Fachhochschule Köln
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UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ

FACULTADES DE CIENCIAS QUÍMICAS, INGENIERÍA Y MEDICINA

PROGRAMAS MULTIDISCIPLINARIOS DE POSGRADO EN CIENCIAS AMBIENTALES

AND

COLOGNE UNIVERSITY OF APPLIED SCIENCES

INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

ENVIRONMENTAL COST-BENEFIT ANALYSIS OF DECENTRALIZED WASTEWATER AND SANITATION TECHNOLOGIES IN THE MICROBASIN OF BARRACÃO DOS MENDES, BRAZIL

THESIS TO OBTAIN THE DEGREE OF

MAESTRÍA EN CIENCIAS AMBIENTALES

DEGREE AWARDED BY

UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ

AND

MASTER OF SCIENCE

TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

IN THE SPECIALIZATION: RESOURCES MANAGEMENT

DEGREE AWARDED BY COLOGNE UNIVERSITY OF APPLIED SCIENCES

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PROYECTO FINANCIADO POR:

PROYECTO ECO (INTECRAL) INTEGRATION OF ECO-TECHNOLOGIES AND SERVICES FOR THE DEVELOPMENT OF A SUSTAINABLE RURAL AREA IN RIO DE JANEIRO

PROYECTO REALIZADO EN:

ITT CON COOPERACION CON EL PROYECTO RIO RURAL

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LA MAESTRÍA EN CIENCIAS AMBIENTALES RECIBE APOYO A TRAVÉS DEL PROGRAMA NACIONAL DE POSGRADOS (PNPC - CONACYT)

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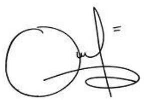
Unterschrift / *Firma*: 

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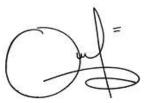
Unterschrift / *Firma*: 

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Dedico este trabajo a mis amados padres Verónica Sánchez y Cuauhtémoc Segovia quienes me han apoyado incondicionalmente en el cumplimiento de mis sueños, gracias por inspirarme cada día a ser un mejor ser humano.

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ABSTRACT

Nowadays rural areas of Rio de Janeiro state present poor sanitation conditions, developing public health and environmental problems. However, sanitation improvements imply high investment cost, which limit its installation especially in rural areas.

In order to improve the sanitation condition of the microbasin of Barracão dos Mendes. The aim of this study was to develop an environmental cost-benefit analysis (ECBA), as an economic tool for the selection of the decentralized wastewater and treatment technology option. The methodology of this study carried out a participative diagnosis, 55 survey, 7 semi-structured interviews (SSI) and the ECBA estimation.

The first three methods results show the lack of sanitation and wastewater treatment infrastructure and water quality monitoring, ground water pollution due to the presence of faecal coliforms and there is an overuse of agrotoxics in the microbasin.

For the ECBA valuation two main scenarios (totally decentralized and semi-decentralized) that compare ten treatment technologies were created. It was considered the valuation of three non-market value benefits: biofertilizer reuse, public health and water reuse. The results show the economic feasibility of semi-decentralized technologies over decentralized technologies in the microbasin, especially when the reuse of water is included into the economic valuation.

Keywords: Environmental cost-benefit analysis, sanitation, wastewater, treatment technologies, decentralized management, rural areas.

RESUMO

Atualmente, as más condições de saneamento cujas quais estão sujeitas as áreas rurais do Rio de Janeiro, levam a graves problemas ambientais e de saúde pública. No entanto, os altos custos necessários para sua instalação dificultam sua implementação.

A fim de melhorar o saneamento da microbacia de Barracão dos Mendes. Este estúdio tem como objetivo desenvolver, uma análise de custo-benefício ambiental (AACA) considerada como uma ferramenta para a escolha de tecnologias em tratamento de águas de esgoto descentralizada. A metodologia empregada compreende um diagnóstico participativo, 55 questionários, 7 entrevistas semi-estruturadas (ESE) e a estimativa da AACA.

Os resultados dos três primeiros métodos revelaram a falta de saneamento e tratamento de água, falta do monitoramento da qualidade de água, a contaminação dos lençóis freáticos devido a presença de coliformes fecais e o uso intensivo de agrotóxicos na microbacia.

A estimativa do AACA compreende cenários principais (totalmente descentralizado e semi-descentralizado), cujos quais comparam dez tecnologias de tratamento. O cálculo de três benefícios sem valor de mercado foi considerado: o reuso de biofertilizantes, saúde pública e reuso da água. Os resultados do estudo demonstraram a adequabilidade econômica do uso de tecnologias semi-descentralizadas em comparação com as descentralizadas, principalmente quando os benefícios de reuso de água são incluídos.

Palavras chave: Análise ambiental de custo-benefício, tecnologias de tratamento, águas de esgoto, gestão descentralizada, áreas rurais

ZUSAMMENFASSUNG

Kennzeichend für die ländlichen Gebiete im Bundesstaat Rio de Janeiro in Brasilien sind mangelnde Sanitäre Einrichtungen, ein unterversorgtes Gesundheitssystem und latente Umweltprobleme in der Region. Allerdings wäre die Verbesserung der Lebensbedingunen der ländlichen Gebiete verbunden mit hohen Investitionskosten, die die Kommunen sich kaum leisten können.

Das Ziel dieser Studie ist, die sanitären Bedingungen des Flussbeckens von Barracão dos Mendes zu Untersuchen und Lösungswege aufzuzeigen unter Berücksichtigung der Umsetzbarkeit von Investitionen in die dezentrale Abwasserbehandlung.

Um dieses Ziel zu erreichen, wurde die Umweltbezogene Kosten-Nutzen-Analyse (ECBA) ausgewählt, weil es eine ökonomische Theorie ist, die hilft Nachhaltig die beste Technologie auszuwählen. Auch führte die Methodologie dieser Studie eine Umfrage durch mit 55 Teilnehmern und 7 halbstrukturierte Interviews (SSI), die in dieser Arbeit ausgewertet wurden.

In der Evaluation der ersten drei Methoden im Projektgebiet wird deutlich aufgezeigt, die ländliche Bevölkerung hat keinen Zugang zu angemessenen sanitären Einrichtungen, die fehlende Infrastruktur im Bereich Abwasserbehandlung, die dürftige Kontrolle der Wasserqualität, Grundwasserverschmutzung durch die Anwesenheit von fäkalcoliforme Bakterien und eine intensiver Einsatz von von Pestiziden im Flussbecken.

Als Lösungsansatz für die ECBA Abschätzung wurden zwei Haupt Szenarien (total-dezentrales Szenario versus halb-dezentrales Szenario) entworfen, dass zehn Aufbereitungstechnologien verglichen hat. Die ECBA berücksichtigt die Bewertung vom Nutzen von drei „Non Market Values: Wiederverwendung von Biodünger, Gesundheitssystem und die Wiederverwendung von Wasser.

Die Ergebnisse zeigen deutlich die wirtschaftliche Machbarkeit der semi-dezentralen Technologien auf im Vergleich zu den dezentrale Technologien im Flussbecken des Projektgebietes, vor allem, wenn die Wiederverwendung von Wasser in die ökonomische Bewertung einbezogen wird.

Keywords: Wasser Qualiät, Umwelt Kosten-Nutzen Analyse, Sanitäre Einrichtungen, Abwasser, Aufbereitungstechnologien, dezentrale Verwaltung, der ländlichen Gebiete.

RESUMEN

Actualmente las malas condiciones de saneamiento que enfrentan las áreas rurales de Rio de Janeiro conducen a graves problemas de ambientales y de salud pública. Sin embargo, los altos costos que implican las inversiones de saneamiento dificultan su implementación.

Con la finalidad de mejorar las condiciones de saneamiento de la microcuenca de Barracão. El objetivo de este estudio fue desarrollar un análisis de costo-beneficio ambiental (ECBA), como una herramienta económica para la selección de tecnologías descentralizadas de tratamiento de agua residuales. La metodología empleada comprende un diagnóstico participativo. 55 encuestas, 7 entrevistas semi-estructuradas (ESE) y la estimación del AACA.

Los resultados de los tres primeros métodos muestran la falta de saneamiento y tratamiento de aguas, la falta de monitoreo de la calidad del agua, la contaminación de las aguas subterráneas derivado de la presencia de coliformes fecales y el uso intensivo de agrotóxicos en la microcuenca.

La estimación del AACA comprende dos escenarios principales (totalmente descentralizado y semi-descentralizado) los cuales comparan diez tecnologías de tratamiento. Se considero el cálculo de tres beneficios que no tienen valor de mercado: el reuso de biofertilizantes, salud pública y reúso del agua. Los resultados de estudio demuestran la factibilidad económica de las tecnologías semi-descentralizadas en comparación con las descentralizadas, especialmente cuando se incluyen los beneficios del reúso de agua.

Palabras clave: Análisis ambiental costo beneficio, saneamiento, tecnologías de tratamiento, agua residual, gestión descentralizada, áreas rurales.

LIST OF ACRONYMS AND ABBREVIATIONS

ANV	Aguas de Nova Friburgo
BCR	Benefit Cost Ratio
BDM	Barracão dos Mendes
BDZ	Bildungs- und Demostrationszentrum für dezentral Abwasserbehandlung
BOD	Biochemical Oxygen Demand
BST	Biodigester Septic Tank
CBA	Cost-benefit Analysis
CBHRDR	Comitê de Bacia Hidrográfica Rio Dois Rios
COD	Chemical Oxygen Demand
COI	Cost of Illness
CVM	Contingent Valuation Method
CWM	Centralized Wastewater Management
DWM	Decentralized Wastewater Management
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
ECBA	Environmental Cost-benefit analysis
EMATER	Empresa de Assistência Técnica e Extensão Rural
EU	European Union
FBB	Fundação Banco do Brasil
FUNASA	Fundação Nacional de Saúde
FIOCRUZ	Fundação Oswaldo Cruz
IBAMA	Instituto Brasileiro de Meio Ambiente
IBGE	Instituto Brasileiro de Geografía e Estatística
INEA	Instituto Estadual do Ambiente
IRR	Internal Return Rate
MAPA	Ministério da Agricultura Pecuária e Abastecimiento
MBDM	Barracao dos Mendes Microbasin
MDA	Ministério do Desenvolvimento Agrário
MDS	Ministério do Desenvolvimento Social
NPV	Net Present Value
O&M	Operation and Maintenance
PEM	Plano Executivo da Microbacia
PES	Payment for Ecosystem Services
PIDs	Planos Individuais do Desenvolvimento
PRR	Projeto Rio Rural
SEEDUC	Secretaria de Estado de Educação
SNIS	Sistema Nacional de Informações sobre Saneamento
SSNF	Secretaria de Saúde do Nova Friburgo
WTP	Willingness to Paid
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

“The wastewater challenge is not only a treat, but a challenge where we can find opportunities for green employment, social well-being and ecological health”

(UN-SGAB, 2010 in Corconran et al., 2010)

Water is a vital natural resource that has been a determining factor for human and species maintenance. The geographical distribution of water had been a decisive factor for the establishment of new cities and in the economic development (UNDP, 2006; Pulido Castañon & De la Maza Borja, 2008). From a socio-economic point of view, water is one of the main environmental resources for the development of socioeconomic activities of consumption and production in a country, for that reason it is essential that water resources are available in the necessary quantity and quality, ensuring the preservation of water for future generations (Soto Montes de Oca, 2012).

According to Lerner (1994), one of the principal causes of the exploitation of natural resources is poverty. Due to this, worldwide economic and demographic growth patterns have caused water resources overexploitation, pollution and modification of its physicochemical properties preventing to the populations from its use and consumption (UNDP, 2006). In 1992 during the International Conference on Water and Environment in Dublin, the mismanagement of natural resources, the impact on human health and wellbeing, food safety, industrial development and ecosystems were emphasized. During the conference, the international society remarked about the critical outlook of global water resources, and encouraged countries to support new perspectives to the assessment and management of water resources, which only could be achieved through political commitment and involvement, between the different levels of government. As result of this conference, the Dublin Principles were established (Solanes & Gonzales-Villareal, 1999). The five Dublin-Rio principles set up the importance of managing water as an economic good; this will allow achieving efficient and equitable water use, and encouraging conservation and protection of water resources. The Dublin-Rio principles were used as the theoretical base for the Integrated Water Resources Management approach (GWP, 2012). The fourth Dublin-Rio principle remarks the importance of the economic water value and that it must be considered as a "public good", and its value depends on the different water uses (Güttermann, 2011). According to the fourth edition of the United Nations World Water Development Report, the global water demand can be classified into four main sectors based on their principal use: agriculture, energy production, industrial and domestic (WWAP, 2012). According to the Brazilian Association for Agricultural Research "*Empresa Brasileira de Pesquisa Agropecuária"*(EMBRAPA) (2013) 69% of the water in Brazil is used for agricultural purposes, 12% is destined for animal production, 7% is for industrial production and 12% of the available water is for human consumption.

For the Human Development Report (2006) a big part of the global population has no access to clean water and sanitation, which are fundamental factors in poverty and inequality around the world, thus, representing an obstacle for the economic development of nations. It is estimated that over 80% of sewage in the world is not collected or treated (UNDP, 2006). Furthermore, the public needs to be informed about the impact of improved consumption on the quantity and quality of water resources (Ünver, et al., 2012). In 2005 the Brazilian government in coordination with the United Nations (UN), declare the "*Brazilian water decade"* (2005-2015) with the purpose of reaching the Millennium Development Goal of reducing the proportion of people without access to water and sanitation (MMA, 2006).

The National institute for Geography and Statistics *"Instituto Brasileiro de Geografía e Estatística"* (IBGE) (2011) reported that 50% of the Brazilian with income above ten minimum wages[1] has access to adequate sewage. Meanwhile only 15% of the population with one minimum wage has access it. Ribeiro Fonseca (2008) points out that even though sanitation services have been improved, there are asymmetries in their distribution among rural and urban areas. Moreover, a sanitation survey in Brazil concluded that the factor that contributed to the rise on sanitation services was the migration from rural areas to urban areas, where sanitation services were already installed (Neri, 2007 in Ribeiro

[1]The art. 7 of Brazilian Constitution (1988) defines the minimum wage as "the minimum wage for meet the basic needs (food, housing, education, etc) of the worker and his family" (Senado Federal, 2014).

Fonseca, 2008). The proportion of Brazilian houses that have cesspits or wastewater that directly runs into the water bodies reaches the 25% (Riberiro Fonseca, 2008). The coverage of sewage collection does not guarantee an improvement of health and environment conditions (Heller, 2006). The WHO (2004) ranked Brazil in place 82 of the countries with death cases related to diarrhea.

Currently, the government through the Rio Rural project has established the Fecam Project[2]. The objective of this program is to improve rural sanitation in Rio de Janeiro. During 2013, the project spends $ 3,1 million for the installation of biodigester septic tanks of individual sanitation for productive areas, and $9,8 million for collective sanitation (Cardona, et al., 2014).

1.1 INTECRAL project

This research is part of the Integrated Eco Technologies and Services for a Sustainable Rural Rio de Janeiro (INTECRAL)[3] project, which is a three-year program (2013-2016), created to improve the sustainable development of the watersheds in rural area of the state of Rio de Janeiro, Brazil. To achieve this goal, the project has been divided in five work packages (Figure 1). And involves the participation of German Universities (Jena, Leipzig, Cologne), the private sector firms ("*Bildungs- und Demostrationszentrum für dezentral Abwasserbehandlung e.V. (BDZ)*" and "*Tilia Unwelt GmgH*" (Tilia Unwelt), among others) and the government of Rio de Janeiro through Project Rio Rural (PRR)[4]organization (ITT, 2013). Under this scenario the RJ government wants to improve the conservation of the natural resources, integrate the work cooperation of public and private sector, and includes the payment for ecosystem services (PES)[5] focusing on the promotion of local projects. One of the principles of the PRR is sustainability as well as improving the participation and cooperation of the community in the decision making process.

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[2] Fundo Estadual de Conservação Ambiental e Desenvolvimento Urbano (Fecam), created in November 10th, 1986 with the aim of meeting the financial needs of projects and environmental programs and urban development.

[3] Website: http://intecral-project.web.fh-koeln.de/

[4] The Rio Rural project is a government program that has the aim to improve life quality in rural areas, increase income generation and natural resources conservation. Website: http://www.microbacias.rj.gov.br/en/programa_rio_rural.jsp,

[5] Ecosystem services are the different benefits obtained from the environment, the Millennium Ecosystem Assessment (2005) divide them in (i) provisioning, (ii) supporting, (iii) regulating and (iv) culture services. According to the Department for Environment, Food and Rural Affairs of the UK (2013), the term PES *"describe schemes in which the beneficiaries and users, of ecosystem services provide payment to the providers of ecosystem services"*.

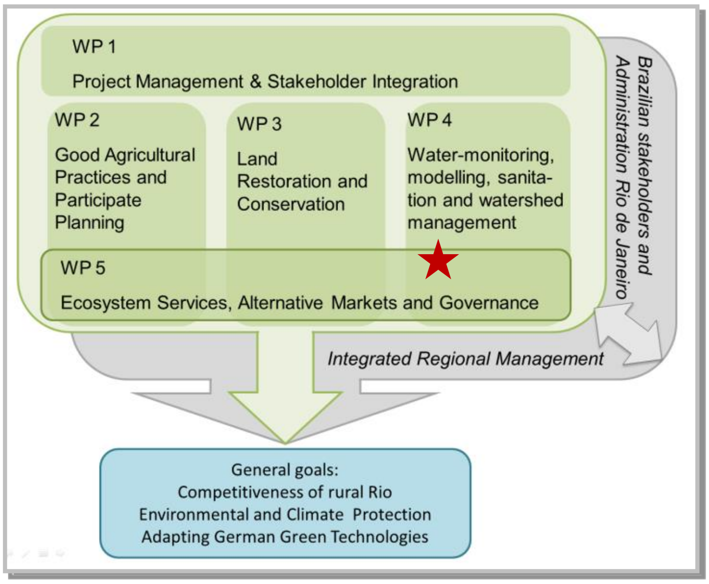


Figure 1: Work packages of the INTECRAL Project
(Taken from ITT, 2013)

This research is part of the fourth work package “Water-monitoring, sanitation and watershed management”. The sanitation team of the project aims at improving the sustainable management of water resources developing and implementing decentralized wastewater treatment and sanitation solution for rural areas in RJ state, through technological adaptation of German private technologies. The objectives of the sanitation team are (Cardona et al., 2014):

- Creation of regional plan for sanitation including the most suitable regions, technologies, operation and financial models for implementation of decentralized wastewater treatment and reuse solutions for a selected river basin for rural communities in the region in Rio de Janeiro.
- Development of guidelines for decentralized wastewater treatment and reuse solutions for selected micro-basins in rural areas of Rio de Janeiro.

In order to achieve these objectives, the introduction of decision-making instruments with economical perspective is required. One of these instruments is the Environmental Cost-benefit analysis, which will be the author contribution for the project.

1.2 Problem Statement

Due to the high cost of environmental management, environmental quality is becoming a privilege, raising the economic and social problems of vulnerable population, often located in rural areas (UNDP, 2006). Nowadays rural areas of the state of Rio de Janeiro are facing an overexploitation of the water natural resources due to the increase of water consumption, dam construction and mineral water plants. Moreover, the state presents a pattern of water pollution growth, with no monitoring networks that are capable of controlling and regulating the water quality and quantity, and there is a clear lack of good infrastructure for the wastewater treatment (ITT, 2013).

According to Liehoop et al. (2013) rural areas are not connected to centralized treatment plants. In 2011, it was estimated that the rural population in Brazil, was approximately of 32 million of inhabitants. The IBGE (2011) reported that 75% of the total rural population lives under bad sanitation services, only 40,7% of the 75% use cesspits and 24% have septic tanks connected with the sewer network (Lopes da Silva, 2013). These systems do not accomplish the Brazilian legal parameters for wastewater treatment disposal (Gallotti, 2008). In addition, they induce environmental and social problems (e.g. groundwater pollution, water related-diseases) (Cardona, et al., 2014). Even though the domestic wastewater pollutants represent 0,1% of the pollutants presented in water, they are responsible for 80% of the wastewater related diseases (Gallotti, 2008). In the case of Brazil, it has been reported that 75% of hospitalization are related to the lack of sanitation (FBB, 2010).

The lack of knowledge about local conditions (e.g. climate, human resources, financial conditions, cultural acceptability) often results in the selection of the wrong technology option. Moreover, the available current technologies that guarantee a sustainable management have high installation, operation and maintenance cost. Consequently, they cannot be installed in rural areas. Based on this, rural areas of Rio de Janeiro needs to invest in wastewater and sanitation services, in order to guarantee water supply with good quality levels and reduce the water scarcity risk to the population of the area (ITT, 2013). Income of the population located in rural areas is lower in comparison to urban areas, and they need government support to increase those services. Supplying the increasing water demand while avoiding ecosystems impacts is one of the core challenges that water management currently present, in order to maintain the environmental quality of the water bodies it is important to implement wastewater treatment technologies adapted to the rural conditions (Molinos-Senante, et al., 2012). The selection of the best technologies should consider legal, social, environmental and economic conditions of the study area (Massoud, et al., 2009).

1.3 Objectives

1.3.1 General Objectives

The aim of this research was to develop an Environmental Cost-benefit Analysis (ECBA) as an economic tool for the decision making regarding decentralized wastewater and sanitation technologies in the microbasin of Barracão dos Mendes.

1.3.2 Specific Objectives

I. Identify the sanitation environmental, social and economic effects related to the sanitation problems.
II. Establish the value of economic, social and environmental benefits and cost of the implementation and operation of the selected technologies, and identify their distribution during the horizon time of the study.
III. Assess the sanitation and wastewater situation in the microbasin.
IV. Create scenarios for the different decentralized and centralized technology options and compare them for the selection of the best option.
V. Select the different decentralized wastewater and sanitation technologies suitable for the microbasin.

1.4 Research Questions

As a result, from the research objectives the following research questions were developed.

- Which is the current outlook of sanitation and wastewater treatment infrastructure in the MBDM?
- Is sanitation a core environmental problem of the MBDM?
- Which are the main pollutants presented in wastewater of the MBDM?
- What are the environmental, economic and social effects of the sanitation current conditions in the MBDM?
- Could a decentralized or semi-centralized sanitation and wastewater treatment technologies be a feasible solution to improve water management in the MBDM?
- According to the ECBA results, which will be the best technology option for the microbasin?

1.5 Justification

Despite water is considered a human right by the international community, increasing water infrastructure and sanitation services imply higher financial cost for governments and water users, so it is extremely important to establish the environment, economic and social benefits that come from these services (UNDP, 2006). The provision of good water quality at an affordable wastewater treatment the rural areas is a challenge for many countries (Massoud, et al., 2009). Public infrastructure interventions depend on financial, technology and institutional factors (Ribeiro Fonseca, 2008)

Over the last years, water management research has focussed on the development of decentralized approaches for wastewater treatment and sanitation. Rural areas are suitable for decentralized systems because of their simplicity and low cost (Massoud, et al., 2009). However, there are few studies addressing the economic valuation of the cost and benefit of decentralized solutions in rural areas of Rio de Janeiro. Water economic benefit valuation is an essential issue for improving decisions between government, international organizations and society (Soto Montes de Oca, 2012).

The economic valuation studies often do not include the environmental and social benefits of wastewater treatment and sanitation, due to the complexity of quantifying non-markets values. The cost-benefit analysis (CBA) is one of the most accepted instruments because it is a rational tool for the decision making process (OECD, 2006). Results from different CBAs (Hutton et al., 2007; Molinos et al., 2010; among others) have shown that wastewater and sanitation improvements are cost-beneficial in developing countries. The present study develops an Environmental Cost-Benefit analysis for the economic valuation of the decentralized and semi-decentralized wastewater treatment technologies.

Heller (2006) argues that even though Brazil has National System of Sanitation Information *"Sistema Nacional de Informações sobre Saneamento"* (SNIS), there is still the need for indicators related to sanitation services. Highlighting the economic, social and environmental cost-benefit, this indicator can support a transparent decision making process (Ribeiro Fonseca, 2008).

Studies from the United States Environmental Protection Agency (USEPA) (1997, 2002 & 2004) demonstrated that decentralized wastewater management technologies are suitable to low populated regions (e.g. rural areas) (Massoud, et al., 2009). The SNIS (2010) expose that in the state of RJ 39,28 % of the wastewater is collected but only 15,58 % of it received some type of treatment. The lack of treatment plants highlights the potential for the development of decentralized wastewater treatment options (IBGE, 2011).

The hydrographical microbasin approach has been used over the last 20 years by the Brazilian government as the unit for planning, intervention and monitoring. The use of microbasin allows direct benefits to rural communities and reduces the complexity between social, economic and environmental variables interaction (PRR, 2012), this approach was used for the development of the INTECRAL Project. One of the priority areas for this project is the microbasin of Barracão dos Mendes.

The selection criteria for the sanitation team to choose were: (I) population distribution, the region allows the installation of collective systems for areas with higher population density and individual systems for the isolated housings; (II) the region presents a good community organization (empowerment of the actors) and (III) accessibility[6]. Furthermore, no previous studies for the determination of an environmental cost-benefit analysis of decentralized wastewater treatment technologies were conducted in that region.

[6] The selection of the study area was done between Rio Rural, BDZ and Tilia Unwelt during the first workshop of the INTECRAL Project in September 2013.

CHAPTER 2

THEORETICAL FRAMEWORK

Wise investments in wastewater management will generate significant returns, as addressing wastewater is a key step in reducing poverty and sustaining ecosystems services

(UN-SGAB, 2010 in Corconran et al., 2010)

2.1 Definitions

2.1.1 Wastewater

Wastewater is defined as "a combination of one or more of: domestic effluent consisting of black water (excreta, urine and fecal sludge) and greywater (kitchen and bathing wastewater); water from commercial institution, industrial effluent, stormwater and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter" (Jayakody, 2008 in Corcoran, et al., 2010).

2.1.2 Sanitation Concepts

The WHO describes sanitation as "the provision of facilities and services for the safe disposal of human urine and feces" (SIWI, 2005). Brazil´s national health association *"Fundação Nacional de Saúde"* FUNASA (1974) considers sanitation as the activities that modify the environment with the aim of preventing from diseases and maintaining population health. Those activities are (1) safe collection, treatment, disposal and reuse of human excreta (black water); (2) collection, disposal, reuse and recycle of household wastewater (gray water); (3) drainage of stormwater; (4) sanitation education; (5) water quality monitoring; among others (Ribeiro Fonseca, 2008).

The Brazilian government introduces the concept of Environmental Sanitation, which is understood as "the set of technical and socioeconomic actions related with public health, including water supply that meets legal conditions for: (1) collection; (2) treatment; (3) and disposal of wastewater, stormwater, sewage, control of environmental disease vector and promotes sanitation discipline of soil. With the purpose of ameliorate living conditions in urban and rural areas" (FUNASA, 2004 in Ribeiro Fonseca, 2008).

2.2 Wastewater treatment

The wastewater treatment objective is to eliminate pollutants present in the wastewater. Table 1 explains wastewater principal biological, chemical parameters and physical that must be taken into consideration in the wastewater treatment process. These parameters are indicators of water quality (Tchobanoglous, et al., 2003).

The measure of these parameters must be done at least in two phases of the treatment process. The first should be done before wastewater begins with the treatment process, this will require an affluent characterization in order to determine the level of removal that must be achieved for each parameters according to the local regulations and for the selection of the appropriate treatment. The second phase is placed at the end of the treatment process, in order to ensure that the effluent achieve the removal levels (EPA, 1997).

Table 1: Principal wastewater parameters

PARAMETER			DESCRIPTION	SOURCE
Physical	Colour		It could be caused by matter presence	Domestic and industrial wastewater, natural decay of organic materials
	Turbidity		Cause by suspended matter	Domestic and industrial wastewater
	Temperature		Sewage temperature is higher than water normal temperature, and contribute to the biological activity	Domestic and industrial wastewater
	Odour		It is produce due to the gases formed during the decomposition process	Decomposing wastewater
	Total Suspended Solids (TSS)	Suspended solids	Solids that are in suspension in water	Domestic and industrial wastewater, soil erosion
		Organic solids	Derives from waste products of animals and vegetables.	
		Inorganic solids	Inter substances, not subject to decay	
		Settleable solids	Fraction of solids that will settle in a period of time	

Chemical	Organic	Biochemical Oxygen Demand (BOD)	Amount of oxygen used by organism while consuming organic matter in wastewater	Domestic and industrial waste water
		Chemical Oxygen Demand (COD)	Amount of pollution (that cannot be oxide biologically) in the water	
	Inorganic	Pesticides and Agrotoxics	Chemicals used to kill or control pests	Agricultural wastewater
		Fats, Oils and Grease (FOGs)	Fats and oils used in food preparation and in the industry processes	Domestic and industrial waste water
		Nitrogen (N)	Is the sum of total oxidised nitrogen (nitrate and nitrite) and total Kjeldahl nitrogen (ammonia and organic nitrogen)	
		Phosphorous (P)	The sum of total phosphorous presented in the water	Domestic and industrial waste water, natural runoff
		pH	Concentration of hydrogen ions in a solution, indicates level of acidity or alkalinity	Domestic and industrial waste water
		Heavy metals	Considered as toxic metals such as: mercury, cadmium, cobalt, manganese and arsenic	Industrial wastewater, mining waste
Biological	Bacteria		There are essential for the wastewater treatment, some of them can be pathogenic and can produce intestinal diseases	Domestic, agricultural and industrial wastewater
	Fungi		Aerobic organism	
	Protozoan		Facultative organism	
	Virus		Parasites that can produce severe diseases	
	Helminth		Complex organism, their eggs can be found in wastewater, and they produce diseases	

(Elaborated by the author based on: EPA, 1997; Cesar Valdez & Vazquez Gonzáles; 2003; Tchobanoglous, et al., 2003; Bergamaschi Teixeira, 2009)

There are three types of treatment: primary, secondary and tertiary, which are explained in Figure 2. During the wastewater process are generated two outputs: the first one is the treated water that could be reuse and the second one is sludge production. The potential of the reuse of the sludge is due to the amount of nutrients it contains. It implies a polishing process to eliminate pathogens present in the sludge. Once the sludge is stabilized, it can be used as compost for agriculture, land restoration, fertilizer for gardening, etc. Furthermore, treated waste can be also reused (Wilderer & Scherff, 2000).

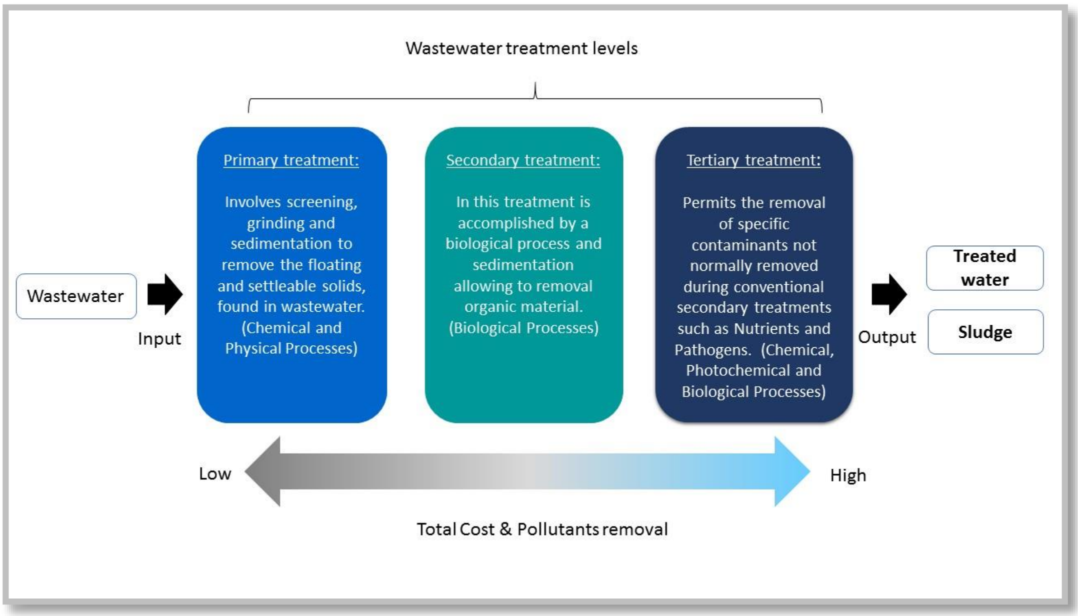


Figure 2: Type of wastewater treatment
(Elaborated by the author based on Metcalf *et al*., 2003; Valdez *et al.* 2003)

2.3 Importance of wastewater and sanitation

When wastewaters are directly discharged into the water bodies without any treatment, they can produce environmental problems related with eutrophication, reduce the amount of drinking water supply, develop social problems related with public health because of the presence of pathogens, bad odors (Wilderer & Scherff, 2000). Moreover, this can damage water quality of the receptor bodies. Many ecosystem services depend on good water quality for its correct functioning and maintenance (e.g. clean drinking water, safe contact water, water recreation, etc.) (Keeler, et al., 2012). The WASH nexus shows the relation between water, sanitation and hygiene, a lack of sanitation has impacts on human health (Hutton, et al., 2007; UNDP, 2006 among others). The consumption and contact with polluted water can produce severe diseases. These diseases are known as "water related diseases". They are classified into the four categories shown in table 2. The literature shows evidence of the diminishing number of disease cases when sanitation and wastewater conditions are ameliorate (Hutton & Haller, 2004; UNDP, 2006). According to several studies, the most common disease related to wastewater is diarrhea. (Hutton, 2004; Fewtrell, 2005, among others), in the case of this disease there is a proportional relation between sanitation improvement and the reduction of 37.5% of diarrhea cases (Esrey, 1996 in SIWI, 2005).

Table 2: Wastewater related disease classification

CATEGORY	DEFINITION	EXAMPLE
Water-borne diseases	Caused by ingestion of contaminated water	Diarrhoeal Diseases, Typhoid Fever, Hepatitis A, Cholera
Water-washed diseases	Diseases due to the lack of proper sanitation and hygiene. This disease are caused by pathogens, bacteria and virus presented in water (e.g. E. Coli)	Ascariasis, Giardiasis, Helminthic diseases
Water-based diseases	Infections transmitted through and aquatic invertebrate organism	Schistomsomiasis
Water-scarce diseases	Occurs due to the lack of water available for washing, bathing and cleaning	Trachoma, diarrhea
Vector-borne diseases	Diseases transmitted by insects that depend on water for their propagation	Malaria, Dengue

(Elaborated by the author based on Funari et al., 2011)

The increase of the water pollution demands more complex and costly wastewater systems (Wilderer & Scherff, 2000). In many countries investment and operation, cost cannot be covered by the local economies and requires governmental support (e.g. subsidize, loans, grants, etc.) (EPA, 2005).

2.4 Brazilian sanitation legal framework

At the highest level, the article 225, included in Chapter IV of the Federal Brazilian Constitution (1998), regulates the right of the Brazilian population of environment ecological balance for quality of life as well as the preservation of natural resources for future generations (INEA, 2012).

The Dublin principals provide the basis for the creation of the National Water Law N° 9.4333/97, this law set up the Brazilian policy regarding water resources management. The objective of this law is to guarantee water resources availability considering the multiple water demand without compromising its sustainability. In order to follow the national legislation, the government of Rio de Janeiro creates the state water law N°3.239/99. This policy creates the State Water Resources Management integrated by: (I) Water Resources State Council "Conselho Estadual de Recursos HÍdricos Estado do Rio de Janeiro" (CERHI); (II) FUNDRI (State water resources found); (III) the watershed committees and (IV) water agencies, these institutions will be in charge of wastewater management (Vera Aguirre, 2012; INEA, 2012).

The state level decree Nº 5.440/05 provides the procedure for water quality control and implements mechanism and tools of water quality for human consumption, and the decree Nº 40.156/06 establishes the technical and administrative procedures to regulate surface water and groundwater uses, as well as integrated supervision with sanitation services operators (INEA, 2012).

Due to the relation between the lack of sanitation and water pollution, the Brazilian government has developed regulations for wastewater discharge. The quality parameters for effluents are content in the Nº 357/05. This resolution divides water in salt, fresh and brackish. It provides the water body's classification, environmental guidelines and establishes the conditions and standards of wastewater discharge, and other measures water effluents only could be discharge into water bodies after their correct treatment, the effluents must not affect the receptor water body (CONAMA, 2005). According to this law, the effluents quality is classified as follows:

- Type 1: Water after simplified treatment (e.g. filtration & disinfection)
- Type 2: Water after conventional treatment (e.g. coagulation, flocculation, decantation, filtration and disinfection)
- Type 3: Water after conventional or advance treatment (e.g. ultrafiltration, osmosis, etc).
- Type 4: Water that would not be intended for human consumption

The legal parameters content in this law for water disposal are shown in table 3.

Table 3: Pollutants legal parameters for water disposal

	CONAMA 357- TYPE OF FRESH WATER			
PARAMETER	**TYPE 1**	**TYPE2**	**TYPE 3**	**TYPE 4**
Ammonia (mgN/ L) pH ≤ 7,5	3,7	3,7	13,3	---
Ammonia (mgN/L) 7,5 < pH ≤ 8,0	2,0	2,0	5,6	---
Ammonia (mgN/ L) 8,0 < pH ≤ 8,5	1,0	1,0	2,2	---
Ammonia (mgN/L) pH > 8,5	0,5	0,5	1,0	---
Nitrate (mgN/L)	10,0	10,0	10,0	---
Nitrite (mgN/L)	1,0	1,0	1,0	
Phosphorus (mgP/ L)	0,1	0,1	0,2	---
Temperature (°C)	---	---	---	---
Settable Dissolved Solids (mg/L)	≤ 500	≤ 500	≤ 500	---
Dissolved Oxygen (O_2 mg/ L)	≥ 6,0	≥ 5	≥ 4	≥ 2
Fats, Oils and Grease (mg/ L)	Absence	absence	absence	---
Floating materials	Absence	absence	absence	---
Surfactants (mg/ L)	0,5	0,5	0,5	---
Turbidity (NTU)	≤ 40	≤ 100	≤ 100	Non required
Colour (Pt – mg/l)	natural	natural	≤ 75	Non refer
Sulphates (mg/L SO_4^{-2})	< 250,0	< 250	< 250	---
Sulphides (S – mg/ L)	< 0,002	< 0,002	< 0,3	---
Zinc (mgZn/L)	< 0,18	< 0,18	5	---
Iron (mgFe/L)	< 0,3	< 0,3	< 5,0	---
Cyanobacteria (Cel./mL)	< 20 000	< 50 000	< 100 000	---
Coliforms (UFC/100ml)	≤ 200	≤ 1000	≤ 1000	0

(Adapted by the author based on CONAMA, 2005; Free translation by the author)

Regarding sanitation, the Federal Law N°11.445/07 establishes the guidelines for basic sanitation principles and indicates the main economic, social and technical aspects for this service (INEA, 2012). According to this law, sanitation must accomplish two aspects. The first one is universalization meaning the access for all the population. The second is integrity in the set of activities of the sanitation services, allowing the population access according to their needs, using the appropriate technology and at the same time consider the payment capacity. In the cases of rural areas, this law aim at providing the adequate sanitation conditions (MDC, 2007).

The guideline DZ-215.R-4 establishes the requirements for the control of biodegradable organic load on effluents form sanitary origin (CECA, 2007). Table 4 shows the parameters for domestic wastewater.

Table 4: Per capita contribution to sewage in residential areas

STANDARD	Per capita water flow (L/day)	Sewage contribution per capita (L/day)	Unitary sewage contribution (g BOD/day)	Unitary sewage contribution (mg/Lof BOD)
HIGH	300	250	60	240
MEDIUM Metropolitan region	250	200	54	270
MEDIUM Interior	200	160	50	310
LOW Cluster residential	150	120	45	375
LOW Disorganized occupation	120	100	40	400

(Elaborate by the author based on DZ-215.R-4, free translation by the author)

The term water flow is the per capita contribution to wastewater depending on the type of residence. According to this guideline, the basins without water and sewage operator, the return coefficient (water/sewage) will be equal to 0.08 (CECA, 2007).

Table 5 shows the parameter for BOD removal efficiency that must be considered in wastewater treatment dimensioning.

Table 5: Removal efficiency in residential areas

ORGANIC LOAD (OL) (kg BOD/day)	NUMBER OF USERS	BOD MINIMUM REMOVAL EFFICIENCY (%)
OL ≤ 5	till 200	30
5 < OL ≤ 25	from 201 to 1000	65
25 < OL ≤ 80	from 1001 to 3000	80
C > 80	more of 3000	85

(Elaborate by the author based on DZ-215.R-4, free translation by the author)

The maximum BOD and TSS allowed for domestic wastewater discharge is shown in table 6.

Table 6: Maximum concentration of organic matter (BOD & TSS)

ORGANIC LOAD (OL) (kg BOD/day)	MAXIMUM BOD AND TSS CONCENTRATION (mg/l)				
	RESIDENTIAL STANDARD				
	HIGH	MEDIUM Metropolitan region	MEDIUM Interior	LOW Cluster residential	LOW Disorganized occupation
OL ≤ 5	170	180	210	260	280
5 < OL ≤ 25	85	100	110	130	140
25 < OL ≤ 80	60	60	60	60	60
C > 80	40	40	40	40	40

(Elaborate by the author based on DZ-215.R-4, free translation by the author)

The sludge production is regulated by the resolution Nº 375/06 which defines the criteria and procedure for the agricultural use of sludge form wastewater treatment stations. This regulation considers that the sludge production is a sub-product resulting from wastewater treatment that can be reuse for agricultural purposes due to its nutrient content. Besides, sewage sludge can contain pathogens, heavy metals and other pollutants that may damage the environment and public health (CONAMA, 2006).

2.5 Decentralized and Centralized Wastewater Management

Wastewater management involves four principal activities: Collection, treatment, disposal and reuse (WERF, 2010). The objectives of wastewater management are shown in figure 3.

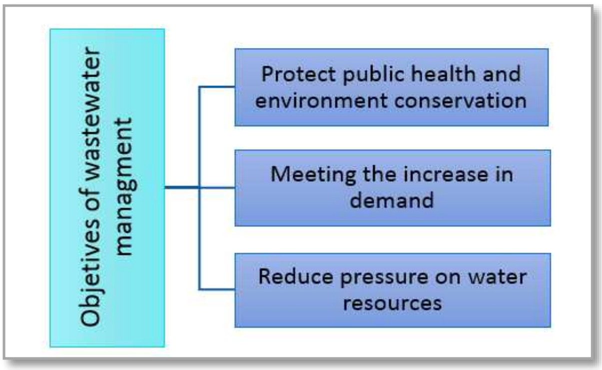


Figure 3: Wastewater management objectives
(Elaborated by the author based on Massoud, et al., 2009)

The wastewater treatment can be done through two types of management: decentralized or centralized, the theoretical aspects of these approaches will be analyzed in this section.

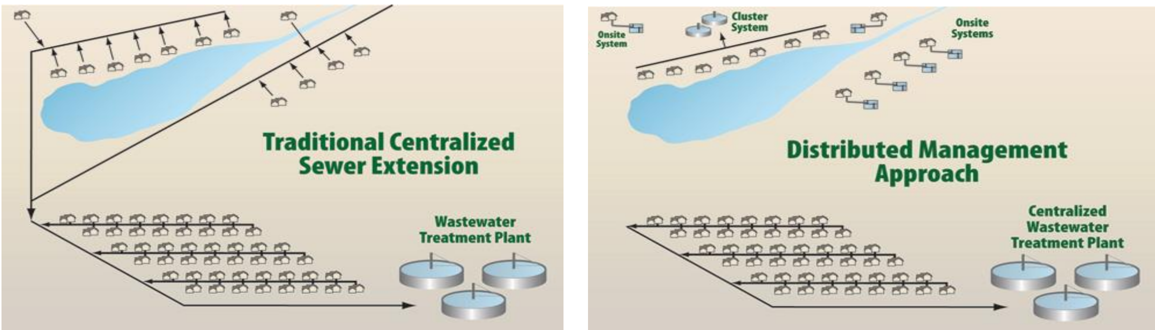


Figure 4: Types of Wastewater Management
(Adapted by the author based on ICMA, 2011; Cardona, et al., 2014)

Wilderer & Scherff (2000) describes Centralized Wastewater Management (CWM) as systems with centralized sewer network for the collection of effluents from domestic, industrial and storm water runoff. The sewer network transports the collected water to a centralized wastewater treatment plant located outside the community limits, in which wastewater and sludge treatment will take place (Figure 4). This type of wastewater management has been applied in areas with high population density. (Maurer, et al., 2006). The principal advantages and disadvantages of this type of management are shown in table 7.

Table 7: Advantage and disadvantage of centralized wastewater management

ADVANTAGES	Treat large volumes of wastewater
	Reach high water pollutant removal
	The management of these systems depends on legal operators, these guarantee high-qualified techniques.
	Require less power participation and awareness
DISADVANTAGES	Costly to build, large capital investment of sewage system and pumping cost
	High energy consumption

(Elaborated by the author based on Wilderer & Scherff, 2000; Massoud, et al., 2009)

Orth (2007) classifies centralized systems into: (I) traditional combined and separated sewage systems; (II) storm-water management and (III) centralized treatment plants. These systems are have been allocated in small communities of developing countries, although they do not have the enough economic requirements and water requirements for a good functioning of a centralized wastewater treatment plant.

Decentralized Wastewater Management (DWM) is defined "as the collection, treatment, disposal and reuse of wastewater from individual homes, clusters of homes, isolated communities at or near the point of waste generation". Decentralized systems maintain solid and liquid components of wastewater close to the original point (Crites & Technobanoglous, 2008). This new approach has been developed over the last years as a reliable alternative for small communities and rural areas (Massoud, et al., 2009)

Crites & Technobanoglous (2008), mention that the decentralized systems pursue three objectives: (I) protection of public health (II) protection of the receiving environment from degradation and contamination and (III) reduction of the treatment cost. Table 8 shows the principal advantages and disadvantages of decentralized of wastewater management.

Table 8: Advantages and disadvantages of decentralized wastewater management

ADVANTAGES	Reduction the cost of the sewer network, lifting and pumping stations
	Failures of single units do not collapse the system
	Possibility of gradual development and investment
	No use of water as a transportation medium
	Adaptability capacity to local requirements
	Management flexibility
	Requires less amount of energy
	Allow the community integration and awareness of the sanitation problems
DISADVANTAGES	The most common type of decentralized technologies (e.g. septic tanks, ponds) present a low water pollutants removal efficiency that in most of the cases do not reach the local legal requirements
	The current system monitoring depends on the householders which normally do not have specialization knowledge about the process involved in the treatment
	If they are not correct operated they can cause environmental damage and increase health impacts

(Elaborated by the author based on Wilderer & Scherff, 2000; Eawag, 2008; Massoud, et al., 2009).

Simple sanitation systems such as pit latrines, pour-flush toilets and composting toilets are systems that only reach minimal hygiene standards leaving aside water pollution (Orth, 2007). Nowadays the most common decentralized systems for individual residences are septic and imhoff tanks (Bakir 2001 in Massoud, et al., 2009). These systems offer primary treatment. They are designed to operate at small scale and depend on local conditions (e.g. high groundwater tables, impervious soils, etc). These systems are inexpensive and easy to operate. However, the sludge production can cause odour problems. These systems do not remove nutrients and pathogens contained in wastewater (WERF, 2010).

DWM should be taken into consideration in areas with the following characteristics (Crites & Technobanoglous, 2008):

- Areas in which operation and management of on-site systems must be improved
- Areas where the local population cannot afford the cost of centralized systems
- Areas which lack a sewer network
- Areas with potential opportunity for water and reuse

While centralized systems involves large construction phases and need to take into consideration an extra capacity for future growth, decentralized systems have high adaptability capacity according to the actual and future requirements (White, 2005).The cost of these systems are focused on treatment, disposal and lower collection. In the case of centralized systems, collection cost could represent 60% of the total costs due to pipe requirements for sewer network, manholes for access, excavation (Hoover, 1999 in Massoud, et al., 2009). Orth (2007) remarks that decentralized systems are built by local residents inside their property, this statement should be taken into consideration in the cost comparison with centralized options.

Wastewater treatment processes are complex. They require high technology systems that sometimes cannot be adapted to decentralized systems. In addition to this, it is important to consider that the investment of a high number of on-site systems may be more expensive in comparison to the investment cost of one centralized WWTP (Wilderer & Scherff, 2000). Another aspect taken into consideration for the selection of either decentralized or centralized wastewater treatment, are long terms changes such as population growth, technology improvements, etc. In this case, it should be analyzed until which point decentralized options will be competitive. Moreover DWM implementation faces some challenges such as a lack of local capacity and institutional arrangements, plus the financial limitations. Wilderer & Schreff (2000) consider that decentralized wastewater treatment technologies can be a good alternative if they accomplish two conditions: (I) when the systems have advance wastewater treatment the investment costs are low and they can be easily operated; and (II) the monitoring and operation are done by specially trained workers.

2.6 Environmental Cost-benefit analysis

The cost befit analysis (CBA) emerges in the19th century with the welfare theory. Moreover, since 1960 it is considered an instrument for public investments. In terms of welfare, a benefit will be consider as “increases in human wellbeing” and cost as “reduction in human wellbeing (OECD, 2006). The theoretical definition of this analysis establishes that a project will only be implemented if the benefits exceed the aggregated cost. The CBA determines a monetary value for all the inputs and outputs of a project. The net profit is the difference between costs and benefits (Equation 1).

$$NP = \sum B_i - \sum C_i \tag{1}$$

Where NP is the net profit, B_i is the value of the benefit item i, and C_i is the value of the cost of the benefit. For a given project, if the result of the calculation is NP>0, then the project is economically viable, while if when value of is NP<0 then the project is not viable in economic terms. The best option will be the one that offers the highest net profit (Chen *et al*., 2009).

Based on the methodology of the European Commission (Fiorio, et al., 2008) the steps for the construction of CBA are: (I) Presentation and discussion of the socio-economic context and the objectives; (II) Identification of the project; (III) Feasibility study of the project and alternative options; (IV) Financial Analysis; (V) Economic Analysis and (VI) Risk Assessment.

The CBA must include feasible financial indicators like Net Present Value (NPV), Cost-benefit Ratio (CBR) and the Internal Return Rate (IRR). The NPV measures the economic value of a project. It is defined as net profit discount show in Eq. (2), where *t* is the time horizon of the project, NP_t is the net profit at time and *r* is the discount rate. The main financial indicator decision rule in the CBA is the NPV. A project with a positive NPV value could be implemented and if the NPV is negative the project should be rejected (OECD, 2006; Fiorio, et al., 2008).

$$NPV = \sum_{t=0}^{T} \frac{NP_t}{(1+r)^t} \tag{2}$$

The BCR is defined as the present value of the cost divided by the present value of the benefits (Eq. 3). The IRR represents the discount rate that equates the present value of the total benefits and costs. A project will be feasible if BCR ≥ 0 and IRR ≥ r rejected (OECD, 2006).

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}} \tag{3}$$

Sanitation and Wastewater Cost

For the cost estimation, fixed (Investment Cost), variable (Operation and Maintenance cost (O&M)) and opportunity cost related with a project. In the case of the WWTP projects have to be considered, table 9 summarizes the most common associated costs. The WWTPs costs depend on the effluent quality, which are determined by the local legislation and the different reuse or disposal for treated water (Fiorio, et al., 2008).

Table 9: WWTP Cost

COST	ITEM
Investment Cost	Land acquisition
	Equipment
	Installment
	Construction
	Engineering and contingency
O&M Cost	Maintenance
	Electrical energy
	Staff
	Sludge disposal

(Elaborated by the author based on: Ko, et al., 2004; Fiorio, et al., 2008).

Sanitation and Wastewater Benefit

Wastewater treatment projects generate environmental and social benefits (e.g. health improvements, water polishing, recreational, water reuse, etc) (OECD, 2011). These benefits should be included into feasibility studies. The main problem is that the complexity of quantifying wastewater treatment benefits in monetary terms, because they are not captured directly by the market and they have to be calculated using non market value instruments like avoided cost, shadow prices, contingent valuation method, among others (table 10) (Fiorio, et al., 2008).

Table 10: Non-market economic valuation methods

VALUATION METHOD	DESCRIPTION
Hedonic prices	This approach is evaluating the market behaviour related to a good or service considering that prices are linked to different characteristics including intangible characteristics and other additional aspect without market value. This method relies on statistical methods to calculate the isolated price of the characteristics that the study pretends to analysis.
Travel cost method	This method estimated the willingness to pay (WTP) of individuals for an specific good or service
Shadow prices	This approach determines a value for of a good and services obtained from the production activities that do not have a monetary value.
Method of Contingent Valuation (CVM)	This method valuated the individual preferences for changes in the quantity or quality of a good or service in monetary terms. The estimation of the value is done through survey, in which the respondent have to select it WTP.

(Elaborated by the author based on: OECD, 2006; Fiorio, et al., 2008; Molinos-Senante, et al., 2010).

The OECD (2006) considers important the economic analysis as crucial for an efficient decision making process. A project will be feasible when it fulfills technical, legal, environmental and financial requirements. An economically feasible wastewater treatment plant means that all the benefits arising from this process exceed its total costs and, therefore, according to different studies it is shown that wastewater treatment is a positive process not only from an environmental point of view, but also economically (Molinos-Senante *et al*., 2010; Cheng & Wang, 2009; among others).

2.6.1 Wastewater cost-benefit analysis studies

A study applied for technology options of wastewater treatment for small WWTP Spain for the design of wastewater treatment plants for low populated areas highlights the importance of introducing economic aspects by using the CBA including environmental factors into decision making process. The study analyses different technologies and introduce the shadow prices for pollutant removal, considering three different options for the market of treated water (I) no sale of the treated water; (II) sale of the 50% of the treated water; and (III) sale of 100% the treated water. In this study it was observed that the reuse of the treated water was the key factor for improving the feasibility of WWT for small populations (Molinos-Senante, et al., 2012). The authors also divide the outputs obtained in the wastewater treatment process as desirable (e.g. treated wastewater) and undesirable (e.g. suspended solids, nutrients, etc) (Molinos-Senante, et al., 2010). Another study conducted by Molinos-Senante, et al., (2011) points out the benefits of water reuse in the evaluation of WWTPs in Spain, through the estimation of the internal benefits of water reuse for agricultural processes saving fertilizer costs and external benefits of the project. The results of these study shows that water reuse and shadow prices valuation are crucial for the sanitation projects feasibility.

Another CBA estimation analyses the PO Valley located in Italy; a region that had problems with water scarcity due to intense drought periods. The study shows the economic potential of reclaimed water use and the valuation of environmental benefits. The project considers four benefits: (I) agricultural water reuse; (II) benefits for the water quality discharge into the body water receptors; (III) financial benefits due to less energy consumption; and (IV) recreational benefits of the park users The study´s results shows that considerable revenues can be obtained when environmental benefits in sanitation investments are considered (Verlicchi, et al., 2012).

Reduction of the public health expenses on water related diseases, have also been included into CBA studies for improvements on sanitation investments. The results of these studies shows that important economic benefits arise when avoided cost of treatment expenditure are estimated (Hutton, et al., 2007; Cheng & Wang, 2009). Other benefits that have been studied are the increase of the net primary production for soil formations as a result of the reuses of wastewater (Ko, et al., 2004).

An EBCA for decentralized wastewater treatment technologies in rural Jordan, estimating economic three types of benefits: (I) Environmental improvements of groundwater using the CVM; (II) health improvements using the cost of illness and method; and (III) the reuse of treated water for irrigation purposes. The results of this study show the economic potential of decentralized solutions in rural areas (Liehoop, et al., 2013).

CHAPTER 3

STUDY AREA

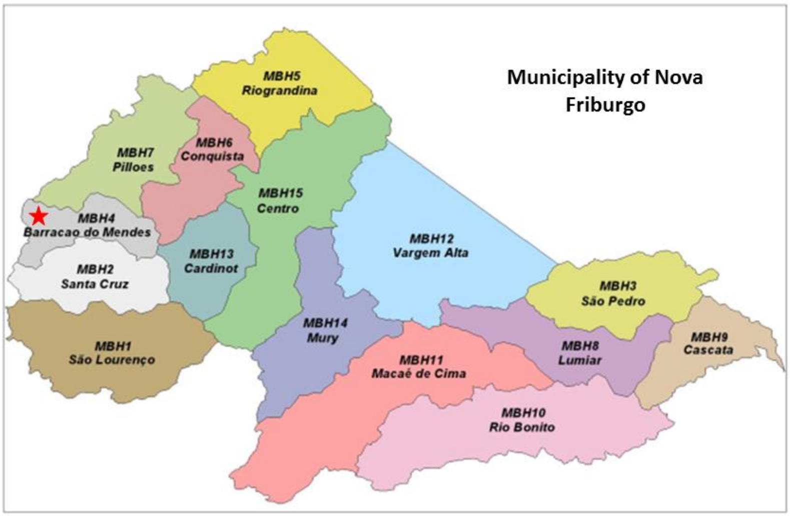
"There never will be any more or any less water on Earth than there is right now. When wastewater receives inadequate treatment, the overall quality of the world´s water supply suffers."

(Pipeline, Fall 1999)

3.1 Location

Figure 5 shows the microbasin of Barracão dos Mendez (MBDM), located in Nova Friburgo municipality from the Serrana region of Rio de Janeiro, with a territorial area of 2.849,53 ha (EMATER, 2012).

Figure 5: Hydrological microbasin of Nova Friburgo



(Taken from PRR, 2012)

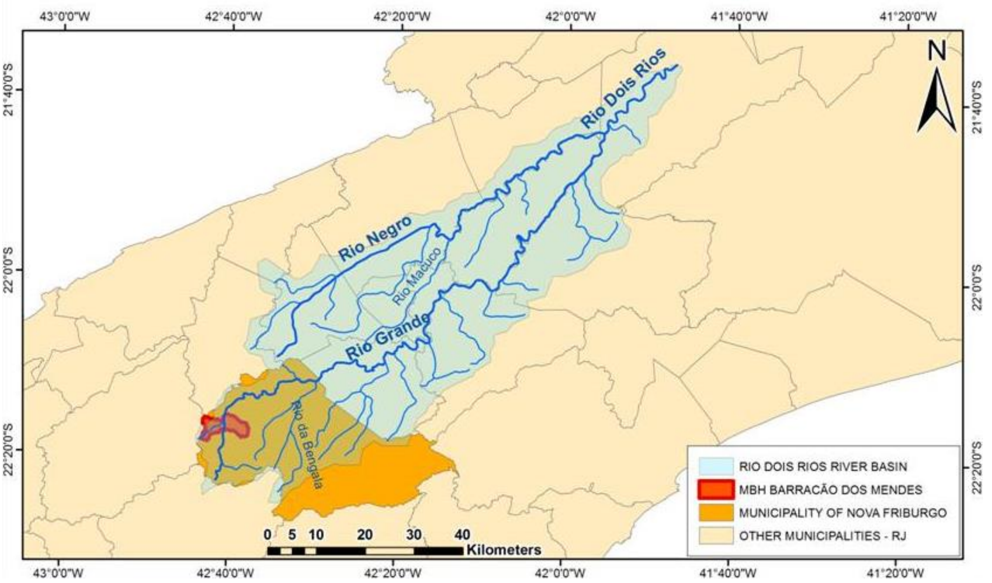
3.2 Geography, Hydrology and Climate

The MBDM presents a high-altitude tropical climate[7]. The average temperature during summer is of 24°Celsius and during winter of 13°Celsius. The average precipitation is 1.650 mm/year (EMATER, 2012).

[7] Based on Köppen (1990) climate classification.

The MBDM belongs to the river basin Rio Dois Rios*,* VII Hydrographic Region (Figure 6). The main river in the region is Rio Grande, which cuts in crosswise direction with the tributaries (I) Grande, (II) Barracão and (III) Florândia, and with the sub-tributaries (I) Serra Nova, (II) Serra Velha, (III) Joao Arouca, (IV) Albino, (V)Toyo and (VI) Gelson Veiga (EMATER, 2012)

Figure 6: Map of the Rio Dois Rio Basin.



(Taken from Cardona et al., 2014)

3.3 Demographics

The MBDM is integrated by five communities (I) Barracão dos Mendes, (II) Florândia da Serra, (III) Rio Grande (IV) Serra Nova and (IV) Serra Velha (Figure 7). According to the rural census applied in the five communities (EMATER, 2009a; EMATER, 2009b; EMATER, 2009c; EMATER, 2010a; EMATER, 2010b), the total population for 2010 was of 1.435 inhabitants. In table 11, the population distribution for each community is shown.

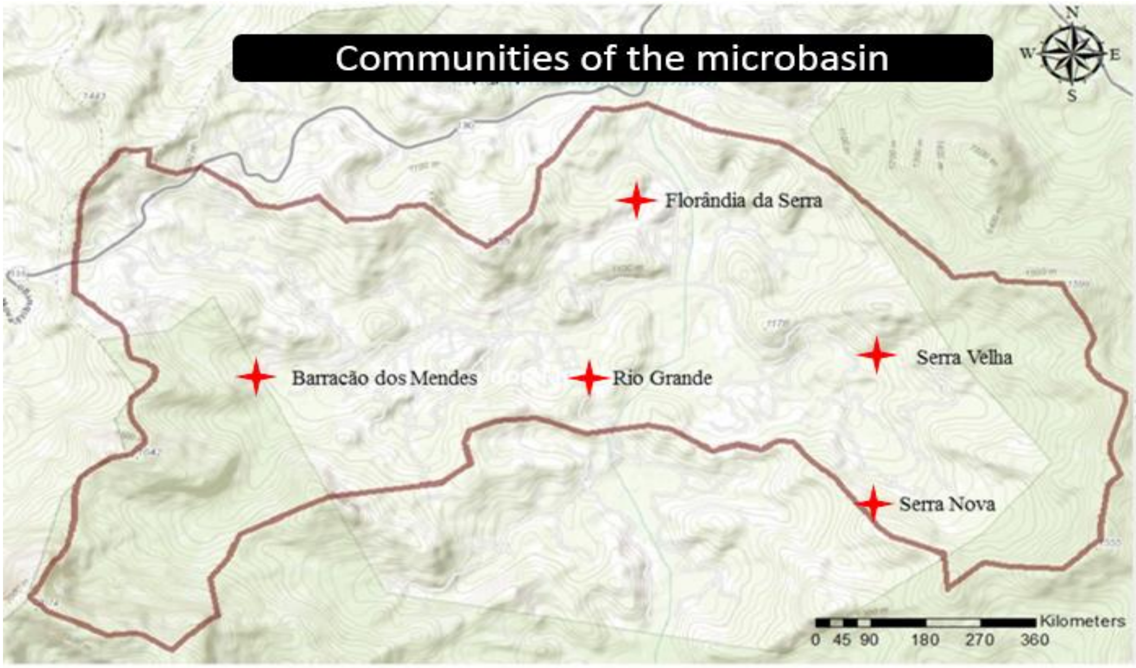


Figure 7: Map of the Microbasin of Barracão dos Mendes communities
(Elaborated by the author based on non-published data from the INTECRAL project)

Table 11: Population of Barracão dos Mendes

COMMUNITY	CHILDREN		YOUNG PEOPLE AND ADULTS				ANCIENTS	INHABITANTS	TOTAL HOUSES
	Children until 7 years old	Children from 8 to 15 years old	Women from 16 to 25 years old	Men from 16 to 25 years old	Women from 26 to 65 years old	Men from 26 to 65 years old	More than 65 years old		
Barracão dos Mendes	101	139	49	97	234	247	60	927	281
Florândia da Serra	33	29	28	19	47	59	9	224	67
Rio Grande	10	13	10	7	15	17	3	75	38
Serra Nova	11	22	4	15	26	24	3	105	27
Serra Velha	13	14	8	15	22	29	3	104	35
TOTAL	**168**	**217**	**99**	**153**	**344**	**376**	**78**	**1435**	**448**

(Elaborated by the author based on EMATER, 2009a; EMATER, 2009b; EMATER, 2009c; EMATER, 2010a; EMATER, 2010b).

3.4 Economics

The main economic activity of the region is family agriculture, which is focused on olericulture[8] production. The most important vegetables grown in the area are tomatoes and cauliflowers (Table 12). Only few famers have animal production and fish-farming for family consumption and recreation (EMATER, 2012).

Table 12: Main crops harvested in the microbasin of Barracão dos Mendes

Vegetable	Area	No. Producers
Cauliflower	1.000	280
Tomatoe	400	150
Lettuce	100	50
Others*	300	200

(Elaborated by the author based on EMATER, 2012)

3.5 Microbasin organization

The microbasin is organized in associations where, each community has an association, and each organization has a president (Table 13). The communication between the local government and the community is mainly done through the association.

Table 13: Microbasin of Barracão dos Mendes Organization

COMMUNITY	ASSOCIATION NAME	ASSOCIATION PRESIDENT*
Barracão dos Mendes	Associação de Pequenos Produtores Rurais de Barracão dos Mendes	Jorge Luiz Pajuaba de Azevedo
Rio Grande	Associação de pequenos produtores rurais de Rio Grande	Margarete Satsumi Tiba Ferreira
Florândia da Serra	Aprofloserra	Rondineli Gomes de Souza
Serra Nova	Associação serra nova dos trabalhadores rurais de rio grande	Hélio Muniz Cardoso
Serra Velha	Associação de produtores rurais de serra velha	Carlas Cordeiro Ferreira

(Elaborated by the author based on field-work results
*Current President-2014)

[8] Olericulture: Term use for vegetable growing (Filgueira, 1972).

3.6 Public Health

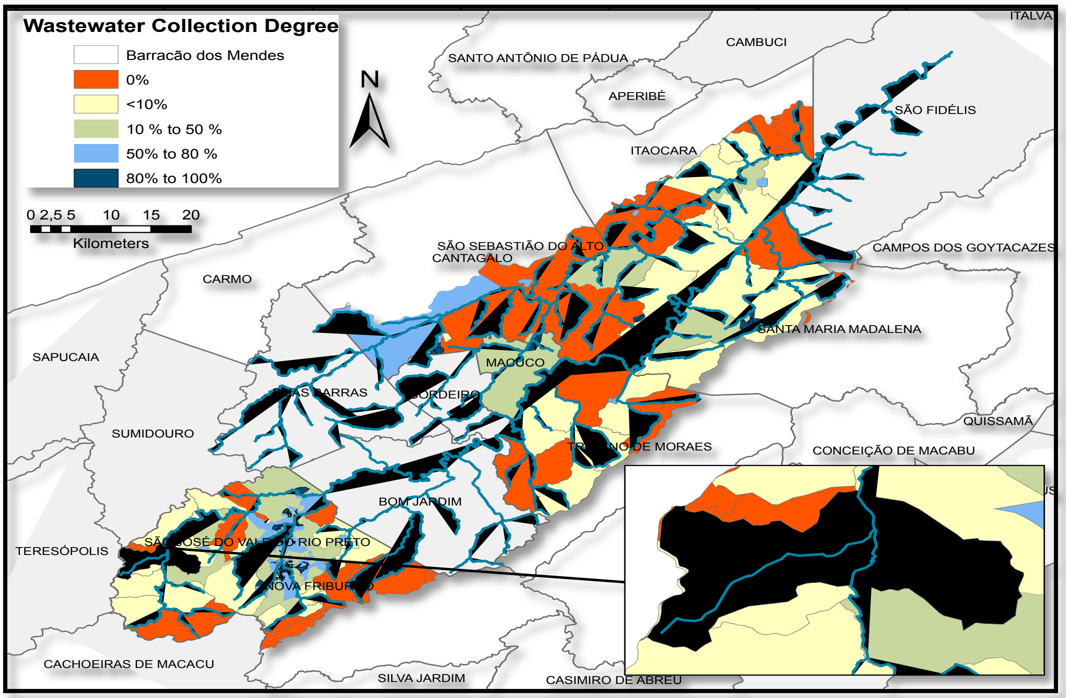
The communities located in the microbasin received medical assistance from the local health agency "Posto de Saúde Centenario". This agency is located outside of the microbasin limits. According to the population, there is a lack of medical assistance in the agency (COGEM, 2012). The population also receives medical consultation from the Health Agency of Nova Friburgo, especially in cases of severe diseases, which is located at 60 minutes by bus from the microbasin. In both agencies, the medical services have no costs (COGEM, 2012; EMATER, 2012).

3.7 Wastewater and Sanitation

The wastewater collection in the microbasin of BDM is mainly below the 10%, which shows the lack of sewer network in the region (Figure 8). Until now, the municipality water operator "*Águas de Nova Friburgo",* does not manage the wastewater treatment of the MBDM[9]. It might be possible that the operator do not cover this rural area because it has low population rates. Normally local operators are in charge of water and sanitation services, water tariffs, etc. Owing to the absence of a local operator in the region, water is not charged.

[9] Information obtained during the interview with André Luis de Paula Marques - Executive Director of AGEVAP.

Figure 8: Basin Rio Dois Rios Wastewater Collection.



(Taken from Cardona et al., 2014).

3.7.1 Wastewater characterization

The MBDM has not installed monitoring networksyet that measure water pollution. In addition to this, it was not possible to find information regarding wastewater characterization of the most important parameters, because until now no wastewater analysis has been conducted. According to the Basin Commmitte *"Comitê de Bacia Hidrográfica Rio Dois Rios"* (CBHRDR) wastewater monitoring is not a compulsory procedure, and if a water body needs to be analyzed the responsible institution for the collection of this information will be the INEA[10].

In the case of water for human consumption, it was possible to collect quality information from the Environmental Monitoring department of the Health Agency of Nova Friburgo. This department collects water samples only in one point of the microbasin, located at the local school of the community of Barracão dos Mendes. The criterion selected for the determination of the collect water points is the population density.

[10] Information taken from the interview with André Bohrer Marques, coordinator of the AGEVAP, CBH-Rio Dois Rios

The physiochemical parameters evaluated from the water sample collections are turbidity, free residual chlorine concentration, colour and odor. The physicochemical analyses are performed in the fieldwork and samples are then sent to the reference laboratory of the State Noel Nutels. The Environmental Department started to collect water in the region since 2011. The results of the samples shows that the water in the community of Barracão dos Mendes present fecal coliforms and *E.Coli* (Table 14), the turbidity parameters in the region meets the guideline 2914/2011 of the Health Ministry. Samples are taken at least three times per year. The environmental monitoring department stated that the principal cause of water pollution in the microbasin is agrotoxics use due agricultural activities.

Table 14: Water sample collects in the community of Barracão dos Mendes (2011-actual)

YEAR	NUMBER OF COLLECTED SAMPLES	RESULTS
2011	6	Sample with total coliforms and E. Coli presence
2012	3	Sample with total coliforms and E. Coli presence
2013	4	Sample with total coliforms and E. Coli presence
2014	1	Sample with total coliforms and E. Coli presence

(Elaborated by the author based on obtained information from the interview with Environmental Monitoring department of the Health Agency of Nova Friburgo)

3.7.2 Wastewater and Sanitation technologies

The results from the microbasin Census shows that the technologies available for wastewater technologies are:

A. Cesspits

A cesspit is a holding tank that collects waste and stores it (Figure 9). This system does not have a pipe for the draining of the wastewater, and no treatment take place on them. They have a limited treatment (WTE, 2007). Cesspit tanks are normally installed per house but there can be shared several families. The system could present different problems such as bad odours. Furthermore, cesspits can overflow especially during the rainy season. It often presents leaks or can sink into the ground. The main problem of this system is the high groundwater pollution (EPA, 2005; SSWM, 2014).

Figure 9: Cesspits in Barracão dos Mendes community
(Taken from Cardona, 2014)

B. Septic Tanks

Septic tanks are systems with two or three chambers, usually made of blocks or bricks. They treat wastewater, using bacteria for the breakdown of solid matter. Sludge is produced at the bottom of the tank and the treated water has to be discharge into the drainage system (Figure 10) (EPA, 2005). The septic tanks must be emptied at least once a year in order to avoid problems with its operation. The size of the septic tank must be defined according the number of users (EDDCEH, 2012). During rainy seasons, the septic tanks can overflow and effluent can appear at ground level, it can also produce bad smell. Problems with septic tanks will depend on the maintenance of the tanks, the soil type, the rainy season and the deterioration of the septic tank itself (WTE, 2007).

Figure 10: Septic Tank in Barracão dos Mendes
(Image taken by the author)

3.8 Water Environmental Problems

Table 15 shows the results of the rural participative diagnosis conducted in the microbasin population regarding the main environmental problems of the area. According to the population, sanitation actions are the first priority followed by the protection of water springs (COGEM, 2012).

Table 15: Water Environmental Problems in the Microbasin

ENVIRONMENTAL ITEM	ENVIRONMENTAL PROBLEM	DEGREE OF IMPACT	SUGGESTED SOLUTIONS	COMMUNITY PARTICIPATION
Wastewater	Reduction of drinking water due to lack of sanitation.	Extremely high	Sanitation (Collective system and septic tanks)	Labour hand and population awareness
Agrotoxics	Use and illegal sell, water pollution and lack of use awareness	Extremely high	Training for their correct use & Use of the organic manures	Non-use ethics
Rivers	Riparian forest absent in long areas	High	Restoration of the riparian forest	Labour hand and protection of the forest
Water	High turbidity and lack of drinking, pollution and erosion	High	Water springs protection	Labour hand

Source: (Elaborated by the author based on COGEM, 2012)

There is an intensive use of agrotoxics and chemical fertilizers for the olericulture. There is no previous training and a lack in information on the correct use of these products (EMATER, 2012). There have been cases of intoxication due to agrotoxics use in the study area. Therefore, environmental impacts studies that considers agrotoxics impacts will be required for water pollution (COGEM, 2012).

METHODOLOGY

"For complex governmental projects such as the introduction of decentralized treatment plants and re-use in rural and semi-urban communities, thorough decision-making processes that includes a feasibility assessment are essential"

(Liehoop, et al., 2013)

This research combines qualitative and quantitative methods. To achieve the specific objectives of this research the methodology was divided into three phases (Figure 11).

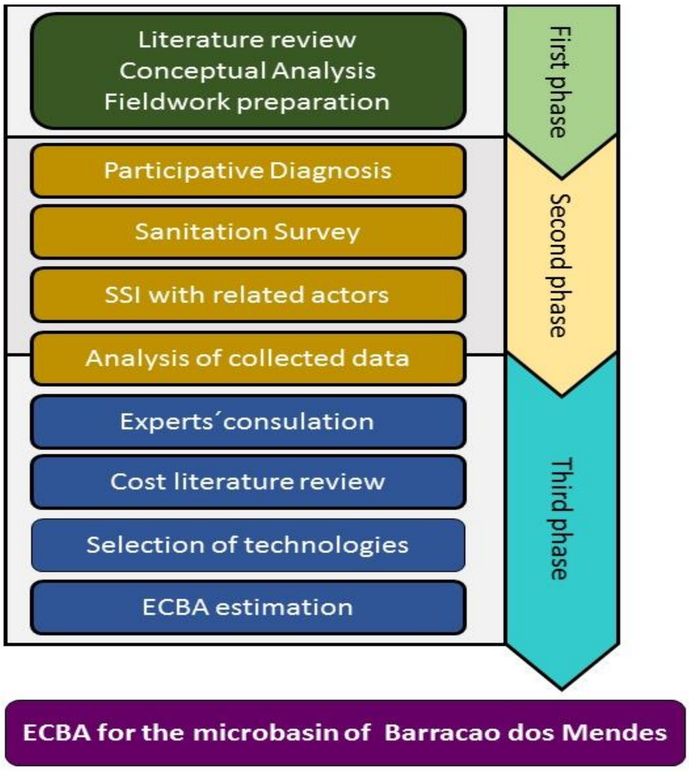


Figure 11: Methodology description
(Elaborated by the author)

The first phase includes a literature review around wastewater and sanitation importance and effects. The second phase was the fieldwork in Barracão dos Mendes microbasin with duration of three months (March to May 2014). The activities concluding during this phase were (I) An introductory workshop; (II) Participatory diagnosis; (III) Semi-structured interviews; and (IV) Survey application. In the third phase (June to August 2014), the data analysis of the information collected in the second phase and the ECBA estimation for different technology option including experts´ consultation (BDZ and Tilia Unwelt firms)[11] was accomplished. This phase concluded with a master thesis as an outcome.

4.1 Participative Diagnosis

With the objective to consider the community perspective regarding sanitation issues in Barracão dos Mendes, a participatory diagnosis with the leaders of the community was conducted. The aim of the diagnosis was to identify the main problems and consequences related with sanitation in the area. Members of the sanitation of the INTECRAL Project applied the diagnosis and it was divided into four parts:

Part 1. Determination of the main problems: The objective of the first part is to know the main problems that the leaders of the community related to the lack of sanitation in the area. This was assessed with a brain storming session, in which the community leaders wrote on yellow papers a problem related with this issue, according to their opinion. Once each member had exposed all his or her ideas, it was discussed which of the mentioned problems might be most critical ones, identifying them on red papers.

Part 2. Strengths of Barracão dos Mendes: In order to identify the strengths of the community when facing the sanitation problems, a new brain storming session was conducted and in this case the strengths were written on green papers.

Part 3. Related institutions: The aim of the third part was to determine the institutions that according to the community leaders can be involved in the solution and improvement of sanitation in Barracão dos Mendes. All the institutions were identified on purple papers. The next step was to match the mentioned institutions with the critical problems.

Part 4. Action Plan Development: With all the collected information the leaders developed an action plan to improve sanitation and wastewater conditions in the region.

[11] The experts consulted were Jaime Cardona from"*Bildungs- und Demostrationszentrum für dezentral Abwasserbehandlung*" and And Stefan Böttger from "*Tilia Unwelt GmgH*".

4.2 Semi-structured Interviews with the main related actors of wastewater and sanitation in MBDM

The semi-structured interviews (SSI) are a combination of questions with the interviewer and other person. The main advantage of this method is that it gives flexibility for research for additional important information (Longhurst, 2003). With the aim of obtain information for the description of the study area and information about the impacts of the lack of sanitation the microbasin SSI were applied to the principal local government institution, the presidents of the association of the microbasin and with other important actors (Figure 12). All of the interviewees were selected according to the results of the participative diagnosis. All the SSIs were done face to face by the author with an average duration of one hour and they were applied during April and May 2014.

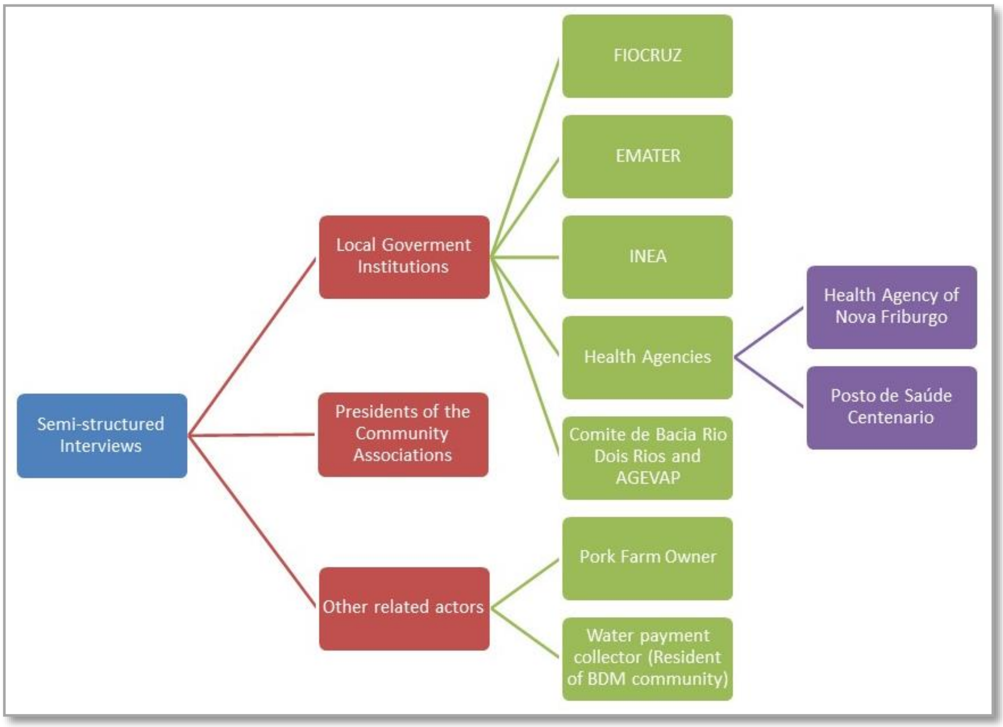


Figure 12: Semi-structured Interview in the microbasin of Barracão dos Mendes
(Elaborated by the author)

4.3 Survey of Sanitation and Public Health

A structured questionnaire was conducted within the population of the MBDM as a tool for survey data collection. In this case, a cross section survey (Mathers, et al., 2009) was chosen, because it will describe the current sanitation conditions of the microbasin. This tool was selected due to its flexibility to collect information about different topics (Kothari, 2004).

4.3.1. Questionnaire design

The questionnaire had 96 questions, including open-ended, dichotomous and multiple-choice questions. It was divided into five sections titled from A to E (See Annex I).

The section A collects general information about the location data of the respondent. Section B presents questions, regarding family composition (e.g. age, gender, occupation, between others) and economic information of the family members. The construction of the questions in section A and B were taken from the literature and on the PRR (2014) survey on impact evaluation it is important to clarify that this survey has not been applied in the region.

Section C´s aim to collect information about water supply, wastewater and sanitation conditions in the microbasin. Moreover, this section addresses questions regarding the respondents´ perceptions about water quality, sanitation importance and their possible willingness to pay for sanitation improvements. Questions 1, 2, 15, 18 and 27 of this section were taken and adapted from PRR (2014). The questions 16, 17, 31 and 32 were based on WHO & UNICEF (2006) guidelines sanitation survey for house. The rest of the questions were designed by the author considering the objectives of the research and the literature review (USAID, 2008; NSSO, 2013).

Section D was a part only for the local farmers with the aim of obtaining information about agricultural and water and agrotoxics use. The design of questions for this section was done by the author based on previous literature review (EPA, 1995; WHO 2009).

Finally, in section E data on health to establish the incidence of the family members to water related disease and their impacts to the family income is collected. Questions 9, 11, 13 15, 16 and 20 were based on WHO (2009) survey. The remaining questions were designed by the author based on literature (Hutton; NSSO, 2013, among others).

4.3.2 Survey application

Prior to the application of the survey, a group of researchers of the INTECRAL project, including the author was presented to the community of Barracão dos Mendes during a community association meeting. In this meeting the importance, objectives and limits of each researcher´s fieldwork were explained to the population. The purpose of this preliminary phase was to obtain the cooperation of the population regarding the fieldwork.

The houses located in the microbasin were chosen as samples, because sanitation and wastewater treatment services are normally supplied per house. The microbasin Census (2009-2010) shows that in the MBDM there are 448 houses. The survey was applied in fifty-five houses of the microbasin. This represents more than the 10% of the houses. The survey distribution is described in Table 16. Convenience sampling method was selected for this study because of the region´s conditions and availability of materials and limited time for the application of the survey.

Table 16: Survey distribution

Community	Number of Surveys
Barracão dos Mendes	29
Florândia da Serra	8
Serra Velha	5
Serra Nova	4
Rio Grande	9
Total	**55**

(Elaborated by the author)

For the application of the survey, there were two basic conditions that the respondent needed to fulfill in order to be interviewed: the first was that the respondent was an adult (older 18 years old) and that he/she is living permanently in the house. The questionnaire draft and its application were concluded in Portuguese, and it had an average duration of thirty minutes per questionnaire. The author applied all the questionnaires, with a period of application of the survey from April 7 th to April 18th, 2014.

4.4 Environmental Cost-benefit analysis Calculation

For the selection of the best technology option for wastewater treatment and sanitation in the MBDM two main scenarios considering decentralized and semi-decentralized solutions were constructed. For each selected option, the ECBA was calculated.

4.4.1 Scenario Definitions

The Scenario A considers a totally decentralized system. The Scenario B includes a semi-decentralized system that will include a small wastewater treatment plant combined with on-site systems. According to the technology treatment used by the small wastewater treatment station, nine sub-scenarios have been considered (Figure 13).

The construction of the first four sub-scenarios considers the technology option given from the experts´ consultation (*BDZ* and *Tilia Unwelt* companies). The technologies were selected due to previous experts' experience applying these technologies in rural areas. In addition to this, the present study includes five sub-scenarios that consider technology options that have already been used in the Brazilian small communities with low-income levels and due to the availability of information for costs estimation.

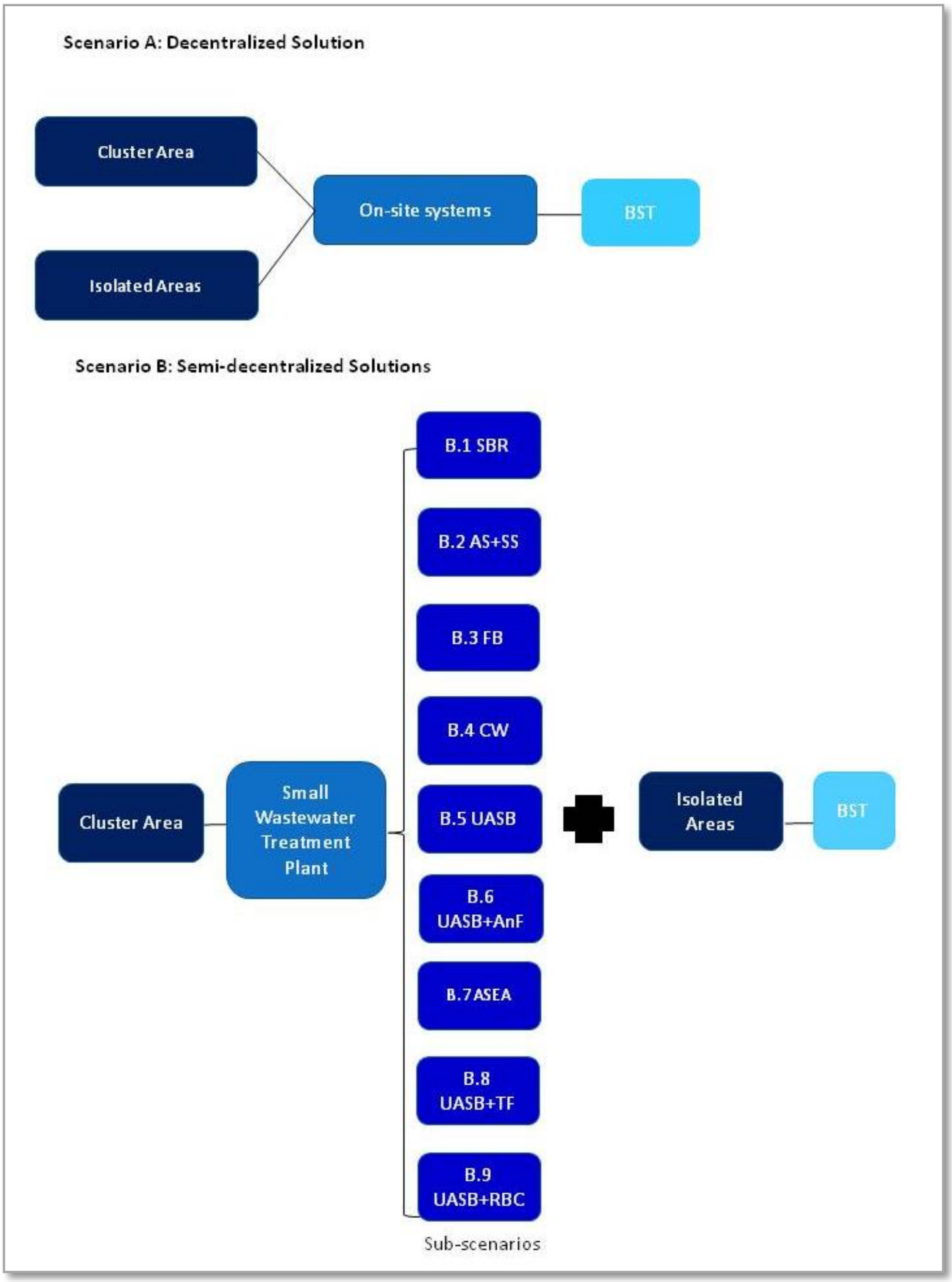


Figure 13: Scenarios definition

(Elaborated by the author; BST=Biodigester Septic Tank; SBR=Sequence Batch Reactor; AS+SS= Activated Sludge + Sludge Stabilization; FB=Fluidized Bed; CW=Constructed Wetland; UASB= Up-flow Anaerobic Sludge Blanket Reactor; AnF= Anaerobic Filter, ASEA: Activated slugged with extended aeration; TF= Trickling filter)

Population Assumptions

Based on the population results from the CENSUS (2009-2010) (EMATER, 2009a; EMATER, 2009b; EMATER, 2009c; EMATER, 2010a; EMATER, 2010b) Barracão dos Mendes community considered the cluster area because it represents the 63 % of the total number of houses in the microbasin, while other communities are considered isolated areas. The average member per family and the number of inhabitants is shown in Table 17.

Table 17: Population factors and distribution in the microbasin of Barracão dos Mendes

COMMUNITY	HOUSES	INHABITANTS	AREA	AVERAGE FACTOR
Barracão dos Mendes	281	927	**Cluster area**	3,3
Florândia da Serra	67	224	**Isolated**	3,0
Rio Grande	38	75		
Serra Nova	27	105		
Serra Velha	35	104		
Total	448	1435	**Total (isolated + cluster)**	3,0

(Elaborated by the author based on EMATER, 2009a; EMATER, 2009b; EMATER, 2009c; EMATER, 2010a; EMATER, 2010b)

The scenarios were calculated considering wastewater and sanitation coverage of the projected population for 2034 (Table 18).

Table 18: Projected Population for the microbasin of Barracão dos Mendes

Item	Houses	Current and Projected Population*			Flow Rate (m^3/d)
		2014	2024**	2034**	
Isolated houses	167	501	526	553	36,30
Cluster houses	281	927	974	1022	61,07
Total	**448**	**1428**	**1500**	**1575**	**97,37**

(Adapted by the author based on Cardona et. al., (2014); *Based on Census (2009-2010) **Assuming 5% population growth each 10 Years (Saraiva, 2014))[12]

[12] The information was collected form an interview with Jarbas Saraiva member of the PRR and member of the sanitation team of the INTECRAL project.

Legal Consideration

Table 19 shoes the removal efficiency that must be achieved by the technology options according to Brazilian sanitation framework for low residential standards (see Section 2.4).

Table 19: Sanitation legal parameters for the microbasin of Barracão dos Mendes

Parameter	Removal efficiency
BOD	65%
TSS	65%
Total Nitrogen	10 mgN/L
Total Phosphorus	0,1 mgP/L

(Elaborated by the author based on: CECA, 2007 & CONAMA, 2005)

Cost and benefits integrated into the analysis

For the determination of the ECBA the total cost and benefits shown in Figure 14 were considered.

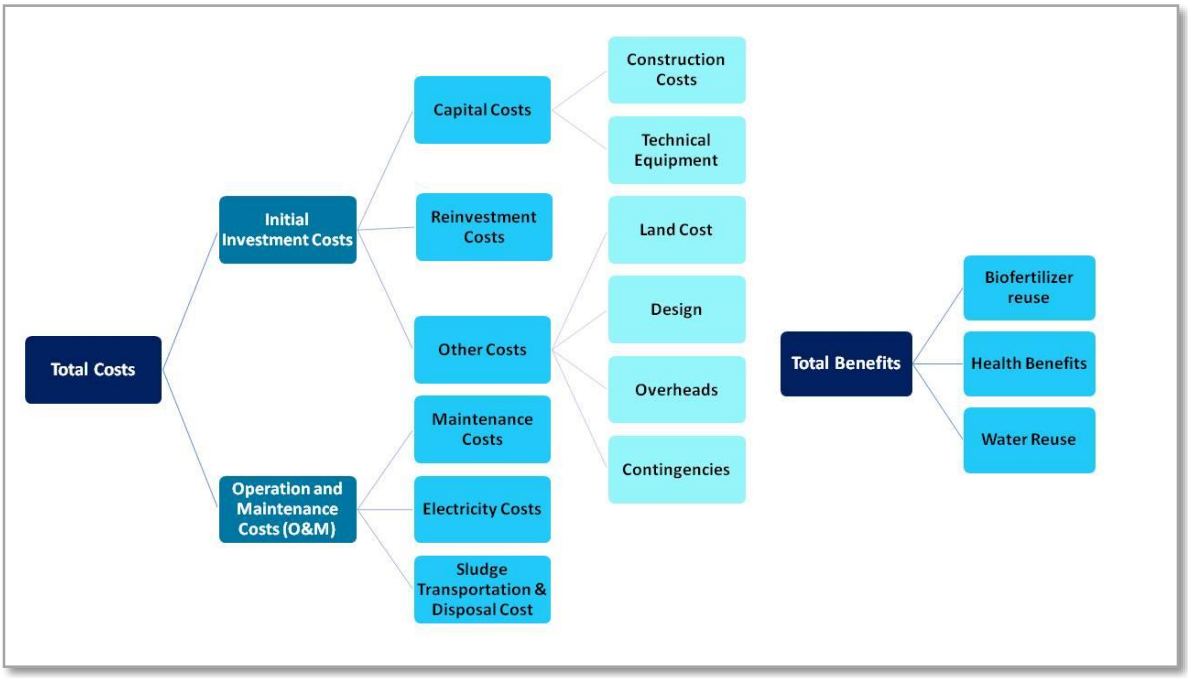


Figure 14: Cost and Benefits breakdown

(Elaborated by the author based on Cheng et al., 2009; Molinos et al., 2012; Cabral da Costa & Martins Guilhoto, 2012)

For the estimation of the total cost two principal cost were considered: (I) the initial investment cost which includes the capital cost, the reinvestment cost and other additional such as: land cost, design, overheads and contingencies. (II) The operation and maintenance cost (O&M), this cost includes the electricity requirements, sludge cost, the staff requirements. The equation (4) shows the quantification of the aggregated cost.

$$CT = C_I + C_{O\&M} \tag{4}$$

Where C_I represents the installation cost and the $C_{O\&M}$ represents the operation and maintenance costs.

For the valuation of the benefits, three benefits were considered: (1) the biofertilizer reuse (*BR*), (2) the health benefits due to sanitation improvements (*HB*), and (3) the benefits of water reuse (*WR*). The aggregated benefits were calculated as follows (Eq.5):

$$BT = BR + HB + WR \tag{5}$$

4.4.2 Scenarios Description

4.4.2.1 Scenario A: Decentralized Solution

In this scenario, isolated and cluster houses will be cover with on-site systems using the Biodigester Septic Tanks (BST) technology.

Technology description

This technology was implemented by EMBRAPA. BST avoid water and soil contamination due to faecal coliforms. This system was designed for rural wastewater treatment and it operates sending human waste from household toilets to three interconnected and buried collection boxes (Figure 15). In the anaerobic biodigestion treatment, bovine manure is used to improve the organic matter degradation of human wastes (FBB, 2010). Inside the tanks, the waste is processed and transformed into an effluent that can be used as fertilizer due to a considerable amount of nutrients for the soil. The system produces around five litters of fertilizer. Based on EMBRAPA´s experience, this fertilizer has been successfully used by rural farmers. The system is designed for house with five inhabitants. Nonetheless, the system is flexible and can be redesigned (FBB, 2010; EMBRAPA, 2013).

Figure 15: Biodigester septic tank in Barracão dos Mendes
(Image taken by the author)

Cost Estimation

- Initial Investment Cost

The first step to estimate the BST calculation of the capital cost. The FBB (2010) have a list of the material required for the installation of this system. The unit prices for each material on the list were estimated considering the current prices of 2014 for civil construction in Brazil. The detailed price information is on the SINAPI (CAIXA, 2014) and EMOP (EMOP, 2013) cost tables that represent the basis for the capital cost estimation (see Annex II). Based on previous installation of the BST in the microbasin, it was assume that two people will be needed for the excavation and installation of the system[13] and that this cost will be covered by the community without payment.

- Re-investment Costs

The re-investment cost are divided into (I) replacements cost which include minor costs equipment replacement and mechanical replacement and (II) construction reinvestment (LAWA, 2005; Tsagaraski, et al., 2003). The LAWA (2005) recommends the reinvestment considering 40% of the capital cost, which can take place every twelve years. In the case of the construction reinvestment cost, it was estimated assuming that can take place every twenty-five years and that they will represent the 60% of the capital cost.

- Other Cost

Even though it is assumed that that there would not be a payment for land cost owing to the fact that the BST will be installed inside the resident property, the value was of it was calculated as an opportunity cost for the resident. According to FBB (2010) the land

[13] Information given from a local resident that has already installed this system, due to the FBB Programm.

requierements for the installation of a BST are 6.5 m^2. The land cost calculation is shown in Equation (6):

$$LC = LQ_i * P_L \quad (6)$$

Where LC represents the land cost, LQ_i is the land requirement for the technology i and P_L is the current land price per m^2 in the microbasin.

The electricity cost is equally assumed to be zero because the BST do not require electricity. The design cost for this technology, contingencies and overhead will also be zero due to previous application of this system in rural areas of Rio de Janeiro and that the system will be in charge of the family members, thus no private operator is required for its functioning.

- O&M costs

The O&M costs were estimated based on previous calculation for on-site septic tanks for small communities (WERF, 2010).

Benefit Estimation

- Public Health Benefits

Previous studies (Fewtrell, 2005, Hutton, 2004 & 2007) have shown that there is a reduction in the number of cases from water related disease when sanitation improvements are made. This research has calculated public health benefits under the assumption that there will be an avoided cost on the number of cases of residents affected by wastewater related diseases. Using the cost of illness (COI) approach, which is based on the calculation of direct costs (medical cost, travel cost, between others) and indirect cost (lost production because of reduced working time) incurred by an illness person (EPA, 2010; WHO, 2009; CDC, 2010). The equation 7 shows the calculation of the COI:

$$COI = CMA + LP \quad (7)$$

In which CMA will be the cost medical assistance and LP will be the loss of productivity. The CMA includes the cost of hospitalization, the cost of diagnosis and treatment and other cost like transportation to the closes medical center or hospital. The determination of productivity loss can be estimated considering loss of adult productivity (LP_A) and indirect loss of productivity from parents or adults in charge of the children (LP_C) (Eq. 8). The LP_A

can be calculated multiplying the number of illness per day by the daily income. The LP_C, will be estimated multiplying the number of absence working days of the adult taking care of the children by the daily income (Conte Grand & Coloma, 2009).

$$LP = LP_A + LP_C \tag{8}$$

For the research, the basic medical attention costs for diarrhea treatment were considered. This disease was selected based on the sanitation survey results elaborated by the present study (see section 5.3). Due to the lack of historical information regarding diarrhea cases, 20% of the population is considered to suffer from diarrhea twice a year with an average duration of two days (based on survey results).

The Brazilian Health Minister divides public health in two categories: basic medical attention and high medical attention (Brazil, 2011c in Cabral da Costa & Martins Guilhoto, 2012). According to Cabral da Costa & Martins Guilhoto (2012), the estimated cost per capita for basic medical attention in Brazil for 2013 was 54.02 US$ (R$116,68)[14] (price update from 2007). The calculation of the CMA was done multiplying the value of medical attention for 2013 with the percentage of the diseased population (20%). The LP was estimated considering the monthly minimum wage in Lei N° 6,702 for 385.10 US$(R$ 831,82) for 2014 (BRASIL, 2014) (See Annex III).

- Biofertilizer reuse

There is potential of the nutrients in wastewater that can be accepted by the crops and soil. For this study, it was considered that the biofertilizer produced by the BSTs will be totally reused for degraded areas restoration. This will contribute to reduce the amount of agrotoxics and fertilizers used by farmers. The biofertlizer benefits are depicted in Equation (9):

$$BR = \sum(Q_{Ni} * P_{Ni}) \tag{9}$$

Where Q_{Ni} is the production of nutrients of the biofertlizer obtained from the biodigester septic tank, considering only nitrogen, phosphorus and potasium (NPK) and the P_{Ni} is the updated market price of each nutrient in Brazil (See Annex IV).

[14] Considering the average exchange rate for 2013 of 2,16 Brazilian reais per dollar (WB, 2014).

- Water reuse

Here, the reuse of the treated water was considered. Even though the region does not have problems related to water scarcity, water reuse will help to the maintain water bodies (water springs), reduce environmental pollution and improve sustainability. The treated water can be used in each house for toilet flushing, gardening, etc. (Hespanhol, 2002). In addition to this, the water can be used to accomplish agricultural water requirements. For the quantification of this benefit, the tariff for tap water and the amount of treated water of the system were considered, as shown in Equation (10):

$$WR = 365 \sum_{i=1}^{n} A_i Q_i \tag{10}$$

Where Q_i is the quantity of water treated; and A_i is the tariff of tap water in Nova Friburgo (Cheng & Wang, 2009).

4.4.2.3 Scenario B: Semi-decentralized Solutions

In this scenario, the isolated houses that belong to Florândia da Serra, Serra Velha, Serra Nova and Rio Grande communities will be supplied with BST system. The small wastewater treatment station will cover the houses located in Barracão dos Mendes community.

Sub-scenario B1: Sequence Batch Reactor (SBR)

According to the EPA (1999) a SBR is "an activated sludge process designed to operate under non-steady state conditions". An SBR operates in a batch mode with aeration and sludge settlement both taking place in the same tank or more. This system is suitable for treat municipal and industrial wastewater. It can be operated under low flow conditions and is suggested for areas with limited available land. This system can be adapted according to the nutrients removal requirements because the cycles of the SBR can be modified. The system is composed of aeration and mixing equipment, a control system, a tank and a decanter. The operation of the systems requires five steps: (I) fill; (II) react; (III) settle; (IV) draw; and (V) Idle (NEIWPCC, 2005) (Figure 16).

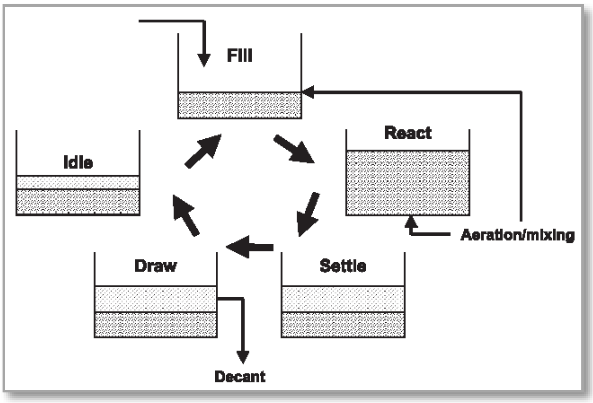


Figure 16: Sequence Batch Reactor
(Taken from: NEIWPCC, 2005)

Sub-scenario B2: Activated Sludge with Sludge Stabilization (AS+SS)

The Activated Sludge (AS) is a multi-chamber reactor unit. It has a tank where primary settlement takes place. The sludge produce in the first tank is pumped into aeration tanks. The system requires constant oxygen supply to maintain the aerobic conditions (Figure 17). This system has been applied in domestic and industrial wastewater treatment (Tilley, et al., 2008).

The sludge stabilization involves three steps: (I) Pathogen reduction; (2) Odors elimination; and (3) Reduction, inhibition or elimination of the matter with potential to putrefaction (Wang, et al., 2009).

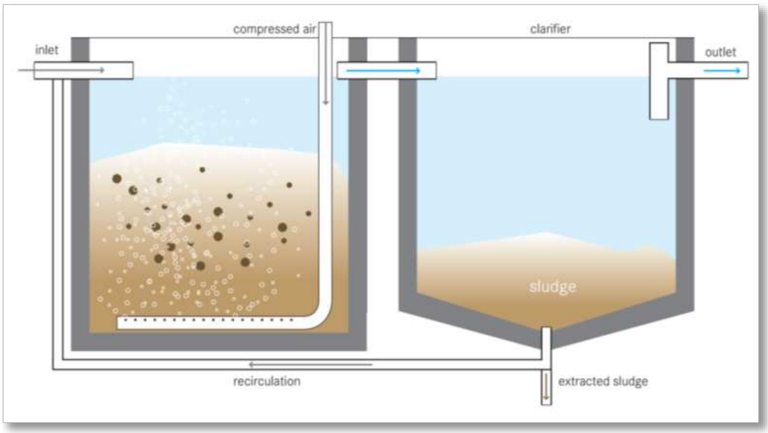


Figure 17: Activated Sludge process
(Taken from: NEIWPCC, 2005)

Sub-scenario B3: Fluidized Bed (FB)

This system is a new technology, which involves fluidized media for cell retention (Burghate & Ingole, 2013). It consists in reactors in which wastewater recycled effluent is introduce at the bottom of the reactor at a hydraulic loading rate or Up-flow velocity sufficient to expand the bed media, resulting in a fluidized state (Wang, et al., 2009). This type of technology is a patented technology from the German firm *BERGMAN A.G.* (Figure 18).

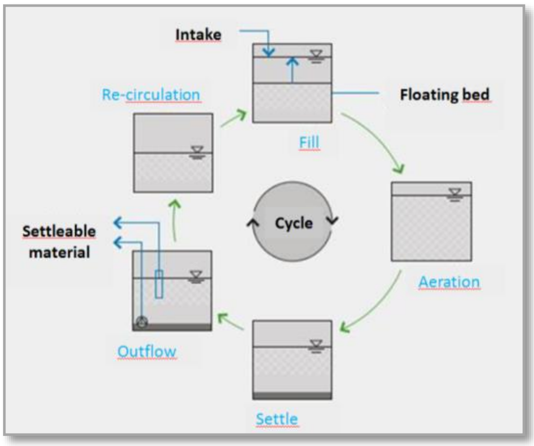


Figure 18: Fluidized bed operation
(Adapted form: Tilia Unwelt, 2014)

Sub-scenario B4: Constructed Wetland (CW)

Constructed wetlands are treatment systems that consist in ponds or channels, which have been planted with aquatic plants, designed for wastewater treatment (Figure 19). This system use biological, physical and chemical processes to treat wastewater (EPA, 2000). In this option, it will be installed a vertical constructed wetland, where the water flows vertically down into the filter (Tilley, et al., 2008). It is recommended to use aquatic plants for the region to guarantee higher efficiency levels (Melbourne Water, 2010).

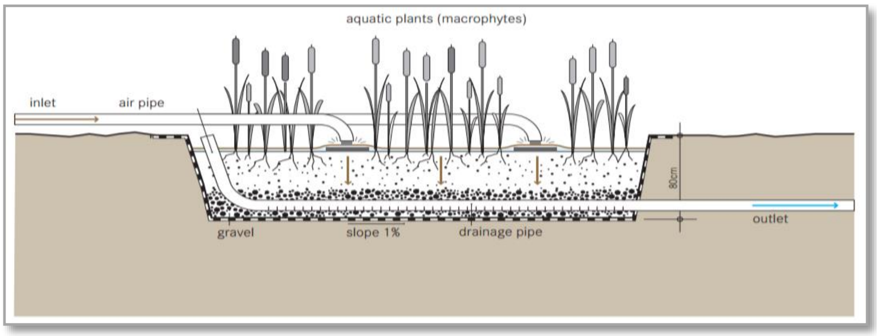


Figure 19: Vertical Constructed Wetland
(Taken from: Tilley, et. al., 2008)

Sub-scenario B5: Up-flow Anaerobic Sludge Blanket Reactor (UASB)

In the UASB process, the waste that to treated is introduced in the bottom of the reactor (Figure 20). The wastewater flows upwards through a sludge blanket composed of biologically formed granules or particles. Treatment occurs when the waste contact the granules (Tilley, et al., 2008).

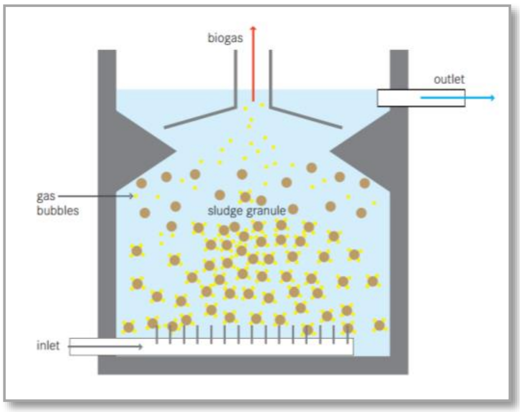


Figure 20: UASB Reactor
(Taken from: Tilley, et. al., 2008)

Sub-scenario B6: UASB with Anaerobic Filter (UASB + AnF)

This option includes an UASB reactor plus and Anaerobic Filter. Tilley, et al. (2008) defines an AF as "a fixed-bed biological reactor". In this system, the wastewater flows through a filter in which the particles are trapped and organic matter is degraded through the biomass of the filter material (Figure 21).

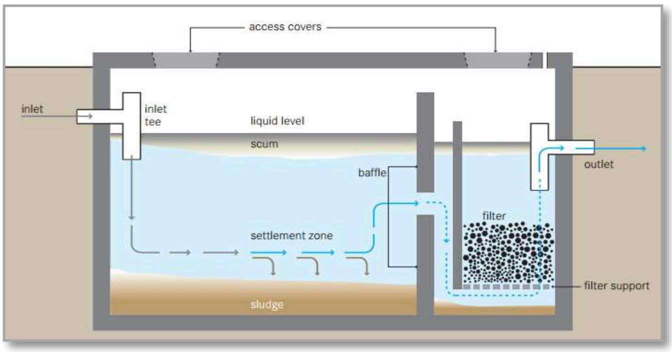


Figure 21: Anaerobic Filter
(Taken from: Tilley, et. al., 2008)

Sub-scenario B7: Activated Sludge with Extended Aeration (ASEA)

This sub-scenario represents a modification of the conventional activated sludge process, which according to EPA (2003) is "a coarse screening aeration using air diffusers or mechanical aerators, secondary settlement with surface skimming and return sludge pumping".

Sub-scenario B8: UASB + Trickling Filter (UASB + TF)

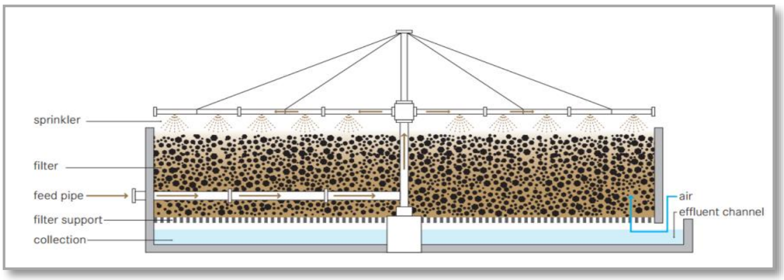


Figure 22: Tricking Filter
(Taken from: Tilley, et. al., 2008)

EPA (2000) defines a trickling filter as "a system that utilizes microorganisms attached to a medium to remove organic matter" (Figure 22). The TF normally operates under aerobic conditions. This system requires a pretreatment that will be cover by the UASB reactor; the pretreatment is essential for an efficient treatment and prevents the TF from clogging (Tilley, et al., 2008).

Sub-scenario B9: UASB with Rotating Biological Contactor (UASB + RBC)

This system uses a biological treatment process and is defined as "large disk with radial and concentric passages slowly rotating" (Kadu, et al., 2013). It requires that the wastewater brought into contact with a biological media for pollutants removal. The exposure to oxygen for the development of the biomass layer is indispensable (Figure 23) (Kadu, et al., 2013).

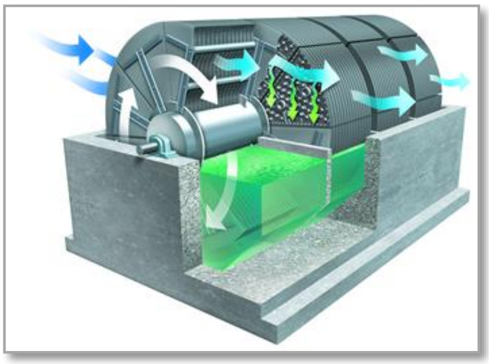


Figure 23: Tricking Filter
(Taken from: Walker Process, 2012)

Cost Estimation

The estimation of the cost for the BST systems of the isolated areas will be calculated with the same consideration as in Scenario A. Regarding cost for the treatment plant, they were estimated as follows:

- Initial Investment and O&M Cost

The first four sub-scenarios (B.1 to B.4), the capital costs from the experts´ consultation (*Tilia Unwelt* and *BDZ* firms) were considered (See Annex V). The O&M cost were obtained from literature according to the typical values that can be considered for each treatment (WERF, 2010; van Haandel & van der Lubbe, 2007).

For the remaining five sub-scenarios (B.5 to B.9) the investment cost and O&M cost information from were taken from the literature (Jordao & Pesoa, 2009 in Bergamaschi Teixeira, 2009). The electricity costs were calculated according to Equation (11).

$$EC = ER_i * EP_{NF} \tag{11}$$

Where EC represents the energy cost, ER_i is the amount of kWh required for the technology I, and EP_{NF} is the KWh price in Nova Friburgo.

- Sewer Cost

The installation of small treatment plants for the cluster area will require a sewer network. In this case, a condominial sewer network was selected. This type of sewer is a low-cost installation option recommended for rural areas (Melo, 2006). The calculation of the sewer cost was done considering a sewer connection length of 1900 m and a connection length per house of 10 m (Tilia Unwelt, 2014) (See Annex VII).

- Reinvestment Cost

The reinvestment cost has been calculated with the same consideration of the Scenario A.

- Other Cost

The land cost for the first four scenarios considers the land requirements for the treatment plant installation, given from the experts’ consultation (*Tilia Unwelt* and *BDZ* firms). The rest of the scenarios consider the land requirements from (Bergamaschi Teixeira, 2009). It was include the land cost for the installation of the BST in isolated araeas. The land cost calculation was done with the equation (6).

The design costs (DeC) were calculated as a 10% of the capital cost of each technology. The contingencies costs (CoC) were calculated as a 15% of the capital cost. The overhead cost (OvC) which consider the wastewater treatment operator utilities were calculated considering a 15% percent of the capital cost[15]. The aggregated other cost (OC) was estimated as below:

$$OC = LC + DeC + CoC + OvC \tag{12}$$

- Sludge disposal Costs

The Brazilian legal framework does not allow the sludge reuse for agricultural purposes (CONAMA, 2006). Due to this, the cost for the disposal and transportation of the sludge produced by the treatment plant to a sanitary landfill has to be included. Equation (13) shows the calculation of the sludge cost.

$$SlC = QSl_i * PSl_{D\&T} \tag{13}$$

Where the SlC is the Sludge Cost, QSl_i is the annual sludge production for the technology i, and $PSl_{D\&T}$ is the price for transportation and disposal of the sludge into the sanitary landfill (See Annex VIII).

Benefits Estimation

For the semi-decentralized options, the same benefits as in scenario A have been taken into account, but the benefits from the biofertilizer from the BST will only be calculated considering the isolated houses.

Environmental Cost-Benefit Calculation

The calculation of the ECBA was done using a dynamic prime cost table for each technology, considering a time horizon of 30 years based on the European Commission guidelines for the calculation of this analysis (Fiorio, et al., 2008). In all the scenarios, land cost and installation were considered to take place during the construction phase of the system

[15] Based on BDZ firms partnership including TILIA Unwelt.

(Year 0). Meanwhile, the operation and maintenance cost will occurs each year once the system starts to operate. Benefits arise from the moment the moment the systems stars functioning (Year 1). This research considers a financial discount rate of 5%, suggested by the European Commission guidelines (2008).

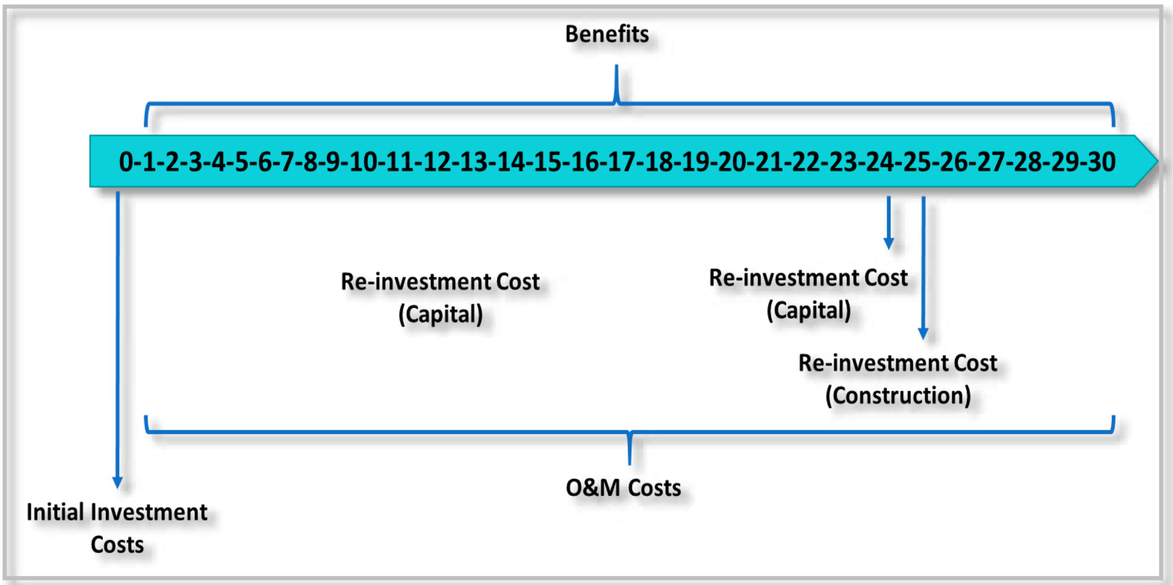


Figure 24: Cost and Benefits over the horizon time
(Elaborated by the author based on LAWA, 2005; Liehoop, et al., 2013)

The net present value (NPV) for each technology was obtained using the Equation (2). For an estimation of a sensibility analysis, the NPV results were compared considering the NPV of the ECBA results for 3%, 5% and 7% financial discount rates. These rates were selected based on the KfW-Bank interest rates for infrastructure investment credits (KfW, 2011 in Liehoop, et al., 2013).

CHAPTER 5

RESULTS AND DISCUSSION

"Guaranteeing sustainable food and water security for all will require the full engagement of all sectors and actors. It will entail transferring appropriate water technologies, empowering small food producers and conserving essential ecosystems services. It will require policies that promotes water rights for all, stronger regulatory capacity and gender equality. Investment in water infrastructure, rural development and water resources management will be essential".

Bank Ki-moon, 2012

5.1 Participatory Diagnosis

In the first part of the diagnosis, the community linked twenty-five problems to sanitation issues (e.g. water pollution, impacts on water quality, fauna alteration, and absence of supervision, between other problems). The critical problems selected by them were:

- **Health problems:** Due to pollutants of animal waste, agrotoxics, and lack of treatment of effluents in the region. In addition, the community leaders mentioned that the population has direct contact with wastewater, consumes polluted water and presents water suffers from water related diseases like diarrhea, typhoid, rotavirus and salmonellosis.
- **Pollutants caused by high scale production:** There is a pork farm in the region, next to the river and there is concern about to animal waste, hormones, medicaments, steroids and other pollutants that might be discharged into the water bodies. The wastewater produced by the farm, requires a treatment process more complicated than the process for domestic wastewater treatment. Even though the main objective of the Sanitation Team in the INTECRAL project is focused on domestic wastewater treatment, this problem has to be addressed for further development projects in the area.
- **Agrotoxics:** Agricultural production is the main economic activity in the region, and for this aim, the famers use high quantities of agrotoxics that have negative impacts on water quality. Even though EMBRAPA informs the population the way how to

use biofertilizer, in many cases the producers do not follow the recommendations of this institution.

- **Poor sanitation conditions:** The region present many problems related with drinking water such as pollution, faecal coliforms and DBO levels, which reduce the water quality. There are houses with polluted wells and sinks without an appropriate maintenance, which also could overflow when there are high precipitation levels.
- **Training deficiency:** The community presents an educational problem because the available technical information is not being applied. Additionally, there is a lack of knowledge about the environmental problems such as: (I) sanitation problems; (II) commercial waste; (III) industrial wastewater; (IV) animal waste and (V) use of agrotoxics. Because of this, they consider that there is a need of better training.

The strengths identified for Barracão dos Mendes were community participation, partnership spirit, participative mobilization, in which all the stakeholders are involved in the decision making process and the empowerment of the actors. In addition to this, they had a strong producers association and the community is aware of the importance of sanitation in the region.

In the third part of the diagnosis there were mentioned thirteen connected institutions that could help to improve sanitation issues were detected. The correlation between institutions and critical problems are shown in the Annex X. In the final part of the diagnosis, the community develop a Sanitation Action Plan for the region (Annex XI), the population take into consideration the critical problems and the possible actions that could be done for improve sanitation. The leaders consider as a priority the introduction of new wastewater and sanitation technologies adapted to the local condition that improves water quality and the public health of the region. These technologies should include good water consumption practices. Regarding the wastewater and sanitation education, the importance of a participative approach involving the schools and association of the region was highlighted.

The results from the diagnosis portray the leader perspective regarding the sanitation conditions in the region, given to the author of the overview of the lack of sanitations effects. The inclusion of the population perspective was very important because, many research projects fail in the practice because as local interests are not considered (CSTA, 2011). Due to restrictions in time, only the communities' leaders were questioned, showing high interest in improving sanitation conditions.

5.2 Semi-structured interviews

The semi-structured interviews (SSI) were applied to the local government institutions EMATER, the river basin committee (CBHRR) and members of PRR. The author intended to interview other government institution (e.g. Águas de Nova Friburgo, Fundação Banco do Brasil, among others), but they could not be interview due to absences of response. FIOCRUZ and INEA were online contacted due to the lack of time availability of the government workers. The collected data from the mentioned institution was used for the description of the study area in Chapter 3.

5.2.1. SSI with the Public Health Agencies

5.2.1.1 Local Health Agency "Posto de Saude Centenario"

According to the health agents, the most important wastewater related disease is diarrheal and there are few cases of dengue and salmonellosis. In most of the cases, the patients do not visit the public health agency for medical treatment because they prefer in first instance home treatment. In addition to this, patients with severe illness prefer to go directly to the municipal health agency in Nova Friburgo.

In the agency only a monthly report of children under two years old treated by diarrhea is collected and prior they send it to the Nova Friburgo health agency "*Secretaría Municipal de Saúde in Nova Friburgo*". In case of infant mortality, notifications to the Nova Friburgo health agency must be sent. However, until now there are low mortality cases.

The health agents assume that the microbasin water present bad quality and that the water contain parasites. In order to avoid parasite illness they deworm all the families of the community twice a year.

The information given from the agency regarding the number cases presented in 2012 of diarrheal in children with less than 2 years old, do not contain representative data due to the low number of cases registered.

5.2.1.2 Nova Friburgo Health Agency

Based on the information given by the epidemiology agent until now they do not have notification regarding diarrhea cases from the microbasin but that does not mean that the region do not have diarrhea cases, it means that the cases where not acute or that they have not been registered. The rest of the water related disease are do not require compulsory notification and until know the region does not register any dengue cases. The main outcome form this interview was information regarding water quality in the region (see Section 3.7.1).

The results from the SSI to the local health agencies shows the lack of historical information about the number of cases of diarrheal or other wastewater related disease. Due to this, the results do not support the results of the participative diagnosis regarding wastewater related diseases in the region.

5.2.2 SSI with the communities presidents

In the communities monthly reunions where agricultural development (e.g. food chain, intermediary transportation cost to CEASA- RJ) represents the main are conducted by the community presidents. The association members are mainly family farmers but there are also local residents that belong to the association. The link between the municipal government and the residents of the microbasin is done through the associations. The municipal government through EMATER supports the communities with agricultural machinery, and the community presidents coordinate its use. Another important example of their cooperation are the projects in course for the individual development *"Planos Individuais do Desenvolvimento"* (PIDs) coordinated through technical organization

EMATER and. The presidents of each association did the selection of the project beneficiaries.

The presidents of the communities considers water quality from the springs is good, even though they mention that it has had a better quality before the mudslides and landslides that took place in 2011. In the case of water payments, the presidents explain that most of the population of the microbasin does not pay a fee for this service. However, the president of the community of Barracão dos Mendes mentions that some resident that pays an informal monthly fee for water supply to a resident of this community (see section 5.2.3.2).

No quality analysis of the spring's water and the wastewater produced in the region has been elaborated. The presidents perceive that the lack of sanitation can develop health problems. In the PIDs, sanitation improvements can be included, imply the installation of a Biodigester Septic Tank. However, in the list of PIDs for Barracão dos Mendes there are no projects related to sanitation (EMATER, 2014).

5.2.3 SSI with other related actors

5.2.3.1 Pork farm owner

The pork farm "*Granja Salinas*" is located in the neighboring community. It was installed 1975. The pork production is around 650 to 750 units per month. The farm counts with wastewater treatment in the form of lagoons and a biodigester. One part of the treated water is reuse on the farm and the other part is disposed into the water bodies. A part of the sludge produced in the treatment process is reused as manure.

Owing to the fact that there are not water quality measures, it was not possible to establish a relationship between the farm effluents and water pollution in Barracão dos Mendes. Though the analysis of the wastewater from the farm is beyond this study, it would be necessary that the municipal government verify if the treated water accomplish with the legal parameters for water disposal into the water bodies, since the results from the participative diagnosis shows that this farm may release an important amount of pollutant over the water bodies.

5.2.3.2 Water fee collector

The fee collector is a permanent resident of the BDM community. He explained that due to the absence of government support the installation of infrastructure for water supply to the community, he decided to make the direct connection with the water spring. For this purpose he collected a group 30 of residents that want to be connected with the water spring. This group of residents pays a monthly water charge is of 2.31 US$ (5R$)[16]. The purpose of this fee is for the maintenance of the hoses connected to the water spring, done by the fee collector.

5.3 Key results of the sanitation and public health survey

Section A collects genera information of the respondents. Section B shows that the wife household head answered 45% of the surveys, 45% by the male householder; 5% were the daughter in the household and the remaining 5% was a householder´s family member. Most of the respondents were owner of their house (85%). Only the 15% rented their house. The samples results show that 56% of the interviewees were local residents and were 44% of them were family farmers. The family´s monthly income distribution is shown in Figure 24, 69% of the sample presented an income of one minimum wage[17] (approx. US$ 370,00), 22% had two minimum wages, the rest of the families incomes are between three and ten minimum wages. However, the monthly family income was an estimation of the respondent, because most of the families depend on agricultural revenues. In almost 50% of the considered cases the income is achieved by two family members, in 33% of the cases by the only one family member, in 10% is achieved by three family members, and the remaining 7% is achieved by more than three family members.

[16] Considering an exchange rate of 2.16 reais per dollar (WB, 2014).

[17] Based on: (Legisweb, 2014).

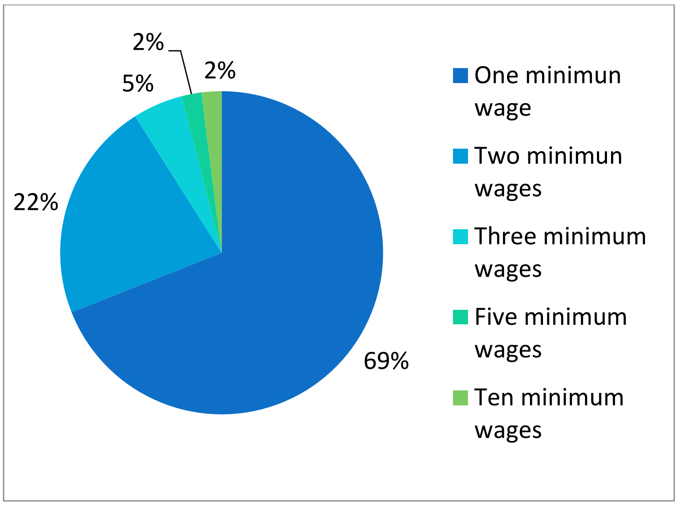


Figure 25: Family monthly income distribution of the sample
(Elaborated by the author with the survey results)

The results from Section C, shows that 100% of the sample of the microbasin do not have piped drinking water. The principal water sources are unprotected water springs (86%). Other sources mentioned were artesian wells and unprotected common wells (Figure 25). 85% of the respondents consider water quality from their water source have as good quality, the 15% that consider to have bad water quality express that the water is dirty in rainy season and yellowish water. It was found that the total of respondents has water every day of the week, and all them has electricity service, showing that the region do not have problems regarding water availability. Furthermore, they shows the high dependency of the population from the spring's water supply for domestic consumption.

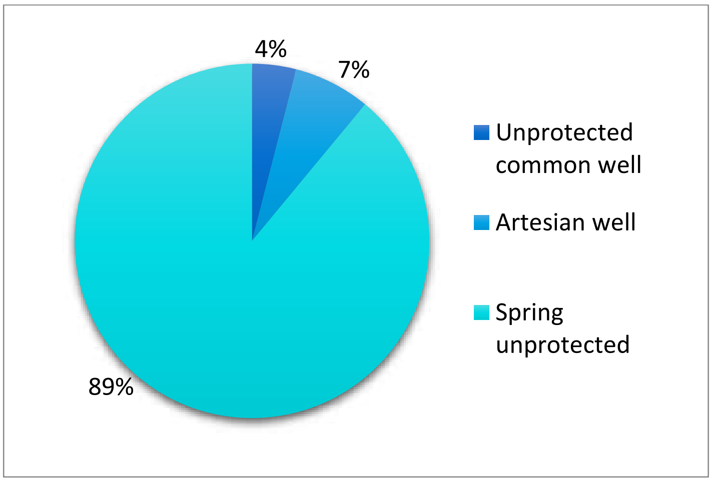


Figure 26: Water principal source
(Elaborated by the author with the survey results)

Only 18% of the sample pay a monthly water fee of 2.31 $US for connection to the water spring maintenance, all of them belongs to Barracão dos Mendes community. These support the information given in the SSI with the water fee collector (see section 5.2.3.1). It is possible that the region is misusing fresh water for the domestic and agricultural consumption. In order to avoid water waste, the population needs to receive training about the water requirements for the olericulture products. This training could be done through the coordination of the presidents of the local association and the local government.

Regarding the sanitation condition inside the houses, the survey result shows that all of the survey houses had at least one bathroom inside the house (73% one bathroom, 24% two bathroom and 3% four bathroom). The most common wastewater disposal systems in the region are cesspits (53%) followed by septic tanks (36%) and biodigester septic tanks (5%). Only 6% of the respondent do not have any wastewater system, form this percentage 4% of the water drain to the soil and 2% goes directly to the river. Table 20 splits the wastewater system for the five communities located in the microbasin.

Table 20: Current Sanitation Technologies in the microbasin

Disposal System	BSM	RG	FS	SN	SV	Microbasin
CP	41%	78%	75%	50%	0%	53%
ST	53%	11%	25%	50%	40%	36%
DS	3%	11%	0%	0%	0%	3%
DR	3%	0%	0%	0%	0%	2%
BST	0%	0%	0%	0%	60%	5%

(Elaborated by the author with the survey results; CP=Cesspits; ST= Septic Tank; DS=Biodigester Septic Tank; DR=directly to the river; DS=Drain to the soil)

The samples results shows that 75% of installation cost of the systems located in the region were covered by the family, 15% were already installed in the house before the resident started to live in the house and the owner of the house covered 10%. The BST installed in the Serra Velha community were donated by the Fundacão Banco do Brasil. The installation of cesspits and septic tanks in rural areas might be related with the low cost of investment and operation, which normally are done by the residents.

More than 90% of the interviewees mentioned that they do not had problems with the system´s functioning since its installation or since the time they are living in the house. Only two cases of sinking cesspits located in Barracão dos Mendes were detected. Similar results were founded for problems with the cesspits, septic tanks and BST during rainy season, none of the interviews answered to have made maintenance of its sanitation system. According to the literature, cesspits could contribute to ground water pollution, especially when they are not sealed correctly (Liehoop, et al., 2013). The fact that the population interviewed considered not having problems with the systems might be because they misunderstood the proper functioning and operation of the system. Moreover, this does not mean that the installed septic tanks are working correctly. The guidelines for correct operation of this type of systems recommend emptying the cesspit every six month to two years, otherwise it will overflow and produce bad odours (Jordão & Pessoa, 2005 in Nava & Lima, 2012; EPA 2005). This process is not done by the residents of the region.

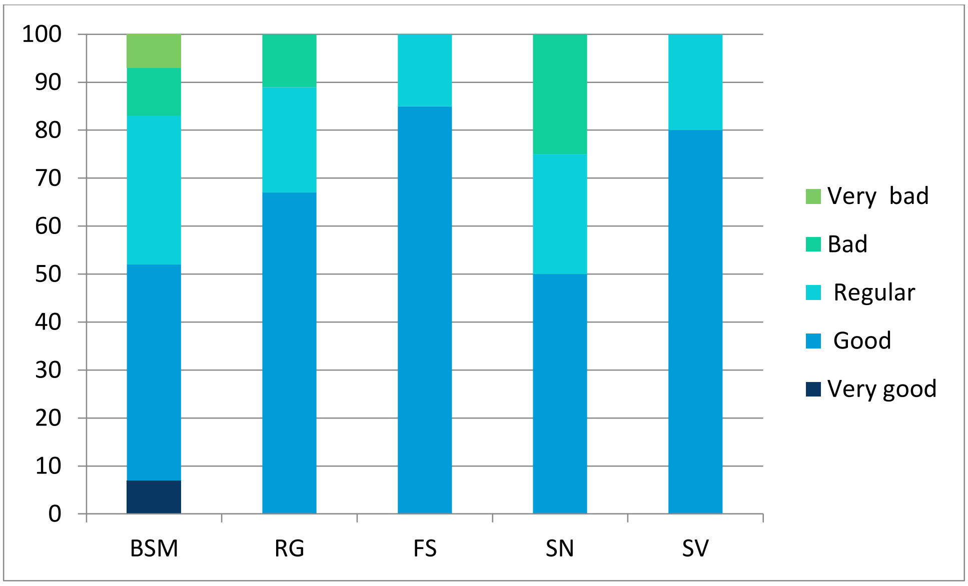


Figure 27: Communities water quality perception
(Elaborated by the author with the survey results)

It was find out that most of the sample considers that the water quality in the community is good (Figure 26). Although, some respondents mentioned that there had not been done water analysis that supports their perception. This result could be explained, considering that the respondent measures water quality based only on physical parameters (e.g. colour, odour, etc) without consider chemical and biological parameters like *E. Coli* presence that has been detected in the water sampling of the region by the municipality health agency of nova Friburgo (see Section 3.7.1). The presence of *E. Coli* (see Section 3.7.1) on fresh water could be related to groundwater pollution due to bad operation of the cesspits located in the region. Even though the municipal health agency of Nova Friburgo has detected that the water in Barracão dos Mendes do not accomplish the legal parameters for human consumption, the local government has not taken action in order to reduce and prevent water pollution.

Currently there is only one point in the microbasin were water quality monitoring is taking place (see section 3.7.1). The microbasin requires waster monitoring along the different communities of the microbasin, in order to know the wastewater characterization regarding the level of pollutants such as BOD, COD, TSS, pathogens, nutrients among others.

The survey results show that more than 50% of them make a previous treatment to the water that the family consumes. The most common treatment mentioned was water filtration. The filters are made of plastic or mud. This type of system only covers solids retention and does not treat chemical and biological pollutants (e.g. *E. Coli*).

In the case of sanitation improvements, 53% of the sample does not consider that they need a better wastewater treatment system. They assume the actual systems as functioning correctly. On the other hand, 47% of the interviewees requested better wastewater treatment. Almost 70% of them are willing to pay (WTP) for improvements in their wastewater treatment system, but they were not able to set an amount of money as incomes are variable income depending on agriculture revenues. It is important to mention that the population perception of a better wastewater treatment is related to the installation of the BST.

The population was very sensible to questions related to WTP, because they are afraid that the government introduce water fees. The limitation to establish a WTP for sanitation improvements could be explained by three main reasons:

(I) Limited income level of the population;
(II) Lack of population knowledge related to sanitation importance;

(III) The population is more interested on health and infrastructure improvements because they have free access to water and a wastewater technology that according to their perception is working correctly.

In the case of the water springs conservation, one third of the respondents mention to have a WTP for their protection. The rest of the sample does not have the WTP, because the population is already taking care of the water springs and the government is seen as responsible to protect them.

All of the family farmers interviewed in section D mention that they use artificial irrigation for crop growing and this process takes place during the non rainy days. The main source (80%) of water for agriculture comes from the water springs, while only 20% comes from the river by highlighting the dependency of agriculture on water from springs. The fact that the population highly depends on water springs for accomplishing the domestic (Figure 24) and agricultural demand, emphasizes the importance to measure groundwater quality in the five communities located in the microbasin.

More than 80% of the farmers have forest and the given reasons for maintaining the forest were to protect the water springs, because it is important for the environment and also because it is forbidden. This result proves that there is a degree of knowledge regarding water conservation importance.

Regarding agrotoxics information, almost 85% of the farmers interviewed use agrotoxics for agriculture production. The survey also asked for information regarding the type of agrotoxics and the quantities used, but only 40% of the farmers responded to the question of the type of agrotoxics. The main agrotoxics mentioned were Curzate, Kocide, Equation, Midas Ridomil, Ampligo, Amistar top and Bravon. The population was also sensible to questions related to agricultural use. Based on this result it could be assumed that there a degree of pollution due to high agrotoxics use.

The survey and the diagnosis result regarding the agrotoxics use for agricultural production show are an important pollutant of the region. Moreover, the microbasin will require complex water analysis in order to determine the level of agrotoxics pollutions over the water bodies located in the region. According to Lopes Soares, et al. (2005) agrotoxics could develop important consequences over public health (e.g. eyes and skin problems, intoxication, etc) and environment degradation. Rural population often had direct contact with agrotoxics that are extremely toxics (Crissman et al. 1994 in Lopes Soares, 2005). In addition, the olericulture production in the region is often related with extensive use of agrotoxics and pesticides, and the amounts of agrotoxics used in agriculture are often established by the farmer (IBGE in Lopes Soareas, 2005). Based on the previous information, it is important to measure its impact over the microbasin environment and population. It will be also important to reduce the agrotoxics overuse, through the training and technical assistance about the nutrients requirements for each crop harvest in the region and with the implementation of programs that promotes the introduction of better agricultural practices in the microbasin.

The results from section E shows that 78% of the sample do not present wastewater related diseases, 20% of the sample has been affected by diarrhea and only a 2% present giardiasis, there were not found other water related diseases (e.g. cholera, dengue, etc) in the sample interviewed.

The sample proportion that answer that they or a family member had been affected of a wastewater related disease over the last two years was adults (58%) followed by children between 6 and 12 years old (25%), the reaming. According to Figure 27, the half of the respondents or they family members presents two or three times per year a wastewater related disease, 33% present them more than three times per year and 17% once a year. The interviewees consider that possible causes of the diseases are bad water quality (69%), food consumption (17%) and (16%) due to a virus. On the other hand, the results duration of the diseases was from two to three days (59%) and from four to five days (25%). Regarding the severity of the disease the respondent answered that 58% was intense, 25% moderate and 17% of the cases were slightly. There were not found any death case associated to wastewater related diseases. The fact that the population make some type of treatment for the drinking water could reduce the number of case of wastewater related diseases. Furthermore, the symptoms of this type of disease could be easily misunderstood with other type of disease.

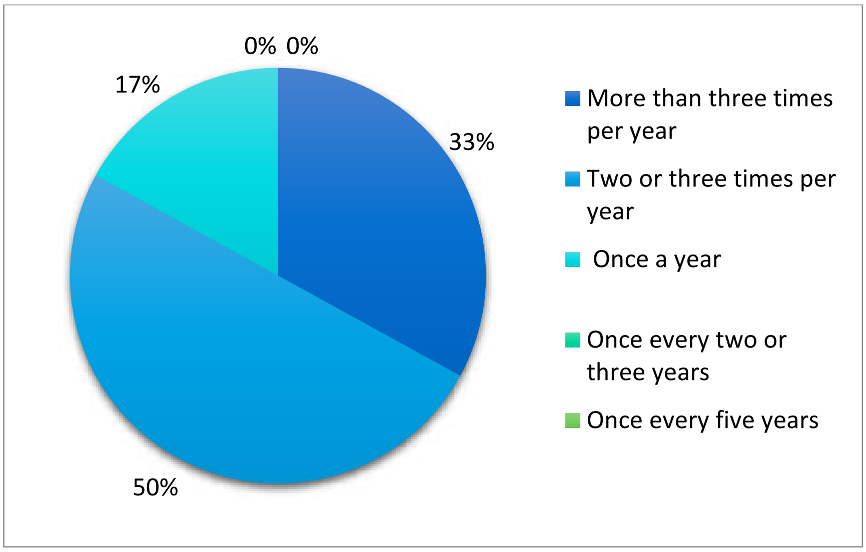


Figure 28: Wastewater related diseases frequency
(Elaborated by the author with the survey results)

Considering the disease treatment almost 60% had home treated, consisting in traditional medicines (71%) and medication (29%). The remaining 40% had for medical assistance, this percentage got a medication prescript by the doctor and they went directly to Nova Friburgo health agency. The 40% that require medical assistance prefers the municipal health agency, this might reflected that the population is not agree with the service or that they do not trust in the medical diagnosis of the local health agency.

Only 5% of the sample mentions that they or a family member had problems with parasites. However, 45% of the respondents currently take medication for deworming. This information was not congruent with the obtained from the SSI with local health agents mentioned because it was assumed that all the population presents parasites, and because of that, they prescribe deworming medication to all of their patients. This might results because there is a part of population that do not assist to the local health agency for received this treatment.

According to the respondents, the medical assistance and consultation had any cost. Due to this, the sample does not consider that wastewater related disease had a negative impact in their income. The results of the survey may be affected by that lack of trust between the interviewer and the respondent and by their sensibility to some of the survey questions.

Although in the participative diagnosis (see Section 5.1) it was considered, that health problems were the main effect of the sanitation problems. According to survey results and the lack of historical data, it can be conclude that public health has a low degree of impact and it is not the main problem affected by sanitation conditions.

The participative diagnosis, the SSI, and the survey results show that the sanitation perspectives change between local institutions, community leaders and the population. The community leaders and the representatives of the local institution seem to be more aware of the sanitation importance on the microbasin in comparison with the rest of the population due to poor environmental education.

The limited knowledge of the population about the sanitation problems remarks the importance of promoting environmental education programs that include the awareness house about negative impacts related to lack of sanitation and the sanitation relation with water ecosystem services.

5.4 Environmental Cost-benefit Quantification

The estimation of the ECBA was done considering three options (1) Without consideration of the benefits from water reuse; (2) considering the benefits of 25% of water reuse; and (3) considering the results of 50% of water reuse. The ECBA breakdown for each technology is show in the Annex section (see Annex XII to XXXI).

Option 1 Results

Table 21 depicts the results of ECBA calculation. It could be shown that the benefits from scenario A are higher than sub-scenarios B, as the scenario A (decentralized solution) includes the benefits of biofertilizer for all the communities in the microbasin. Meanwhile, the semi-decentralized solutions only include the benefits of biofertilizer reuse for the isolated communities. The sub-scenario B.5 (UASB) has the lowest total cost in comparison to the rest of the solutions.

Table 21: ECBA results without considering water reuse

Scenario	Technology	Initial Investment Cost (PV)	O%M Cost (PV)	Total Cost (PV)	Total Benefits (PV)	NPV
		Discount Rate: 5%				
A	**BST**	$669.729,13	$650.808,09	$1.320.537,22	$1.141.956,15	**$178.581,07**
B.1	**SBR**	$652.644,65	$497.494,85	$1.150.139,49	$624.317,57	$525.821,92
B.2	**AS + SS**	$652.217,99	$916.940,33	$1.569.158,32	$624.317,57	$944.840,74
B.3	**FB**	$707.896,65	$762.471,42	$1.470.368,07	$624.317,57	$846.050,50
B.4	**CW**	$613.909,07	$720.533,22	$1.334.442,28	$624.317,57	$710.124,71
B.5	**UASB**	$405.456,57	$376.153,31	$781.609,88	$624.317,57	**$157.292,31**
B.6	**UASB + AnF**	$415.813,01	$452.548,42	$868.361,43	$624.317,57	**$244.043,86**
B.7	**ASEA**	$441.212,55	$1.450.968,29	$1.892.180,84	$624.317,57	$1.267.863,27
B.8	**UASB + TF**	$427.440,19	$452.184,03	$879.624,22	$624.317,57	$255.306,64
B.9	**UASB + BCR**	$437.239,35	$529.486,26	$966.725,61	$624.317,57	$342.408,04

(Elaborated by the author)

The NPV was used as an indicator for the selection of the best technology option. The decision criterion was to select the technology with less NPV value; representing the technology with lowest costs. The technology options with the lower cost were the UASB, the BST and the UASB+AnF.

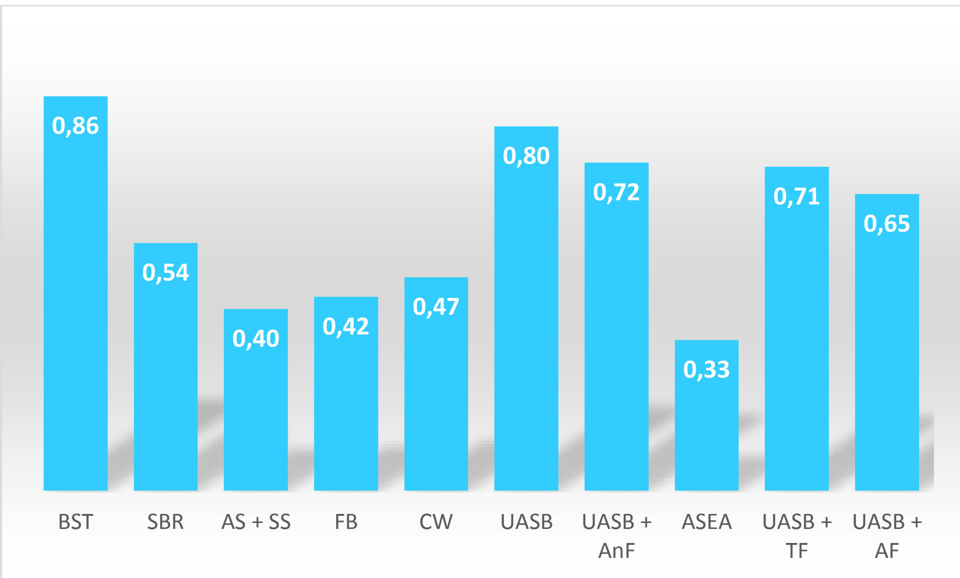


Figure 29: BCR without considering water reuse
(Elaborated by the author)

In option 1, none of the technology will be feasible, because they the total cost are not cover by the benefits. Even though the results of the BCR calculation (figure 28) shows that the benefits of the COI and the Biofertilizer reuse can cover from a 30% to an 80% of the total cost depending on the technology option.

Option 2 Results

When the 25% of the water reuse benefits are taken into consideration (table 22) the benefits, increase a 75% in comparison to option 1. For option 2, there are four semi-decentralized technologies (UASB, UASB+AnF, UASB+TF and UASB+RBC) and the decentralized system (BST) that have NPV with negative values this mean that this systems are feasible from the economic point of view.

Table 22: ECBA results considering 25% of water reuse

Scenario	Technology	Initial Investment Cost (PV)	O%M Cost (PV)	Total Cost (PV)	Total Benefits (PV)	NPV
		Discount Rate: 5%				
A	BST	$669.731,04	$650.808,09	$1.320.539,12	$1.615.293,60	**-$294.754,47**
B.1	SBR	$652.644,65	$497.494,85	$1.150.139,49	$1.097.655,02	$52.484,47
B.2	AS + SS	$652.217,99	$916.940,33	$1.569.158,32	$1.097.655,02	$471.503,30
B.3	FB	$707.896,65	$762.471,42	$1.470.368,07	$1.097.655,02	$372.713,05
B.4	CW	$621.017,51	$720.533,22	$1.341.550,73	$1.097.655,02	$243.895,71
B.5	UASB	$411.597,62	$375.992,72	$787.590,34	$1.097.655,02	**-$310.064,68**
B.6	UASB + AnF	$415.813,01	$452.387,82	$868.200,84	$1.097.655,02	**-$229.454,18**
B.7	ASEA	$441.212,55	$1.408.263,08	$1.849.475,63	$1.097.655,02	$751.820,61
B.8	UASB + TF	$430.068,05	$452.184,03	$882.252,08	$1.097.655,02	**-$215.402,94**
B.9	UASB + BCR	$434.560,69	$529.486,26	$964.046,95	$1.097.655,02	**-$133.608,07**

(Elaborated by the author)

The ECBA results show the potential of the semi-decentralized technologies. Figure 29 shows that with the inclusion of 25% of water reuse the technologies can cover at least 61% benefits and some technologies can reach benefits superior to 20% of the cost. For option 2 the best technology is the UASB that has the best NPV and **BCR** values, followed by the **BST** and the **UASB+AnF**.

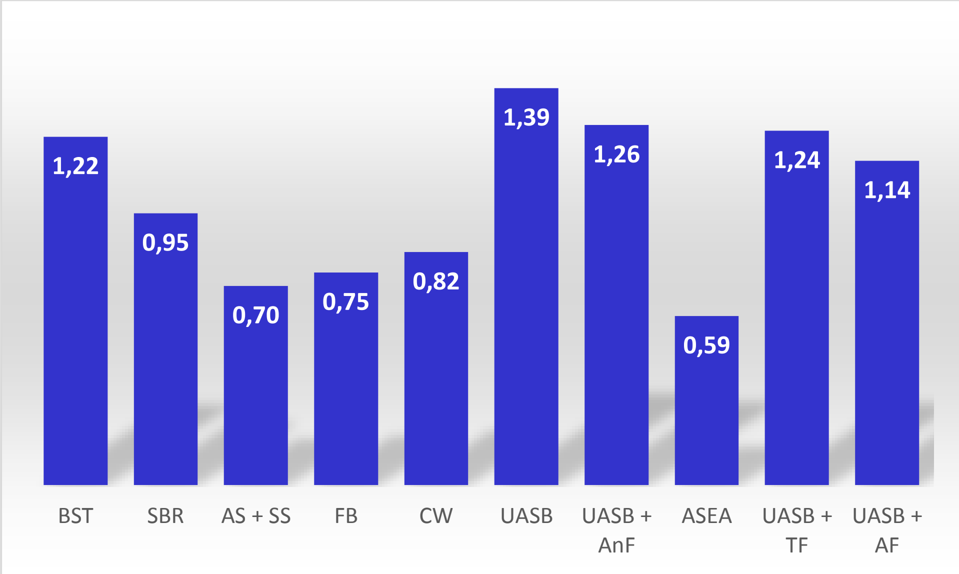


Figure 30: BCR considering a 25% of water reuse
(Elaborated by the author)

Option 3 Results

Scenario	Technology	Initial Investment Cost (PV)	O%M Cost (PV)	Total Cost (PV)	Total Benefits (PV)	NPV
		Discount Rate: 5%				
A	BST	$669.731,74	$650.808,09	$1.320.539,83	$2.088.631,04	-$768.091,22
B.1	SBR	$652.644,65	$497.494,85	$1.150.139,49	$1.570.992,47	-$420.852,97
B.2	AS + SS	$652.217,99	$916.940,33	$1.569.158,32	$1.570.992,47	-$1.834,15
B.3	FB	$707.896,65	$762.471,42	$1.470.368,07	$1.570.992,47	-$100.624,40
B.4	CW	$621.017,51	$720.533,22	$1.341.550,73	$1.570.992,47	-$229.441,74
B.5	UASB	$411.597,62	$375.992,72	$787.590,34	$1.570.992,47	-$783.402,13
B.6	UASB + AnF	$415.813,01	$452.387,82	$868.200,84	$1.570.992,47	-$702.791,63
B.7	ASEA	$441.212,55	$1.408.263,08	$1.849.475,63	$1.570.992,47	$278.483,16
B.8	UASB + TF	$430.068,05	$452.184,03	$882.252,08	$1.570.992,47	-$688.740,39
B.9	UASB + BCR	$434.560,69	$529.486,26	$964.046,95	$1.570.992,47	-$606.945,52

Table 23: ECBA results considering 50% of water reuse
(Elaborated by the author)

Considering a reuse 50% of the water, there is an increase of 150% in comparison with the benefits in option 1 and of 43% in comparison with the benefits in option 2. Almost all the semi-decentralized solutions are feasible from the economic point of view (table 23). In option 3, the technology cost can be covered in at least 87% for the ASEA technology.

Meanwhile, for the rest of the options the costs are completely covered, and the technology can reach higher benefits (Figure 30). In this option, the best technology is UASB that has the highest NPV and BCR values. The BST (Option A) has a best NPV value in comparison to the UASB+AnF and UASB+TF options, but this options presents a higher BCR ration compared with the BST.

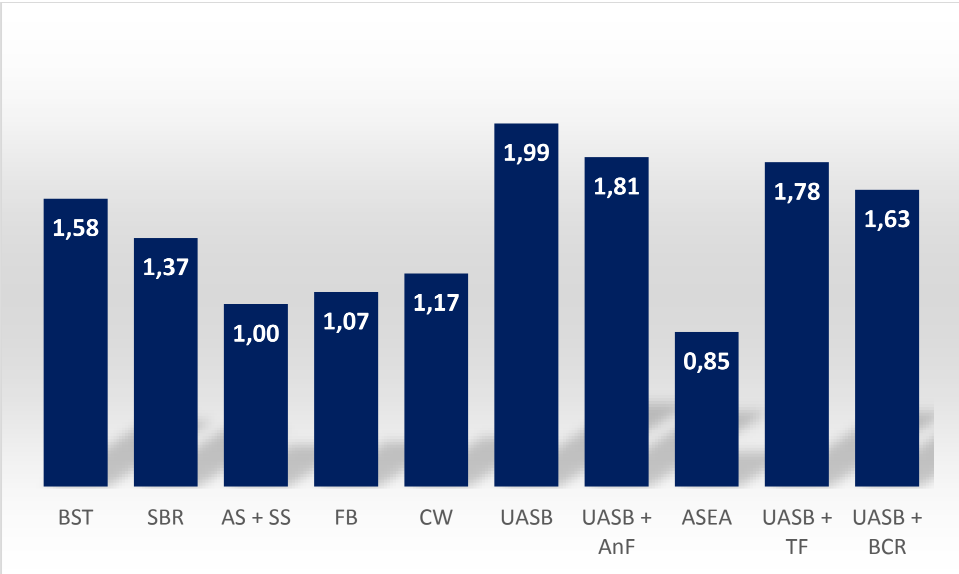


Figure 31: BCR considering a 50% of water reuse
(Elaborated by the author)

The NPV comparison between 3%, 5% and 7% is shown in table 24, was calculated for obtain a sensibility analysis. When the discount rate is of 3% the benefits are higher. However when the discount rate is of 7% the benefits are reduced. The NPV values remains stable with the three technology options. Showing that the best technology option will be the **UASB** (B.5), followed by the **BST** (A) and the **UASB+TF** (B.8).

Table 24: NPV - discount rate comparison

Scenario	Technology	Non-water Reuse			Water Reuse 25%			Water Reuse 50%		
		NPV 3%	NPV 5%	NPV 7%	NPV 3%	NPV 5%	NPV 7%	NPV 3%	NPV 5%	NPV 7%
A	BST	**$197.229,50**	**$178.581,07**	**$187.614,95**	**-$406.293,18**	**-$294.754,47**	**-$194.475,32**	**-$1.009.815,86**	**-$768.091,22**	**-$576.565,58**
B.1	SBR	$600.549,85	$525.821,92	$176.030,70	**-$3.207,17**	$52.484,47	$105.602,08	-$606.729,85	-$420.852,97	**-$276.488,19**
B.2	AS + SS	$1.145.431,96	$944.840,74	$961.230,06	$541.674,95	$471.503,30	$437.378,94	**-$61.847,73**	**-$1.834,15**	$55.288,68
B.3	FB	$1.009.422,17	$846.050,50	$811.555,51	$405.430,83	$372.713,05	$365.706,62	**-$198.091,85**	**-$100.624,40**	**-$16.383,64**
B.4	CW	$841.561,85	$710.124,71	$673.716,91	$252.567,12	$243.895,71	$252.567,12	**-$350.955,56**	**-$229.441,74**	**-$129.574,24**
B.5	UASB	**$148.858,87**	**$157.292,31**	**$170.354,61**	**-$442.144,88**	**-$310.064,68**	**-$209.260,34**	**-$1.045.667,56**	**-$783.402,13**	**-$591.350,60**
B.6	UASB + AnF	**$265.870,02**	**$244.043,86**	**$237.145,28**	**-$337.886,99**	**-$229.454,18**	**-$144.944,98**	**-$941.409,67**	**-$702.791,63**	**-$527.035,25**
B.7	ASEA	$1.593.122,91	$1.267.863,27	$1.051.231,45	$932.192,72	$751.820,61	$636.517,93	$328.670,04	$278.483,16	$254.427,67
B.8	UASB + TF	$278.880,45	$255.306,64	$247.551,99	**-$322.117,02**	**-$215.402,94**	**-$132.220,42**	**-$925.639,70**	**-$688.740,39**	**-$514.310,69**
B.9	UASB + BCR	$390.184,30	$342.408,04	$317.631,03	**-$215.912,41**	**-$133.608,07**	**-$66.821,89**	**-$819.435,09**	**-$606.945,52**	**-$448.912,15**

(Elaborated by the author)

The advantages and disadvantages of each technology are show in table 25. The BST is the suitable solution for isolated areas, do not have energy requirements and it is easy to operate. This technology has been successfully installed in rural areas of Brazil with important revenues from the biofertilizer reuse (FBB, 2010) (Cabral da Costa & Poppi, 2011). Although constructed wetlands are suitable for rural areas, the high land requirements do not make feasible the selection of this technology. Activated sludge has high efficiency removal levels but it involves complex operation and maintenance. The UASB reactor can reach high efficiency levels for BOD and TSS but requires skilled operation and monitoring. The UASB+TF are suitable for rural areas but can have odour problems and require constant monitoring.

Table 25: Advantages and disadvantages for the selected technologies

SCENARIOS	TECHNOLOGY	ADVANTAGES	DISADVANTAGES
A	**Biodigester Septic Tank (BST)**	Suitable for rural areas, easy installation, small land requirements, Additional benefits from the biofertilizer reuse, non-electrical energy required.	Low pathogen and nutrient removal, depends on resident management
B.1	**Sequence Batch Reactor (SBR)**	Low installation and maintenance costs, requires less input compare with more complicated systems, minimal footprint.	Requires high level of sophistication and maintenance, potential of discharging settle sludge
B.2	**Activated Sludge plus Sludge Stabilization (AA+SS)**	High efficiency levels, nutrient removal, can be operated at range of organic and hydraulic loading rates can be modified to meet specific discharge limits.	High construction and operation cost, complex operation, requires expert design and supervision, effluent might require further Constant source of electricity is required, the sludge needs treatment or an appropriate discharge
B.3	**Fluidized Bed (FB)**	High efficiency levels of BOD, COD and nutrients removal; high flow rate can be achieved, low land requirements.	Require pumping power required to operate and the correct design of inlet and outlet arrangement for proper distribution of flow.
B.4	**Constructed Wetland (CW)**	Suitable for rural areas, offers and nice landscape, low operation cost, easy management, good BOD, SS and pathogens removal.	Clogging could be a common problem, high land requirements, lack of agreed design criteria, weed control could be problem, concern about odors and disease vector, low nutrient removal
B.5	**Up-flow Anaerobic Sludge Blanket (UASB)**	Absence of energy consumption, lower sludge production, high reduction on BOD, the biogas can be used for energy.	Difficult to maintain proper hydraulic conditions, long start up time, requires a constant water flow; skilled operators for monitoring and maintenance are required.
B.6	**UASB + Anaerobic Filter (UASB + AnF)**	Resistant to organic and hydraulic shock loads, no electrical energy required, high reduction of BOD and SS, moderate capital an operation costs	Low reduction of pathogens and nutrients, requires expert design and construction , long start up time
B.7	**Activated Sludge with extended aeration (ASEA)**	Low initial cost, lowest sludge production, high quality removal, and minimal land requirements.	Land retention times, high power consumption, high operation and maintenance cost, blower noise, skilled operators are required.
B.8	**UASB + Trickling Filter (UASB + TF)**	Low power requirements, appropriated for small and medium communities, requires low technical expertise, can be operated at a range of organic and hydraulic loading rates, moderate operating cost	Requires regular operator attention, odor problems, requires expert design, high capital cost, not all parts and materials may be available locally
B.9	**UASB + Contact Biological Reactor (CBR)**	Simple operation and maintenance, low sludge production, high efficiency removal, low power requirements, short retention times	Needs daily inflow, shaft failures, odor problems, require frequent maintenance

(Elaborated by the author based on: EPA, 1997; EPA, 2003; von Sperling, et al., 2001 & Tilley, et al., 2008)

Regarding the benefits of the BST over cesspits and septic tanks located in the region, table 26 shows that this technology option, improves the sanitation and environmental due to the reduction pollution in water bodies.

Table 26: Decentralized technologies

	Cesspit	Septic Tank	BST
Surface water pollution	YES	NO	NO
Groundwater pollution	YES	NO	NO
Reusable effluent	NO	NO	YES
Proliferation of disease-spreading vectors	YES	YES	NO
Bad odors	YES	YES	NO

(Adapted by the author based on: Cabral da Costa & Poppi , 2011)

Table 27 shows the percentage of removal for the main parameters that can be reached by the semi-decentralized technologies. Considering the lack of information regarding the wastewater characterization for the microbasin, it can be considered that the removal efficiency for BOD and TSS (65%) will be achieved by all the technology options. Regarding the nutrients removal (Total Nitrogen 10 mg/L and Total Phosphorus of 0.1 mg/L) it can be consider that only the FB can achieve the nitrogen level of removal. In the case of total phosphorus, none of the technologies can achieve the removal legal requirements.

Table 27: Removal efficiency for semi-decentralized technologies

Scenarios	Technology	BOD_5(%)	TSS(%)	N(%)	P(%)
B.1	**Sequence Batch Reactor (SBR)**	80-90	85-99	55-90	25-70
B.2	**Activated Sludge plus Sludge Stabilization (AS+SS)**	80-90	85-99	<60	<30
B.3	**Fluidized Bed (FB)**	80-90	85-99	<10	NA
B.4	**Constructed Wetland (CW)**	80-90	60-98	30-70	20-60
B.5	**Up-flow Anaerobic Sludge Blanket Reactor (UASB)**	50-70	60-80	<30	<30
B.6	**UASB + Anaerobic Filter (UASB + AnF)**	70-80	70-80	<30	<30
B.7	**Activated Sludge with Extended Aeration (ASEA)**	80-90	85-99	<60	<30
B.8	**UASB + Trickling Filter (UASB + TF)**	80-90	80-90	<60	<30
B.9	**UASB + Contact Biological Reactor (CBR)**	80-90	80-90	60-80	20-60

(Elaborated by the author based on: EPA, 1997; EPA, 2003; von Sperling, et al., 2001 & Tilley, et al., 2008; Tilia Unwetl, 2014)

The current sanitation legal framework implies high removal efficiency levels especially regarding nutrients removal (CONAMA, 2005), which implies a complex treatment process that cannot be achieved with low cost technologies. It is also important to consider the final destination of the treated water, because depending on it the degree of removal efficiency will be defined. It would be important to calculate the self-cleaning capacity of the water bodies located in the microbasin in future studies. This information can be useful for the selection of the level of efficiency removal, because if the water bodies present a high self-cleaning capacity of the system and reduce the treatment cost. Additionally, adaptation of the legalisation especially on the rural areas with low population should be considered for further research.

The Brazilian legislation does not allow the sludge reuse for olericulture production (CONAMA, 2006), which are the main crops cultivated in the area. Although the study pretends to estimate the benefits from sludge reuse, these values could not be obtained due to the lack of information. Nevertheless, the potential of these benefits should be considered for further research in the region, which could increase the potential of the semi-decentralized solution over the decentralized solution and reduce the amount of agrotoxics used in the region.

The business as usual (BAU)[18] scenario was not considered in this study. Because the technology options that are located in the microbasin (cesspools and septic tanks) do not achieve the legal requirements. Moreover, the centralized option was not evaluated because most of the communities are isolated which will increase the sewer network cost due to the requirement of more pumping stations.

Even though, the ECBA results shows the SBT (Scenario A) presents highest benefits, the semi-decentralized scenario using UASB (Scenario B.5) presents the best NPV value, making this technology option more feasible. The benefit with higher impact in this study was the water reuse as it has been show in the results for option 2 and 3 of the ECBA calculation. Positive results of the potential of the water reuse into the CBA valuations where obtained by Molinos-Senante, et al., (2011); Verlicchi, et al., (2012) and Liehoop, et al., (2013). The

[18] The BAU scenario represents the actual conditions without any improvement or investment (Fiorio, et al., 2008)

study results revels that the wastewater treatment costs can be covered when environmental benefits are taking into consideration the same results were obtained by Liehoop, et al., (2013); Cheng & Wang, (2009); Molinos-Senante, et al., (2011).

The general objective was accomplished. However, the results of the ECBA present uncertainty due to the lack of: (1) Accurate cost information; (2) wastewater characterization; and (3) historical data related to wastewater related diseases in the microbasin.

According to Hutton, et al., (2007) the scientific community can misunderstand the results from the estimation of environmental benefits, due to the lack of agreement of the valuation methods. Moreover, the valuation of the environmental cost can be easily sub-estimated due to the complexity of non-market value estimation, especially in the case of water related ecosystem services (Keeler, et al., 2012).

The ECBA, do not consider who the benefits will be distributed and who will be in charge of the technologies and who will be responsible for the payment of the installation and O&M cost (Liehoop, et al., 2013). Even though sanitation installation cost are often covered by the local government it will be expected that the population covers part of the O&M costs (Wilderer & Scherff, 2000), which can be a problem because the population do not pay for water and sanitation services and they do not have WTP for sanitation services.

In the case of the semi-decentralized solutions, who will be in charge of the operation of the small wastewater treatment must be considered. This process can be done by an authorised operator (e.g. Àguas de Nova Friburgo) or by the residents of the Barracão dos Mendes community. In addition, the decentralized and semi-decentralized solutions (Scenario A & B) requires the community involvement for guarantee the correct operation of the on-site systems. For accomplish the objective it will be necessary to trainee the population for use correct use of the systems, and introduce monitoring periods for guarantee their correct functioning. The potential of the associations for the created capacity house inside the microbasin should be considered.

CONCLUSIONS AND RECOMMENDATIONS

"Both centralized and decentralized system alternatives need to be consider in upgrading failing (wastewater) systems to provide the most appropriate solution to wastewater treatment problems."

EPA, 1997

The main objective of this research was accomplished. Still the results have to be considered as a first approach of the ECBA calculation for the microbasin. The information presented in this thesis can be used as a guide for the construction of the EBCA involving other environmental areas. The methodology used in this study proves the importance of including environmental benefits (public health improvements, biofertilizer and water reuse) into the economic feasibility assessment.

Although on-site solutions are considered by the Brazilian government as the best option to improve sanitation conditions in rural areas this study reveals the potential of semi-decentralized solutions (UASB, UASB+TF), over totally decentralization solution (BST) especially when water reuse benefit are considered (25% and 50%). According to ECBA results, the best technology option will be the UASB. However, it will be necessary to remake the ECBA calculation when (1) the suitable area for the installation of the small wastewater treatment plant is selected; (2) the information of the operation and maintenance cost are adjusted according to local area; and (3) there is information regarding the wastewater pollutant degree. The study shows that sanitation investments in the microbasin are feasible when semi-decentralized option including non-monetary value are estimated. It is recommend including the valuation of different semi-decentralized solutions in other rural areas, because this option might increase the feasibility of sanitation investments.

Thus, the ECBA has been used as effective tool for the decision making process. It is important to include other economic valuation such as the Cost-effectiveness approach, the multi-criteria analysis and the best available technology approach. Furthermore, since decision making process focus on monetary criteria, the economic valuation of environmental non market values must be increased in order to improve their inclusion into these methods. In addition, for the final decision making the evaluation social (e.g. quality life and aesthetics improvements) and political indicators (e.g. sanitation budgets) should be also taken into account, in order to develop an integral improvement of the sanitation conditions in the study area.

For the selection of the best technology option, it is required to develop studies regarding water springs and groundwater quality and water characterization for the MBDM. Moreover, the study shows the importance of research environmental and social impacts due to the intensive use of agrotoxics in the microbasin.

It is important that the local government consider an adaptation framework of the sanitation legal requirement, because they cannot be accomplished with low-cost technology normally used in rural areas and small communities. As this will allow the introduction more sanitation investments, this adaptation should consider that the technologies at least fulfill the minimum quality standards. Further research on new decentralized and semi-decentralized technologies should be encouraged in order to have systems created especially for this type of approach with high removal efficiency, instead of the adaptation of the systems normally used for centralized wastewater.

The awareness training of the microbasin´s population is of crucial importance in order to guarantee the correct use and maintenance of the cesspits and septic tanks, and thereby improve their current conditions. This will further reduce groundwater pollution. It is necessary to train the farmers about the water requirements for the olericulture products, in order to reduce water waste due to artificial irrigation. This training could be done through the coordination of the presidents of the local association and the local government.

While decentralized approach in rural areas involves community participation it is extremely important to develop and educational program that increases the awareness of public health, wastewater and sanitation importance through the development of sanitation environmental education. An example for is the program “Water fun water for live” that has recently started under the INTECRAL project work (Cardona, et al., 2014).

Due to the complexity of environmental problems, the lack of sanitation cannot be solved unilaterally for just one of the stakeholders. Indeed all of them should be integrated in order to improve sanitation conditions in the case study region. In this sense, it is important to develop an integral sanitation plan, this could promote the water conservation in the microbasin. The Sanitation Plan outcome in the participative diagnosis of this research could be used as a first approach for the development of this plan (Annex X).

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ANNEX

I. Questionnaire of Sanitation and Public Health for the Microbasin of Barracão dos Mendes

QUESTIONÁRIO NA MICROBACIA: BARRACÃO DOS MENDES

SEÇÃO A: INFORMAÇÃO GERAL

1.Questionário No:		**2.Data:**	____/____/____
3.Comunidade:		**4.Altitude:**	
5.Latitude:		**6.Longitude:**	

SEÇÃO B: INFORMAÇÃO DE MEMBROS FAMILIARES

1.Nome completo do (a) entrevistado (a):				
2.Chefe de família:	_____ 1.Sim _____2.Não			
4.Rendimento mensal familiar:	____________________	**3.Número de pessoas que contribuem para a renda familiar mensal:**		
5.Quanto tempo tem morando nesta casa?		**6.A casa onde mora é:**	___ 1.Própria ___ 2. Aluguel: _____________ Reais por mês	

7.Membros da Casa - Nome:	**8.Parentesco**	**9.Idade:**	**10.Sexo**	**11.Ocupação:**
1.				
2.				
3.				
4.				
5.				
6.				

Código para Parentesco (com base em pessoa entrevistada): 1=Pessoa entrevistada 2= Cônjuge 3=Filho (a) 4.Mãe ou pai 5. Agregado (não é parente da pessoa entrevistada ou de seu conjuge e não paga aluguel ou hospedagem) 99=Outro (especificar) **Código para sexo:** 1=Homem 2=Mulher **Código para ocupação:** 1= Estudante 2=Trabalhador 3=Trabalhador Independente 4=Desempregado 5= Administrador domestico 6=Aposentado 99=Outro

SEÇÃO C: INFORMAÇÃO SOBRE A ÁGUA, ESGOTO E SANEAMENTO

1 Água potável encanada 1	___ 1. Sim, dentro e fora da casa ___ 2. Sim, somente dentro da casa ___ 3. Sim, somente fora da casa ___ 4. Nao
2. Qual é a origem principal da água utilizada nesta casa? (Marque todas as que se aplicam)2	___ 1. Rede geral de abastecimento/rede pública ___ 2. Poço comum protegido ___ 3. Poço comum sem proteção ___ 4. Poço artesiano ___ 5. Fonte/nascente protegida ___ 6. Fonte/nascente sem proteção ___ 7. De terceiros (vizihnos, amigos etc.) ___ 8. Outro origem: Especifique:_____________________________
3. Com base na pergunta anterior, a qualidade dessa água é boa? 3	____ 1.Sim (Ir a pergunta 3) ____ 2.Não(Ir a pergunta 4)
4. Explique os problemas com água: 4	

5. Voces pagaron por pela conexão com a nascente (tubo, mangueira)		**6. Quanto você pagou pela conexão?**		**7. Quem realizou a conexão?**	Poner opciones Familia Dueno Otro

8. Você paga por serviço de água:	____ 1.Sim (pase a pergunta revisar si esta se quita en este caso) ____ 2.Não(Ir a pergunta 6)	**9. Valor pagado mensalmente:**	

10. Você tem eletricidade?	Esta pregunta no es relevante	**12. Que voce paga mensalmente**	

13. A casa tem poço:	____ 1.Sim (Ir a pergunta 7) ____ 2.Não(Ir a pergunta 10)	**14. Há quanto tempo:**	____ anos

15. Existe banheiro ou sanitário nesta casa?	___ 1. Sim, banheiro dentro de casa ___ 2. Sim, banheiro fora de casa ___ 3. Sanitário (vaso ou casinha), dentro de casa ___ 4. Sanitário (vaso ou casinha), fora de casa ___ 5. Não

16. Quantos banheiros ou sanitários tem a casa?		**17. Além de membros da família outras pessoas usam o banheiro?**	____ 1.Sim (Ir a pergunta 13) ____ 2.Não(Ir a pergunta 15)

18. Para onde são destinados os resíduos deste banheiro ou sanitário? (Marque todas que se aplicam)	___ 1. Rede coletora de esgoto ou pluvial ___ 2. Fossa séptica ligada à rede coletora de esgoto ou pluvial** ___ 3.Fossa séptica não ligada à rede coletora de esgoto ou pluvial (sumidouro)** ___ 4.Fossa rudimentar (fosa negra, poço, buraco, etc.)** ___ 5.Direto para o rio, lago ou mar ___ 6. Escorre pelo solo ___ 7. Outra forma: Especifique:___________________________ **Em caso de que la casa cuente com fosa contestar las preguntas, em caso contrario pase a la pregunta
19. Há quanto tempo a fossa foi instalada?	____ Anos

20. Desde a instalação da fossa, esta apresentou algum problema no seu funcionamento	___ 1. Sim (Ir a pergunta 18) ___2. Não (Ir a pergunta 19)	**21. Mencione o tipo de problema**	
22. A fossa tem algum problema durante a estação chuvosa	___ 1. Sim (Ir a pergunta 20) ___2. Não (Ir a pergunta 21)	**23. Mencione o tipo de problema**	
24. Você tem feito qualquer tipo de manutenção desde a sua instalação:	___ 1. Sim (Ir a pergunta 22) ___2. Não (Ir a pergunta 23)	**25. Há quanto tempo:**	____ meses

<table>
<tr><td colspan="2">26. Os custos para aquisição e instalação foram cobertos por:</td><td colspan="3">___ 1. Família

___ 2. Governo

___3. House owner

____4 Outro: Especifique:
________________________________</td></tr>
<tr><td colspan="2">27. Qual é o destino da água residual da cozinha?</td><td colspan="3">___ 1. Rede coletora de esgoto ou pluvial

___ 2. Fossa séptica ligada à rede coletora de esgoto ou pluvial

___ 3.Fossa séptica não ligada à rede coletora de esgoto ou pluvial (sumidouro)

___ 4.Fossa rudimentar (fosa negra, poço, buraco, etc.)

___ 5. Vala

___ 6.Direto para o rio, lago ou mar

___ 7. Escorre pelo solo

___ 8. Outra forma:
Especifique:___________________________</td></tr>
<tr><td>28. Tem água em casa todos os dias da semana:</td><td>____ 1. Sim (Ir a pergunta 24)

___2. Não (Ir a pergunta 25)</td><td colspan="2">29. Quantos dias por semana, tem água:</td><td>_____ dias</td></tr>
<tr><td colspan="2">30. Você cosidera que a qualidade da água em sua comunidade ?</td><td colspan="3">___ 1. Muito boa ___ 4. Ruim

___ 2. Boa ___ 5. Muito Ruim

___ 3. Regular</td></tr>
<tr><td>31. Realiza algum tratamento da água consumida pelos membros da família</td><td>____ 1. Sim (Ir a pergunta 29)

___2. Não (Ir a pergunta 30)</td><td colspan="2">32. Que tipo de tratamento:

(Marque todas as que se aplicam)</td><td>___ 1. Ferver

___ 2. Cloração

___ 3. Filtro de água **

___ 4. Desinfecção solar

___ 5. Outro: Especifique:

_______________________</td></tr>
<tr><td>33. Você troca seu filtro</td><td>____ 1. Sim (Ir a pergunta 29)

___2. Não (Ir a pergunta 30)</td><td colspan="2">34. A cada quanto tempo</td><td>___ meses</td></tr>
</table>

35. Você considera que precisa de um melhor tratamento de águas de esgoto nasua casa	____ 1.Sim ____ 2.Não	**37. Você estaria disposto a pagar por tem un melhor tratamento de águas de esgoto (instalação) na sua casa**	____ 1.Sim ____ 2.Não
38. Quais são as razões pelas quais você não gostaria de pagar por um sistema melhor		**39. Quanto você estaria disposto a pagar**	

40. Você considera que a região tem problemas com a águas de esgoto e de saneamento:	____ 1. Sim (Ir a pergunta 29) ___2. Não	**41. Mencione o tipo de problema:**	

II. Cost breakdown for the Biodigester Septic Tanks

ITEM	UNIT	SOURCE	QUANT.	COST PER UNIT	TOTAL COST
Caixa de cemento o vidrio (1000 L)	pcs	EMOP	3,00	$213,98	$641,94
Tubo PVC 100mm para esgoto	m	SINAPI	6,00	$40,53	$243,18
Válvula de retenção de PVC 100mm	pcs	SINAPI	1,00	$486,18	$486,18
Curva 90° longa de PVC 100mm	pcs	EMOP	2,00	$38,18	$76,36
Luva de PVC 100mm	pcs	SINAPI	3,00	$12,55	$37,65
Tê de inspeção de PVC 100mm	pcs	EMOP	2,00	$33,54	$67,08
O'ring 100mm	pcs	Online supplier	10,00	$2,60	$26,00
Tubo de PVC soldável 25mm	m	SINAPI	2,00	$6,11	$12,22
Cap de PVC soldável 25mm	pcs	SINAPI	2,00	$3,89	$7,78
Flange de PVC soldável 25mm	pcs	Online supplier	2,00	$9,70	$19,40
Flange de PVC soldável 50mm	pcs	Online supplier	1,00	$16,70	$16,70
Tubo de PVC soldável 50mm	m	SINAPI	1,00	$16,69	$16,69
Registro de esfera de PVC 50mm	pcs	EMOP	1,00	$24,09	$24,09
Cola de silicone de 300g	pcs	Online supplier	2,00	$13,00	$26,00
Pasta lubrificante para juntas elásticas em PVC rígido – 400g	pcs	EMOP	1,00	$16,89	$16,89
Adesivo para PVC – 100g	pcs	Online supplier	1,00	$8,67	$8,67
Neutrol	l	Online supplier	1,00	$69,90	$69,90
Serra copo 100mm	pcs	Online supplier	1	$177,00	$177,00
Serra copo 50mm	pcs	Online supplier	1	$97,00	$97,00
Serra copo 25mm	pcs	Online supplier	1	$32,00	$32,00
Aplicador de silicone	pcs	Online supplier	1	$23,90	$23,90
Arco de serra c/ lâmina de 24 dentes	pcs	Online supplier	1	$1,12	$1,12
Furadeira elétrica	pcs	Online supplier	1	$159,00	$159,00
Estilete ou faca	pcs	Online supplier	1	$12,00	$12,00
Lixa comum no. 100	pcs	Online supplier	2	$0,72	$1,44
Total Biodigester Septic Tank Cost (In Reais)					$2.300,19
Total Biodigester Septic Tank Cost (In Dollars)*					**$1.064,90**

(Adapted by the author based on FBB, 2010; *Considering and exchange rate of 2.16 Brazilian reais per dollar (WB, 2014).

III. Cost of Illness calculation

ASSUMPTIONS		
Total population 2034	1575	Inh
20% of diseased population	315	Inh
Basic Medical attention per capita (2007)	83,71	R$
Basic Medical attention per capita (2013)*	116,68	R$
Basic Medical attention per capita (2013)	54,02	US$
Monthly Minimum wage (2014)**	831,82	R$
Monthly Minimum wage (2014)	385,1	US$
Exchange rate***	2,16	US$

CAM=Cost of Medical Assistance; LP=Lost of productivity; COI= Cost of illness

COST UPDATE	
Year	**Inflation Rate (%)***
2008	5,69
2009	4,31
2010	5,91
2011	6,5
2012	5,84
2013	5,91

COST	VALUE	
CMA	36755,4	R$
LP	17468,22	R$
COI	54223,62	R$
COI	25103,53	**US$**

* Montly minimum wage (Legisweb, 2014)
** Inflation Rates (Banco Central do Brasil, 2014)
*** Average exchange rate for 2013 (BM, 2014)

IV. Biofertilizer benefits calculation

Fertilizer Price 2014 (US$/T)		
Nitrogen Fertilizer	**Phosphate Fertilizer**	**Fertilizer with Potassium**
(Scot Consultoría, 2012) prices updated		
637,20	434,22	765,16

(Own chart based on Scot Consultoría, 2012; Banco Central do Brasil , 2014)

Type of Houses	**Sludge production (T/a) (Tilia Unwetl, 2014)**			**Nutrients Cost US$/a**			**TOTAL NPK US/a**
	N	**P**	**K**	N	P	K	
Isolated Houses	13,33	13,95	1,25	$8.496,97	$6.056,05	$956,21	$15.509,23
Cluster Houses	28,95	30,28	2,71	$18.448,34	$13.148,69	$2.076,10	$33.673,13
Isolated + Cluster	42,29	44,23	3,96	$26.945,31	$19.204,74	$3.032,31	$49.182,36

(Own chart based on Scot Consultoría, 2012; Banco Central do Brasil , 2014 and inofrmation given by TIlia Unwetl)

V. Breakdown Cost of Scenarios B.1, B.2, B.3 and B.4

ASSUMPTIONS		
Inhabitant per cluster building	3,3	inh
Cluster Population	1022	inh
Future Cluster Buildings	310	buildings
Exchange Rate*	$2,16	1,00 R$
Connection Length sewer	1900,00	m
House Connection Length	10,00	m
Cost per m^2	$7,41	16,00 R$

*Exchange rate from:

Scenario	Technology	Land Requirements (m^2)	Land Cost (US$)	Construction costs (US$)	Technical Equipment (US$)	Total Capital Cost (US$)	O&M Cost (US$/a)
B.1	Sequence Batch Reactor (SBR)	300	$2.222,22	$34.722,22	$109.259,26	$160.056,48	$13.837,84
B.2	Activated sludge with integrated sludge stabilization (AA+SS)	120	$888,89	$26.851,85	$121.296,30	$160.579,63	$43.035,34
B.3	Fluidized Bed (FB)	240	$1.777,78	$28.703,70	$151.388,89	$193.381,48	$32.488,09
B.4	Constructed Wetland (CW)	3.938	$29.166,67			$120.375,14	$29.500,00

(Adapted by the author based on the given information form BDZ and TIlia Unwelt)

VI. Breakdown Cost of Scenarios B.5 to B.9

ASSUMPTIONS

Exchange Rate	2,16	reias per dollar
Inhabitants per cluster house	3,3	houses
Electricy Cost NF municipality	0,324101	Kwh
Land cost	16	reais
Population	1022	Inh

Scenario	Technolgy	Land req. (m2/hab)	Energy req. (kWh/year /inh)	Energy Cost (US$/hab)	Average (US$/house) 2014	Installation (R$/hab)	Average (US$/hab)	Average (US$/house) 2009	Average (US$/house) 2014	Land Cost (US/m2)	O&M (R$/hab)	Average (US$/hab)	Average (US$/house) 2009	Average (US$/house) 2014
B.5	**UASB**	0,07	0,00	0,00	0,00	40,00	86,40	26,18	36,11	492,07	10,00	4,63	15,28	21,07
B.6	**UASB + Anaerobic Filter**	0,10	0,00	0,00	0,00	50,00	108,00	32,73	45,14	757,04	17,50	8,10	26,74	36,88
B.7	**Activated Sludge + Extended Aeration**	0,19	32,50	4,88	16,09	105,00	226,80	68,73	94,80	1400,52	110,00	50,93	168,06	231,81
B.8	**UASB + Trickling Filter**	0,15	0,00	0,00	0,00	75,00	162,00	49,09	67,72	1135,56	17,50	8,10	26,74	36,88
B.9	**UASB + Biological Contact Rotor**	0,20	2,50	0,38	1,24	90,00	194,40	58,91	81,26	1514,07	25,00	11,57	38,19	52,68

(Adapted by the author based on Bergamaschi Teixeira, 2009)

VII. Calculation of Sewer Cost

ASSUMPTIONS		
Inhabitant per cluster house	3,3	Inh
Cluster Population	1022	Inh
Future Cluster Houses	310	Houses
Exchange Rate	$2,16	1,00 R$
Connection Length sewer	1900,00	m
House Connection Length	10,00	m
Cost per m^2	$7,41	16,00 R$

Technology	Total Investment (US$)	Cost O&M (US$)
sewer lines including inspection chambers	$45.046,30	
house connections	$22.670,00	
Total Sewer Network	$150.000,00	$2.268,52

VIII. Sludge Transportation and Disposal Cost

Technology	Average (m3*inh/a)	Sludge Production (m3/a)	Sludge Production (Ton/a)	Sludge Cost
SBR	0,6	613,2	216,54	$1.299,24
AA + SS	1,6	350	123,6	$741,60
FB	0,44	350	123,6	$741,60
CW	0,4	408,8	144,36	$866,16
UASB	0,15	148,19	52,33	$313,98
UASB + AnF	0,23	229,95	105,92	$635,52
ASEA	1,6	1635,2	577,71	$3.466,26
UASB + TF	0,29	296,38	103,6	$621,60
UASB + BCR	0,29	296,38	103,6	$621,60

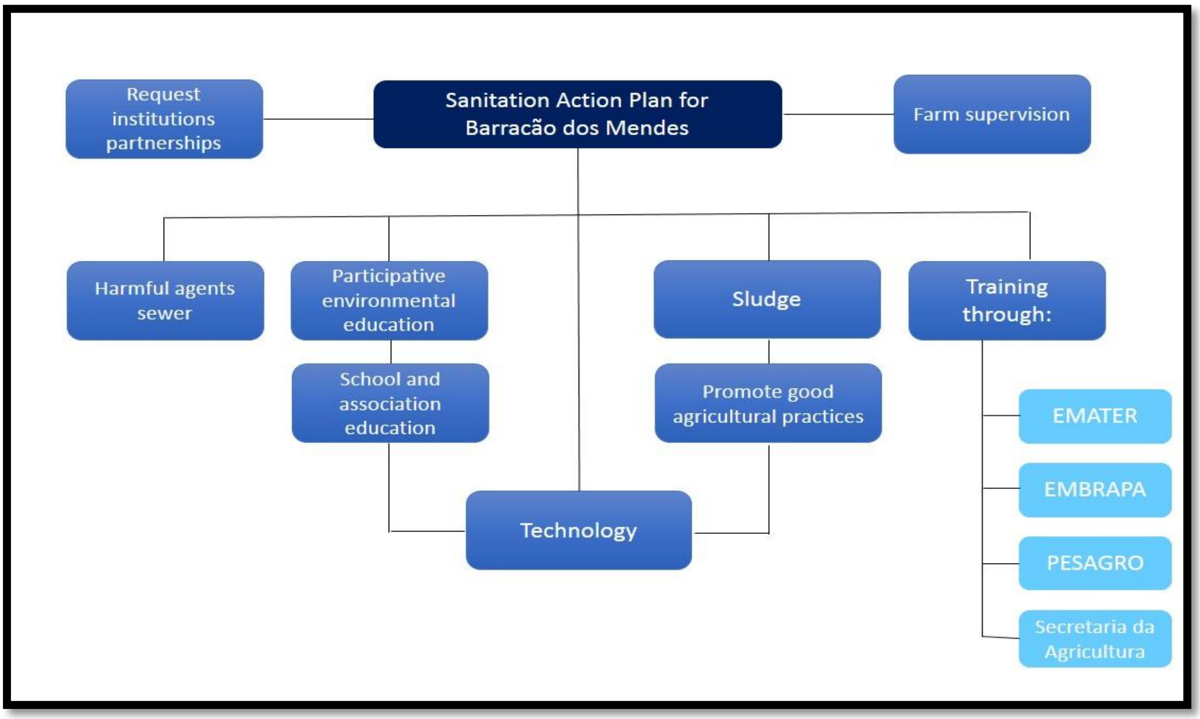
(Elaborated by the author based on the Bergamaschi Teixeira, 2009; Tilia Unwelt, 2014)

IX. Sanitation Problems in the MBDM and Government Institutions relations

SANITATION PROBLEMS	INSTITUTIONS
Lack of Sanitation	Prefeitura
	Aguas de Nova Friburgo
	Instituto Brasileiro de Meio Ambiente
	Ministério das Cidades
Training deficiencies	Secretaria de Estado de Educação
	Ministério do Desenvolvimento Agrário
	FIOCRUZ
	Ministério do Desenvolvimento Social
	Instituto Brasileiro de Geografía e Estatística
Public health, agrotoxics and farm production	Instituto Estadual do Ambiente
	Ministério da Agricultura Pecuária e Abastecimiento
	FIOCRUZ
	Secretaria de Saúde do Nova Friburgo
	Posto de Saúde Centenario

(Elaborated by the author based on the diagnosis results)

X. Sanitation Action Plan



(Elaborated by the author based on the diagnosis results)

XI. General Assumptions for ECBA Estimation

ASSUMPTIONS SCENARIO A		
Inhabitants per Isolated house	3,0	Inh
Inhabitants per Cluster houses	3,3	Inh
Population Isolated	552	Inh
Future Isolated houses	184	houses
Population Cluster	1022	Inh
Future Cluster houses	310	houses
Population Total	1575	Inh
Future Total houses	494	houses
Discount rate	0,05	
Exchange rate*	2,16	
Wastewater Production	217	l.c.d
BOD Loding Rate**	40	g/m^3
BOD Concentration	184,33	g/m^3
Total Flow Rate	341,71	m^3/d
Annual flow rate	124724,17	m^3/a
PE	184,33	

ASSUMPTIONS SCENARIO B		
Inhabitants per Isolated house	3,0	Inh
Inhabitants per Cluster houses	3,3	Inh
Population Isolated	552	Inh
Future Isolated houses	184	Houses
Population Cluster	1022	Inh
Future Cluster houses	310	Houses
Future Houses	494	Houses
Network House Connection	5	m/house
Sewer Network	6,76	m/house
Connection Lenght Sewer	1900	m
House Connection Lenght	10	m/house
Discount	0,05	
Exchange rate	2,16	
Wastewater Production	217	l.c.d
BOD Loding Rate*	40	g/m3
BOD Concentration	184,33	g/m3
Total Population	1575	Inhabitants
Total Flow Rate	341,71	m3/d
Annual flow rate	124724,17	m3/a
PE	184,33	

XII. EBCA Scenario A without water reuse

Technology: Biodigester Septic Tank (BST)

Year	Basis Data	Capital cost	Total Capital cost (US)	Re-Investment	Total Re-Investment (US)	Other Costs				Total Other Costs (US)	**Total Initial Investment costs (US)**	O&M Costs	**Total O&M (US)**	Benefits			**Total Benefits (US)**
	Wastewater Production in m3/a	BST System (US)		BST System (US)		Land (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost (US)		Fertilizers (US)	COI (US)	Reuse wastewater (US)	
0	124724,17	$525.977,64	$525.977,64		$0,00	$23.785,18	$0,00	$0,00	$0,00	$23.785,18	$549.762,82	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
2	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
3	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
4	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
5	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
6	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
7	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
8	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
9	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
10	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
11	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
12	124724,17		$0,00	$117.153,61	$117.153,61					$0,00	$117.153,61	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
13	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
14	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
15	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
16	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
17	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
18	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
19	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
20	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
21	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
22	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
23	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
24	124724,17		$0,00	117153,61	$117.153,61					$0,00	$117.153,61	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
25	124724,17		$0,00	175730,42	$175.730,42					$0,00	$175.730,42	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
26	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
27	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
28	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
29	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
30	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$0,00	$74.285,89
PV			$500.931,08		$146.147,40						$669.731,04	$622.258,17	$650.808,09	$756.053,42	$385.902,73	$0,00	$1.141.956,15
																NPV	**$178.581,07**

XIII. EBCA Scenario A considering water reuse (25%)

Technology: Biodigester Septic Tank (BST)

Year	Basis Data	Capital cost	Total Capital cost (US)	Re-Investment	Total Re-Investment (US)	Other Costs				Total Other Costs (US)	**Total Initial Investment costs (US)**	O& M Costs	**Total O&M (US)**	Benefits			**Total Benefits (US)**
	Wastewater Production in m3/a	BST System (US)		BST System (US)		Land (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost (US)		Fertilizers (US)	COI (US)	Reuse wastewater (US)	
0	124724,17	$525.977,64	$525.977,64		$0,00	$23.785,18	$0,00	$0,00	$0,00	$23.785,18	$549.762,82	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
2	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
3	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
4	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
5	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
6	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
7	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
8	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
9	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
10	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
11	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
12	124724,17		$0,00	$117.153,61	$117.153,61					$0,00	$117.153,61	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
13	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
14	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
15	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
16	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
17	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
18	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
19	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
20	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
21	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
22	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
23	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
24	124724,17		$0,00	117153,61	$117.153,61					$0,00	$117.153,61	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
25	124724,17		$0,00	175730,42	$175.730,42					$0,00	$175.730,42	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
26	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
27	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
28	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
29	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
30	124724,17		$0,00		$0,00					$0,00	$0,00	$44.452,80	$44.452,80	$49.182,36	$25.103,53	$30.791,28	$105.077,17
PV			$500.931,08		$146.147,40						$669.731,04	$622.258,17	$650.808,09	$756.053,42	$385.902,73	$473.337,45	$1.615.293,60
																NPV	**-$40.265,34**

XIV. EBCA Sub-scenario B.1 without water reuse

Technology: Sequence Batch Reactor (SBR)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	SBR (US)		BST (US)	SBR (US)		Land SBR (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$160.111,02	$506.229,69			$0,00	$2.222,22	$8.864,92	$16.011,10	$24.016,65	$24.016,65	$75.131,55	$581.361,24	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.299,24	$33.980,89	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.300,24	$33.981,89	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.301,24	$33.982,89	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.302,24	$33.983,89	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.303,24	$33.984,89	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.304,24	$33.985,89	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.305,24	$33.986,89	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.306,24	$33.987,89	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.307,24	$33.988,89	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.308,24	$33.989,89	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.309,24	$33.990,89	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$35.662,32	$79.333,42						$0,00	$79.333,42	$16.570,58	$13.842,56	$2.268,52	$1.310,24	$113.325,32	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.311,24	$33.992,89	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.312,24	$33.993,89	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.313,24	$33.994,89	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.314,24	$33.995,89	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.315,24	$33.996,89	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.316,24	$33.997,89	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.317,24	$33.998,89	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.318,24	$33.999,89	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.319,24	$34.000,89	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.320,24	$34.001,89	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.321,24	$34.002,89	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$35.662,32	$79.333,42						$0,00	$79.333,42	$16.570,58	$13.842,56	$2.268,52	$1.322,24	$113.337,32	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$53.493,48	$119.000,14						$0,00	$119.000,14	$16.570,58	$13.842,56	$2.268,52	$1.323,24	$153.005,03	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.324,24	$34.005,89	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.325,24	$34.006,89	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.326,24	$34.007,89	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.327,24	$34.008,89	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.328,24	$34.009,89	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$482.123,52			$98.967,27							$652.644,65					$497.494,85	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	**$525.821,92**

XV. EBCA Sub-scenario B.1 considering water reuse (25%)

Technology: Sequence Batch Reactor (SBR)

Year	Basis Data	Capital cost				Re-Investment			Other Costs							O&M Costs					Benefits			
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	SBR (US)	**Total Capital cost (US)**	BST (US)	SBR (US)	Total Re-Investment (US)	Land SBR (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)	Total Other Costs (US)	**Total Initial Investment costs (US)**	Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	**Total O&M (US)**	Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	**Total Benefits (US)**
0	124724,173	$150.051,11	$196.067,56	$160.111,02	$506.229,69			$0,00	$2.222,22	$8.864,92	$16.011,10	$24.016,65	$24.016,65	$75.131,55	$581.361,24	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.299,24	$33.980,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.300,24	$33.981,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.301,24	$33.982,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.302,24	$33.983,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.303,24	$33.984,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.304,24	$33.985,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.305,24	$33.986,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.306,24	$33.987,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.307,24	$33.988,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.308,24	$33.989,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.309,24	$33.990,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$35.662,32	$79.333,42						$0,00	$79.333,42	$16.570,58	$13.842,56	$2.268,52	$1.310,24	$113.325,32	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.311,24	$33.992,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.312,24	$33.993,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.313,24	$33.994,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.314,24	$33.995,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.315,24	$33.996,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.316,24	$33.997,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.317,24	$33.998,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.318,24	$33.999,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.319,24	$34.000,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.320,24	$34.001,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.321,24	$34.002,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$35.662,32	$79.333,42						$0,00	$79.333,42	$16.570,58	$13.842,56	$2.268,52	$1.322,24	$113.337,32	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$53.493,48	$119.000,14						$0,00	$119.000,14	$16.570,58	$13.842,56	$2.268,52	$1.323,24	$153.005,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.324,24	$34.005,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.325,24	$34.006,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.326,24	$34.007,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.327,24	$34.008,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$13.842,56	$2.268,52	$1.328,24	$34.009,89	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$482.123,52			$98.967,27							$652.644,65					$497.494,85	$238.414,85	$473.337,45	$1.097.655,02	$71.404,03
																							NPV	**$52.484,47**

XVI. EBCA Sub-scenario B.2 without water reuse

Technology: Technology: Activated Sludge + Sludge Stabilization (AA+SS)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	AA+SS (US)		BST (US)	AA+SS (US)		Land AA+SS (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost AA+SS (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$160.634,35	$506.753,02			$0,00	$888,89	$8.864,92	$16.063,43	$24.095,15	$24.095,15	$74.007,55	$580.760,57	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$35.778,89	$79.449,99						$0,00	$79.449,99	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$35.778,89	$79.449,99						$0,00	$79.449,99	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$53.668,33	$119.174,98						$0,00	$119.174,98	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$482.621,92			$99.112,68							$652.217,99					$916.940,33	$238.414,85	$473.337,45	$1.097.655,02	$71.404,03
																							NPV	**$471.503,30**

XVII. EBCA Sub-scenario B.2 considering water reuse (25%)

Technology: Technology: Activated Sludge + Sludge Stabilization (AA+SS)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	AA+SS (US)		BST (US)	AA+SS (US)		Land AA+SS (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost AA+SS (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$160.634,35	$506.753,02			$0,00	$888,89	$8.864,92	$16.063,43	$24.095,15	$24.095,15	$74.007,55	$580.760,57	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$35.778,89	$79.449,99						$0,00	$79.449,99	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$35.778,89	$79.449,99						$0,00	$79.449,99	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$53.668,33	$119.174,98						$0,00	$119.174,98	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$43.050,01	$2.268,52	$741,60	$62.630,70	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$482.621,92			$99.112,68							$652.217,99					$916.940,33	$238.414,85	$473.337,45	$1.097.655,02	$71.404,03
																							NPV	**$471.503,30**

XVIII. EBCA Sub-scenario B.3 without water reuse

Technology: Fluidized Bed (FB)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	FB (US)		BST (US)	FB (US)		Land FB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost FB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$193.447,38	$539.566,05			$0,00	$3.840,00	$8.864,92	$19.344,74	$29.017,11	$29.017,11	$90.083,87	$629.649,92	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$43.087,50	$86.758,60						$0,00	$86.758,60	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$43.087,50	$86.758,60						$0,00	$86.758,60	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$64.631,24	$130.137,89						$0,00	$130.137,89	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$513.872,43			$108.230,07							$707.896,65					$762.471,42	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	$846.050,50

XIX. EBCA Sub-scenario B.3 considering water reuse (25%)

Technology: Fluidized Bed (FB)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	FB (US)		BST (US)	FB (US)		Land FB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost FB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$193.447,38	$539.566,05			$0,00	$3.840,00	$8.864,92	$19.344,74	$29.017,11	$29.017,11	$90.083,87	$629.649,92	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$43.087,50	$86.758,60						$0,00	$86.758,60	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$43.087,50	$86.758,60						$0,00	$86.758,60	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$64.631,24	$130.137,89						$0,00	$130.137,89	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$32.499,16	$2.268,52	$741,60	$52.079,85	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$513.872,43			$108.230,07							$707.896,65					$762.471,42	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	**$372.713,05**

XX. EBCA Sub-scenario B.4 without water reuse

Technology: Vertical Constructed Wetland (CW)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	FB (US)		BST (US)	FB (US)		Land FB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost FB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$120.416,16	$466.534,83			$0,00	$28.703,70	$8.864,92	$12.041,62	$18.062,42	$18.062,42	$85.735,09	$552.269,92	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$26.820,89	$70.491,99						$0,00	$70.491,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$26.820,89	$70.491,99						$0,00	$70.491,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$40.231,33	$105.737,99						$0,00	$105.737,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$444.318,89			$87.937,72							$613.909,07					$720.533,22	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	**$710.124,71**

XXI. EBCA Sub-scenario B.4 considering water reuse (25%)

Technology: Vertical Constructed Wetland (CW)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	FB (US)		BST (US)	FB (US)		Land FB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost FB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$120.416,16	$466.534,83			$0,00	$28.703,70	$8.864,92	$12.041,62	$18.062,42	$18.062,42	$85.735,09	$552.269,92	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$26.820,89	$70.491,99						$0,00	$70.491,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$26.820,89	$70.491,99						$0,00	$70.491,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$40.231,33	$105.737,99						$0,00	$105.737,99	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$29.510,05	$2.268,52	$866,16	$49.215,31	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$444.318,89			$87.937,72							$613.909,07					$720.533,22	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	**$243.895,71**

XXII. EBCA Sub-scenario B.5 without water reuse

Technology: UASB

Year	Basis Data	Capital cost			**Total Capital cost (US)**	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	**Total Initial Investment costs (US)**	O&M Costs				**Total O&M (US)**	Benefits			**Total Benefits (US)**
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB (US)		BST (US)	UASB (US)		Land UASB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$11.551,01	$357.669,68			$0,00	$1.062,88	$8.864,92	$1.155,10	$1.732,65	$1.732,65	$14.548,20	$372.217,88	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$2.572,81	$46.243,91						$0,00	$46.243,91	$16.570,58	$6.323,80	$2.268,52	$313,98	$71.720,79	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$2.572,81	$46.243,91						$0,00	$46.243,91	$16.570,58	$6.323,80	$2.268,52	$313,98	$71.720,79	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$3.859,22	$69.365,87						$0,00	$69.365,87	$16.570,58	$6.323,80	$2.268,52	$313,98	$94.842,74	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.323,80	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$340.637,79			$57.688,60							$412.181,82					$372.992,34	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	**$157.292,31**

XXIII. EBCA Sub-scenario B.5 considering water reuse (25%)

Technology: UASB

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB (US)		BST (US)	UASB (US)		Land UASB (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$11.551,01	$357.669,68			$0,00	$1.062,88	$8.864,92	$1.155,10	$1.732,65	$1.732,65	$14.548,20	$372.217,88	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.476,87	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.682,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.683,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.684,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.685,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.686,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.687,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.688,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.689,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.690,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.691,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$2.572,81	$46.243,91						$0,00	$46.243,91	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.692,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.693,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.694,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.695,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.696,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.697,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.698,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.699,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.700,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.701,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.702,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.703,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$2.572,81	$46.243,91						$0,00	$46.243,91	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.704,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$43.671,10	$3.859,22	$69.365,87						$0,00	$69.365,87	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.705,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.706,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.707,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.708,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.709,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$313,98	$25.710,81	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$340.637,79			$57.688,60							$412.181,82					$376.153,31	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	**-$312.480,86**

XXIV. EBCA Sub-scenario B.6 without water reuse

Technology: UASB + Anaerobic Filter (AnF)

	Basis Data	Capital cost				Re-Investment			Other Costs							O&M Costs					Benefits			
Year	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB AnF (US)	**Total Capital cost (US)**	BST (US)	UASB AnF (US)	Total Re-Investment (US)	Land UASB AnF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)	Total Other Costs (US)	**Total Initial Investment costs (US)**	Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	**Total O&M (US)**	Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	**Total Benefits (US)**
0	124724,173	$150.051,11	$196.067,56	$13.985,52	$360.104,19			$0,00	$757,04	$8.864,92	$1.398,55	$2.097,83	$2.097,83	$15.216,17	$375.320,36	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$3.115,07	$46.786,17						$0,00	$46.786,17	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$3.115,07	$46.786,17						$0,00	$46.786,17	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$4.672,60	$70.179,25						$0,00	$70.179,25	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$342.956,37			$58.365,05							$415.813,01					$452.548,42	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	**$244.043,86**

XXV. EBCA Sub-scenario B.6 considering water reuse (25%)

Technology: UASB + Anaerobic Filter (AnF)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB AnF (US)		BST (US)	UASB AnF (US)		Land UASB AnF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$13.985,52	$360.104,19			$0,00	$757,04	$8.864,92	$1.398,55	$2.097,83	$2.097,83	$15.216,17	$375.320,36	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$3.115,07	$46.786,17						$0,00	$46.786,17	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$3.115,07	$46.786,17						$0,00	$46.786,17	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$4.672,60	$70.179,25						$0,00	$70.179,25	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$6.528,74	$2.268,52	$635,52	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$342.956,37			$58.365,05							$415.813,01					$452.548,42	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	-$233.997,23

XXVI. EBCA Sub-scenario B.7 without water reuse

Technology: Activated Sludge Extended Aeration (ASEA)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs					Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	ASEA (US)		BST (US)	ASEA (US)		Land ASEA (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost ASEA (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	Energy Consumtion (US/a)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$29.369,60	$375.488,27			$0,00	$1.400,52	$8.864,92	$2.936,96	$4.405,44	$4.405,44	$22.013,28	$397.501,55	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$6.541,64	$50.212,74						$0,00	$50.212,74	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$6.541,64	$50.212,74						$0,00	$50.212,74	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$9.812,45	$75.319,11						$0,00	$75.319,11	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$357.607,87			$62.639,65							$441.212,55						$1.451.128,88	$238.414,85	$385.902,73	$0,00	$624.317,57
																								NPV	$1.268.023,86

XXVII. EBCA Sub-scenario B.7 considering water reuse (25%)

Technology: Activated Sludge Extended Aeration (ASEA)

Year	Basis Data	Capital cost				Re-Investment			Other Costs							O&M Costs						Benefits			
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	ASEA (US)	**Total Capital cost (US)**	BST (US)	ASEA (US)	Total Re-Investment (US)	Land ASEA (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)	Total Other Costs (US)	**Total Initial Investment costs (US)**	Manteinance cost BST (US)	Manteinance cost ASEA (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	Energy Consumtion (US/a)	**Total O&M (US)**	Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	**Total Benefits (US)**
0	124724,173	$150.051,11	$196.067,56	$29.369,60	$375.488,27			$0,00	$1.400,52	$8.864,92	$2.936,96	$4.405,44	$4.405,44	$22.013,28	$397.501,55	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$6.541,64	$50.212,74						$0,00	$50.212,74	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$6.541,64	$50.212,74						$0,00	$50.212,74	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$9.812,45	$75.319,11						$0,00	$75.319,11	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$71.816,09	$2.268,52	$3.466,26	$4.985,50	$99.106,95	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$357.607,87			$62.639,65							$441.212,55						$1.451.128,88	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																								NPV	**$718.016,93**

XXVIII. EBCA Sub-scenario B.8 without water reuse

Technology: UASB + Trickling Filter (TF)

Year	Basis Data	Capital cost			Total Capital cost (US)	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	Total Initial Investment costs (US)	O&M Costs				Total O&M (US)	Benefits			Total Benefits (US)
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB + TF (US)		BST (US)	UASB + TF (US)		Land UASB + TF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB + TF (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$20.978,28	$367.096,95			$0,00	$1.135,56	$8.864,92	$2.097,83	$3.146,74	$3.146,74	$18.391,79	$385.488,74	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$4.672,60	$48.343,70						$0,00	$48.343,70	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00	$43.671,10	$4.672,60	$48.343,70						$0,00	$48.343,70	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00	$65.506,65	$7.008,90	$72.515,55						$0,00	$72.515,55	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$349.616,15			$60.308,05							$427.440,19					$452.344,62	$238.414,85	$385.902,73	$0,00	$624.317,57
																							NPV	$255.467,24

XXIX. EBCA Sub-scenario B.8 considering water reuse (25%)

Technology: UASB + Trickling Filter (TF)

Year	Basis Data	Capital cost			**Total Capital cost (US)**	Re-Investment		Total Re-Investment (US)	Other Costs					Total Other Costs (US)	**Total Initial Investment costs (US)**	O&M Costs				**Total O&M (US)**	Benefits			**Total Benefits (US)**
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB + TF (US)		BST (US)	UASB + TF (US)		Land UASB + TF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)			Manteinance cost BST (US)	Manteinance cost UASB + TF (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)		Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	
0	124724,173	$150.051,11	$196.067,56	$20.978,28	$367.096,95			$0,00	$1.135,56	$8.864,92	$2.097,83	$3.146,74	$3.146,74	$18.391,79	$385.488,74	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$4.672,60	$48.343,70						$0,00	$48.343,70	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$4.672,60	$48.343,70						$0,00	$48.343,70	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$7.008,90	$72.515,55						$0,00	$72.515,55	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$11.425,29	$2.268,52	$621,60	$30.899,90	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$349.616,15			$60.308,05							$427.440,19					$452.344,62	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	**-$219.583,95**

XXX. EBCA Sub-scenario B.9 without water reuse

Technology: UASB + Biological Contact Rotor (BCR)

Year	Basis Data	Capital cost				Re-Investment			Other Costs							O&M Costs					Benefits			
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB AnF (US)	**Total Capital cost (US)**	BST (US)	UASB AnF (US)	Total Re-Investment (US)	Land UASB AnF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)	Total Other Costs (US)	**Total Initial Investment costs (US)**	Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	**Total O&M (US)**	Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	**Total Benefits (US)**
0	124724,173	$150.051,11	$196.067,56	$25.173,94	$371.292,61			$0,00	$1.514,07	$8.864,92	$2.517,39	$3.776,09	$3.776,09	$20.448,57	$391.741,18	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
10	124724,173				$0,00			$0,00						$0,00	$49.278,22	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
12	124724,173				$0,00	$43.671,10	$5.607,12	$49.278,22						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
24	124724,173				$0,00			$0,00						$0,00	$49.278,22	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
25	124724,173				$0,00			$0,00						$0,00	$73.917,33	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
26	124724,173				$0,00	43671,1009	5607,11709	$49.278,22						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
27	124724,173				$0,00	65506,6513	8410,67563	$73.917,33						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$0,00	$40.612,75
PV					$353.612,01			$0,00							$437.239,35					$529.646,85	$238.414,85	$385.902,73	$0,00	$624.317,57
								0															NPV	**$342.568,63**

XXXI. EBCA Sub-scenario B.9 considering water reuse (25%)

Technology: UASB + Biological Contact Rotor (BCR)

Year	Basis Data	Capital cost				Re-Investment			Other Costs							O&M Costs					Benefits			
	Wastewater Production in m3/a	Sewer Network (US)	BST (US)	UASB AnF (US)	**Total Capital cost (US)**	BST (US)	UASB AnF (US)	Total Re-Investment (US)	Land UASB AnF (US)	Land BST (US)	Design (US)	Overheads (US)	Contingencies (US)	Total Other Costs (US)	**Total Initial Investment costs (US)**	Manteinance cost BST (US)	Manteinance cost UASB (US)	Manteinance cost Sewer (US)	Sludge Transportation (US)	**Total O&M (US)**	Biofertlizer BST (US)	COI (US)	Reuse wastewater (US)	**Total Benefits (US)**
0	124724,173	$150.051,11	$196.067,56	$25.173,94	$371.292,61			$0,00	$1.514,07	$8.864,92	$2.517,39	$3.776,09	$3.776,09	$20.448,57	$391.741,18	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00	$0,00
1	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
2	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
3	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
4	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
5	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
6	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
7	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
8	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
9	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
10	124724,173				$0,00			$0,00						$0,00	$49.278,22	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
11	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
12	124724,173				$0,00	$43.671,10	$5.607,12	$49.278,22						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
13	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
14	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
15	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
16	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
17	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
18	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
19	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
20	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
21	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
22	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
23	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
24	124724,173				$0,00	$43.671,10	$5.607,12	$49.278,22						$0,00	$49.278,22	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
25	124724,173				$0,00	$65.506,65	$8.410,68	$73.917,33						$0,00	$73.917,33	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
26	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
27	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
28	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
29	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
30	124724,173				$0,00			$0,00						$0,00	$0,00	$16.570,58	$16.321,84	$2.268,52	$621,60	$36.166,03	$15.509,23	$25.103,53	$30.791,28	$71.404,03
PV					$353.612,01			$64.152,51							$437.239,35					$529.646,85	$238.414,85	$385.902,73	$473.337,45	$1.097.655,02
																							NPV	**-$219.583,95**

XXXII. Participative Diagnosis photo

XXXIII. SSI with the Public Health Agency photo

XXXIV. Sanitation and public health survey photos