidad
- ○ Sí, pero no existen protocolos que la aseguren y refuercen
- ○ Sí, pero sólo para apoyo económico
- ○ No, no nos comunicamos
- ○ Otro: _____

Cúal cree que son los puntos más débiles en la comunicación y apoyo entre instituciones?

- ☐ Falta de canales establecidos
- ☐ Falta de coordinación
- ☐ Sólo se lleva a cabo cuando es imprescindible pero no de forma sistemática
- ☐ Otro: _____

Cúal cree que son los puntos fuertes en la comunicación y apoyo entre instituciones?

- [ ] Existen protocolos establecidos
- [ ] Existe una buena coordinación
- [ ] Se lleva a cabo de forma sistemática y regular
- [ ] Otro:

Cuando el CIMAC plantea un proyecto para una mejora medioambiental se pone en contacto con ONG's…

- ( ) Nunca, no se pide apoyo exterior
- ( ) Regularmente para pedir asesoramiento técnico
- ( ) Regularmente para a poyo económico
- ( ) Otro:

¿Cuál es la tendencia presupuestaria en el CIMAC en los últimos años?

- ( ) Aumenta
- ( ) Disminuye
- ( ) Se mantiene estable

Cuales, a su juicio, son los principales problemas en la contaminación de agua del río Chiquito

Determine de 1 a 7 valorando de mayor a menor importancia

- [ ] a. Fugas del alcantarillado sanitario
- [ ] b. Efluentes de las tenerías
- [ ] c. Efluentes del Rastro
- [ ] d. Débil actuación de la planta de tratamiento
- [ ] e. Desperdicios sólidos
- [ ] f. Falta de inversión
- [ ] g. Falta de interés político o cruce de intereses
- [ ] Otro:

Escriba aquí la valoración de la anterior pregunta

por ejemplo (1-d; 2-g;3-c...)

Con que problemas relacionados con el río Chiquito está el CIMAC trabajando o tiene planes de hacerlo?

- [ ] Fugas del alcantarillado sanitario
- [ ] Efluentes de las tenerías

- [ ] Efluentes del Rastro
- [ ] Débil actuación de la planta de tratamiento
- [ ] Desperdicios sólidos
- [ ] Falta de inversión
- [ ] Falta de interés político o cruce de intereses
- [ ] Otro:

¿Cómo valora el cambio que experimentará el río cuando el proyecto del Rastro se ponga en funcionamiento en relación con la totalidad de la situación?

- ( ) No se notará la diferencia, la problemática es muy compleja
- ( ) No se notará la diferencia pero cada medida tomada es importante
- ( ) El impacto será moderado pero el modelo de ejemplaridad es importante
- ( ) Otro:

Cuál cree que es la forma más acertada de garantizar el mantenimiento a largo plazo de la instalación para tratar los efluentes en el rastro?

- [ ] Contratar a una empresa externa
- [ ] Involucrar y formar al encargado del futuro manteniemiento en fases tempranas del proyecto
- [ ] Involucrar a los trabajadores del rastro en fases tempranas del proyecto
- [ ] Cambiar la gestión en el rastro
- [ ] Aumentar el control en el proceso de matanza
- [ ] Otro:

Cuáles han sido desde su punto de vista los factores que han impedido que los proyectos previos de cooperación no hayan resultado tan bien como se esperaba

Determine de 1 a 4 valorando de mayor a menor importancia

- ( ) a. Falta de seguimiento por parte de la administración Local
- ( ) b. Mal planteamiento inicial del proyecto
- ( ) c. Falta apropiado mantenimiento por escasez de recursos técnicos
- ( ) d. Falta apropiado mantenimiento por escasez de apropiado conocimiento
- ( ) Otro:

Escriba aquí la valoración de la anterior pregunta

por ejemplo 1-b; 2-d...

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