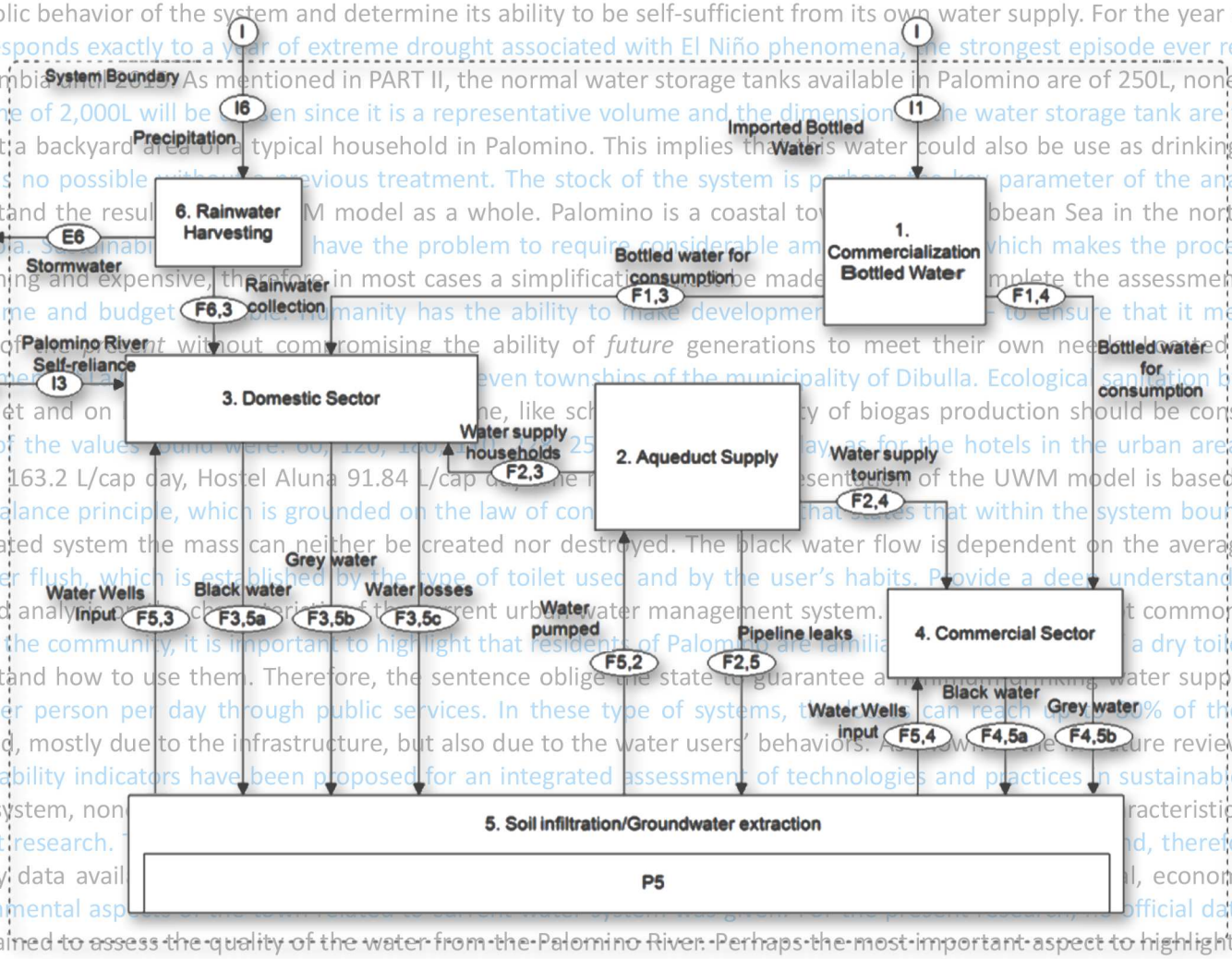
Sustainable Urban Water Management System in Palomino, Colombia

An Urban Water Metabolism Approach

By Natalia Uribe Calvo



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Abstract

This master thesis is an attempt to contribute to the understanding of urban water systems through the use of the urban metabolism (UM) framework. By developing steady-state models with STAN, a software used for material flow analysis (MFA), the urban water flows are quantified and analyzed as they enter the system boundary and are transformed by anthropogenic processes.

Such a model has been applied to a specific urban water system in the town of Palomino, Colombia, to research the main barriers and opportunities for a sustainable urban water system. The area under study corresponds to a system boundary of 4.83 km^2, and the analysis was performed for the year 2015. A detailed examination of Palomino's water system was established based on primary data collection through survey processes, mapping, and semi-structured interviews. Based on the qualitative and quantitative characteristics of the water system, a conceptual urban water metabolism (UWM) model was created to identify the critical flows of the water system through a monthly (31-day) analysis based on fourteen scenarios, each including four variables: Touristic season, Hours without electricity per month, Percentage of water losses due to pipelines leaks, and Percentage of water losses due to user's behavior. Subsequently, a definition of sustainable urban water management system (SUWMS) was generated based on a literature review and an industrial ecology perspective, wherein the system is analyzed using a holistic, system thinking approach. Guided by the SUWMS definition and the local conditions of Palomino's urban water system, various sustainable water technologies and initiatives are introduced as a set of potential solutions to shift the current water system towards a SUWMS.

Finally, the potential of the sustainable water supply technique of rainwater harvesting to influence the current UWM of Palomino was assessed by identifying changes in the UWM for three key years: 1969, a year of extreme rainfall; 1997, a year of El Niño phenomenon characterized by extreme drought, and 1987, a year of 'standard' precipitation. The analysis was based on a critical scenario with the highest water losses and water demand. The rainwater harvesting collection capacity was determined by a storage capacity of 2000 L per household, while taking into account water consumption (water demand) per household between rain events on a monthly basis analysis. This condition implied that, even though the analysis was based on steady-state modeling, a semi-dynamic analysis was performed based on the variations of the stored rainwater volume (ΔV) between the time intervals determined by the rain events per month (Δt).

Some of the most influential results of this research are explained in the subsequent sections. Palomino is a town rich in water resources; the nearby Palomino River and an elevated groundwater table provide steady water resources year around. Nonetheless, the inhabitants are strongly affected by water scarcity, caused by a poor centralized water supply infrastructure and high water prices. As a result, a significant amount of time is spent collecting water from the river, a burden largely shouldered by the women of the community. The water demand for each household varies greatly due to socio-economic factors and the location of the household in the urban area; it ranges between 33 L/cap day to 90 L/cap day. Water quality was found to be satisfactory, according to the community's perception. Leach pits, the most common method for sanitation in Palomino, provide considerably good hygiene conditions, but high risks of groundwater contamination and unbalanced loads of nutrients in the urban settlement. Hygiene in education centers (preschools, primary, and secondary schools) needs urgent improvements. Floods are common in the rainy seasons, and present a high risk to human health due to the possible fecal contamination of the water and the spread of vector-borne diseases.

The identification of the water system's critical flows was guided by the variation in the UWM caused by the importation of water required to satisfy the metabolic needs of the system. For the critical scenario (scenario 2 - Highest water losses and the highest water demand), the imports of water resulted in 23 L/cap day, while the net extraction of water from the Palomino River resulted in 22 L/cap day. By decreasing the water losses linked to the scenario's variables, negative values for water importation arose from scenarios 6, 12, 13 and 14, thus implying that the UWM system has a surplus of water. For scenario 13 (lowest water losses and highest water demand), a surplus of 21 L/cap day was obtained. The analysis of the fourteen scenarios resulted in the identification of two critical flows that significantly affect the UWM: Hours without electricity per month, and Percentage of water losses due to pipeline leaks. These two flows represent major water losses in the water system and strongly influence the metabolic behavior of the UWM in Palomino.

'A sustainable urban water management system is a system that includes the technical processes of collection, treatment and distribution of water, wastewater and stormwater. As well as the social engagement, environmental awareness and education of the community to guarantee the right of present and future generations to safe and clean water; while striving towards the conservation of ecosystem services, human well-being and minimization of the use of natural and economic resources.' Guided by this definition, potential water technology solutions were proposed for water supply, wastewater treatment and stormwater management. Among these solutions are solar panels to feed the energy need of the centralized system, rainwater harvesting, manual pumping wells, compost toilets, anaerobic digestion for biogas production, shared laundry rooms, constructed wetlands, pervious pavements, and infiltration trenches. These technologies provide the possibility of urban synergies between the urban water system, agriculture, energy and tourism development clusters. The analysis of the rainwater harvesting potential was based on the critical scenario (scenario 2) and resulted in the construction of thirty-six models for the three reference years, analyzed on a monthly basis. For the year 1969, the volume of rainwater collected reached maximum capacity, with a volume of 40 L/cap day for the first month and 31 L/cap day for the remaining months. The surplus of water arose to a negative value on water collected from the Palomino River: -18 L/cap day for the first month and -9 L/ cap day for the next months. For the year 1997, the extreme drought limited the volume of water that could be stored per month; here, only for two months (June and November) was the collected rainwater sufficient to obtain a surplus of water input of -5 L/cap day and -7.56 L/cap day, respectively. Lastly, for the year 1987, a surplus of water was obtained for a total of seven months of the year with a maximum value of -18 L/cap day.

Palomino has the potential to shift from the current water system towards a SUWMS, using low-tech water technologies and implementing management initiatives to facilitate the transition. The analysis of the critical water flows showed that the current water system could, theoretically, have the ability to be self-sufficient from a water supply perspective. The current mix of water supply technologies could satisfy the water system's metabolic needs, if the water losses were slightly diminished. Rainwater harvesting has the potential to be an efficient practice for a complementary water supply, since it drastically influence the UWM in rainy seasons (or months). The water system would then be capable of satisfying the urban water metabolic needs while providing a small buffer of stored water. The reliability of rainwater is certainly an issue because of its strong monthly variations, even in years of typical climatic conditions. This implies that the water supply challenges in Palomino cannot be solved solely with the collection of rainwater, and that this technique should be used as a complementary water source to increase the resilience of the water system.

One of the most significant results is that the applied methodology proved to be successful in terms of understanding water systems—not by the traditional approach of modeling based on average values, but rather by using scenarios that explain the variations and dynamics in the water systems. The changes in the UWM are then understood by the use of signals (e.g. positive and negative values) to determine the metabolic changes and water needs of the urban systems. This methodology could be applied in a larger context, especially in developing countries that have limited data to undertake a statistical analysis.

Keywords: Urban metabolism (UM), Urban water metabolism (UWM), Material flow analysis (MFA), Sustainable urban water management systems (SUWMS), Rainwater harvesting, Data poor locations, Industrial Ecology.

Resumen

Esta tesis de maestría pretende contribuir a la comprensión de los sistemas de agua urbanos a través del uso de la metodología del metabolismo urbano (UM[1]). Mediante el desarrollo de modelos de estado estacionario con STAN, un software utilizado para el análisis de flujo de materiales (MFA), los flujos urbanos de agua han sido cuantificados y analizados a medida que ingresan los límites del sistema y son, posteriormente, transformados por procesos antropogénicos.

Este modelo ha sido aplicado a un sistema de agua urbano específico para la ciudad de Palomino, Colombia, con el fin de investigar las principales barreras y oportunidades para alcanzar un sistema urbano sostenible de agua. El área de estudio corresponde a 4,83 km^2 y el análisis se efectuó para el año 2015. Se realizó un estudio detallado del sistema de agua de Palomino basado en la recolección de datos primarios a través de procesos de encuestas, reconocimiento cartográfico y entrevistas semiestructuradas. Con base en las características cualitativas y cuantitativas del sistema de agua, se creó un modelo conceptual del metabolismo urbano del agua (UWM) con el fin de identificar los flujos críticos del sistema de agua. Éstos fueron identificados a través de un análisis mensual (a 31 días) basado en un total de catorce escenarios, cada uno incluyendo cuatro variables: Temporada turística, Horas sin electricidad por mes, Porcentaje de pérdidas de agua debido a fugas en tuberías, y Porcentaje de pérdidas de agua debido al comportamiento del usuario. Posteriormente, se generó una definición de un sistema de gestión sostenible urbano de agua (SUWMS) basada en una revisión bibliográfica y en una perspectiva de ecología industrial, en la que el sistema se analiza utilizando un enfoque holístico; un pensamiento sistémico. Guiado por la definición del SUWMS y las condiciones locales del sistema urbano de agua de Palomino, se introducen varias tecnologías e iniciativas de manejo sostenible del agua como un conjunto de potenciales soluciones para transformar el actual sistema de agua hacia un SUWMS.

Por último, se evaluó el potencial que tendría la técnica de abastecimiento de agua a partir de la recolección de agua de lluvia para influenciar el UWM actual de Palomino. Identificando los cambios en el UWM durante tres años clave: 1969 - un año de precipitaciones extremas; 1997 - un año del fenómeno de El Niño caracterizado por una sequía extrema, y 1987 - un año de precipitación "estándar". El análisis se basó en un escenario crítico con las mayores pérdidas de agua y la mayor demanda de agua. La capacidad de recolección de agua de lluvia fue determinada por una capacidad de almacenamiento de 2000 L por hogar, teniendo en cuenta el consumo de agua (demanda de agua) por hogar entre los eventos de lluvia del análisis mensual. Esta condición implicó que, a pesar de que el análisis se basó en un modelo de estado estacionario, un análisis semi-dinámico fue realizado basado en las variaciones del volumen de agua de lluvia almacenada (ΔV) entre los intervalos de tiempo determinados por los eventos de lluvia por mes (Δt).

Algunos de los resultados más importantes de esta investigación se explican en las siguientes secciones; Palomino es una ciudad rica en recursos hídricos: el Río Palomino y el elevado nivel freático proporcionan recursos de agua constantes durante todo el año. Sin embargo, los habitantes están fuertemente afectados por la escasez de agua causada por la pobre infraestructura del abastecimiento central y los altos precios del agua. Como resultado, la población dedica una cantidad significativa de tiempo recolectando agua del río, una carga impuesta, en su mayoría, a las mujeres de la comunidad. La demanda de agua por hogar varía enormemente debido a factores socioeconómicos y la ubicación en el área

[1] Para ser coherente con el resto del texto, en el Resumen se utilizan las siglas en inglés.

urbana; ésta varía entre 33 L / hab día a 90 L / hab día. La calidad del agua es satisfactoria, según la percepción de la comunidad. Los pozos sépticos es el método más común para el saneamiento básico en Palomino, éstos proporcionan condiciones de higiene considerablemente buenas, pero altos riesgos de contaminación de aguas subterráneas y altas descargas de nutrientes en el asentamiento urbano. La higiene en los centros de educación (preescolar, primaria y secundaria) necesita mejoras urgentes. Las inundaciones son comunes en las estaciones lluviosas y presentan un alto riesgo para la salud humana debido a la posible contaminación fecal del agua inundable y la propagación de enfermedades transmitidas por vectores.

La identificación de los flujos críticos del sistema de agua fue establecida por la variación en el UWM causada por la importación de agua necesaria para satisfacer las necesidades metabólicas del sistema. Para el escenario crítico (escenario 2 - Las mayores pérdidas de agua y la mayor demanda de agua), las importaciones de agua resultaron en 23 L / hab día, mientras que la extracción neta de agua del Río Palomino resultó en 22 L / hab día. Al disminuir las pérdidas de agua relacionadas con las variables de los escenarios, valores negativos para la importación de agua surgieron de los escenarios 6, 12, 13 y 14, lo que implica que el sistema UWM tiene un exceso de agua. Para el escenario 13 (menores pérdidas de agua y mayor demanda de agua), se obtuvo un exceso de 21 L / hab día. El análisis de los catorce escenarios resultó en la identificación de dos flujos críticos que afectan significativamente el UWM: Horas sin electricidad por mes, y Porcentaje de pérdidas de agua debido a fugas en la tubería. Estos dos flujos representan grandes pérdidas de agua en el sistema e influyen fuertemente en el comportamiento metabólico del UWM en Palomino.

'Un sistema de gestión sostenible urbano del agua es un sistema que incluye los procesos técnicos de recolección, tratamiento y distribución de agua, aguas residuales y aguas pluviales. Así como el compromiso social, la conciencia ambiental y la educación de la comunidad para garantizar el derecho de las generaciones presentes y futuras al agua limpia y segura; mientras se persevera la conservación de los servicios de los ecosistemas, el bienestar humano y la minimización del uso de recursos naturales y económicos.' A partir de esta definición, se propusieron posibles soluciones tecnológicas para el suministro de agua, tratamiento de aguas residuales y manejo de aguas pluviales. Entre estas soluciones están los paneles solares para abastecer la necesidad energética del sistema centralizado, la recolección del agua de lluvia, pozos de bombeo manual, baños de compostaje, digestión anaeróbica para la producción de biogás, zonas de lavandería comunales, humedales construidos, pavimentos permeables y trincheras de infiltración. Estas tecnologías ofrecen la posibilidad de sinergias urbanas entre diferentes claustros del sistema como: agua, agricultura, energía y desarrollo turístico.

El análisis sobre el potencial de recolección de agua de lluvia se basó en el escenario crítico (escenario 2) y resultó en la construcción de treinta y seis modelos, analizados mensualmente, para los tres años de referencia. Para el año 1969, el volumen de agua de lluvia recogida alcanzó su capacidad máxima, con un volumen de 40 L / hab día para el primer mes y 31 L / hab día para los meses restantes. El excedente de agua se vio reflejado en un valor negativo del agua recolectada del Río Palomino: -18 L / hab día para el primer mes y -9 L / hab día para los próximos meses. Para el año 1997, la sequía extrema limitó el volumen de agua que se podía almacenar al mes; acá, sólo durante dos meses (Junio y Noviembre) el agua de lluvia recogida fue suficiente para obtener un excedente de agua de -5 L / hab día y -7,56 L / hab día, respectivamente. Por último, para el año 1987, se obtuvo un excedente de agua durante un total de siete meses del año con un valor máximo de -18 L / hab día.

Palomino tiene el potencial de cambiar el actual sistema de agua hacia un SUWMS, utilizando un conjunto de técnicas de manejo de agua de baja tecnología e implementando iniciativas de gestión para facilitar la transición. El análisis de los flujos críticos de agua mostró que el sistema actual de agua podría, teóricamente, tener la capacidad de ser autosuficiente desde la perspectiva del suministro de agua. La mezcla actual de tecnologías de suministro de agua podría satisfacer las necesidades metabólicas del sistema de agua, si las pérdidas de agua son ligeramente disminuidas. La recolección de agua de lluvia tiene el potencial de ser una práctica eficiente para el suministro complementario de agua, ya que influye drásticamente en el UWM en las estaciones lluviosas (o meses). El sistema de agua sería entonces capaz de satisfacer las necesidades metabólicas urbanas del agua mientras proporciona una pequeña reserva de agua almacenada. La estabilidad del agua lluvia es sin duda un problema debido a las fuertes variaciones mensuales, incluso en años de condiciones climáticas típicas. Esto implica que los desafíos en el abastecimiento de agua en Palomino no pueden ser resueltos únicamente con la recolección de agua lluvia y que esta técnica debe ser utilizada como una fuente de agua complementaria para aumentar la resiliencia del sistema de agua.

Uno de los resultados más significativos es que la metodología aplicada demostró ser exitosa en términos de entender sistemas de agua - no por medio del enfoque tradicional de modelos basado en valores medios (promedios) sino a través de escenarios que explican las variaciones y dinámicas en los sistemas de agua. Los cambios en el UWM se analizan entonces mediante el uso de señales (por ejemplo, valores positivos y negativos) para determinar los cambios metabólicos y las necesidades de agua de los sistemas urbanos. Esta metodología podría aplicarse en un contexto más amplio, especialmente en países en desarrollo que disponen de datos limitados para llevar a cabo un análisis estadístico.

Palabras clave: Metabolismo Urbano (UM), Metabolismo Urbano del Agua (UWM), Análisis de Flujo de Materiales (MFA), Sistema de Gestión Sostenible Urbano del Agua (SUWMS), Recolección de Agua Lluvia, Ubicaciones con Limitaciones de Datos, Ecología Industrial.

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This thesis is largely dedicated to the community of Palomino for giving me inspiration and reason to strive for what I believe is important; without these beautiful people it all might seem inconsequential.

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List of Acronyms and Abbreviations

DPS	Departamento para la Prosperidad Social
HWTS	Household water treatment and safe storage
IDEAM	Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia
IT	Information Technology
IWA	International Water Association
IWRM	Integrated Water Resources Management
GIS	Geographical Information Systems
GPS	Global Positioning Systems
GWP	Global Water Partnership
m.a.s.l.	Meters above sea level
MDGs	Millennium Development Goals
MFA	Material Flow Analysis
MPA	Methodology for Participatory Assessment
NNP	National Natural Park
PEI	Programa de Estudios Internacionales
PNUD	Programa de las Naciones Unidas para el Desarrollo
SES	Social Ecological Systems
SISBEN	Sistema de Identificación de Potenciales Beneficiarios de Programas Sociales
SDGs	Sustainable Development Goals
SUWMS	Sustainable Urban Water Management System
UWM	Urban Water Metabolism
WASH	Water, Sanitation and Hygiene
WDS	Water Distribution System
WHO	World Health Organization
WTP	Water Treatment Plant
WRM	Water Resources Management

Glossary

Basic drinking-water:
"Basic drinking-water systems include water supply through low-cost technologies, such as hand pumps, spring catchment, gravity-fed systems, rainwater collection, storage tanks and small distribution systems."[2]

Basic sanitation:
"Basic sanitation systems include sanitation through low-cost technologies such as latrines, small-bore sewers and on-site disposal (e.g. septic tanks)."[3]

Blackwater:
"Human body waste discharge either direct to a vault toilet, or through a flush toilet and/or urinal."[4]

Drought:
"The naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems."[5]

Ecosystem services:
"The benefits derived from ecosystems, including provisioning, regulating, cultural functions, and supporting services."[6]

Escherichia coliform (E. coli):
"One of the species of bacteria in the coliform group. Its presence is considered indicative of fresh fecal contamination."[7]

Greywater:
"Water from the kitchen, bath and/or laundry which, generally, does not contain significant concentrations of excreta"[8]

Groundwater:
"Freshwater beneath the earth's surface (usually in aquifers) supplying wells and springs."[9]

Integrated Water Resources Management:
"IWRMS is a process which promotes the co-ordinate development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem."[10]

Non-revenue water:
"Non-revenue water represents water that has been produced and is 'lost' before it reaches the customer (either through leaks, through theft, or through legal usage for which no payment is made)."[11]

Pathogens:
"Micro-organism that are potentially disease-causing; these include bacteria, protozoa and viruses."[12]

Sanitation:
"The provision of facilities for the safe disposal of human excreta. It refers to the safe management of excreta from collection, emptying, transport, treatment and disposal or reuse."[13]

Social-Ecological Systems:
"Social-ecological systems are complex, integrated systems in which humans are part of nature."[14]

"An integrated system of ecosystems and human society with reciprocal feedbacks and interdependence. The concept emphasizes the 'Humans-in-nature' perspective."[15]

[2] (WHO, 2014, p. 64)
[3] (WHO, 2014, p. 64)
[4] (Ferguson, Dakers, & Gunn, 2003, p. 125)
[5] (WWAP, 2012, p. 373)
[6] (Resilience Alliance, 2010, p. 51)
[7] (Ferguson, Dakers, & Gunn, 2003, p. 127)
[8] (WHO, Sanitation safety planning: Manual for safe use and disposal of wastewater, greywater and excreta, 2016, p. ix)
[9] (Corcoran, et al., 2010, p. 77)
[10] (Global Water Partnership (GWP), 2000, p. 22)
[11] (WHO, 2014, p. 65)
[12] (Ferguson, Dakers, & Gunn, 2003, p. 129)
[13] (WHO, 2015, p. 28)
[14] (Berkes & Folke, 1998)
[15] (Resilience Alliance, 2010, p. 52)

Stromwater:
"Rainwater run-off from impervious surfaces (roofs, roads, driveways, paths, parking lots and ground surfaces)."[16]

Sustainable Urban Water Management System:
'A system that includes the technical processes of collection, treatment and distribution of water, wastewater and stormwater. As well as the social engagement, environmental awareness and education of the community to guarantee the right of present and future generations to safe and clean water; while striving towards the conservation of ecosystem services, human well-being and minimization of the use of natural and economic resources.'[17]

Urban Metabolism (UM):
"The sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy, and elimination of waste."[18]

Urban Water Metabolism (UWM):
"Urban water metabolism can be understood by analysis of metabolic flux and structure, social economic factors and driving mechanisms, and this analysis can assist identification of the water metabolism capacity bottlenecks which constrain city expansion and development, and identification of adapting mechanisms to cope with pollution, drought and flooding."[19]

Vector-borne disease:
"Diseases (e.g. malaria, leishmaniasis) that can be transmitted from human to human via insect vectors (e.g. mosquitos, flies)."[20]

Wastewater:
"Contaminated water from domestic, commercial and industrial activities"[21]

Water quantity:
"Provision of facilities and services that increase the amount of water available for drinking, cooking and maintaining good hygiene practices within households, health care facilities or school; and reduce the time and effort required to collect the water."[22]

Water quality:
"The physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose."[23]

"Improvement and protection of the microbiological (or chemical, such as arsenic) quality of drinking-water through water treatment and safe storage or by improving existing water sources to protect them from outside contamination."[24]

Water supply:
"The provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes."[25]

Water stress:
"The symptomatic consequence of water scarcity (physical or economical), which may manifest itself as increasing conflict very sectoral usage, a decline in service levels, crop failure, food insecurity and so forth. It is often measured by the extent of the difference between supply and demand."[26]

[16] (Ferguson, Dakers, & Gunn, 2003, p. 130)
[17] Own definition. Refer to Part IV of the present research
[18] (Kennedy, Cuddihy, & Engel-Yan, 2007, p. 44)
[19] (Huang, Vause, Ma, & Yu, 2013, p. 20)
[20] (WHO, Sanitation safety planning: Manual for safe use and disposal of wastewater, greywater and excreta, 2016, p. xi)
[21] (Ferguson, Dakers, & Gunn, 2003, p. 131)
[22] (WHO, 2015, p. 4)
[23] (WWAP, 2012, p. 379)
[24] (WHO, 2015, p. 4)
[25] (WHO, 2015, p. 28)
[26] (WWAP, 2012, p. 379)

Glossary and terminology for Material Flow Analysis (MFA)

Material Flow Analysis (MFA):
"Material flow analysis (MFA) is the systematic assessment of the flows and stocks of materials within a system defined in space and time."[27]

Good:
"Goods are defined as economic entities of matter with a positive or negative value (e.g. drinking water, fuel oil, and solid waste, sewage, respectively). Some goods have no economic value, i.e., they are neutral in their values, such as air, exhaust or precipitation."[28]

Material:
"The term material serves as an umbrella term for both substances and goods."[29]

"It includes raw materials as well as all physically or chemically modified substances. The term material is used in cases of looking at goods and substances, or when it is not yet clear at which level (goods or substances) an analysis will take place."[30]

Process:
"A process is defined as the transformation, transport, or storage of goods and substances. Processes are: the metabolism of a city, human, or animal; an activity in a household (e.g. waste separation), or plant (e.g. waste incineration furnace, paper mill, landfill); an activity in an environmental medium (e.g. atmosphere, hydrosphere, or soil); a service (e.g. collection of residual waste). *Usually, processes are defined as black box processes, meaning that processes within the box are not taken into account. Only the inputs and outputs are of interest.*"[31]

Stock:
"The total amount of materials stored in a process is designated as the stock of materials."[32]

Flow:
"A flow is defined as a "mass flow rate". This is the ratio of mass per time that flows through a conductor, e.g., a water pipe. The physical unit of a flow might be given in units of kg/sec or t/year."[33]

System:
"A system is the actual object of an MFA investigation. A system is defined by a group of elements, and the interaction between these elements, and the boundaries between these and other elements in space and time. It is a group of physical components connected or related in such a manner as to form and/or act as an entire unit."[34]

System boundary:
"The system boundaries are defined in time and space (temporal and spatial system boundaries). Commonly applied temporal boundaries for anthropogenic systems such as an enterprise, a city, or a nation, periods of 1 year are chosen for reasons of data availability. The spatial system boundary is usually fixed by the geographical area in which the processes are located. Flows into a system are called imports, flows leaving a system are exports."[35]

Transfer coefficient:
"The transfer coefficient TCx,j describes the partitioning of a material (good or substance) x within a process, and it's transfer into a specific output flow j."[36]

[27] (Brunner & Rechberger, 2004, p. 3)
[28] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, p. 5)
[29] (Brunner & Rechberger, 2004, p. 37)
[30] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, p. 5)
[31] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, pp. 5,6)
[32] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, p. 6)
[33] (Brunner & Rechberger, 2004, p. 39)
[34] (Brunner & Rechberger, 2004, p. 43)
[35] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, p. 6)
[36] (Vienna University of Technology. Institute for Water Quality Resources and Waste Management, 2012, p. 7)

Part I: Introduction

"No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all."
Kofi Annan
Former UN Secretary-General
Nobel Peace Prize 2001

1.1 Background

1.1.1 Cities and water in a global context

Water has become a scarce resource, and while some take for granted a steady supply of clean and safe drinking water, others—mainly in developing countries—struggle with drought and water borne diseases. Cities and countries must adapt to increases in population, and as consequence, they often struggle to cope with rising demand to supply and treat the water needed to satisfy each citizen's consumption. The absence of proper treatment before the disposal of wastewater increasingly threatens the conservation of water bodies and freshwater reserves by constantly impacting the natural environment. Globally each year, we discharge 2 million tons of untreated wastewater, produced predominantly by industrial, agriculture activities and sewage (Corcoran, et al., 2010) (Gleick & Ajami, 2014).

Currently, forty percent of the global population is affected by water scarcity. This is defined not only the absence of water resources, but also the inadequate infrastructure and/or lack of governance to ensure the supply of quality water wherever is required (United Nations, 2015). Immediate action is crucial to address this problem, as it is predicted that new levels of water stress derived from overwhelming increasing demands could push the global water supply up to 40 percent beyond its sustainable capacity by 2030 (World Economic Forum, 2015).

Though cities are the center of many problems, they have the potential to become hubs for sustainable solutions and innovations. Their growth is inevitable; by 2050, the world's population is forecasted to increase from 7 billion to 9 billion people, with potentially 70% living in urban areas. In particular, Latin American countries are among the most urbanized in the world—in 2010, 72% of the population in Latin America lived in cities (Ranhagen & Groth, 2012). These indicators underscore both the urgency and opportunity for tackling problems of water scarcity in Colombia, as around the world.

1.1.2 Water in the Colombian context

Over the past 15 years, Colombia has made considerable efforts to achieve the United Nations Millennium Development Goals (MDGs) and, despite not accomplishing all eight goals, its performance was one of the best in Latin America. By the year of 2015, 81% of the population of Colombia (an estimated 48 million people) had accesses to sanitation, and 88% had access to potable water (World Bank, 2015). Despite these positive markers, heterogeneous development remains one of the country's chief development-related obstacles, characterized by stark gaps in economic inequality between urban and rural areas. In Colombia, one in every four citizens is affected by poverty in urban areas, while one in two are affected by poverty in rural areas. The same applies to access to drinking water and sanitation. While access to drinking water in urban areas is near 97%, some rural areas do not reach even 50%. Access to sanitation in urban areas is nearly 90%, while the coverage rate in rural areas is close to 70%, with some of the most vulnerable Departments (e.g. La Guajira and Chocó) satisfying their population's needs by less than 50%.

This wide gap between urban and rural areas contributes to Colombia being one of the ten most unequal countries in the world (PNUD, 2015).

The year 2015 stands as the year of culmination for the Millennium Development Goals (MDGs), and opens the chapter of the Sustainable Development Goals (SDGs), a period of 15 years to pursue more inclusive and integrated goals towards a sustainable development, democratic governance, and climate resilience. The SDGs include a total of 17 goals, including one specifically for clean water and sanitation (Goal 6). Among others, targets for this goals include access to safe and affordable drinking water, access to proper sanitation and hygiene, guaranteed quality and preservation of natural ecosystems, and the implementation of programs for integrated water resource management, including water reuse and treatment of waste water (UN, 2015). If Colombia is to accomplish this goal, it must reduce the existing inequality between urban and rural areas by immediately focusing its efforts on the rural areas of the country. The challenge of these goals is enormous; rapid integration between national policies and action plans at the municipalities and local levels should be a priority in order to accomplish the SDGs by 2030.

1.1.3 Understanding water in the context of complex social-ecological systems: The need for a systems thinking approach

Water management in urban areas is a complex challenge, one that requires a new perspective of understanding: an integrated, holistic approach, rather than conventional causality analysis. The functionality of cities is dependent on a multitude of dimensions and structures (infrastructure, spatial and resource distribution, social-economic conditions, cultural dimensions, existing social networks and links, etc.) (Bettencourt, 2013). When examining these factors and interactions, a constant dynamic and different networks that outline the system's complexity becomes immediately apparent: "Cities are complex systems whose infrastructure, economic and social components are strongly interrelated and therefore difficult to understand in isolation." (West & Bettencourt, 2010, p. 912).

It is important to understand that problems in complex systems cannot be addressed by deconstructing the problem with simple cause-and-effect analysis and isolation of parts and bits of the system by deconstruction of the problem. Rather, a deep understanding of complex systems requires a systems thinking approach that reflects the interdependent nature of the factors at play (Aronson, 1999). In this regard, this research will be framed by the concept of *social-ecological systems,* defined as, "a commitment to adopt a holistic, systemic perspective towards human and non-human elements of a problem situation of interest." (Hilliday & Glaser, 2011, p. 1).

Social-ecological systems represents the complex environment in which human are embedded in nature, this system is the setup in which societies interact. We are bound to nature and nature is bound to us by constant reciprocal feedbacks. There are several definitions for complex social-ecological systems and it can be argued that it is still a 'working definition', nonetheless, the key characteristics of these systems that will be consider for this research are: complex systems, human are embedded in natural systems, systems with interdependencies (e.g. social-ecological interdependencies) and feedback loops (Resilience Alliance, 2010).

Finally, in order to emphasize on the need of a systems thinking approach in urban water management it is worth mentioning some of the interdependencies that are found in water systems. They are the link between demand and water resources, communities' lifestyle, population dynamics, infrastructure,

spatial and resource distribution, variability on time-space scale, water needs and requirements, water uses (e.g. drinking water, irrigation, industrial), along with hydrological conditions (Savenije, Hoekstra, & van der Zaag, 2014). Using a systems thinking approach characteristic of the Industrial Ecology discipline will allow us to understand sustainable urban water management systems in the context of complex social-ecological systems, and help us to identify interconnected solutions for water problems in urban areas.

1.2 Research Design

1.2.1 Problem Statement

Currently, the town Palomino, Colombia, deals with water scarcity and, potentially, groundwater contamination due to wastewater infiltration. The lack of an integrated water resources management, along with a poor infrastructure and governance, threatens a safe drinking water supply, sustainable solutions for wastewater disposal, and the preservation of ecosystem services. The town's largest industry is tourism, accounting for a seasonal increase of the local population by one third. This increased seasonal demand places additional water stress on the region, and poses a new challenge to overcome in addition to continual problems.

1.2.2 Aim and objectives of the research

The aim of this research is to contribute to the understanding of urban water systems making use of material flow analysis under the urban metabolism (UM) framework. In addition to define and provide potential solutions for a sustainable urban water management system (SUWMS) providing an industrial ecology perspective, wherein the system is analyzed using a holistic, system thinking approach.

Objectives:

1. Provide a deep understanding and detailed analysis on the characteristic of the current urban water management system.
2. Develop an urban water metabolism model for Palomino in order to identify critical water flows.
3. Provide a first approach towards a SUWMS based on an industrial ecology perspective where the system is analyzed using a holistic, system thinking approach that enables synergies between different urban clusters and functions.
4. Make use of the urban water metabolism (UWM) model to assess the potential of a sustainable water technology to determine changes in the current UWM of Palomino and identify possible material benefits.
5. Identify the opportunities and constrains for a system shift from the current water system to a SUWMS.

1.2.3 Research Questions

The following research questions will guide the approach and structure of this masters thesis research in order to fulfil the aforementioned objectives.

Primary research question:

What are the main barriers and opportunities for the implementation of a sustainable urban water management system in Palomino?

Research sub-questions:

1. *What are the main qualitative and quantitative characteristics of the current urban water management system?*
2. *How can the current urban water metabolism best be represented with a conceptual model?*
3. *Which are the critical water flows of the current urban water metabolism in Palomino?*
4. *How could sustainable urban water management system (SUWMS) be defined?*
5. *Which technologies and initiatives are applicable in this local context for a sustainable urban water management system?*
6. *Which technology could potentially address the critical water flows of the current UWM?*
7. *How would this technology affect the UWM of the current system for a critical scenario?*

1.2.4 System Boundary

1.2.4.1 Study Area

The area under research is the town of Palomino, located on the Caribbean Coast of northern Colombia, at the foothill of the highest mountain peak of the country, the Sierra Nevada de Santa Marta.

Palomino is one of five townships in the municipality of Dibulla, in the Department of La Guajira. Figure 1 illustrates the geographical location of Palomino (in yellow) on different scales: Global, Continental, Departmental, and in terms of distance relative to other main townships and cities.

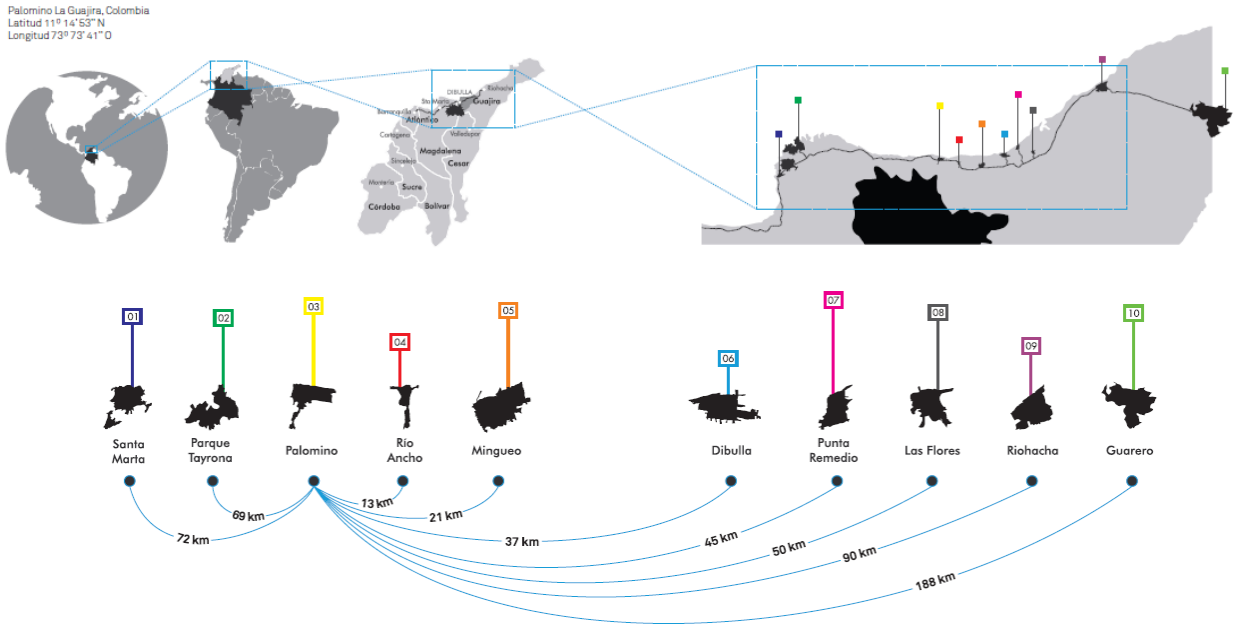


Figure 1: Geographical location of Palomino, Colombia (Palomino Cultural, 2011, pp. 24,25).

Using Google Earth as a GIS tool, a polygon was created to limit the system boundary of the area under study. Figure 2 illustrates the system boundary (in red), including the main features of the water system infrastructure (water wells, storage tanks, and the Palomino River), as well as the two principal sites where actors are located, namely the *urban settlement* and the *recreational and touristic sector*.
The system boundary corresponds to a total area of *4.83 km^2*.

Figure 2: Geographical location of the system boundary (Image Google Earth 2013; own figure).

1.2.4.2 Time Frame

The analysis of this research is conducted for the year of 2015, since the field research and, therefore, the primary data available is from that year.

1.2.5 Field research and data acquisition

One of the main challenges of choosing a case of study in Palomino is the lack of available information. Dealing with a data-poor location dictates the necessity of field research in order to acquire primary data, obtain interviews, and explore the area under study. For this masters thesis, the field research was conducted from September 11, 2015 until September 28, 2016 with the close collaboration of Carlos Hernandez Correra, Director of the International Studies Program (PEI) at the Javeriana University, in Bogota, Colombia, and of the El Matuy Natural Reserve, in Palomino, Colombia. Both parties provided valuable information and support by facilitating communication with local authorities and multiple keys actors from the community.

The methods followed to conduct the field research are based on semi-structured interviews, primary data collection by survey processes, mapping, and observation. These methods were targeted at participatory approaches, wherein the community and key actors were directly involved in the assessment process. Overall, the field research was performed under the following principle:

"Water users are experts – The local community is a valuable source of information and their knowledge should be fully utilized. Water users are as important as water specialists or consultants when it comes to providing information about water resources." (Philip, et al., 2008, p. 38).

1. **Semi-structured interviews:**

Semi-structured interviews are used to gather qualitative information about a specific topic. Background questions were prepared ahead of time to direct the conversation towards useful answers, opinions and/or perceptions on the problem that is under research. The interview is flexible enough to allow the interviewee to express freely their concerns (Laforest, 2009).

Twenty semi-structured interviews were conducted for the purpose of gathering information and perceptions about the current water management system in Palomino. In order to obtain a wide range of viewpoints and insights regarding the water problems that affect the community and water user, a large variety of actors were chosen. The actors can be roughly divided into the following categories: water users, local authorities, water experts, community leaders and school coordinators.

All interviews were executed in Spanish and recorded for subsequent translation. The corresponding transcripts of the interviews can be found under Appendix C. The list of the persons interviewed for this research is provided under Table1.

Table1: Persons interviewed for this research

Name	Short Description	Location	Coordinates (only if applicable)		Date
			N	W	
Arq. Carlos Hernandez	Director of PEI, Javeriana University	Bogota D.C	-	-	11.09.2015
Silvia Amado	Architecture Student	Bogota D.C	-	-	11.09.2015
Gregorio Rojas	Graduate student of Industrial Design	Bogota D.C	-	-	14.09.2015
Esteban	Artist	Palomino	-	-	15.09.2015
Abelaido and Deiner	Primary School Students	Palomino	-	-	15.09.2015
Dionisio	Fisherman	Palomino	-	-	16.09.2015
Orfelina	DPS employee	Palomino	11°14'44.51"	73°33'44.06"	17.09.2015
Adriana Mariño	Local Farmer	Palomino	11°14'45.82"	73°33'30.96"	17.09.2015
Mara Zambrano	Homemaker	Palomino	11°14'44.35"	73°33'27.71"	17.09.2015
Idalnis Móvil	Inspector	Palomino	11°14'45.16"	73°33'41.71"	17.09.2015
Geovannys Marbello	Employee, Aguas de Dibulla	Dibulla	-	-	18.09.2015
Oscar Redondo	Functionary, SISBEN	Dibulla	-	-	18.09.2015
Bacilia	Homemaker	Palomino	11°14'28.98"	73°33'41.37"	18.09.2015
Juan de Dios	Farmer	Palomino	11°14'25.17"	73°33'38.82"	18.09.2015
Johana	Preschool Coordinator, Hogar de Primera Infancia	Palomino	11°14'43.63"	73°33"24.88"	23.09.2015
Ir. Edgar Uribe Schroeder	Civil Engineer	Bogotá D.C	-	-	25.09.2015
Angel Pinto	Primary and Secondary School Coordinator	Palomino	11°14'44.88"	73°33'42.01"	28.09.2015
Edinson Rivadeneira	Operator, Palomino Aqueduct	Palomino	-	-	28.12.2015

2. Surveys:

Different survey formats were created specifically for the actor to whom they were addressed. The surveys were designed for the collection of key primary data, which would contribute, from a community perspective, to the understanding of the water system and social conditions in Palomino. To elaborate the surveys, three references were chosen; each contributed with a methodology that served as a guideline for participatory approaches. Table 2 shows the information regarding each reference. It presents detailed information concerning the key aspect of each methodology and the tools or abstract that were used.

Table 2: References used to elaborate the surveys

Reference	Key Aspect	Abstract/Tool	Page
The best of two worlds? Methodology for Participatory Assessment (MPA) of community water services (2001). Wijk-Sijbesma, C.A. van. IRC.	A methodology for the assessment of community water services with emphasis on the analysis of gender and poverty issues.	Table 10: Variables, sub-variables, and indicators of the MPA. Relevant variables: Variable A – Sustained Service Variable B – Effective Use Variable C – Demand-responsive Projects	117
Keep it working: a field manual to support community management of rural water supplies (2001). Bolt, E., Fonseca, C.. IRC.	This manual offers fact sheets from different aspects of community management of rural water services, as well as related tools and checklists for analysis. It serves as a guideline for strategic fieldwork with the community.	Fact sheet: 6) Identifying problems and resources with the community. 8) The meaning of 'management' and management arrangements Checklist: 4) Indicators to assess water availability in the community. 5) Indicators to assess water transport, storage, treatment and waste practices. 6) Identification of burdens and health risks. 7) Selection of water source.	35 36 39-41 145-151
Appropriate Technology for Water Supply and Sanitation. Sociocultural Aspects of Water Supply and Excreta Disposal (1980). Elmendorf, M and Buckles, P. World Bank.	This report provides a study on social and cultural aspects related to people's responses to different appropriate technologies for water supply and wastewater disposal.	Annex A: World Bank Research Project 671-46: Sociological Questionnaire on water supply, wastewater, and excreta disposal.	55

Figure 3 synthesizes the general survey process. It specifies how many surveys were interviewed per actor and the main features of the content of each survey. Surveys per Households, Hotels, and Stores and Commerce can be found under Appendix D, E and F correspondently.

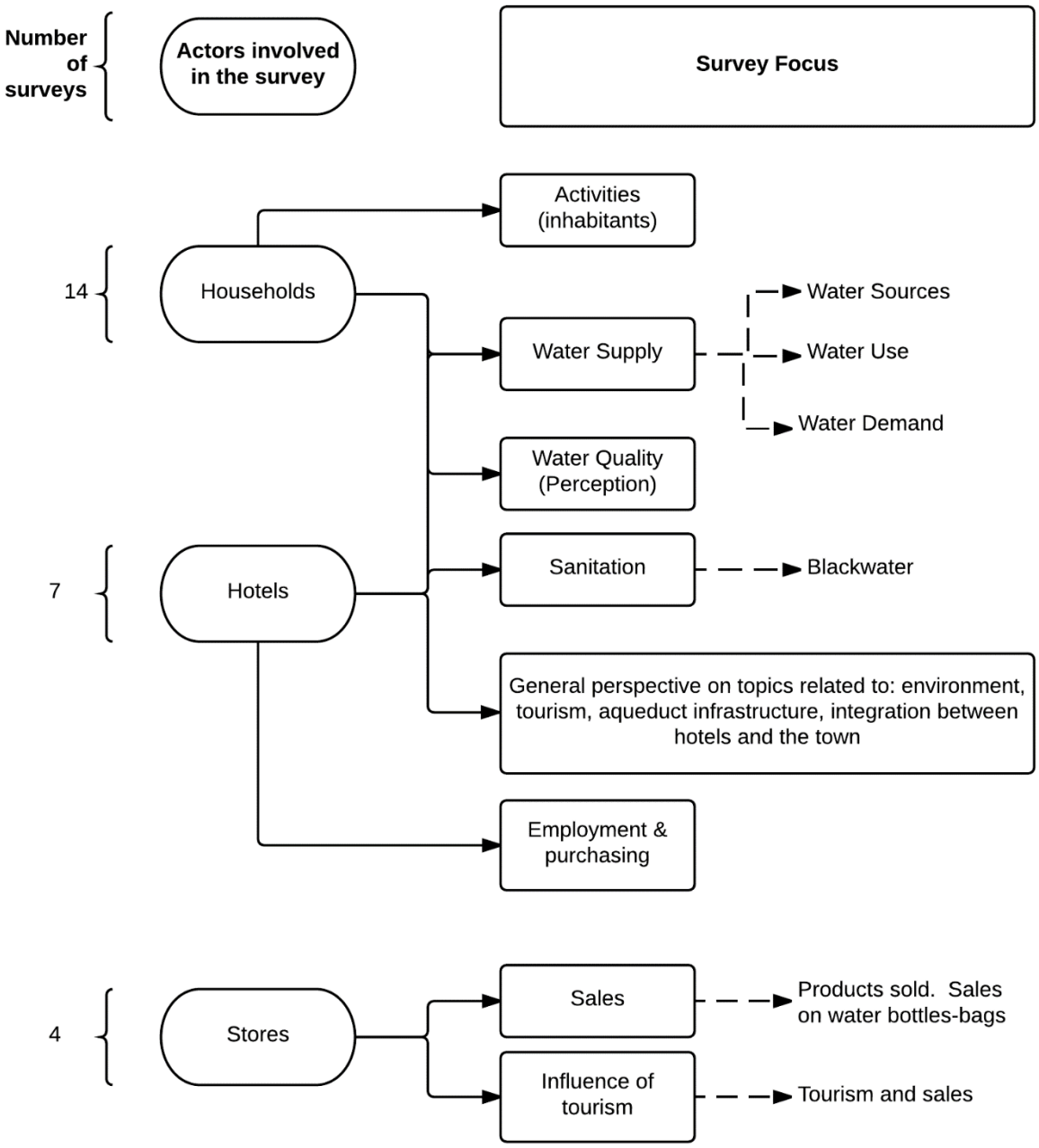


Figure 3: General survey process.

3. Mapping and observations:

An important part of the field research was based on field observations, which helped to create an overview of the system and the local conditions. Mapping key aspects of the water system was also crucial, since there is no cartography available, nor any blueprints that specified the system's infrastructure, in Palomino. Using the Global Positioning System (GPS) incorporated in the application of Google Earth, the main infrastructure and technical devices were able to be spatially defined. In the same manner, the interviews and surveys performed were georeferenced in order to obtain insights on spatial-related problems (for example: which areas of the town have no access to the water supply, is this a common feature in this area, or is it an individual problem?). Figure 4 gives an overview of the spatial distribution of the surveys and interviews made in Palomino during the field research. As is evident from the map below, the household surveys were performed across a wide area, since the aim was to collect data that was, to the extent possible, representative of the entire community.

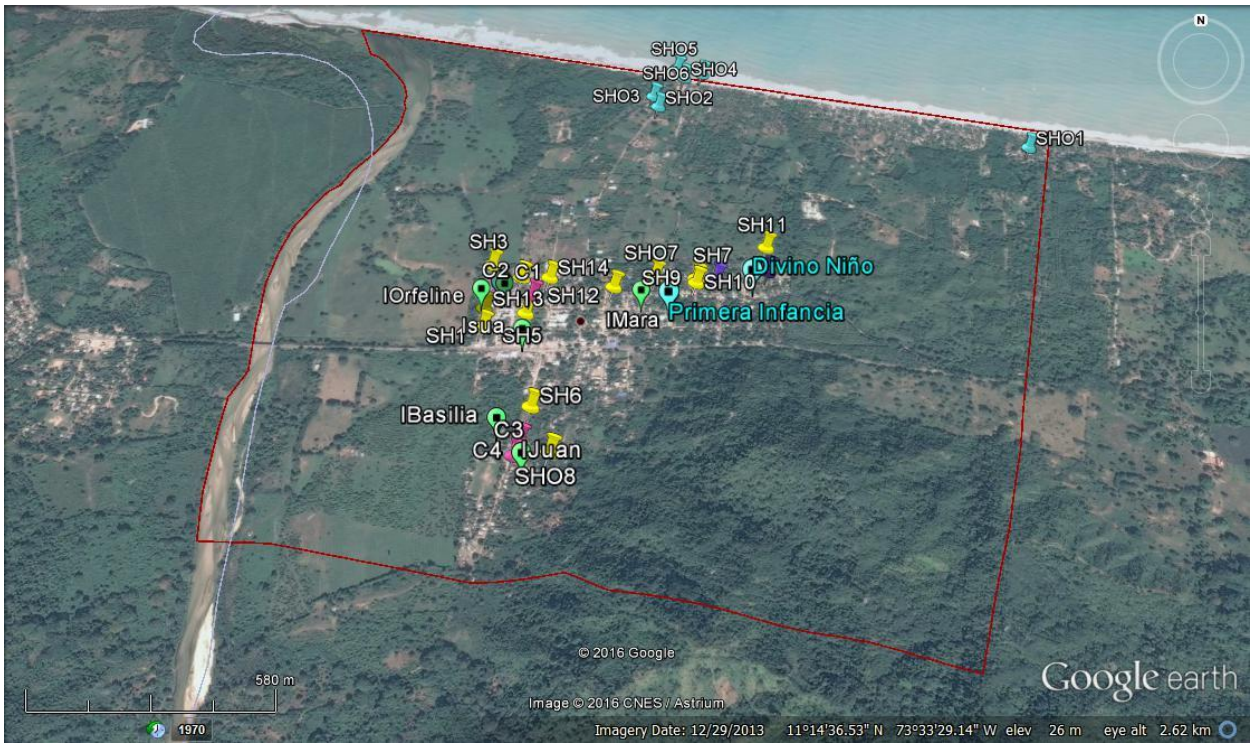


Figure 4: Surveys and interviews location overview. (Image Google Earth 2013; own figure).

1.2.6 Research design

This masters thesis consists of five parts or chapters, each designed to address one or more research sub-questions. *Part V: Discussion and Conclusions* will ultimately answer the primary research question. Figure 5 is a schematic visualization of the research outline followed throughout this report.

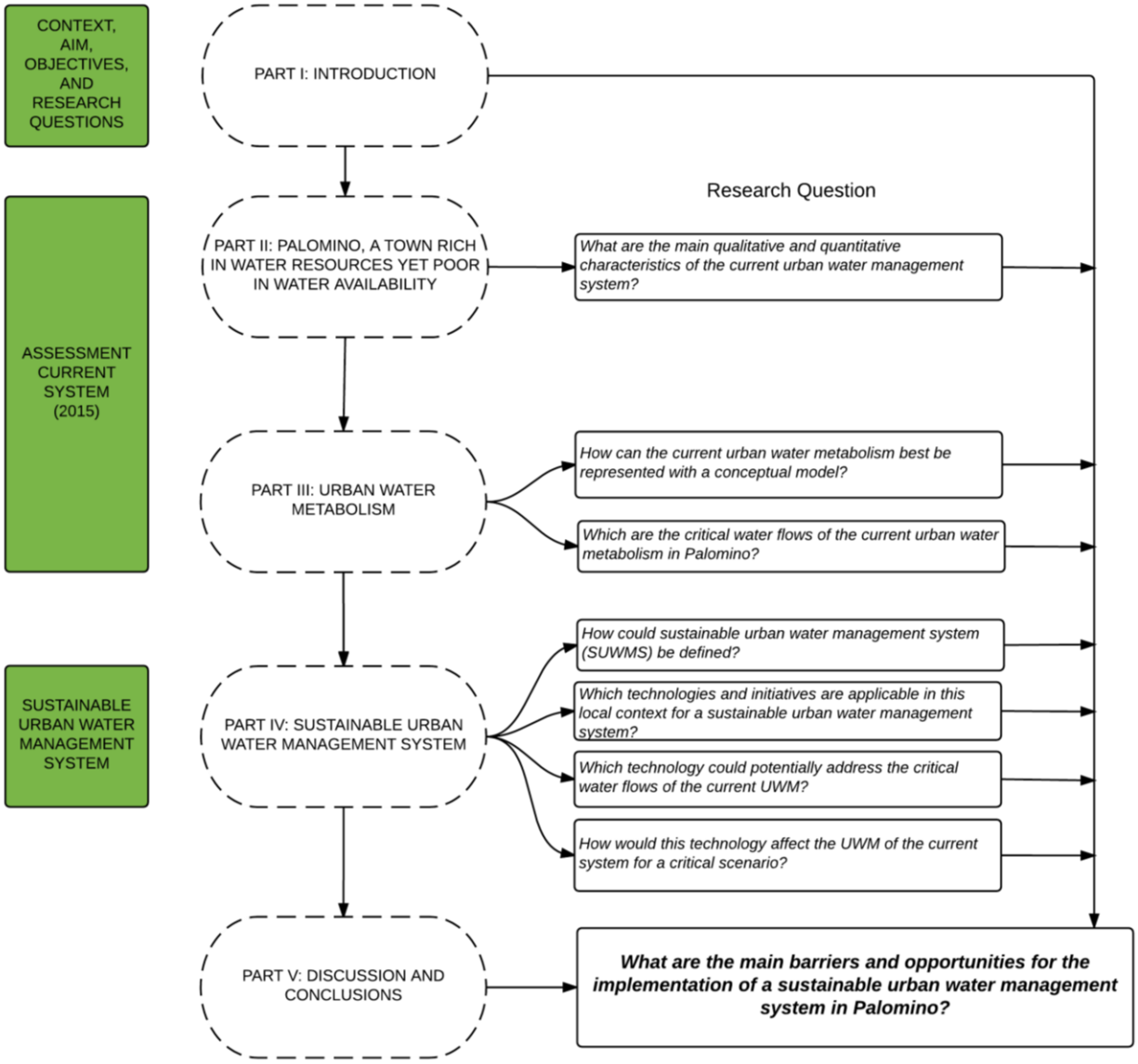


Figure 5: Outline of the research for this masters thesis.

Part II: Palomino, a town rich in water resources yet poor in water availability

"Macondo, más que un lugar en el mundo es un estado de ánimo"[37]
Gabriel García Marquez
Nobel Prize in Literature 1982

This chapter presents the baseline study for Palomino. It details the social, economic, and environmental aspects of the town, in order to identify and analyze the key qualitative and quantitative features of the urban water management system in the study area.

The research makes use of methods implemented during the field research, information gathered through semi-structure interviews, survey processes, mapping, and field observations—all in order to conduct a detailed analysis that covers the different levels, scales, and actors of the water system. This chapter will address the following research sub-question in the range from technical systems and management tactics at a household level up to centralized systems:

1. *What are the main qualitative and quantitative characteristics of the current urban water management system?*

2.1 General context of Palomino

2.1.1 The municipality of Dibulla

The municipality of Dibulla is comprised of five townships: Las Flores, La Punta de los Remedios, Mingueo, Río Ancho, and Palomino. These make up an area of 1744 km^2, out of which 7054km^2 or 55% are indigenous territories (mainly from the communities Kogui, Wiwa, and Arguaco). The population of Dibulla is estimated at 29,446 inhabitants in 2011, with 62% of the population under the age of 27. The level of poverty in the municipality is high, with the number of people having 'unsatisfied basic needs'[38] at 66% above the national level; the municipality also presents a high level of internal displacement. Furthermore, 14% of Dibulla's adult population are illiterate, while only 52% have a primary education (Alcaldía Municipal de Dibulla, 2015).

2.1.2 Urban structure

Palomino presents a linear layout; it is divided by the highway *Troncal del Caribe*, which connects the main cities of Santa Marta and Riohacha. As Figure 6 illustrates, the urban structure is characterized by an orthogonal grid pattern, as is typical of many Colombian coastal towns.

[37] "Macondo, more than a place in the world is state of mind."
[38] The index is assess by measuring specific indicators on the living conditions of the population (e.g., access to education, access to WASH services, economic capacity, etc.)For more information visit the following link (Spanish) http://www.dane.gov.co/index.php/estadisticas-sociales/necesidades-basicas-insatisfechas-nbi

Figure 6: Palomino's urban structure. Based on the cartography from 2002[39].

Palomino extends North towards the Caribbean Sea and South of the Troncal del Caribe highway. The town has an elongated shape with a secondary road to access the Sierra Nevada Mountain. The indigenous people who live in the Sierra Nevada use the road to reach the sea for ritual proposes, or to enter the urban area of Palomino for commercial exchange. The tourism sector uses this road to access the river on the upper side of the mountain, for the recreational activity of tubing (Observation, September 17, 2015).

The urban growth of Palomino has been characterized by a lack of urban planning and relative rapid expansion. In 1980, the construction of the Troncal del Caribe highway boosted local commercial activity. This phenomenon was accelerated in the 1990's and early 2000's, when, under the control of paramilitary forces, the town saw rapid expansion of informal settlements, due to the high level of internal displaced in the region (República de Colombia & PEI, 2011) (Mariño, A., personal interview, September 17, 2015).

2.1.2 Climate

The climate of Palomino is characterized by its proximity to the sea, with average elevation of 20 meters above sea level, and its location near the foothill of the *Sierra Nevada de Santa Marta National Natural Park (NNP).* This NNP was declared Biosphere Reserve by the UNESCO in 1979 and it has the highest coastal mountain in the world with an altitude of 5775 meters above sea level (Parques Nacionales Naturales de Colombia, 2015).

Palomino has only two water monitoring stations: one to record the levels of precipitation, and one to measure the discharge of the River Palomino. The two nearest climate stations are the Tayrona and the Dibulla stations, due to their close proximity and available information, they will be used as an approximation to assess the climate conditions in Palomino. Figure 7 indicates the geographical locations

[39] For the original cartography refer to Appendix B. The original cartography was obtained during field research on Friday 18, September 2015 at the Department of Planning and Development, Municipality of Dibulla. Dibulla, Colombia.

of the previously mentioned stations and their corresponding longitude and latitude coordinates (IDEAM, 2014).

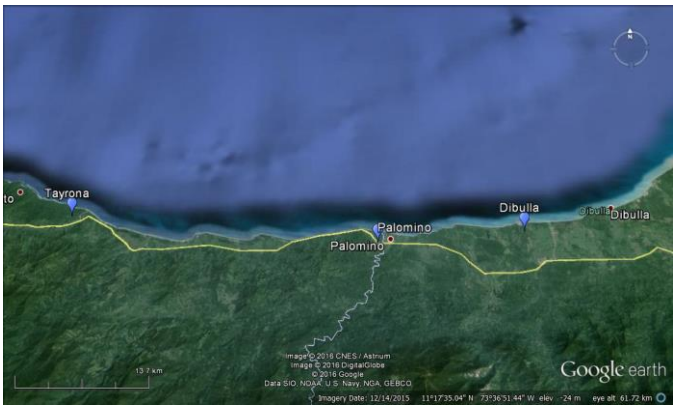


Figure 7: Localization measuring stations. Dibulla [11°16'16.0"N - 73°18'23.0"W], Palomino [11°14'41.0"N - 73°34'24.4"W] and Tayrona [11°17'30.0"N - 73°54'37.0"W]. (Image Google Earth, 2013; own figure).

The approximate distance between the station of Dibulla and Palomino is 17km, and from Tayrona to Palomino is 38km. The following climate characteristics are from the records of the IDEAM (the government-run *Hydrological, Meteorological, and Environmental Studies Institute* in Bogotá), and are displayed according to each climate characteristic as follows:

1. Temperature, Humidity, and Sunshine hours: Stations Dibulla and Tayrona, Average values, Time series 1981-2010.
2. Precipitation: Station Palomino, Time series 1961 – 2006.

1. Temperature, Humidity, and Sunshine hours (Time series 1981-2010)

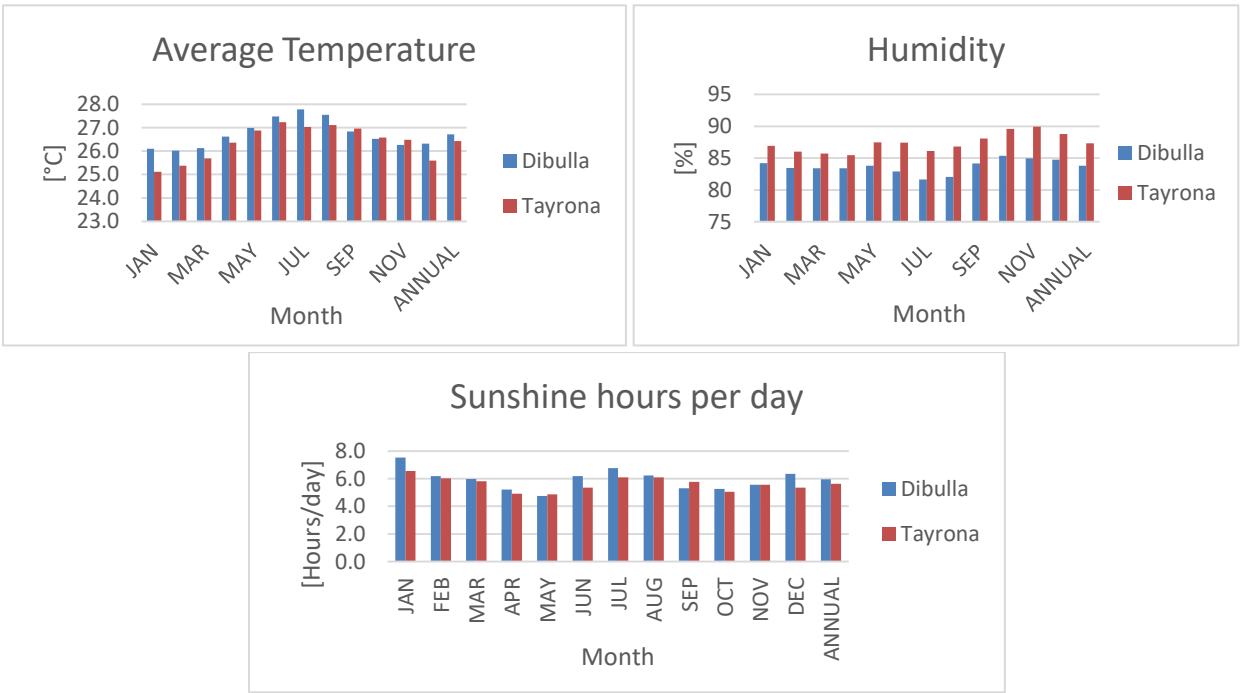


Figure 8: Average Temperature, Humidity, and Sunshine hours. Station Dibulla and Tayrona (1981-2010) (IDEAM, 2014).

2. Precipitation (Time series 1961-2006)

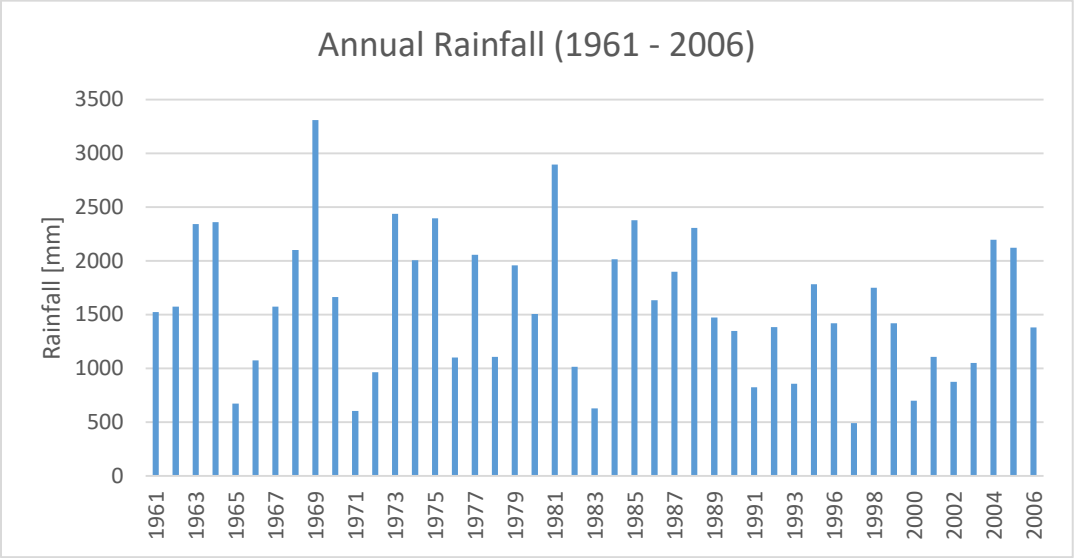


Figure 9: Annual rainfall time series, 1961-2006 (IDEAM, 2015).

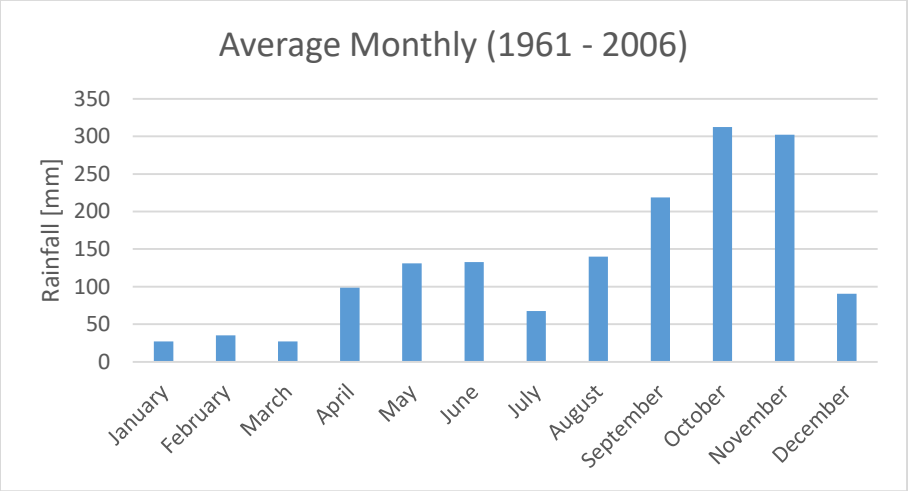


Figure 10: Average monthly rainfall time series, 1961-2006 (IDEAM, 2015).

Evaluating of the graphs above, it can be determined that Palomino presents a tropical humid climate and an average temperature of 26°C throughout the year. The relative humidity is high (between 75-80%), the sun shines a high number of hour per day (between 5 and 7), and the precipitation varies heavily between rainy seasons and dry seasons. Typically, the rainy seasons last from April to June and from September to November. Nonetheless, it is important to emphasize that Colombia is subjected to extreme variations in climate due to phenomena of El Niño and La Niña; these events affect the entire country, and are known to bring about extreme drought and flooding (IDEAM, 2007).

2.1.3 Socio-cultural conditions and population dynamics

Palomino is a town with a high ethnic diversity; the majority of the population is mestizo, followed by afro-Colombians and four main indigenous communities: Kogui, Arhuaco, Wiwa, and Kankuamos (Palomino Cultural, 2011). The social and cultural vulnerability of the community is high due to the low levels of education and high levels of poverty, in addition to the presence of the displaced population from the upper part of the Sierra Nevada. The indigenous communities and 'the civilized' (as they call the western-influenced people) live in relative harmony in the town, although the cultural integration is low. There are no arenas for cultural exchange, nor opportunities for the native *palominenses* to learn the traditional languages of the indigenous communities (Observation, September, 2015). The base population of Palomino was estimated at 2,286 inhabitants[40] in 2015, with high fluctuations during the year caused by tourism; during the peak season for tourism, Palomino experiences an influx of nearly 1,000 tourists (Ramirez Alvarez, 2014). The tourism industry has attracted some foreigners—mainly from Argentina and Peru—seeking job opportunities. The growth of tourism in Palomino has enhanced the ethnic diversity of the town's population (Observation, September, 2015).

2.1.4 Economy

Tourism is indisputably the largest source of income to many families and local businesses in Palomino. The region is currently at a high point for tourism, and new accommodations are steadily being constructed. This uncontrolled and informal growth could create a negative effect once supply surpasses demand. Most of the accommodations found in town are from private investors—typically not from Palomino. Even though the economy is improving, the level of poverty is still high. In addition, a majority of the population (roughly 70%) is small farm holders, their yield produced is mainly for consumption, and little of it is produced for economic gain (Palomino Cultural, 2011).

Despite being a coastal town, fishing is not a strong source the income for families; only artisanal fishing of local species such as: mero, sawfish, and sea bass is found. The local fishermen complain about the recent and sharp decline of the fish population and attribute this reduction to four main factors: the low level of rain, the destruction key ecosystem such as mangroves, the construction of the port 'Buena Vista,' and the industrial fishing in Santa Marta and Mingueo (nearby regions) (Dionisio, personal interview, September 16, 2015).

Another source of income for some families is handicrafts, which they produce in their homes and sell mainly to tourists. A final informal market in Palomino is that of gasoline importation (smuggling), which is incentivized by the low gas prices in Venezuela; in the local market, the price of fuel is ten times lower than in the rest of Colombia, therefore high volumes of gasoline are smuggled each year. (República de Colombia & PEI, 2011).

2.1.5 Health care

Palomino has one health center on the main town square, which serves only for minor treatments and general medical diagnosis. In cases of emergency, patients have to be transported to the only hospital in

[40] Estimation based on the technical report for the optimization of the sewage system in Palomino. The report has been obtained by personal communication with Ir. Rafael Gallardo on September 16, 2015. Program water for La Guajira. Ministry of environment and sustainable development Colombia. Source: (Departamento de La Guajira, 2012).

the municipality, *Santa Teresa de Jesús de Avila,* located in Dibulla at a distance of 37 km. (Alcaldía Municipal de Dibulla, 2015). The health care center does not possess an ambulance, therefore, in emergency medical situations, the patient or the patient's family are forced to find private transport with no medical equipment or personnel, and pay the distance by their own means (Mariño, A., personal interview, September 17, 2015).

The inhabitants of Palomino suffer mainly from vector-borne diseases (chikungunya, dengue fever, and malaria), as well as stomach ache and diarrhea, probably related to waterborne diseases. Cholera has not been present since 1990 (Nurse Palomino, personal communication, September 21, 2015) (Surveys Household – Appendix D).

2.1.6 Public education

On a municipal level, school enrollment is 93% of the eligible population. The percentage of representation for each educational stage is as follow: 39% preschool (ages 3 to 4 and 5 to 6), 15% primary school (ages 7 to 11) and 46% secondary school (ages 12 to 17). According to the national standardized test, *Saber*[41], the level of education is unsatisfactory; teachers are generally not highly qualified, and the investment in Information Technology is insufficient (Alcaldía Municipal de Dibulla, 2015).

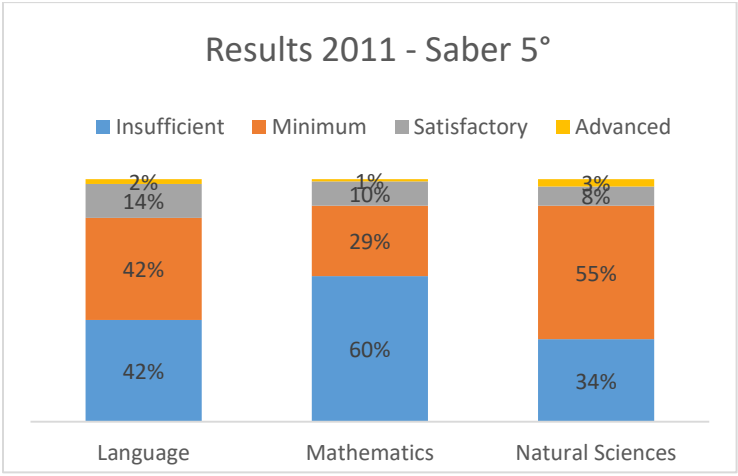


Figure 11: Results 2011 National Test on school education 'Saber 5°' - Fifth grade (Alcaldía Municipal de Dibulla, 2015).

There are three schools in Palomino: *Institución Educativa Rural San Antonio de Palomino,* which hosts primary students in the morning hours (from 7:30-12:30) and secondary students in the afternoons (from 12:35 – 17:30); *Divino Niño* for primary students (sessions in the morning and afternoon); and *Hogar de Primera Infancia* for preschool students. The number of students in primary and secondary school is roughly 500 students; there are 150 children enrolled in preschool (Johana, personal interview, September 23, 2015) (Pinto, A., personal interview, September 28, 2015).

Figure 12 illustrates the location and the geographical coordinates of the schools in Palomino.

[41] This national test is performed to students enrolled on the 3th, 5th, 9th and 11th grade to assess the level of primary and secondary education. For more information visit the following link (Spanish): http://www.mineducacion.gov.co/1759/w3-article-244735.html

Figure 12: Location of schools in Palomino. Institución Educativa Rural San Antonio de Palomino, Hogar de Primera Infancia, and Divino Niño.

2.1.7 Public infrastructure and access to public services

The public infrastructure of the town is in a deteriorated state, the streets have no pavement nor are they leveled; therefore, they commonly have holes and depressions. During the rainy season, the streets become muddy, since there is no proper drainage system. The town has three parks, one church, one police station, three schools, and one health center.

Figure *13* illustrates the statistics from the governmental institution SISBEN[42] (in English, *Identification System for Potential Beneficiaries of Social Programs*) regarding the accessibility to public services in Palomino. The database contains a total of 1706 data, the information is from a time series of 2009 until 2015, therefore no information is available precisely for 2015. The situation has not changed drastically in recent years (according to interviewees); consequently, it can be assumed that this data is a good estimation of the current situation.

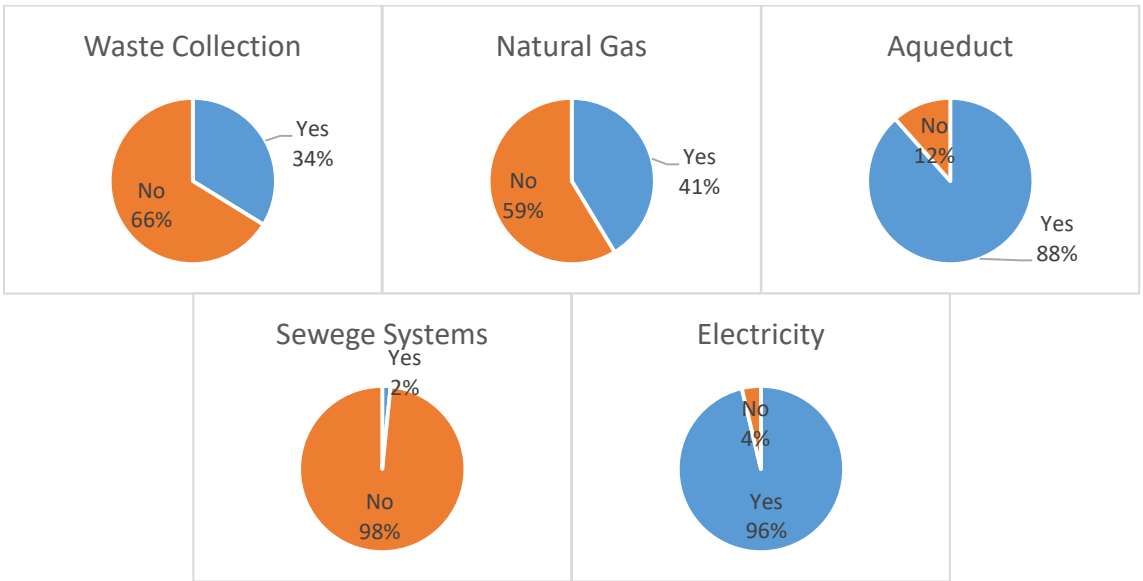


Figure 13: Summary charts of access to public services (SISBEN, 2009-2015).

[42] Refer to Appendix G for more information.

2.2 Water supply in Palomino

2.2.1 Overview on the water supply

The water supply in Palomino is divided into two sets: centralized water supply and decentralized water supply. The centralized water supply is the aqueduct system run by *Aguas de Dibulla*, a governmental institution from the Department of Planning and Development in Dibulla. The decentralized water supply is based on private initiatives: self-reliance (i.e., water taken out directly from the river for consumption), water wells, and rainwater harvesting. On a household level, 100% of people interviewed confirmed to have access to the centralized supply; however, 93% claimed to not receive enough water to satisfy their household activities. On the other hand, the aqueduct service is not regular. It is frequently subjected to malfunctions due to equipment failure and breaks in the electric supply. As a consequence, a mix of centralized and decentralized water supply systems is common in this location.

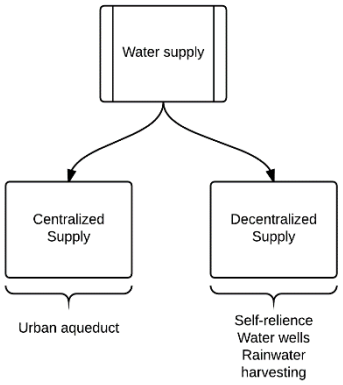


Figure 14: Overview water supply in Palomino.

2.2.2 Water Resources

In Palomino, there are three main water sources available: The Palomino River, groundwater, and rainwater. These water sources can be classified as either constant or variable sources. Constant sources are those always available, despite being influenced by climate conditions. Variable sources, conversely, are those directly affected by the environment, and hence not guaranteed to be available year-round. Figure 15 illustrates the water resources and their correspondent classification in constant and variable sources.

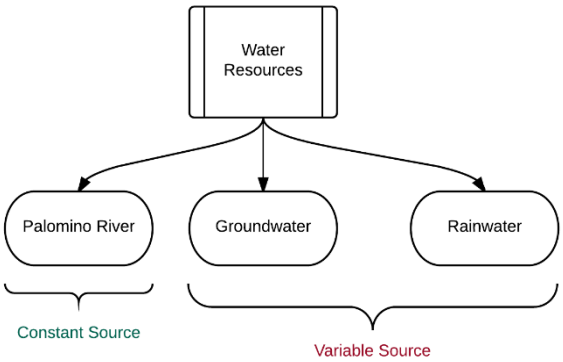


Figure 15: Water resources in Palomino.

1. Constant water sources

Palomino River:

There are five defined hydrographic areas in Colombia, cataloged under the following labels: 1. Caribe, 2. Magdalena-Cauca, 3. Orinoco, 4. Amazon, and 5. Pacific. For reasons unknown to the author, Palomino River has no specific classification; yet due to its location, it can be concluded that the Palomino River follows under the classification: AH 1 – Caribe Hydrographic Area, ZH 15 Caribe-Guajira Watershed Area. The closest cataloged hydrologic basin is the Don Diego River (classified under AH1, ZH15, SZH 1502, Area 542 km^2) (IDEAM, 2013).

Figure 16 illustrates the geographical location of the five hydrographic areas and the specific classification for the Caribe-Guajira Watershed, where the Palomino River can be seen.

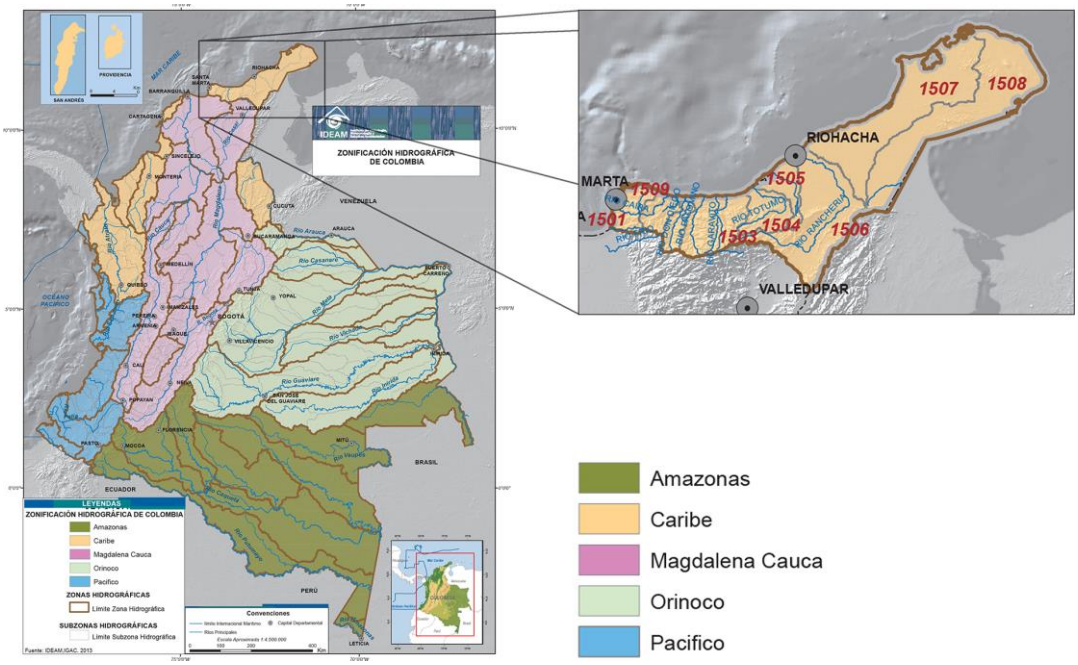
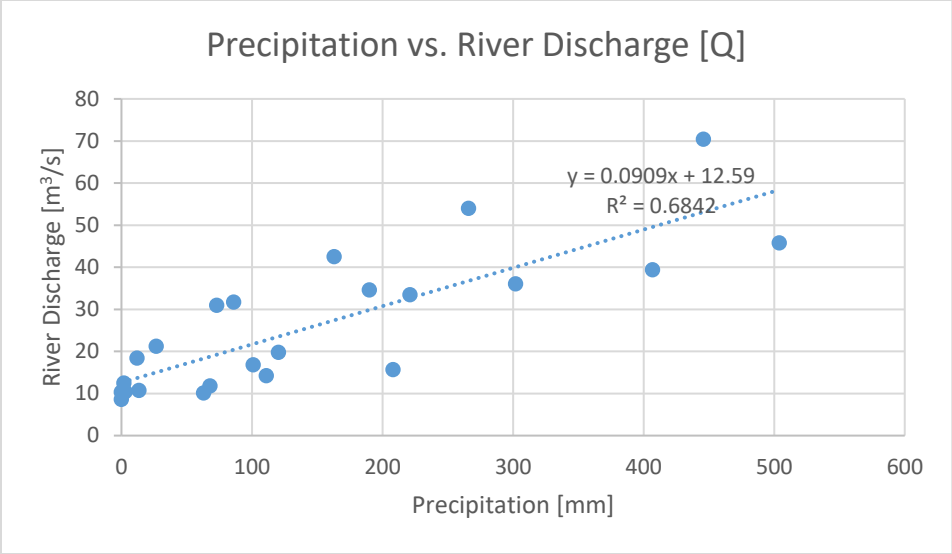


Figure 16: Hydrographic areas in Colombia and detailed classification of the ZH15 Caribe – Guajira Watershed. (IDEAM, 2013, pp. 23, 42).

The hydrologic basin of the Don Diego and Palomino Rivers is fed by the perpetual snow from the glaciers found at the NNP Sierra Nevada de Santa Marta (IDEAM, 2015), and is also influenced by the precipitation in the region. Having these two sources, the Palomino River can be considered a mix river. The flow of the river has remained uninterrupted, according to the evaluation of the monthly discharge data from 1974 to 2011. Currently, no studies have been made as far as the influence of the precipitation on discharge from the Palomino River; Figure 17 visualizes this relationship. The figures chosen are the highest and the lowest recorded value under the analysis of the time series of the precipitation (1961-2006) and of river discharge (1974-2011). For the overlapping time series (1974-2006), the highest value of precipitation corresponds to the year 1981 with an annual value of *2,896 mm,* and the lowest value of precipitation is found in the year 1997 with an annual value of *492.5 mm*.



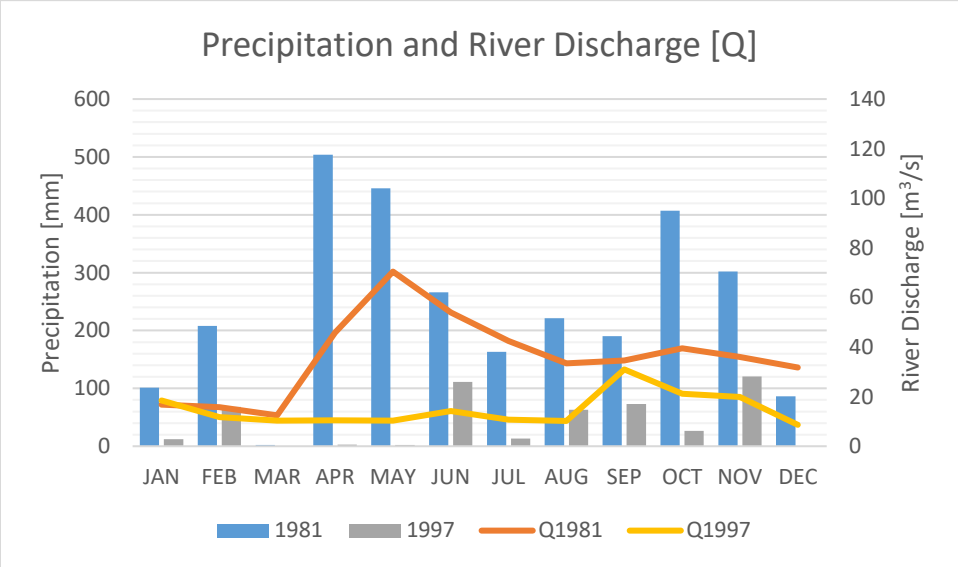


Figure 17: Influence of monthly precipitation on monthly river discharge from the driest year (1997) and the rainiest year (1981) (Time series analysis 1974 – 2006) (IDEAM, 2015).

Figure 17 suggests a correlation between regional precipitation and river discharge, implying that the Palomino River is a mix river. It is also evident that an increase of the discharge occurs during the rainy seasons and consequently diminishes during dry seasons. Despite the variations, the river discharge does not fall below the 10 m^3/s, which guarantees a constant water source for the town.

One of the main threats to the conservation of the Palomino River is the loss of glacier area due to climate change. The increased temperatures have led to a national glacier area reduction of 23.5 % between 1930 and 1950 and a reduction of 57% between 1980 and 2010. The total national glacier area for 2010 is 45.3 km^2; 7.4km^2 correspond to the glacier area of NNP Sierra Nevada de Santa Marta (IDEAM, 2014).

Figure 18: Glacier NNP Sierra Nevada de Santa Marta (Palomino Cultural, 2011, p. 170).

For the present research, no official data could be obtained to assess the quality of the water from the Palomino River. The water basin upstream of the urban area of Palomino is considered to be relative pure, since there are no relevant pollution sources. Since the territory is property of the Arguaco and Kogui indigenous communities, there are few human settlements up the mountain. Additionally, there is no extensive agriculture or animal husbandry practiced in the area.

Figure 19: Indigenous settlements. Upstream of Palomino River. (Archive Colectivo Mitín, 2009).

2**. Variable water sources:**

Groundwater:

Little is known about the groundwater conditions in Palomino. No scientific literature is available to analyze this water source, and only basic considerations can be made based on filed observations and geophysical conditions. The town of Palomino sits between two rivers: The Palomino River to the West, and San Salvador River to the East. By this merit, the town can be considered to be positioned in a natural aquifer. The steep slope of the Sierra Nevada leads the terrain to drain towards the sea, passing through the town. The constant availability of water from both rivers allows the soil (predominantly porous soil – sand) to have high levels of saturation. However, in precise instances, the level of saturation may be affected by the time of year and the immediate topography—during the field research, is was found that some public and private water wells were dry, indicating the variability of the groundwater table in specific locations during dry seasons. Please note here that 'groundwater' refers to superficial water, since none of the water wells surpass a depth of 8 m.

Figure 20: Possible groundwater drainage (Image Google Earth, 2013; own figure).

Rainwater:

As mentioned in Section 2.1.2, rainwater is highly variable in the region, with inherent challenge in the alternation between rainy and dry seasons. Moreover, this challenge is particularly evident in cases when these seasons are augmented. The reality of this is reflected in the surveys conducted for the present research, wherein a majority of those surveyed agreed that the rhythm of the rainy and dry seasons had varied tremendously. For 2015, the inhabitants affirm that there was no rain for nine continuous months; consequently the region suffered a prolonged drought (Surveys Household – Appendix D).

2.2.3 Centralized water supply

The centralized system for water supply in Palomino can be consider an aqueduct system of low complexity. It is constituted by three main technical elements: one water well, one pumping and treatment station, and two storage tanks. The information presented on this section is based on field observations and the interview of Geovannys Marbello, an employee of *Aguas de Dibulla,* the organization in charge of the operation and management of the system (Marbello, G., personal interview, September 18, 2015). Figure 21 illustrates the general diagram of the system for the centralized water supply (aqueduct).

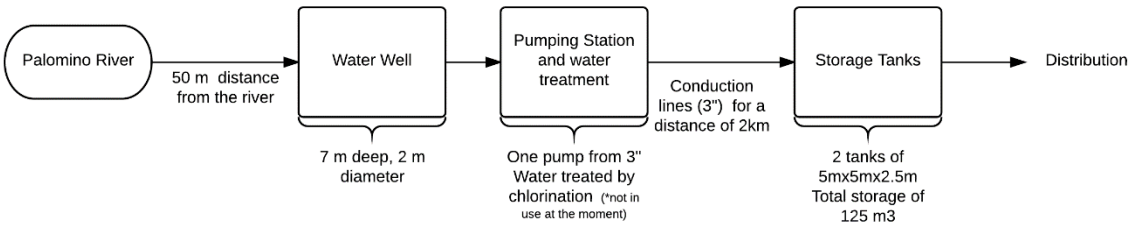


Figure 21: Overview general system for centralized water supply.

The water well, located approximately 50 m away from the Palomino River and at an altitude of approximate 30 m above sea level, is constructed from concrete with low steel reinforcement. The water source from the system is groundwater; its level is directly influenced by the river. The river feeds the well through percolation, therefore maintaining a constant level of groundwater for extraction. The land between the river and the water helps improve the water quality, since the granular soil here works as a large natural filtration bed. In the proximity of the catchment area, there are no notable sources of pollution from agriculture, settlements, or cattle. Figure 22 are pictures of the current state of the catchment area and water well.

Figure 22: Riverbed of the Palomino River (top) and water well for groundwater extraction (bottom).

Figure 22 shows damage to the water well's infrastructure: the pipeline of 3" used for the extraction of the water has no proper support, and has been balanced using wood, rocks, and metal (bottom right image). The hole designated to pass the pipeline does not seem to be part of the original design of the well, but rather a piece of retroactive engineering. Here, the steel is uncovered and susceptible to corrosion and the diameter of the hole is too big; consequently, it has been covered with rocks to avoid the entrance on the well of animals and different impurities from the external environment.

Figure 23 displays the new facility (right) and the old facility (left); the year of the construction of either of the facilities is unknown to the author. The new facility serves as the pumping and water treatment station, the old facility is abandoned at the moment, and has no apparent use.

Figure 23: New facility (left) and old facility (right).

Inside the new facility is the main pump with an input and output pipeline of 3". The groundwater is continuously moved through this electrical pump, then transported through 3" conduction pipelines to the main storage tanks. As is visible in Figure 24, the water distribution system (WDS) transports water directly from groundwater to distribution—no water treatment is functioning at the moment. Inside the facility, one can see a former disinfection process through chlorination denominated MIOX, a hypochlorite generator with a capacity of treatment 1,817m^3/day (USA Global Market S.A, 2013).

Figure 24: Water pump (right) and disinfection method (left).

The system presents a vulnerability to malfunctions, since it is easily subject to sudden lack of electric power and high voltages spikes coming from the main lines of transmission. It is highly probable that the MIOX treatment suffered electrical damages from voltage spikes and/or the discontinuities in electric energy and water flow.

The conduction lines from the pumping station to the water storage tanks are 3" PVC pipelines. From the pumping station, the water is pumped approximately 2km to two reinforced concrete storage tanks, each 5m x 5m x 2.5m; consequently, the total storage capacity is of 125 m^3. The storage tanks are located close to the town at an elevation of approximately 30 m above sea level. From the tanks, the water is distributed by gravity to each household. Figure 25 illustrates the storage tanks and an unauthorized connection found on the main distribution line. These unauthorized connections are consequence of the lack of investment, regulation, and enforcement found in Palomino, and impose a challenge in controlling water use and tariffs for water charges.

Figure 25: Storage tanks (right) and unauthorized connections (left).

Finally, the WDS is sectored by 2" PVC until the main valve, 1.5" PVC on the main streets, 1" PVC for household sector, and lastly, 1/2" PVC for the household connection.

Water management, operations, and governance:

The management and operation of the aqueduct system is the responsibility of the governmental institution, Aguas de Dibulla. From this central office, the local operator of the aqueduct system generates and distributes the tariff and receipts for each household in the community. In Palomino this responsibility belongs to Edison Rivaneida. The household tariff is determined by the socio-economic condition, information provided by the Department of Planning and Development of the Municipality of Dibulla. This department is also responsible for the infrastructure and maintenance of the system.

The tariff is not dependent on the water use, since there are no water meters per household. Figure 26 is a receipt for water and waste management, both tariffs are charge simultaneously. The municipality has established a total of six deferent values according to the stipulated subsidies.

	SERVICIO ACUEDUCTO			SERVICIO ASEO			
RESIDENCIAL	Tarifa anterior	Tarifa a Diciembre 2015		Tarifa anterior	Tarifa a Diciembre 2015		Porcentaje Subsidio y Contribución.
TARIFAS 2015		12.850			15.000		
Estrato 1.	4.696.	7.710	5.140	4.740	9.000	6.000.	60%
Estrato 2.	7.900.	3.855	8.995	8.220	4.500	10.500.	30%
Estrato 3.	11.228.	1.285	11.565	12.240	1.500	13.500.	10%
OFICIAL	12.500.	12.850.		13.600.	15.000.		
COMERCIAL	18.750.	19.275		20.400.	22.500.		+ 50%
INDUSTRIAL	16.243.	16.705.		17.680.	19.500.		+ 30%

Figure 26: Receipt for water and waste management service (right); main valve (left).

The main functions of the operator of the aqueduct system in Palomino are: turning on and off the water pump, opening and closing the main distribution valves, and collecting the monthly fee from the users. When the tariff is paid, the operator and the user each receive a voucher of confirmation.

As for the WDS, there are seven sectoral valves in Palomino which correspond to different neighborhoods: two in Divino Niño, one in Carmen Garzon, one in Centro, one in Sierrita, and finally, one in La Loma. The main valve is open from 10:30am until 14:00, and from 18:00 until 6am; this schedule allows the water tanks to be refilled in the morning and afternoon, and each neighborhood is supplied for one day a week (picture main valve Figure 26). In terms of water quality, Mr. Rivaneida claims that there is a regular check in three key points for water sample: one at the main water well, one at the storage tanks and one at the household level. The results are part of the water quality test from Aguas de Dibulla; unfortunately, no results were granted for the present research. In the same manner, no information was disclosed regarding the exact location of the water valves (Rivadeneira, E., personal interview, December 28, 2015).

2.2.4 Decentralized water supply

The decentralized water supply comes from three main sources: rainwater harvesting, groundwater extraction through private water wells, and self-reliance practices, which consist on collecting water directly from the river. The most economical and most commonly used practice among the community is

self-reliance—depending on the economic condition of the household, inhabitants go themselves directly to the river to collect water, or they pay for service. The traveling time depends directly on the location of the house in relation to the river, and can vary from 30 minutes to 2 hours. The location of the collection point at the river is commonly known as 'El paso de las mujeres' ('The path of the women') since mostly women are in charge of collecting water, and also come to this site to wash clothing. The number of travels made per household also depends on the carrying capacity and on the household's demand. Figure 27 shows different transportation methods for the self-reliance method of water supply.

Figure 27: Man collecting water from the Palomino River (left); transportation method for several water containers called 'pimpinas' – 5 gallon container (middle); water purchasing from informal sellers (1 m^3).

The price of water in Palomino is excessively high. One 5-gallon (approx. 20-liter) pimpina costs 2.000 Colombian pesos, and one cubic meter costs 15.000 Colombian pesos, the equivalent to 0.57 and 4.29 euros respectively[43].

Rainwater harvesting is a practice that is commonly used in the community, though few households have integrated rainwater collection systems that make use of the roof surface. The most common practice to collect rainwater is to place a collection tank outdoors while it is raining. Although this method may be inefficient, it is not unpopular—57% of interviewees claim that they practice rainwater harvesting in some capacity (Appendix D, Question 22).

Groundwater use in Palomino is high; mainly, the water is extracted from private water wells and used directly. Few households have the privilege of owning a water well: from field observations, only two households had water wells (the existence of another three was mentioned, but the location is unknown to the author); two public water wells were constructed in the town, though they are dry and out of service, as if abandoned. Figure 28 illustrates the typically construction of a private water well, and also a public water well, currently out of service. The hotels that are outside of the urban perimeter all use groundwater to satisfy the water demand on their premises. There are no permits for the use of water wells, nor is any type of registration required; consequently, there is no control or oversight with regard to groundwater use.

[43] Exchange rate from the day Monday 7, March 2016. 3,496 Colombian pesos are equivalent to 1 euro.

Figure 28: Water well for private use in a household in 'El Divino Niño' neighborhood (right); public water well in the 'Cultural house' (left).

2.2.5 Geographical location of key infrastructure for water supply

Figure 29 illustrates the geographical location of the key infrastructure for the centralized and decentralized water supplies. The location is based on mapping made during field research. Near the beach, where most of the hotels are located, there are many more private water wells.

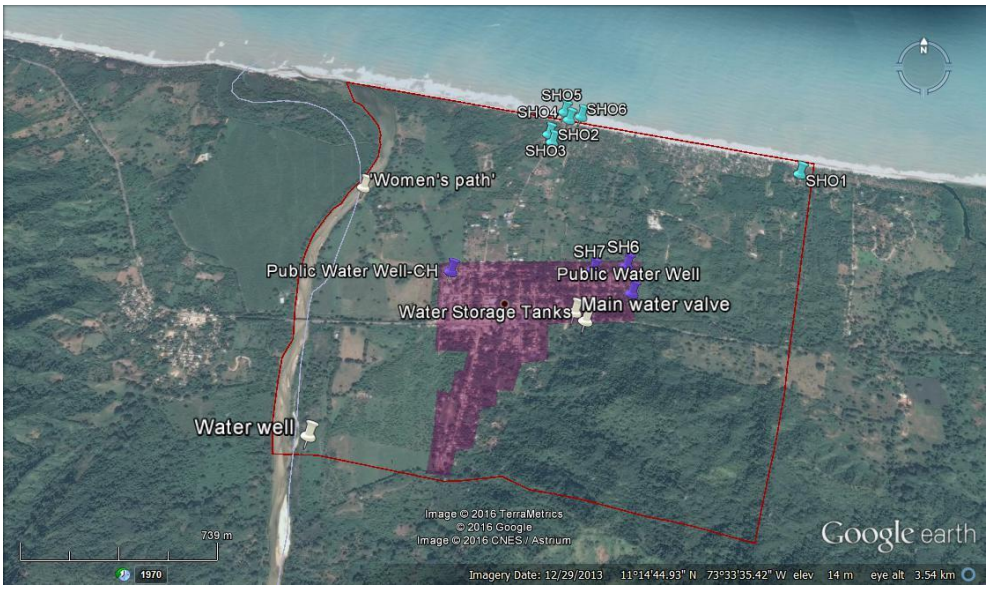


Figure 29: Location Infrastructure. Dark blue: private and public water wells in the urban perimeter. Light blue: private water wells from hotels. White: infrastructure centralized system (aqueduct). (Image Google Earth, 2013; own figure).

2.3 Sanitation and hygiene

The municipality of Dibulla has insufficient public infrastructure. This includes sewage systems, for which the municipality had a coverage of only 15% for the year of 2015 and no waste water treatment plant (Alcaldía Municipal de Dibulla, 2015). Palomino has no central waste water treatment plant, though some technical studies were made for the construction of an aerated or oxidation lagoon on the year of 2012. Some pipelines and inspection chambers (Figure 30) of the sewage system were constructed, but currently do not serve any functional propose.

Figure 30: Inspection chamber of the sewage system in Palomino.

Though they are often referred to in Palomino as 'septic tanks', the most common practice for blackwater disposal is technical a leach pits. Figure 31 illustrates a schematic of a leach pit in Palomino, where it can be seen that the blackwater infiltrates directly into the soil, increasing the risk of groundwater contamination in the area. Some septic tanks also have a small aeration tube that allows gases created in the decomposition process to exit the leach pit.

The hygiene situation in Palomino is good, due to the use of leach pits and the absence of open defecation or discharges in open gutters. However, during the rainy season, some areas of the town (especially the neighborhood of 'El Divino Niño') present flooding risks. The inundation can reach up to 15 cm (as it is shown in Figure 32), and its water likely contains human excreta due to the fact that the groundwater table is very high and that the pits prone to overflowing. During this flood scenario, the community complains about strong odors, and serious hygienic problems can occur.

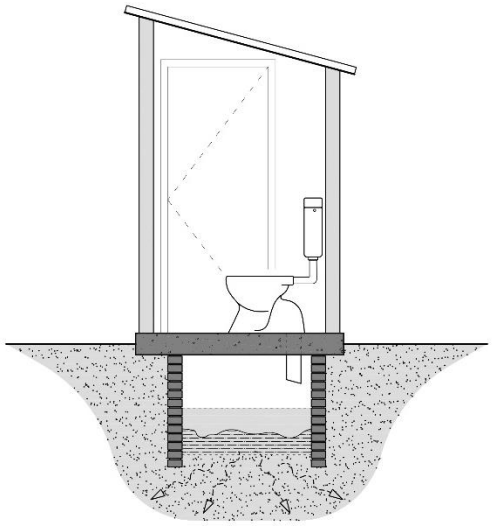


Figure 31: Cross section representation of a typical toilet in Palomino. Discharge to a leach pit.

Figure 32: Women showing the flood level on rainy seasons in the neighborhood 'El Divino Niño'. Approximate 15 cm was measured.

An alternative sanitation option is dry toilets. Although they are not commonly used among the community, it is important to highlight that residents of Palomino are familiar with the concept of a dry toilers, and understand how to use them. Figure 33 shows images from the dry toilet belonging to farmer Juan de Dios. This toilet has been in use for over 4 years; its residual mix is a compost base rich in nutrients, which Juan uses as a fertilizer (principally for reforestation projects, and not crops) (de Dios, J., personal communication, September 18, 2015).

Figure 33: Juan's dry toilet. Toilet base (right), aeration tube and storage tank (middle), compost base (left).

2.4 Water management

This section exposes the water management at a household (or, domestic sector) level, hotel (or, commercial sector) level, and at education centers. This section is largely based on the results obtained from field research—primarily from the survey results (found in Appendix D and E), from personal interviews (found in Appendix C), and from performed field observations and mapping. The water management is divided into four classes: Water supply and storage, Water use and water demand, Water quality (perception) and Sanitation.

2.4.1 Household level

Water supply and storage

The water supply for the household level is based on either the centralized system or decentralized option, or most commonly, a mix of both. The water supplied from the centralized system does not cover all

households within the urban perimeter; it was also observed that most of the households utilize a small 1/2" water pump to 'pull' the water, as it is commonly expressed in Palomino (Figure 34). Water pumps are used for two main reason: first, since the water available to supply households within the urban perimeter is limited, residents use water pumps to guarantee the collection of water in their homes; second, since most houses are built without a connection to the main water pipeline, many residents use a pump to connect their homes to the water supply.

According to the survey, 57% of households in Palomino use a water pump, while 43% do not. This reflects the reality that most of the households do not receive a steady water supply: 79% claimed that they do not receive water from the aqueduct service every week, only 21% responded positive to this question. Since the water supplied from the centralized system variates greatly in terms of volume and schedule, we see that the water received per household is not enough to satisfy the weekly household's activities and chores: 93% claimed that the water supplied is not sufficient, therefore, they must rely on alternative water sources. The 7% that claimed to have enough water supplied to meet their demand, normally had an alternative water source, such as a private well. An important feature of the water supply system is that water users do not know on which days nor at what time they will receive the water service; this generated great inconsistencies among water users.

As shown in Figure 34, the water is typically stored in constructed concrete water tanks, as well as plastic water tanks. It is not common to observe houses with elevated water tanks, since few have a direct connection to showers, sinks or toilets.

Figure 34: 1/2" water pump (left), 250L plastic water storage tank (middle) and constructed water storage (commonly known as 'alberca') (left).

Survey's results vs. SISBEN's results

This section shows the quantitative results with regard to the water supply by the centralized system. These survey results are compared with the results obtained by analyzing the database from the institution SISBEN, which correspond to the years 2009 through 2015 (Appendix G).

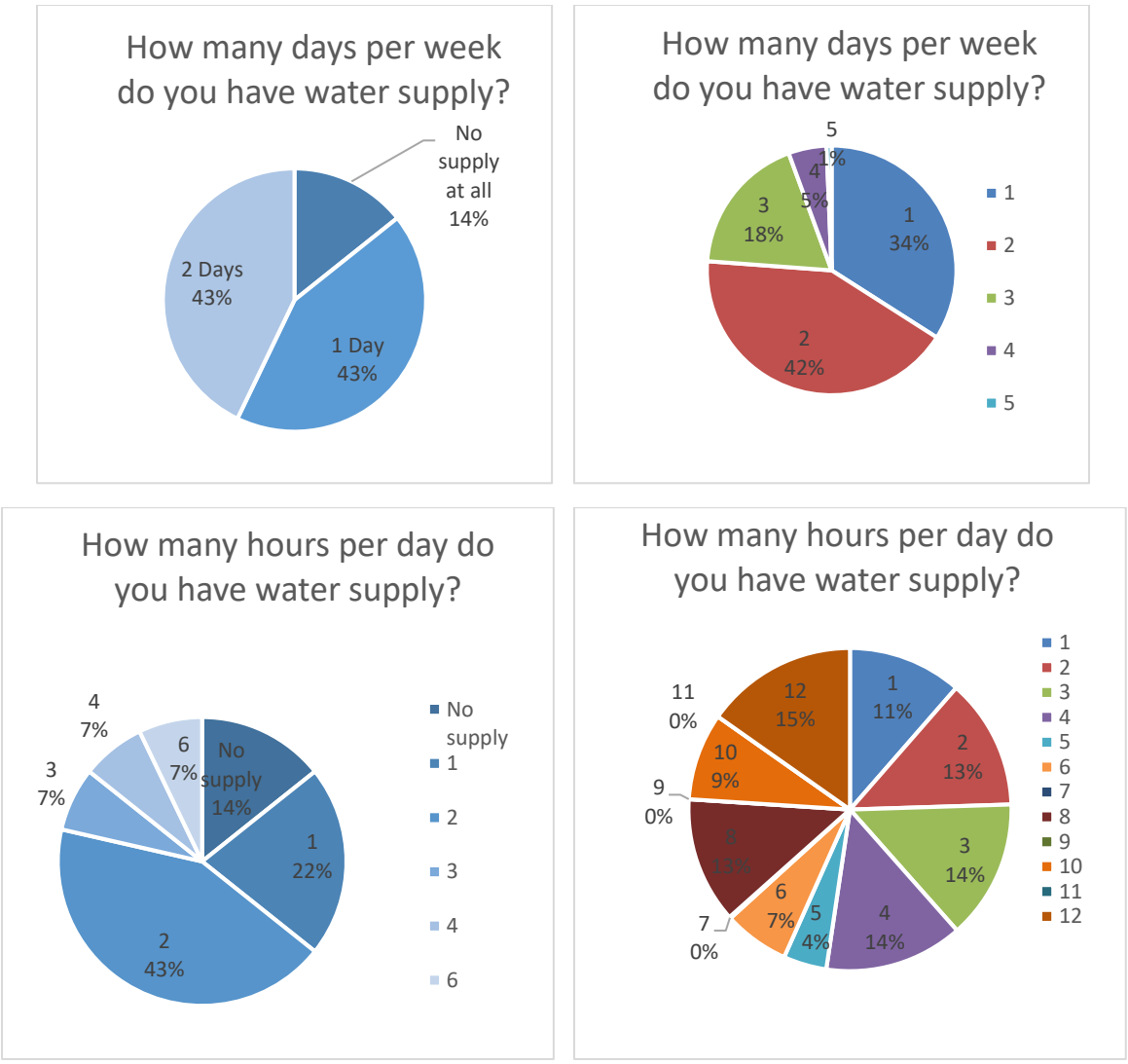


Figure 35: Water supply results comparison: Survey results on the left and SISBEN results on the right.

Water use and water demand

The water demand at the household level was quite difficult to assess in a precise manner, since water metering data is not available by household. As mentioned before, water users do not pay for the service based on their consumption level, but rather by the socio-economic condition of their household.

In Palomino, water consumption is not controlled by incentives such as water price, but rather by the limited availability of water. The estimate for household water demand is based on the water supplied by the centralized system, the water collected directly from the Palomino River, and the water storage capacity per household. Figure 36 illustrates the results of the household water demand of the interviewees and Figure 37 shows the water volume that each household collects on a daily basis to compensate for the lack of water supplied by the centralized system.

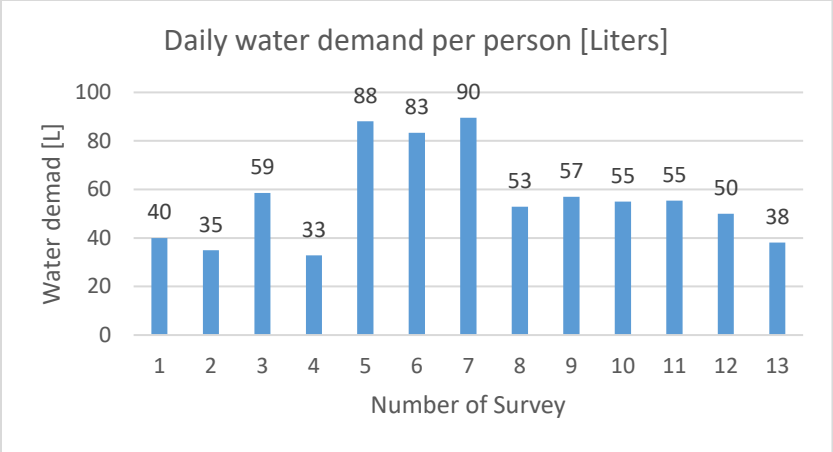


Figure 36: Daily water demand per household in liters.

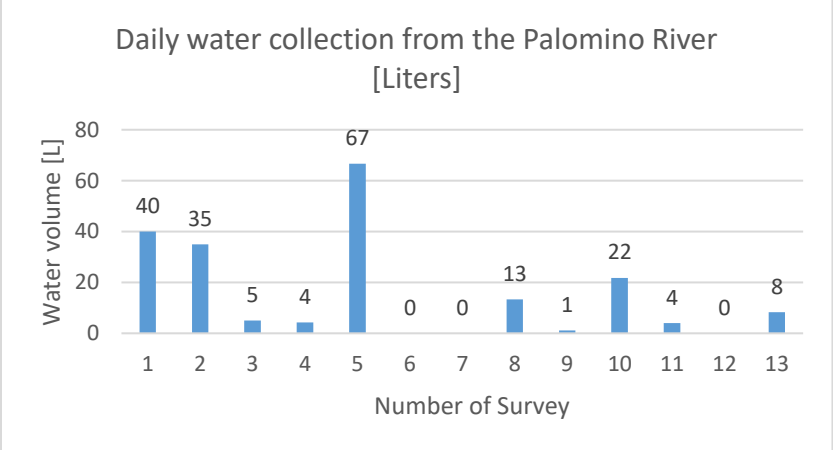


Figure 37: Volume of water collected from the Palomino River.

As it can be seen in Figure 36, the daily water demand per household varies from 30L to 90L. Household 5, 6 and 7, which show the highest water demand, also had greater water availability than the rest of the households. Households 6 and 7 each had a private water well; therefore, they could extract groundwater whenever necessary, and (as seen in Figure 37) they do not need to collect water from the river. The majority of the water for household number 5 is collected from the river, though this family owns a motorbike, and travels to the river up to 20 times a day to collect water.

In Figure 37, we see that high volumes of water collected from the Palomino River. Families commonly make up to 3 trips on foot each day to collect water; the time spent on this task is considerable. Depending on the location of the house relative to 'The Women's Path,' a round trip could take between 30min and 2 hours.

It is worth mentioning that the low water reflects the methods of water use in each household; 92% of the households do not own a washing machine, and 96% do not have a shower directly connected to the pluming of the house (SISBEN, 2009-2015). Likewise, it was often mentioned that it is common to wash clothing and to bathe directly in the river.

Water quality – perception

The water quality in Palomino is presumably acceptable, though no data is available to assess if it satisfies the World Health Organization (WHO) drinking-water quality standards, which it likely does not in every aspect. In order to assess the quality of the water supplied by the centralized system in Palomino, some basic questions were asked about water-related health issues: 7% of those surveyed reported skin rashes, 33% reported stomachache, and 18% reported occasional diarrhea. There are no cases of high risk of water-borne diseases, like cholera. Figure 38 illustrates the results from the water purification method employed for consumption at a household level, although the correlation between the treatment (or no treatment) of the water for consumption and the health complaints is not clear, Figure 38 gives an overview on the behavior of water users.

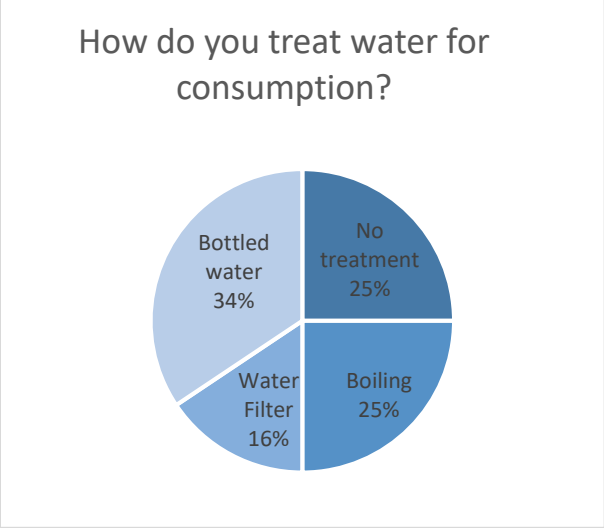


Figure 38: Household-level water treatment for consumption

The most common complaint about the water quality is related to high chlorine levels; the inhabitants complained about burning sensation in eyes and mouth, and stories were told about how all the fishes kept in the main water storage tanks died at once as a result of high chlorine levels. In Palomino, it is common to find fishes as a method to control mosquitos and larvae in the water tanks, this practice no longer exists.

Figure 39 shows the results of the qualitative assessment on users' perceptions of the quality of the water supplied by the centralized system.

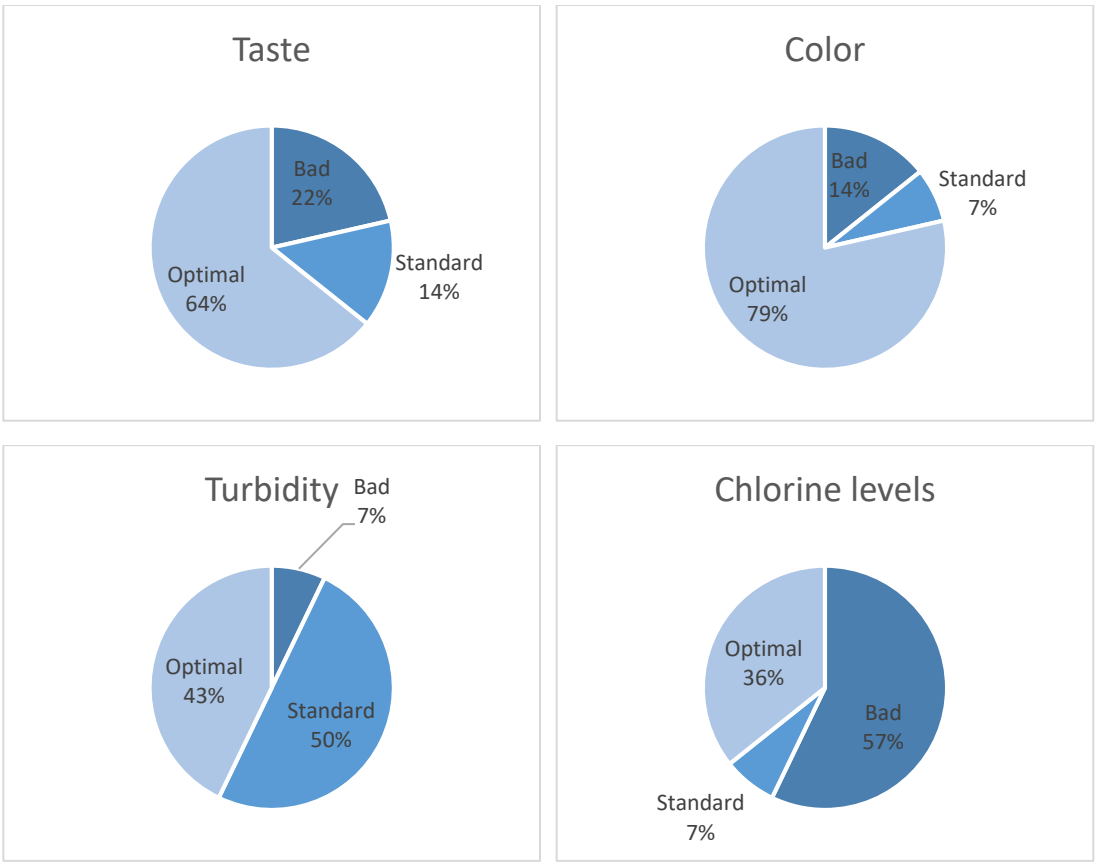


Figure 39: Users' perceptions of water quality.

Sanitation

As mentioned above, the sanitation in households consists of toilets that flush directly into a leach pit. The toilets are typically conventional flush toilets (as shown in Figure 40), and not 'modern' dual flush toilets with water-saving possibilities that reflect the user's choice to flush either for urine or feces discharge. 100% of the interviewees claimed to use a flush toilet connected to a leach pit, and none paid for this service, since its construction and management is for individual private use.

In Palomino, it is common to find bathroom facilities outside of the house (often, in the backyard); this practice facilitates the construction process of the leach pit, and prevents odors in the house. An important finding was that 29% of interviewees complained about some type of malfunction of the leach pit and sanitation facility. Most complained about flooding, which may happen for two reasons: either the leach pit needs maintenance and the capacity of it is surpassed by the volume of the discharge, or the groundwater table rises during the rainy seasons. It can also result from a combination of the two.

The SISBEN database shows similar results for the household sanitation options, where 67% claim to have their sanitary facilities outside of the house, and 94% claim the sanitary facilities to be exclusive to their household (SISBEN, 2009-2015).

Figure 40: Typical household toilet (left) and sanitation facility (right).

2.4.2 Hotels level

For hotels, the situation is quite simple compared to that of households. Most hotels are outside of the urban perimeter, and thus have their own water supply via water wells. The daily water demand can easily be satisfied by extracted groundwater; only one hotel has experienced water shortages due to low groundwater levels. All hotels have a large water storage capacity, including the hotels in the urban area; hence these hotels do not worry about water scarcity, even though the water supplied by the centralized system is limited.

The hotels performed all their activities satisfactorily with a water demand ranging from 60 for a hostel to 160 L per person per day for a hotel. None of the hotels interviewed claimed any problems with their water quality, and no complaints from visitors have been recorded. Finally, the sanitation in hotels works in the same manner as in the urban area: flush toilets connected to leach pits. No sanitation issues were noted by any of the hotels that participated in the survey process.

2.4.3 Education centers

Water Supply and sanitation

The education centers are located in some of the most densely-populated areas within the urban perimeter of Palomino. Consequently, the water demand and use is high in these institutions during peak hours of the day, and the absence of a regular water supply from the aqueduct system to the public education centers greatly affects the proper operation of the institutions.

The hygiene problems for the educational centers are a combination of two main factors: first, the lack of electric energy, which makes it impossible to water pumps to force the water to reach the elevated water storage tanks for the subsequent distribution by gravity to the toilets and sinks; second, the lack of the water resource itself, due to the lack of water supply by the aqueduct system. When no water is available for the use of the flush toilets, the personnel has to carry water manually to fill each toilet's tank, and since this task is almost impossible to carry out each time a student enters the toilet, the hygiene

conditions of the toilets at school is undesirable, both in terms of sanitation standards and from a user's perspective.

For the preschool, the aqueduct service comes every 8 to 10 days, which obligates the school to buy water from informal water sellers in order to accommodate the water demand of approx. 150 students, plus the personnel. In 2015, the preschool bought at least one trip per month, paying—per trip—between 12,000 to 20,000 Colombian pesos for 1 to 1.5 m^3 of water (Johana, personal interview, September 23, 2015).

The primary and high school institution San Antonio suffers from the same water issues; 18 teachers, 2 cleaning personnel, one coordinator, and approx. 250 students attend the institution each day. The water supply from the aqueduct is variable and is only available around two days a week. The school has several storage tanks, but this storage capacity is not enough for the school to fulfill its needs without a steady water supply (Pinto, A., personal interview, September 28, 2015).

Figure 41: San Antonio School: Female toilet facilities (left), flush toilet (middle), toilet sinks (right).

Figure 41 shows images from the facilities of the San Antonio school. The lack of sanitation is visually evident, and the odors of the facilities are quite strong. It is also worth mentioning that (as is visible in the right picture) water was left running in most of the sinks, exhibiting a lack of environmental awareness and lack of water sensibility from users (students). This type of behavior makes the water problems worse, since the water losses are increased in a location that already suffers from water stress (Observation, September 2015).

2.5 What water costs

This section presents a comparison of water prices in Palomino. Figure 42 shows the water costs per household in Palomino according to the survey results, and the water affordability according to water users. Most of the interviewees consider the cost of the aqueduct service high not due to the price itself, but due to the deficient service and the lack of a steady water supply.

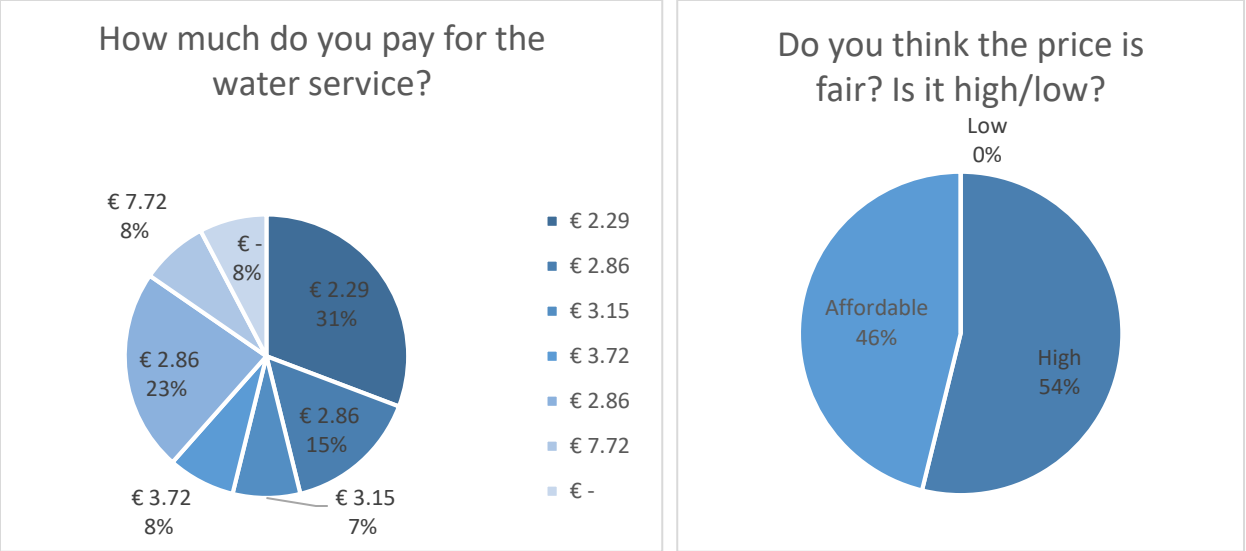


Figure 42: Aqueduct service cost per household[44] (left) and water affordability (right).

Figure 43 illustrates the water cost in various cities worldwide; for the case of Palomino, the value presented corresponds not to the aqueduct service value, but to the water price if purchased from informal sellers. As shown in the Figure, the water prices in Palomino are extremely high, even in comparison to other cities in developing countries. Unfortunately, due to the lack of data, it is not possible to compare the proportion of the cost of the water in Palomino in relationship to an average monthly income.

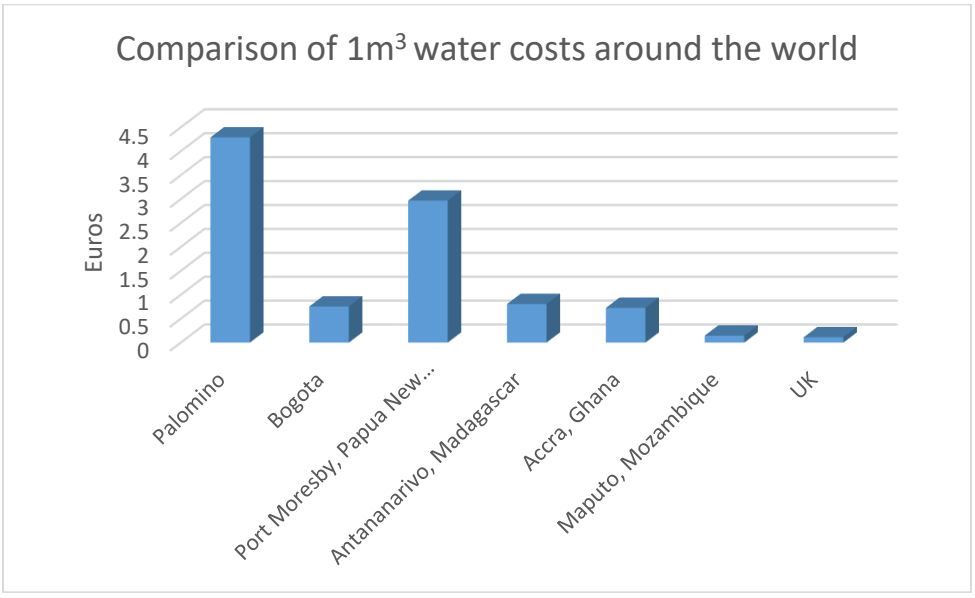


Figure 43: Water costs in different cities around the world (1m³)[45].

[44] Exchange rate from the day Monday 7, March 2016. 3,496 Colombian pesos are equivalent to 1 euro.

[45] The values for this graph are obtained from (WaterAid, 2016, p. 4) and (Acueducto agua y alcantarillado de Bogotá, 2016). The tariff for Bogota is for *Estrato 6* level. Exchange rate from the day Monday 7, March 2016: 3,496 Colombian pesos are equivalent to one euro and exchange rate from the day Tuesday 5, April 2016: 1 pound is the equivalent to 1.24 euros.

2.6 What do water users think are the problems with the water supply in Palomino?

Throughout this thesis research, water users have been the primary source of information; their opinion should be considered seriously. Water users know the problems they suffer, yet it is not always clear if they understand the root of the problems. Therefore, it is quite interesting to present what water users think are the main issues related to the water supply in Palomino. What users might think is the problem becomes a reality in a 'collective imaginary' perspective. Figure 44 exposes what water user think are the main problems for a steady and quality water supply in Palomino.

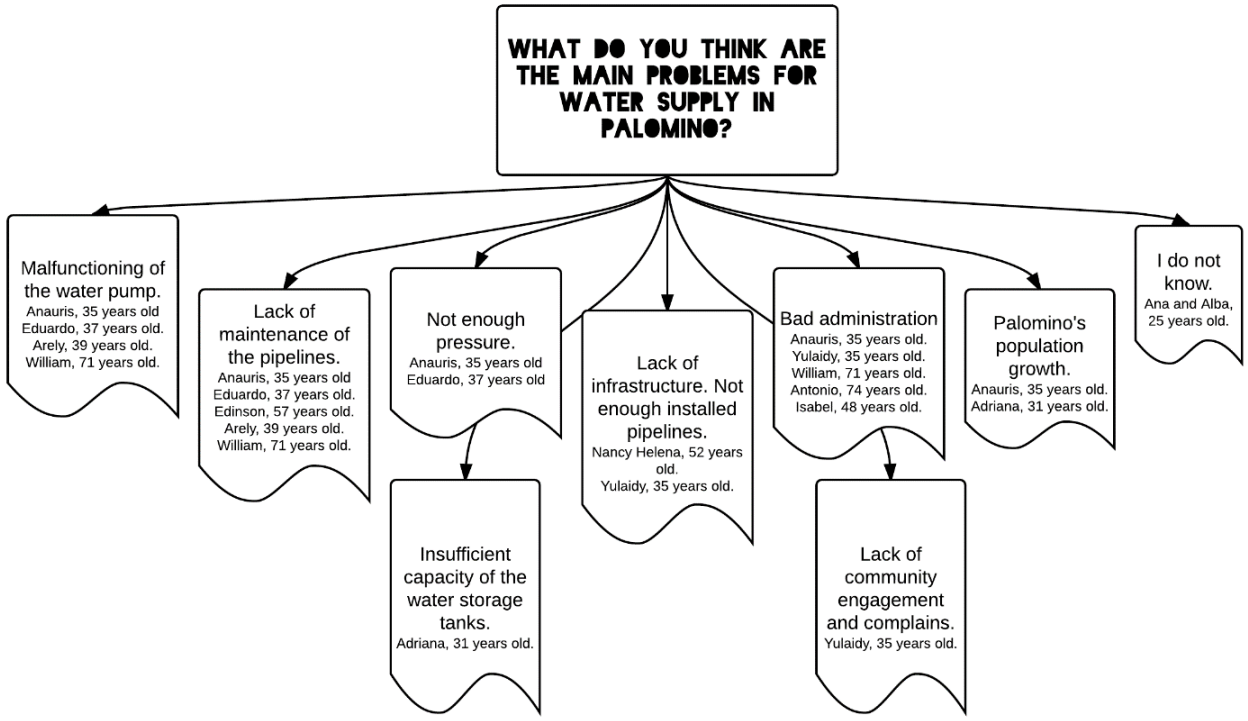


Figure 44: Water users' perspectives on Palomino's water supply issues.

2.7 Strengths and Weaknesses of Palomino's water system

This section presents a short overview of what is considered by the author to be the main strengths and weaknesses of the current water system.

Table 3: Strengths and Weaknesses of Palomino's current water system

Strengths	*Weaknesses*
Water resources	
• The main water sources of Palomino: the Palomino River and groundwater, are mostly reliable, and in general, they present good quality.	• Loss of glacier area due to climate change. • There is no data available about wastewater discharge to the river from indigenous communities.

• The Palomino River originates from glacier waters, which is well preserved due to the National Natural Park condition of the Sierra Nevada de Santa Marta.	• Rainwater availability varies greatly between rainy and dry seasons.
Centralized water supply	

• The groundwater pumped from the water well has good quality, due to the water source and a large sand based filtration bed.
• Main water storage tanks and pumping station are in acceptable conditions.
• Most of the households in the urban perimeter have connection to the system.
• Water quality perception from water user is overall positive.
	• Lack of maintenance of the WDS. Pipelines of the distribution network are likely to present leaks.
	• Lack of steady water supply.
	• No treatment of the groundwater extracted to supply the system, therefore the water supplied is not potable.
	• Lack of administration
	  ○ No schedules available for the water supply.
	  ○ Lack of valves and proper connections per households.
	• Unauthorized connections are a consequence of the lack of governance.
	• The volume of water supplied per household is quite limited; a large amount of water must be collected from the river by the community.

Decentralized water supply	
• Groundwater has good quality. • Groundwater table is high and provides a steady water source. • Rainwater harvesting (to some degree) is a common practice.	• The price of water bought from informal sellers is extremely high. • Community spends considerable amount of time collecting water from the river. • The carrying capacity for water collection is very limited, forcing the people to make several trips per day to collect water.
Sanitation	
• No open defecation nor discharge in open gutters is present in the town. • Toilets are found outside the house, this prevents strong odors and facilitates the construction of leach pits. • Ecological sanitation – dry toilets.	• Flooding and malfunction of leach pits. • Risk of groundwater contamination. • No nutrient recovery. • Lack of investment priorities: for example, sewage pipelines do not serve any function. • Poor hygiene conditions in the education centers.

2.8 Part II Discussion

At this point it has become clear that Palomino is indeed a town rich in water resources, yet poor in water availability. Its proximity to both Palomino River and San Salvador River make Palomino an attractive location for steady water resources, not only in terms of superficial water but also for its high groundwater table.

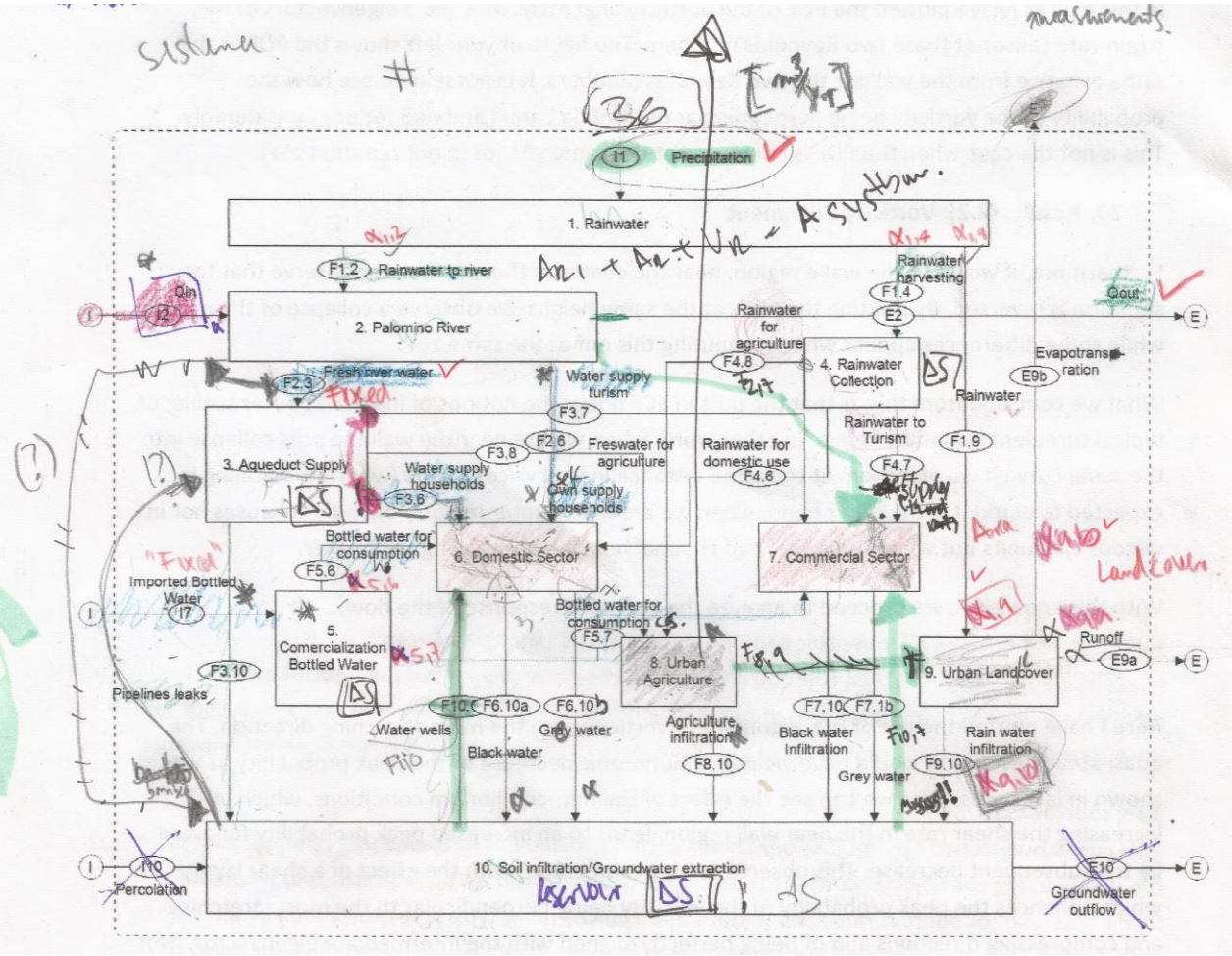
The problems stemming from poor administration have caused Palomino's community to suffer greatly with regards to its water supply. The lack of governance, building of new infrastructure, and maintenance of the central water infrastructure, in addition to unorganized urban growth are undoubtedly some of the main issues affecting the water supply in Palomino. The responsible institutions seem to be uncoordinated in terms of understanding the needs of the community and prioritizing their investments accordingly.

The lack of a schedule for the water supply creates great inconsistencies among the water users. The water service fee varies greatly between households, and most of the population consider this fee to be high in relation to the quality of service that it buys. Some households have not received any water at all for more than 10 months, yet the administration continues to charge them for service.

Inhabitants have to invest a considerable amount of their incomes purchasing water, paying the central administration, in addition to stores and informal water sellers who benefit greatly from the lack of water supply in the town. Furthermore, the community spends a substantial amount of their time collecting water from the river. This condition limits the inhabitants' ability to use their free time on cultural activities or on activities of their interest; it most adversely affects women, whose main duty as homemakers is to wash clothing in the river and collect the water from the river on a daily basis.

In terms of sanitation, the use of leach pits contributes greatly to the good hygiene conditions in the town, though they present a risk of groundwater contamination and unbalanced loads of nutrients in soil of the urban settlement. The problem with the heavy flooding in the rainy seasons is a high risk for human health, since it probably contains fecal matter from the overflow of leach pits, and stagnated water in a tropical climate generates the ideal conditions for vector-borne diseases (Chikungunya, Dengue fever, Yellow fever and Zika). Likewise, it is of great importance to address the problem of WASH services in education centers.

This section has outlined the main characteristics of the water system in Palomino. It is clear that the population is suffering from water scarcity, in addition to some relevant sanitation issues that greatly affect their wellbeing. Now that the system has been described in terms of its current modus operandi, the next section will aim to research—through the urban metabolism concept—where the main problems of the water system exist, by identifying the critical water flows of the system in order to complement the understanding of the current water system.



Part III: Urban water metabolism

3.1 Theoretical Framework

3.1.1 Urban Metabolism: An overview

3.1.2 Material Flow Analysis: A tool of analysis for urban metabolism studies

3.1.3 Urban Water Metabolism: Literature review and applications of UWM

3.2 Urban Water Metabolism Model

3.2.1 Method

3.2.2 Urban water metabolism in Palomino

3.3 Part III Discussion

"Everything should be made as simple as possible, but not simpler"
Albert Einstein

This chapter is divided into three main sections: the theoretical framework, the urban water metabolism (UWM) model, and the discussion of the main outcomes from this chapter. The theoretical framework is intended to clarify some of the key aspects of the concepts of Urban Metabolism (UM), Material Flows Analysis (MFA), and Urban Water Metabolism (UWM). It is based on different scientific sources, and addressed from a literature review perspective.

The urban water metabolism model focusses on the model developed for the specific area of study in Palomino. The UWM is the basis for the quantitative analysis of the local urban water system, and is derived from the qualitative and quantitative characteristics of the water system exposed under the analysis in PART II.

Throughout this chapter, the following sub-questions of this research will be answered:

2. *How can the current urban water metabolism best be represented with a conceptual model?*
3. *Which are the critical water flows of the current urban water metabolism in Palomino?*

3.1 Theoretical Framework

3.1.1 Urban Metabolism: An overview

The concept of urban metabolism (UM) was first developed in 1965 by Abel Wolman, when addressing the metabolism of cities in response to the concern of the deterioration of water quality and the increase of air pollution (Decker, Elliot, Smith, & Sherwood, 2000). Wolman developed a model to calculate the inputs and outputs of key material and waste flows in a hypothetical American city of one million inhabitants (Kennedy, Cuddihy, & Engel-Yan, 2007). Though Wolman pioneered the concept of UM in the context of modern cities, the intellectual concept of UM can be traced back to Karl Marx, who, in 1883, discussed the urban metabolism as a critique of industrialization, using a description of the material and energy exchanges between nature and society (Pincelt, Bunje, & Holmes, 2012).

The concept of an urban metabolism can be understood by the analogy between metabolic processes from ecosystems in the biosphere and metabolic processes in complex urban settings in the built environment (Zhang, Urban metabolism: A review of research methodologies, 2013). Similar to the way that organisms transform material and energy flows through biological metabolic processes, an urban metabolism evaluates the resources in an urban area as they enter the system boundary, are transformed, and subsequently, leave the system. In a broader context, the UM framework can be defined as, "the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy, Cuddihy, & Engel-Yan, 2007, p. 44).

One major advantage of UM is that it can be measured spatially by defining the system boundary of the area of study, hence research can be done on the scale of a city, a region, or even an entire country. The early 1970's were the beginning of the first metabolic studies for complete cities and large metropolitan areas (as is the example of Brussels, shown in Figure 45).

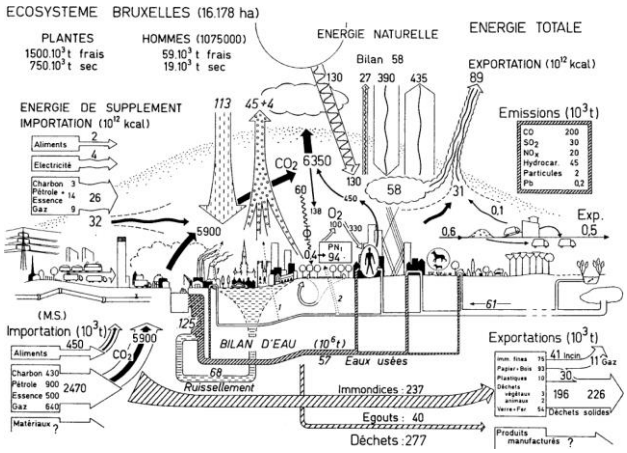


Figure 45: Urban metabolism study developed by Duivigneaud and Denayeyer for Brussels, Belgium in 1977 (Kennedy, Cuddihy, & Engel-Yan, 2007, p. 47).

Considering that urban areas consume between 70 and 80 percent of all resources extracted on a global scale, it becomes extremely important to understand the transformation of resources in urban settings (Baccini, 2007). Consequently, significant efforts have been made by the scientific community to contribute to UM studies, as is detailed in Table 4.

Table 4: Chronological review of urban metabolism studies since 1965 (Kennedy, Pincetl, & Bunje, 2011, p. 1966)

Author (year)	City or region of study	Notes/contribution
Wolman (1965)	Hypothetical US city of 1 million people	Seminal study
Zucchetto (1975)	Miami	Emergy approach
Stanhill (1977); Odum (1983)	1850s Paris	Emergy approach
Hanya and Ambe (1976).	Toyko	
Duvigneaud and Denayeyer-De Smet (1977)	Brussels	Includes natural energy balance
Newcombe et al. (1978); Boyden et al. (1981)	Hong Kong	Particularly comprehensive metabolism study
Girardet (1992)		Recognized link to sustainable development of cities
Bohle (1994)		Critiqued metabolism perspective for studying food in developing cities
European Environment Agency (1995)	Prague (comprehensive metabolism study)	Energy use data for Barcelona and seven other European cities given in the report.
Nilson (1995)	Gävle, Sweden	Phosphorus budget
Baccini (1997).	Swiss Lowlands	
Huang (1998).	Taipei	Emergy approach
Newman (1999); Newman et al. (1996)	Sydney	Adds liveability measures
Stimson et al. (1999)	Brisbane & Southeast Queensland	Framework relating urban metabolism to quality of life.
Hermanowicz and Asano (1999)		Water
Hendriks et al. (2000).	Vienna & Swiss Lowlands	
Warren-Rhodes and Koenig (2001).	Hong Kong	
Baker et al. (2001)	Phoenix & Central Arizona	Nitrogen balance
Sörme et al. (2001)	Stockholm	Heavy metals
Svidén and Jonsson (2001)	Stockholm	Mercury
Obernosterer and Brunner (2001)	Vienna	Lead
Færge et al. (2001)	Bangkok	Nitrogen & Phosphorus
Chartered Institute of Wastes Management (2002)	London	
Gasson (2002)	Cape Town	
Barrett et al. (2002)	York, UK	Materials
Obernosterer (2002)		Metals
Sahely et al. (2003).	Toronto	
Emmenegger et al. (2003)	Geneva	
Burstrom et al. (2003)	Stockholm	Nitrogen & Phosphorus
Gandy (2004)		Water
Lennox and Turner (2004)		State of the Environment report
Hammer and Giljum (2006)	Hamburg, Vienna and Leipzig	Materials
Kennedy et al. (2007)		Review of changing metabolism
Schulz (2007)	Singapore	Materials
Barles (2007a)	Paris	Historical study of nitrogen in food metabolism
Forkes (2007)	Toronto	Nitrogen in food metabolism
Zhang and Yang (2007)	Shenzhen, China	Develops eco-efficiency measure
Ngo and Pataki (2008)	Los Angeles	
Chrysoulakis (2008)		New project under EU 7th framework
Schremmer and Stead (2009)		New project under EU 7th framework
Barles (2009, 2007b)	Paris	Analysis of central city, suburbs and region.
Zhang et al. (2009)	Beijing	Emergy approach
Niza et al. (2009)	Lisbon	Materials
Deilmann (2009)		Studies relationship between metabolism and city surface
Baker et al. (2001)		Water
Thériault and Laroche (2009)	Greater Moncton, New Brunswick	Water
Browne et al. (2009)	Limerick, Ireland	Develops measure of metabolic efficiency

We can further understand the concept of UM by studying how this framework provides an overview on urban systems through the analysis of different material and energy flows. In short, "research on urban metabolism focuses on the sources and consumption of resources, and on their cycling within the system plus the emission, treatment, recycling of wastes" (Zhang, Urban metabolism: A review of research methodologies, 2013, p. 464). Another key step towards understanding UM is to examine the tools that UM studies employed in order to execute analyses. According to Holmes & Pincetl, 2012, UM studies are performed mainly by means of material flow analysis and emergy tools *(available energy to produce a product or service; embodied energy)* (Holmes & Pincetl, 2012). To summarize the methods used for UM analysis, an overview of different tools is presented in Table 5.

Table 5: Comparative urban metabolism measurement methods (Pincelt, Bunje, & Holmes, 2012, p. 197).

Method	Merits	Drawbacks
Emergy	Draws attention to ecosystem and natural resource basis of flows; unsubstitutable role of solar energy for life processes. May be best used for non-urban analyses such as agricultural production as the calculations are straightforward.	Difficult to operationalize in seJ metric due to inadequate data, difficulty in integrating and expressing different urban processes in one similar unit. Neglects geotechtonic or climatic processes, nuclear energy, and qualitative factors (Smil, 2008; Cleveland, Kaufmann, & Stern, 2000).
Material flow analysis	Can be used to derive aggregated indicators for sustainability, especially those relating to pressures on the environment. Quantifies inputs and outputs of numerous commodities.	Requires data about materials extraction and use and the ability to interpret and utilize for policy changes. Does not by itself integrate multiple materials transformational processes.
Mass balance	Draws attention to degradation of resource through use. Can track resource flows of industries, geographical regions, materials or products and how these resource flows change over time.	Lack of consistent classification of data has frequently been a major barrier to the amalgamation of datasets. Integration into other methodologies still being developed (such as ecological footprinting).
Life cycle assessment	Provides cradle-to-grave accounting of resource use and associated environmental impacts from extraction to disposal.	Defining the boundaries must be made explicit. How far upstream to take the analysis still problematic. Continued debate on the appropriate application of different LCA methods to urban systems.
Economic Input–Output Life Cycle Assessment (EIO-LCA)	Adds economic factors to the LCA, and provides ability to link to dollar metrics.	Requires significant, nationally specific data. Utilizes economic (capital) metrics as a proxy for many materials and processes that are often difficult to integrate with material flows or mass/energy balance.

Finally, it is important to mention that, despite the advances in urban metabolism research, various opportunities lay ahead for future research. For instance, carbon-related metabolic processes to assess the contribution of a city's metabolism to climate change, social network analysis linked to UM, resource control and human factors in metabolic flows (Zhang, Urban metabolism: A review of research methodologies, 2013), as well as resource use optimization by the translation of urban metabolism results and finding in policy making processes (Holmes & Pincetl, 2012).

3.1.2 Material Flow Analysis: A tool of analysis for urban metabolism studies

In the early 1970's, the analytical tool of Material Flow Analysis (MFA) emerged as a method for studying the metabolic flows of urban areas under the urban metabolism framework (Holmes & Pincetl, 2012). To demonstrate the use of the urban metabolism framework and MFA, Figure 46 illustrates a case study for the city of Toronto, Canada. Here, a group of graduate students from Toronto University, designed a sustainable metabolism, where some of the flows of the city were closed. By closing the loops for materials, nutrients, energy, and water, the city was able to become less energy- and material-intensive, resulting in the preservation of natural resources (Kennedy, Pincetl, & Bunje, 2011).

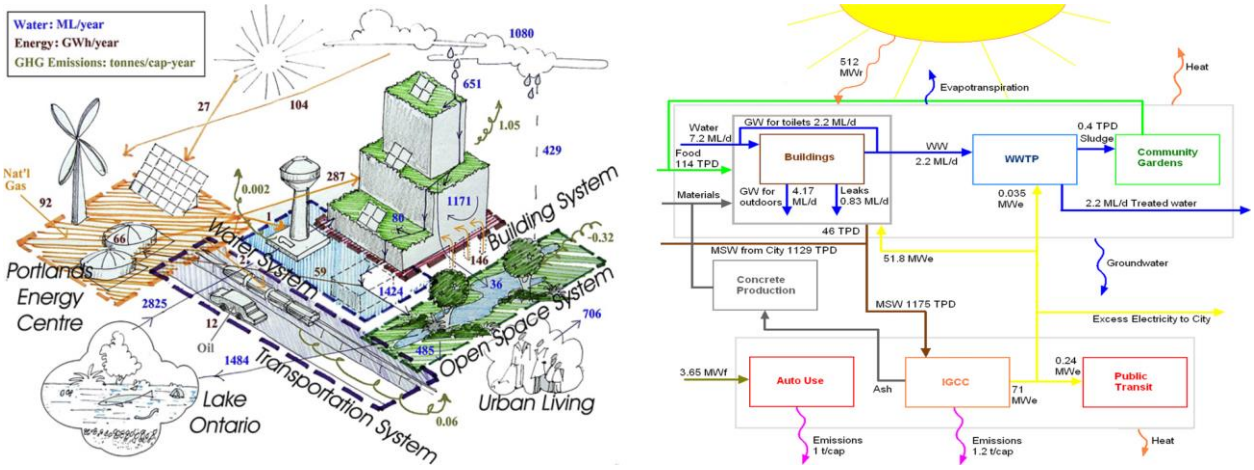


Figure 46: Sustainable metabolism and material flow analysis for the city of Toronto, Canada (Kennedy, Pincetl, & Bunje, 2011, pp. 1970,1971).

Material Flow Analysis enables the quantification of inputs, outputs, and stocks of the city's main flows, which, in turn, can serve as a basis for sustainable urban design and urban planning (Kennedy, Pincetl, & Bunje, 2011). In addition, the results of a MFA analysis can be useful in the context of UM by providing solutions as to how to best manage resources in an urban areas, model current and future scenarios for material flows, and identify problematic flows (and therefore, identify opportunities for improving flows). Perhaps the relevant use of MFA for policy-makers is to input its results to help define goals from a material and resource management perspective (Binder, van der Voet, & Sinclair Rosselot, 2009).

The most commonly used MFA method is denominated economy-wide MFA, or the Eurostat method. Based on Figure 47, the economy-wide MFA consists of inputs flowing into the economy (which serves as system boundary) and outputs flowing out of the system. The inputs are comprised of domestically extracted materials and imports that flow into the economy. Once within the economy, the inputs—in addition to contributing to an accumulation (stock) of materials within the system boundary—are transformed by production and consumption processes, resulting in air emissions, waste disposal, and exports as output flows (Eurostat, 2001).

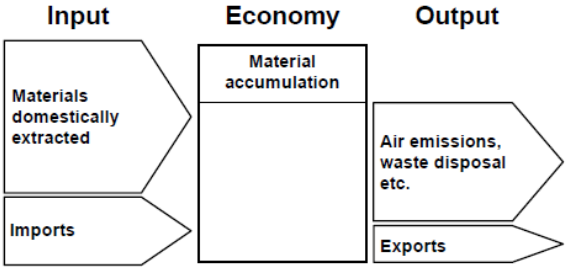


Figure 47: Scope of economy-wide MFA (Eurostat, 2001, p. 9).

The principle of MFA is thusly based on Lavoisier's law of mass conservation, which, in essence, states that within a system boundary, the inputs are equal to the outputs, as mass can neither be created nor destroyed. Accordingly, MFA begins with a classification of the materials flows, and concludes with a balance sheet of the accountings of these flows, all of which are components of an urban system (Binder, van der Voet, & Sinclair Rosselot, 2009).

3.1.3 Urban Water Metabolism: Literature review and applications of UWM

The urban metabolism framework underpins the urban water metabolism (UWM) concept. In 1981, Tambo pioneered the concept of urban water metabolic system as an approach to ensure that a water supply could meet a city's demand, in terms of water quality and quantity. Later, in 2002, this author suggested that water pollution arises as an imbalance in the urban water metabolism (Zhang, Yang, & Fath, 2012). Overall, there has been relatively little research on UWM, which makes it difficult to settle on a unified definition of the concept. Regardless of this fact, understanding the UWM as a specific material analysis under the UM framework enables the following characterization: "Urban water metabolism can be understood by analysis of metabolic flux and structure, social economic factors and driving mechanisms, and this analysis can assist identification of the water metabolism capacity bottlenecks which constrain city expansion and development, and identification of adapting mechanisms to cope with pollution, drought and flooding" (Huang, Vause, Ma, & Yu, 2013, p. 20).

Figure 48 portrays a conceptual illustration of UWM in the built environment, depicting the water metabolism not as water consumption through anthropogenic processes, but rather as an integration of natural cycles (e.g. precipitation, evaporation) and urban hydrological cycles (e.g. infiltration, runoff parameters).

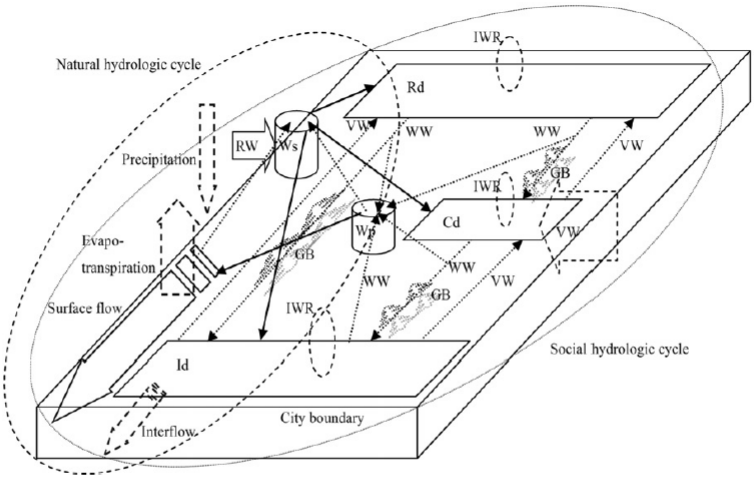


Fig. 2. A conceptual representation of improving urban water metabolism based on integrated analysis of natural and social hydrologic cycles. Notes: arrows denote water flow direction, dashed arrows and circles indicate the flow processes that are priority areas for water use optimization. Wide arrows indicate natural processes in the urban hydrologic cycle; small circles and fine arrows indicate processes in the social hydrologic cycle. Rd = residential district, Cd = commercial district, Id = industrial district; Wp = wastewater processing, Ws = water supply; IWR = internal water recycling within a urban functional district, i.e. cascading use of water flowing through a building, block, and industrial chain according to its quality as affected by different water users; RW = net real water input from outside the city system, VW = net virtual water (i.e. products or services) input from outside the city system, WW = wastewater; GB = green belt or wetlands which can purify wastewater from residential or commercial districts.

Figure 48: Conceptual representation of urban water metabolism. Integration of natural and social hydrological cycles (Huang, Vause, Ma, & Yu, 2013, p. 23).

Understanding urban water metabolism within the metabolic processes of urban areas is of great importance for the development of sustainable cities, because (in terms of mass) "the flux of water stands out as the dominant material flux across megacities, comprising up to 90% of all material entering the system" (Decker, Elliot, Smith, & Sherwood, 2000, p. 727). The hydrological performance of cities is set beyond the water demand and supply; it is linked to water quantity and quality for consumption, water production, wastewater emissions, water losses, and water pollution across metabolic pathways (Kenway, Gregory, & McMahon, 2011).

An enhancement of the urban hydrological performance would optimize water flows and identify new sources of water, as well as provide an urban configuration to improve the use of water. UWM assists in the understanding of water flows throughout a city's system boundary, and provides an urban mass balances framework within which to quantify all anthropogenic and natural flows. In short, it is a water focus application for the urban metabolism framework that enables further water accounting, monitoring, and management (Kenway, Gregory, & McMahon, 2011).

Table 6 provides a review of different efforts made to research the urban mass balances in different cities worldwide.

Table 6: Urban Water Balance studies on various cities worldwide; including the main water flows. (Kenway, Gregory, & McMahon, 2011, p. 696)

				Inputs†				Outputs†			
City analyzed, year	*Author*	*Boundary of system assessed*	*Model used?*	C	D_R/D_G	P	Re	W	R_s	G	ET
Sydney, 1990	Newman (1999)	City	N	√	×	×	×	√	×	×	×
Toronto, 1999	Sahely and colleagues (2003)	Greater Toronto	N	√	×	×	×	√	×	×	×
London, 2000	Chartered Institute of Wastes Management (2002)	Greater London	N	√	×	×	×	×	×	×	×
Vienna, 1996	Hendriks and colleagues (2000)	City	N	√	×	×	×	√	×	×	×
Hong Kong, 1997	Warren-Rhodes and Koenig (2001)	Special administration region	N	√	×	√ (mm/year)	×	√	×	×	×
Cape Town, 1996–1998	Gasson (2002)	Metropolitan area	N	√	×	×	×	√	×	×	×
Tianjin 1989–1990	Leitmann (1994)	Metropolis, urbanized or city	N	√	×	√ (mm/year)	×	√	×	×	×
Hypothetical city of 1,000,000 people	Wolman (1965)	Undefined	N	√	×	×	×	√	×	×	×
City of Moncton, Canada, average year c. 2005	Theriault and Laroche (2009)	Greater Moncton administrative boundary (227 km^2)	N	√	×	√ (m^3/year)	×	√	√	√	√
Canberra, 1979–1996	Mitchell and colleagues (2003)	Woden Valley (27.5 km^2)	Y	√	×	√ (L/d)	×	√	√	×	√
Leipzig, 1870–2003	Haase and Nuissl (2007)	Leipzig City (297.5 km^2)	Y	×	×	× (mm/year)	×	×	√	×	√
Rastatt, Germany, 1996–2004	Klinger and colleagues (2006)	City	Y	√	×	√	×	√	√	√	√
Tunja, Columbia	Binder (1997)	City and catchment (74 km^2)	Y	√	×	√ (m^3/year)	×	√	√	√	√

Note: C = centralized water flows; D = decentralized flows; D_G = decentralized water from groundwater; D_R = decentralized water from rainwater tanks; P = precipitation (including rain, snow, and dew); Re = reuse; W = wastewater; R_s = stormwater runoff; G = flows to groundwater; ET = evapo-transpiration; mm = millimeters; km^2 = square kilometers.
†See figure 2 and equation 5.

3.2 Urban Water Metabolism Model

The UWM of the current water system in Palomino will be analyzed on the basis of a development scenario. Some parameters of the urban water metabolism model will be changed according to each scenario, while the processes and flows of the UWM conceptual model remain unchanged. The analysis on a scenario basis improves the understanding of the water system by helping on the identification of the critical flows of the system.

3.2.1 Method

The flow diagram presented in Figure 49 shows the method developed to execute the analysis under the UWM model of the current water system in Palomino. The method consists of a total of six consecutive steps, starting with the definition of the system boundary (to delineate the space and time frame for the analysis of the UWM model) and continuing with the development of the conceptual model and the main mass balance equation, next, passing through the scenarios development, data acquisition (necessary to analyze the scenarios and run the models), and finishing with the outcomes of each UWM model per scenario and an analysis of the obtained results.

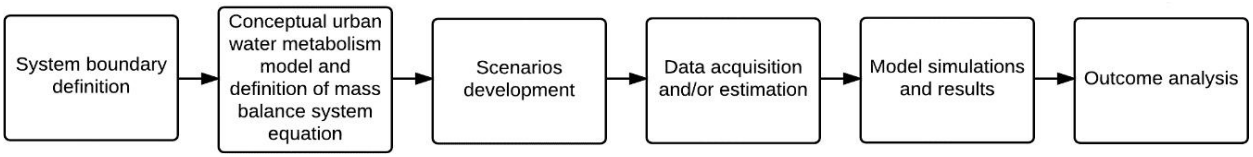


Figure 49: Flow diagram of the method for the UWM model of the current water system in Palomino.

3.2.2 Urban water metabolism in Palomino

3.2.2.1 System boundary definition

The system boundary use for this model is based on the study area described in PART I. The spatial dimension corresponds to a polygon with an area of 4.83 km^2. The model's system boundary encloses the main economic flows of the urban water metabolism in Palomino on the basis of two central actors: Domestic sector and Commercial sector (equivalent to the tourism sector). The time frame chosen for the analysis is one month of 31 days for the year of 2015.

3.2.2.2 Conceptual urban water metabolism model and definition of mass balance system equation

Figure 50 illustrates the conceptual model for the urban water metabolism in Palomino. As previously mentioned, it contains the key economic flows, which are linked to anthropogenic processes. Both processes and flows are directly associated with the influence of socio-economic relations between the built environment and the water transformations in the urban water metabolism.

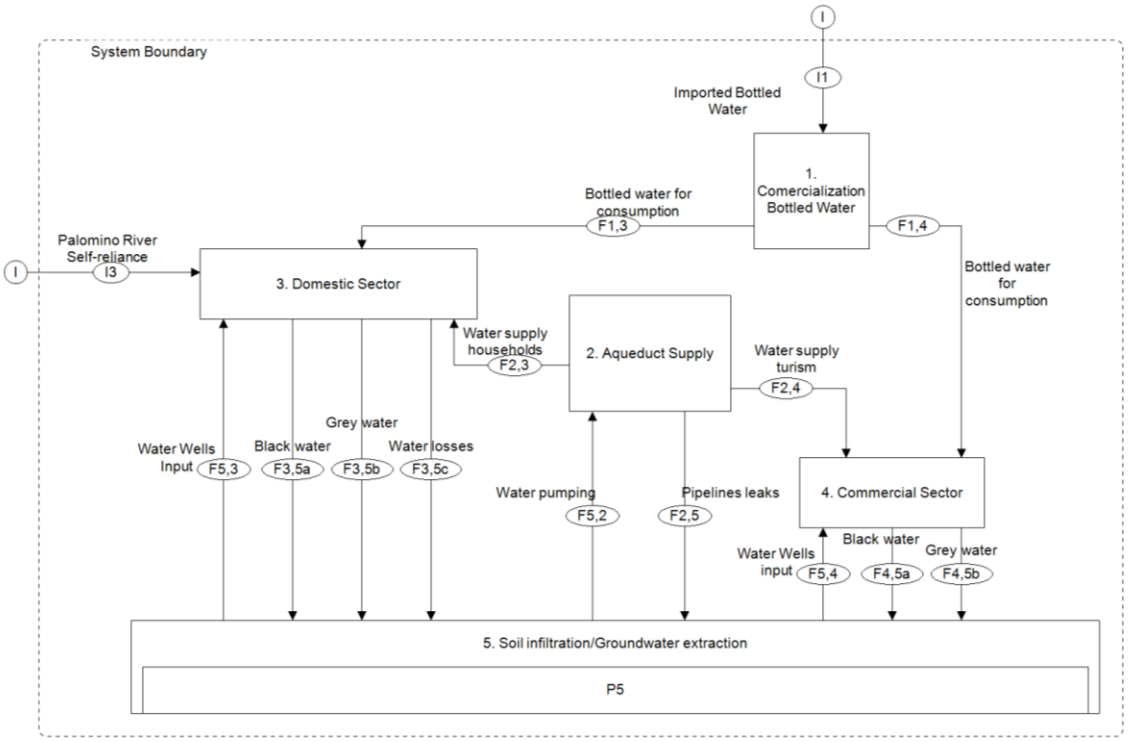


Figure 50: Conceptual UWM model for Palomino.

The system boundary includes the main flows and processes for the centralized and decentralized water supplies, as well as the different water uses, losses, and final deposition. The presented UWM is the representation of the main characteristic found and analyzed under PART II of the present research. The following two assumptions were made for the elaboration of the UWM model:

- Due to lack of precise data, rainwater collection and urban agriculture are not considered in the model, even though the results of the surveys showed that 57% of the households performed, in some degree, rainwater collection and urban agriculture.
- Due to lack of precise data, it is assumed that the commercial sector does not acquire water from the Palomino River in the form of self-reliance. This is certain for hotels within the urban perimeter, as it is for hotels outside this perimeter. This flow showed negligible impact in the survey's results.

As illustrated in Figure 50, the UWM model is formed by a total of five processes (one of which P5 Soil infiltration/Groundwater extraction acts as a stock), two inflows, and thirteen internal flows.

The subsequent nomenclature has been chosen for each component of the model:

5 processes	P*i*, P= Process and *i*= number of the process.
2 Inflows	I*n*, I= Inflow and *n*= number of destination process.
13 Internal flows	F*i,j*, F= Flow; *i*= number of source process and *j*= number of destination process.

The UWM model is a stationary model, based on a Material Flow Analysis, representing a snapshot in a determinate time (in this case one month of 31 days). The mathematical representation of the UWM model is based on the mass balance principle, which is grounded on the law of conservation of mass that states that within the system boundary of an isolated system the mass can neither be created nor destroyed. Derived from the law of mass conservation, in a system boundary, the inputs should be equivalent to the outputs of the system.

The UWM model is a system of linear equations, defined by the specificity of the conceptual model. For the conceptual UWM model for Palomino, no outputs are present in the system; since P5 serves as a stock process, the overall equation that describes the system is as follows:

$$\Delta S = I_1 + I_3$$

Where:
$\Delta S = Stored\ Water$
$I_1 = Imported\ bottled\ water$
$I_3 = Palomino\ river\ self - reliance$

The following Table 7,Table 8 and Table 9 describe the elements in the UWM model, the processes involved, as well as the associated inflows and inner flows.

PROCESSES

Table 7: Description of the processes in the UWM model

Nomenclature	Name	Description
P1	Commercialization of bottled water	This process represents the distribution process of bottled plastic water or the plastic water bags that enter the system boundary for household consumption in Palomino, and for tourists and employees of the tourism sector.
P2	Aqueduct supply	The process of centralized water supply, as described in PART II of the present research.
P3	Domestic sector	This refers to the process of water transformation within households. Drinking water and untreated water is supplied to each household in the urban perimeter of Palomino, and is then used for household activities and consumed for human needs. Finally, the transformation of the supplied water can be divided into two classes of waste water: black water and grey water.
P4	Commercial sector	In the same manner as the domestic sector process, the commercial sector process refers to the water supplied, consumed, used and transformed by the tourism sector.
P5	Soil infiltration / Groundwater extraction	This process is the stock of the system. It is both a source from groundwater extraction and a sink for wastewater disposal.

INFLOWS

Table 8: Description inflows UWM model

Nomenclature	Name	Description	Process IN
I1	Imported Bottled Water	Water entering the system boundary in form of bottled water or plastic water bags. This water is only use for human consumption. Bottled water is mainly distributed in hotels; plastic water bags are purchased mainly in local stores by the community.	Commercialization Bottled Water (1)
I3	Palomino River self-reliance	Uptake of fresh, but untreated water from the Palomino River for consumption and household activities.	Domestic Sector (3)

INNER FLOWS

Table 9: Description inner flows UWM model

Nomencla-ture	Name	Description	From Process	To Process
F2,3	Water supply households	Fresh water supply coming from the main aqueduct for household consumption.	Aqueduct Supply (2)	Domestic sector (3)
F2,4	Water supply tourism	Fresh water supply coming from the main aqueduct for consumption in the hotels within the area of the urban perimeter.	Aqueduct Supply (2)	Commercial Sector (4)
F2,5	Pipelines leaks	Technical water losses in the aqueduct system. The losses are mainly due to the poor integrity of the distribution pipelines.	Aqueduct Supply (2)	Soil Infiltration / Groundwater extraction (5)
F1,3	Bottled water for consumptions.	Water purchased in local stores and distribution centers for human con-sumption on a household level.	Commercialization Bottled Water (1)	Domestic sector (3)
F1,4	Bottled water for consumptions.	Water imported into the system boundary for human consumption in the commercial sector.	Commercialization Bottled Water (1)	Commercial Sector (4)
F3,5a	Black water	Waste water coming from household sanitation systems.	Domestic sector (3)	Soil Infiltration / Groundwater extraction (5)

F3,5b	Grey water	Waste water from the households activities, such as cleaning, showering, etc.	Domestic sector (3)	Soil Infiltration / Groundwater extraction (5)
F3,5c	Water losses	Due to the lack of valves in the storage tanks installed in the household level. Freshwater supplied by the aqueduct system is wasted and spilled due to overflow of the water storage tanks. This is considered as water losses due to water user's behavior.	Domestic sector (3)	Soil Infiltration / Groundwater extraction (5)
F4,5a	Black water	Waste water coming from the sanitation system use in hotels.	Commercial Sector (4)	Soil Infiltration / Groundwater extraction (5)
F4,5b	Grey water	Waste water from the hotels activities, such as cleaning, showering, etc.	Commercial Sector (4)	Soil Infiltration / Groundwater extraction (5)
F5,2	Water Pumping	Groundwater extraction to feed the main pumping system of the central aqueduct.	Soil Infiltration / Groundwater extraction (5)	Aqueduct Supply (2)
F5,3	Water Wells Input	Groundwater extraction for private use at a household level.	Soil Infiltration / Groundwater extraction (5)	Domestic sector (3)
F5,4	Water wells	Groundwater extraction for private use at a hotel level.	Soil Infiltration / Groundwater extraction (5)	Commercial Sector (4)

3.2.2.3 Scenario development

The scenarios developed in this section are the basis of the UWM analysis in Palomino. The scenarios aim to interact with the variable flows of the model in order to create different conditions or combinations for which critical flows and reactions of the UWM can be detected. The scenarios are developed by defining some basic assumptions about the UWM model and by identifying the constant and variable flows.

Principal assumptions of the model:

- Water demand is proportional to water availability, the more water is available, the more will be expended; therefore, water demand for the domestic and commercial sectors is based on the results of the surveys from the field research.
- Domestic demand does not vary during the month of the analysis. This is true when calculating the standard demand on the basis of the population, which can be considered constant during the timeframe of the scenario.
- Commercial demand differs only between high and low season, but it is constant during each season.
- The Palomino River is an endless water resource.
- Imported water bottled could be endlessly introduced to the system.
- The groundwater available in the system is modelled as a stock, without the external influences of recharge by percolation and discharge by drainage.

The next illustration, Figure 51, is a visualization of the division between the inner flows of the UWM model on constant and variable flows. Through this figure, it is possible to observe and establish which flows could be combined and subsequently modified for the creation of a different set of scenarios. Four dependencies/variables can be identified: 1. Touristic season 2. Hours without electric energy per month 3. Percentage of water losses due to pipelines leaks and 4. Percentage of losses due to users' behavior; each of these variables affect directly one or more inner flows of the UWM model.

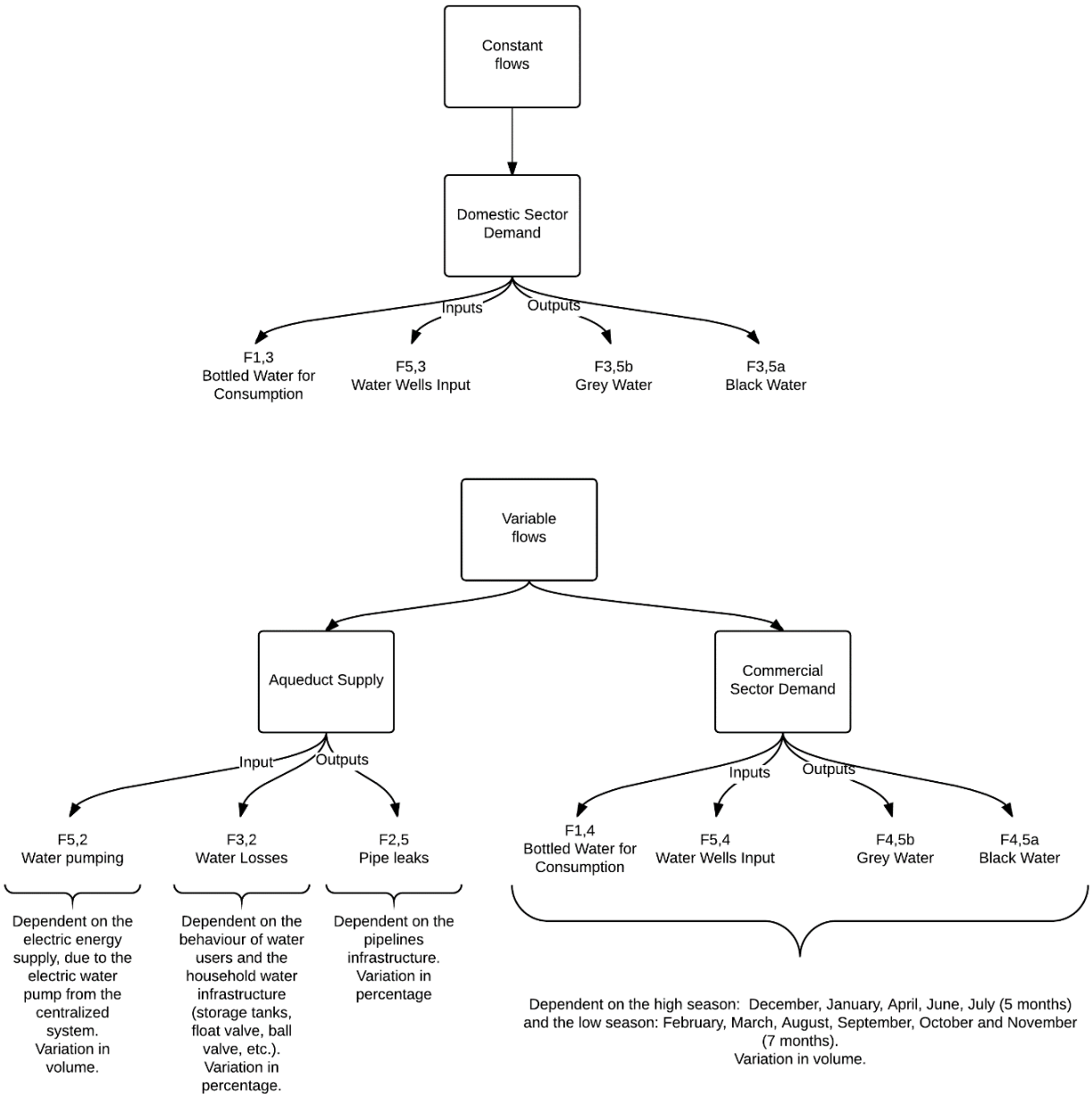


Figure 51: Constant flows and variable flows from the UWM model and dependencies of the variable flows.

Description of the scenario's variables:

1. **Touristic Season:**

It is hard to determine the exact number of tourists visiting Palomino throughout the year, or even in the high or low tourist season. Though only 18 hotels are officially registered in the chamber of commerce[46], there are roughly 40 are present in Palomino (Observation, September, 2015). It is estimated that a total

[46] For the list of registered hotels refer to Appendix H.

of 1,000 tourists visit Palomino during the high season, while only 600 visit during the low season (Ramirez Alvarez, 2014). The tourist season affects directly the commercial sector's water demand.

2. Hours without electric energy per month:

Electric energy is critical to the centralized water supply system, since it depends on one electric water pump for the groundwater extraction. It is assumed that the water pump runs at its maximum capacity for the 24 hours of the seven days of the week, unless its functionality is affected by the lack of electricity.

Due to irregular electricity service, between October 2014 and January 2015, from a total of 123 days or 2952 hours, an estimated 216 hours was the town of Palomino without electricity. This is the equivalent to 7.3% of losses in the water system due to lack of operation of the main pump. For the month of October, 2014 the lack of electric energy was of 70 hours, as for the month of November, 2014 was 38 hours and December, 2014 correspond to 35 hours (Palomino Guajira, 2015). Here, a range between 70hours/month and 35hours/month will be used. No assumptions are made for the lack of operation of the water pump due to repairs or dysfunctionalities.

3. Percentage of water losses due to pipelines leaks:

"Over 37 years ago, the pipelines were installed in Palomino" Miles Hernandez, 62 years old.

There is no certain way to establish the percentage of water losses due to the lack of maintenance of the water distribution system (WDS) with the available data. The pipeline network in Palomino is extremely old, according to the local population, and the system has had very few improvement in recent years. The Colombian technical norm for drinking water supply and basic sanitation (RAS 2000) estimates a technical loss of maximum 30% for a system with the complexity of Palomino[47] (Ministerio de Desarrollo Económico. Dirección de Agua Potable y Saneamiento Básico, 2000). In Latin America, water losses due to technical cause are estimated to be around 40-55% of the water delivered (Mutikanga, 2012). Nonetheless, these approximations could not represent at all the percentage of water losses for the specific case of the WDS in Palomino, since they are dependent on the local conditions of the system. For this reason, a range between 50% and 70% will be chosen, large water losses can be expected from an almost-40-year-old infrastructure.

4. Percentage of losses due to user's behavior:

The losses in the individual households are large, and they depend on both the household infrastructure (such as the presence of float valves) and on the users' behavior (i.e., how efficiently they use the supplied water). In these type of systems, the losses can reach up to 80% of the water supplied, mostly due to the infrastructure, but also due to the water users' behaviors. (Uribe Schroeder, E., personal interview, September 25, 2016).

The households in Palomino do not have valves in their water tanks, nor water metering; some inhabitants complain of water waste in other households due to the overflow of the water in the storage tanks (Observation, September, 2015). The water losses due to users' behavior is hard to measure, though for the purpose of the scenarios, it is estimated to range from 15% to 25% of losses of the water distributed from the aqueduct supply.

[47] Level of complexity of the system is established under Report A, Chapter A.3.1 – Table A.3.1. Asignación de nivel de complejidad. The system of Palomino has a level of complexity *Medio.* The maximum technical losses depend on the level of complexity of the system and are found under Report B, Chapter B.2.5 – Table B.2.4 Porcentajes máximos admisibles de pérdidas técnicas.

Scenarios:

Table 10 specifies the scenarios developed for the analysis of the UWM model. A total of 14 scenarios were created based on a combination of the previously mentioned variables of the UWM model. Here, two different sets of scenarios can be identified: one of a high touristic season and one of a low touristic season. All the developed scenarios could represent a 'real scenario', as a consequence that each variable has a range that might be possible to observe in Palomino. Nonetheless, the results of the combination of these variables could not represent what has been observed in the current UWM in Palomino; therefore, the analysis on a scenario basis serves mainly to help identify critical flows and more deeply understand the implications of certain flows in the UWM.

Scenario 1 is a scenario that could be a 'real scenario;' for example, the month of October, in instances when it has been registered a low touristic season, 70 hours/month of no electric energy and it is a month of 31 days. From this scenario on, a more systematic approach is developed by maintaining some variables fixed and modifying others, with the goal of identifying the changes in the system and the causal relations amongst the different sets of variables.

Table 10: Scenarios for UWM model

Variables /Scenarios	1. Touristic season	2. Hours without electric energy per month [Range: 70h/month-35h/month]	3. Percentage losses due to pipelines leaks [Range: 70%-50%]	4. Percentage of losses due to user's behavior [Range: 25%-15%]
Scenario 1	LOW	70 h/month	70%	25%
Scenario 2	HIGH	70 h/month	70%	25%
Scenario 3	LOW	60 h/month	70%	25%
Scenario 4	LOW	70 h/month	70%	15%
Scenario 5	LOW	70 h/month	60%	25%
Scenario 6	LOW	70 h/month	55%	20%
Scenario 7	LOW	50 h/month	65%	20%
Scenario 8	HIGH	35 h/month	70%	25%
Scenario 9	HIGH	40 h/month	60%	20%
Scenario 10	HIGH	35 h/month	70%	15%
Scenario 11	HIGH	35 h/month	60%	15%
Scenario 12	HIGH	35 h/month	55%	15%
Scenario 13	HIGH	35 h/month	50%	15%
Scenario 14	LOW	35 h/month	50%	15%

3.2.2.4 Data acquisition and/or estimation

The required data is determined by the UWM conceptual model, where the majority flows and transfer coefficient must be established in order to obtain a system that is determinate and can be solved using the linear equations that govern the system. The flows are quantified by using the data available either by primary data (results obtained from field research) or secondary data. The quantifications of the flows in this section are based mainly on the results presented in PART II (section 2.4 Water management) of this masters thesis report. In addition to the quantification of the flows and determination of the transfer coefficients, when necessary, the equations that define the calculation of the flows within the system are presented.

DOMESTIC SECTOR DEMAND

The water demand for the households in Palomino is around 30 L/cap day and 60 L/cap day (PART II). To calculate the demand on a monthly basis, a standard value of **50 L/cap day** is chosen. The population for 2015 is necessary to calculate the total demand of the domestic sector, the estimation made in PART II will be used. For the year of 2009, an estimated population of 2.141 inhabitants in an average of 498 households, and for 2015, the estimate of the urban population is approximate **2286 inhabitants** (PARTII) (Departamento de La Guajira, Catastro, diagnóstico y optimización del sistema de alcantarilllado del corregimiento de Palomino del municipio de Dibulla, La Guajira, 2012). Finally, the demand for the domestic corresponds to:

Demand domestic sector = 3543.3 m^3/month

COMMERCIAL SECTOR DEMAND

Variation in the touristic sector is high, and it dependents strongly on climate conditions and the type of activities and accommodation offered (for example, a tropical climate in a four star hotel with a pool has a bigger water demand than a non-luxury accommodation in a cooler climate). These variations are significant and can range from 150 L/day per tourist to 400 L/day per tourist, reaching up to 600 L/day per tourist in more luxurious accommodations (Gössling, et al., 2012). Consequently, the water demand of the commercial sector will be determine by the results found in the surveys in Appendix D.

The survey's results showed a variation from 60L/cap day to 250 L/cap day. The lowest value corresponds to a hostel-type of accommodation and the highest to a hotel. It was also found that the demand varied according to the water available, thus hotels that owned a private well had a larger water demand than those found on the urban perimeter. Some of the values found were: 60, 120, 180, 110, 228, 250 and 160 L/cap day, as for the hotels in the urban area: Hotel Nakua: 163.2 L/cap day, Hostel Aluna 91.84 L/cap day (PART II). For the purpose of the estimation of the commercial demand, a standard demand of **160 L/day tou**[48] will be chosen, which variates monthly according to the high or low touristic season.

Demand commercial sector HIGH SEASON = 4960 m^3/month

Demand commercial sector LOW SEASON = 2976 m^3/month

INFLOWS

<u>Estimation of the inflows:</u>

I1 Imported Bottled Water:

The imported bottled water flow depends on the bottled water purchased for the consumption of the domestic and commercial sectors, as follows:

$$I_1\ [m^3/\ month] = F_{1,3}[m^3/month] + F_{1,4}[m^3/month]$$

Where

$F_{1,3} = Bottled\ or\ plastic\ water\ bags\ for\ domestic\ consumption$

$F_{1,4} = Bottled\ or\ plastic\ water\ bags\ for\ commercial\ consumption$

[48] tou refers to tourist. cap refers to capita. Using these units the flows are estimated based on a unitary value.

I3 Palomino River self-reliance:
The input of river water is dependent on the demand of the domestic sector in relation to the lack of water supplied either by the centralized system and/or the private wells (from groundwater extraction).

$$I_3\ [m^3/month] = Dd[m^3/month] - F_{1,3}[m^3/month] - F_{2,3}[m^3/month] - F_{5,3}[m^3/month]$$

Where
$Dd = Demand\ domestic\ sector$
$F_{1,3} = Bottled, plastic\ water\ bags\ for\ domestic\ use$
$F_{2,3} = Water\ supplied\ from\ the\ aqueduct$
$F_{5,3} = Groundwater\ extraction\ from\ water\ wells$

INNER FLOWS

Estimation of inner flows:

Process 1 – P1 Bottled Water Commercialization

F1,3 Bottled water/bags for domestic consumption:
The estimation for the demand for plastic or bottled water for household consumption is based on primary data collected during the survey process. The flow is estimated using primary data, since it is a flow subject to the economic capacity per household, rather than to the demand or need per household.
Table 11 is a summary table of the survey's results for the question 18b, Appendix D - Surveys per household used to estimate the standard volume of water purchased per inhabitant per day.

Table 11: Results of water volume purchased in the form of bottled/plastic water bags per inhabitant per day

Survey	Tenants	Plastic bags	Volume per bag [L]	Purchased every # days	Volume per week [L]	Volume [L]/day hab	Average [L]/day hab
SH1	6	20	0.3	1	42	1.00	0.63
SH2	4	3	0.3	7	0.9	0.03	
SH3	4	0	0	0	0	0.00	
SH4	7	20	0.3	1	42	0.86	
SH5	12	5	5	1	175	2.08	
SH6	6	40	0.3	1	84	2.00	
SH7	10	40	0.3	7	12	0.17	
SH8	11	0	0	0	0	0.00	
SH9	5	0	0	0	0	0.00	
SH10	9	40	0.3	1	84	1.33	
SH11	17	3	5	2	52.5	0.44	
SH12	6	60	0.3	7	18	0.43	
SH13	6	20	0.3	2	21	0.50	
SH14	6	0	0	0	0	0.00	

The monthly flow is then estimated by the following equation:

$$F_{1,3}[m^3/month] = \frac{0.63}{10\text{^}3}\ [m^3/dayhab] * 31[day/month] * 2286\ [hab]$$

$$F_{1,3} = 44.65\ [m^3/month]$$

F1,4 Bottled water/bags for commercial consumption:
Due to water quality in Palomino, none of the hotels interviewed offer tap water for consumption; instead, they rely on bottled water with a standard volume of 600cc (cubic centimeters). Based on the surveys per hotel – Appendix E, question 18b – and field observations, average consumption has been estimated at approximately 2 bottles per person per day.

$$F_{1,4}[m^3/month] = 0.0012\ [m^3/daytou] * 31[day/month] * \#tourists\ [tou]$$

$$F_{1,4\ HIGH\ SEASON} = 37.2\ [m^3/month]$$

$$F_{1,4\ LOW\ SEASON} = 22.32\ [m^3/month]$$

Process 2- P2 Aqueduct Supply

F5,2 Water pumping:
As mentioned before, this flow is contingent upon the supply of electric energy. The centralized system for water supply has a capacity of pumping 4 L/s, which is the equivalent to a volume of 388.8 m^3 per day. The groundwater extraction for water supply is therefore calculated based on the hours without electric energy supply as established in each scenario:

$$F_{5,2\ FOR\ 70HOURS/MONTH} = 10918.8\ [m^3/month]$$

$$F_{5,2\ FOR\ 60HOURS/MONTH} = 11080.8\ [m^3/month]$$

$$F_{5,2\ FOR\ 50HOURS/MONTH} = 11242.8\ [m^3/month]$$

$$F_{5,2FOR\ 40HOURS/MONTH} = 11404.8\ [m^3/month]$$

$$F_{5,2\ FOR\ 35HOURS/MONTH} = 11485.8\ [m^3/month]$$

F2,5 Pipelines leaks:
The volume of the water losses due to damages in the infrastructure and leaks in the WDS is determined by:

$$F_{2,5}[m^3/month] = F_{5,2}[m^3/month] * TC_{2,5}$$

Where:
$F_{5,2} = Groundwater\ pumped\ to\ supply\ to\ centralized\ water\ supply\ system$
$TC_{5,2} = Transfer\ Coeficient\ pipelines\ leaks\ (\%\ of\ water\ losses\ according\ to\ the\ scenario)$

F2,3 Water supply households and F2,4 Water supply for tourism:
These two flows are extremely difficult to estimate, since they depend on the location of the hotels within the urban perimeter of Palomino. The surveys per hotel showed that the two hotels interviewed in the urban area had larger capacity for water storage than the common households. By this token, none of these hotels presents a lack of infrastructure needed to fulfill its own needs from the water supplied by the aqueduct system, even if they were to receive water only one day per week. For example, in the case of the Hotel Nakua, two water tanks were available: one of 6,000L and another of 10,000L (equivalent to

the average demand of 14 people), and the Hostel Aluna had one tank of 22.5 m^3 or 225,000 L (the average demand of 35 people), in comparison with the average storage capacity of a household, between 600 L and 1500 L.

Figure 52 illustrates the hotels available for accommodation in Palomino, according to Trip Advisor. Among them, three hotels that were not interviewed are found within the urban perimeter: Jaguar Azul (5 rooms, capacity 16 people), Hostel Tamarindo (10 rooms, approximate capacity 10 people), and La Media Luna (4 rooms, approximate capacity 16 people). Three more hotels are located within the perimeter of the urban area, according to the list of registered hotels: Hostal Aluna Bunkua (5 rooms, capacity 20 people), Palomino Breeze (11 rooms, capacity 15 people), and Casa Silvestre (1 rooms, capacity 2 people) (Appendix H). From the previous data, a total of 9 hotels can be found inside the urban perimeter having an approximate capacity of 128 tourist per day. Estimating an increase of 10% of unregistered hotels results in a total of **141 tourists** hosted in the urban perimeter in the high season and **85 tourists** in the low season.

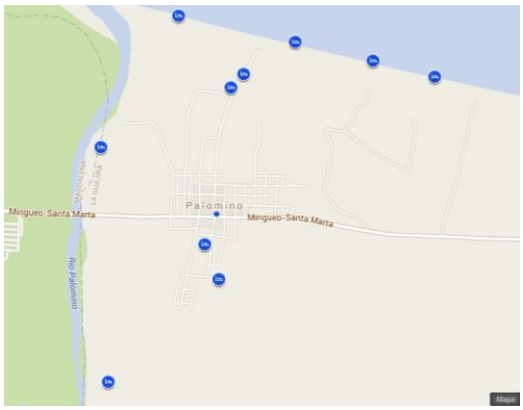


Figure 52: Image hotels in Palomino (Trip Advisor, 2016).

According to the standard commercial demand and the number of tourist within the urban perimeter, the flows are calculated as follow:

$$F_{2,4}[m^3/month] = \frac{160}{10\text{^}3}\ [m^3/daytou] * \#tourists\ [tou] * 31[day/month]$$

$$F_{2,4HIGH\ SEASON} = 699.36\ [m^3/month]$$
$$F_{2,4LOW SEASON} = 421.16\ [m^3/month]$$

And

$$F_{2,3}[m^3/month] = F_{5,2}[m^3/month] - F_{2,4}[m^3/month]$$

Where
$F_{5,2} = Groundwater\ pumped\ to\ supply\ to\ centralized\ water\ supply\ system$
$F_{2,4} = Supplied\ water\ for\ the\ centralized\ system\ to\ the\ commercial\ sector$

Process 3 – P3 Domestic Sector

F5,3 Water Wells Input:

As shown in Figure 53, few water wells are available for household use in Palomino. During the field research and the survey process, only households SH6 and SH7 had private water wells used to extract groundwater for home consumption. Two public water wells were found, but neither was functioning. During the interview process, it was said that roughly five private water wells were operative for household use in the area of the neighborhood, 'El Divino Niño'.

Figure 53: Identified water wells in Palomino (Image Google Earth, 2013; own figure).

Table 12 displays the results of the groundwater extraction on the household level; here, an average of 92.15 L/well day are extracted from the ground by a total of 5 wells.

Table 12: Results on water volume purchased in the form of bottled/plastic water bags per inhabitant per day

Survey	Tenants	Storage Tank	Field # per day	Volume [L/hab/day]
SH6	6	500	1	83.3
SH7	10	495	2	99.0

$$F_{5,3}[m^3/month] = \frac{92.15}{10^3}[m^3/\,well\ day] * 5\ [well] *\ 31\ [day/month]$$

$$F_{5,3} = 14.13\ [m^3/month]$$

F3,5c Water losses:

The volume of the water losses due to the water user's behavior is determined by:

$$F_{3,5c}[m^3/month] = F_{2,3}[m^3/month] * TC_{3,5c}$$

Where:

$F_{2,3} = Water\ supplied\ by\ the\ aqueduct\ system\ to\ the\ domestic\ sector$

$TC_{3,5c} = Transfer\ Coeficient\ water\ losses\ (\%\ of\ water\ losses\ according\ to\ the\ scenario)$

F3,5a Black Water:
The black water flow is dependent on the average liters used per flush, which is established by the type of toilet used and by the user's habits. This estimation must be made according to literature, since this is hard to accurately measure, given the circumstances in Palomino. A case study in Kumasi, Ghana (Erni, 2007) has estimated a use of 15L/cap day for a flush toilet; the same value was found under the case study in Harare, Zimbabwe (Gumbo, 1999). Even though this value can be considered to be conservative, it can serve as a standard to use for the case of Palomino, since the water demand on the domestic sector there is set to 50 L/cap day.

$$F_{3,5a}[m^3/month] = \frac{15}{10\text{^}3}\ [L/cap\ day] * 2285\ [cap] * 31\ [day/month]$$

$$F_{3,5a} = 1062.52\ [m^3/month]$$

F3,5b Grey Water:
The output of grey water from the domestic sector is dependent on the demand of the domestic sector and on its proportion used and transformed in the form of black water:

$$F_{3,5b}[m^3/month] = Dd - F_{3,5a}$$

$$F_{3,5b} = 2480.78\ [m^3/month]$$

Where
$Dd = Demand\ domestic\ sector$
$F_{3,5a} = Black\ water\ output\ from\ the\ domestic\ sector$

Process 4 – P4 Commercial Sector

F5,4 Water Wells Input:
The input of groundwater extraction form private water wells is dependent on the demand of the domestic sector in relation to the lack of water supplied by the centralized system and/or by groundwater extraction from private wells.

$$F_{5,4}[m^3/month] = Dc[m^3/month] - F_{1,4}[m^3/month] - F_{2,4}[m^3/month]$$

Where
$Dc = Demand\ commercial\ sector$
$F_{1,4} = Bottled, plastic\ water\ bags\ for\ commercial\ use$
$F_{2,4} = Water\ supplied\ from\ the\ aqueduct\ service$

F4,5a Black Water:
The black water flow for the commercial sector is estimated at double the water used on the household level. Therefore, a standard of 30L/tou day is used on the commercial sector.

$$F_{4,5a}[m3/month] = \frac{30}{10\text{^}3}\ [m^3/daytou] * \#tourists\ [tou] * 31[day/month]$$

$$F_{4,5a\ HIGH\ SEASON} = 930\ [m^3/month]$$

$$F_{4,5a\ LOW\ SEASON} = 558\ [m^3/month]$$

F4,5b Grey Water:
The output of grey water from the commercial sector is dependent on the demand of the commercial sector, and its proportion used and transformed in the form of black water is as follows:

$$F_{4,5b}[m3/month] = Dc - F_{4,5a}$$

$$F_{4,5b\ HIGH\ SEASON} = 4030\ [m^3/month]$$

$$F_{4,5b\ LOW\ SEASON} = 2418\ [m^3/month]$$

Where
$Dc = Demand\ commercial\ sector$
$F_{4,5a} = Black\ water\ output\ from\ the\ commercial\ sector$

Process 5 – P5 Soil Infiltration / Groundwater extraction:
This process is the stock of the model. It represents the balance of the water imports to the UWM model, which dominates by the overall mass balance equation:

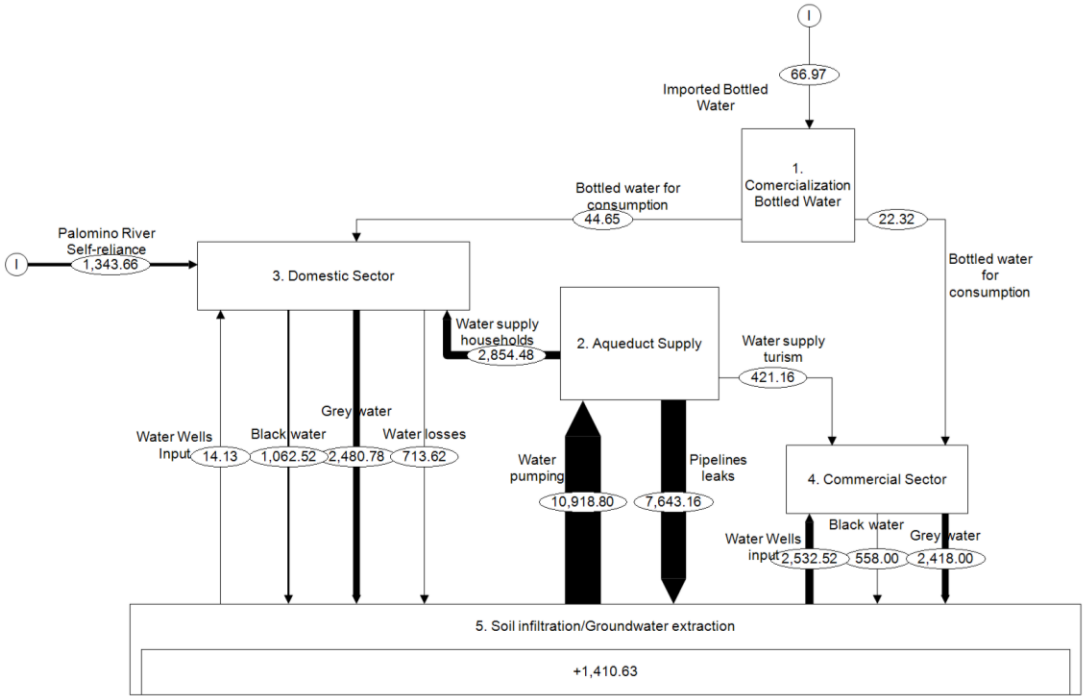
$$\Delta S = I_1 + I_3$$

Here, it is important to notice that if $\Delta S > 0$, the system is importing water. If $\Delta S < 0$, the system has a surplus of water.

3.2.2.5 Model simulations and results

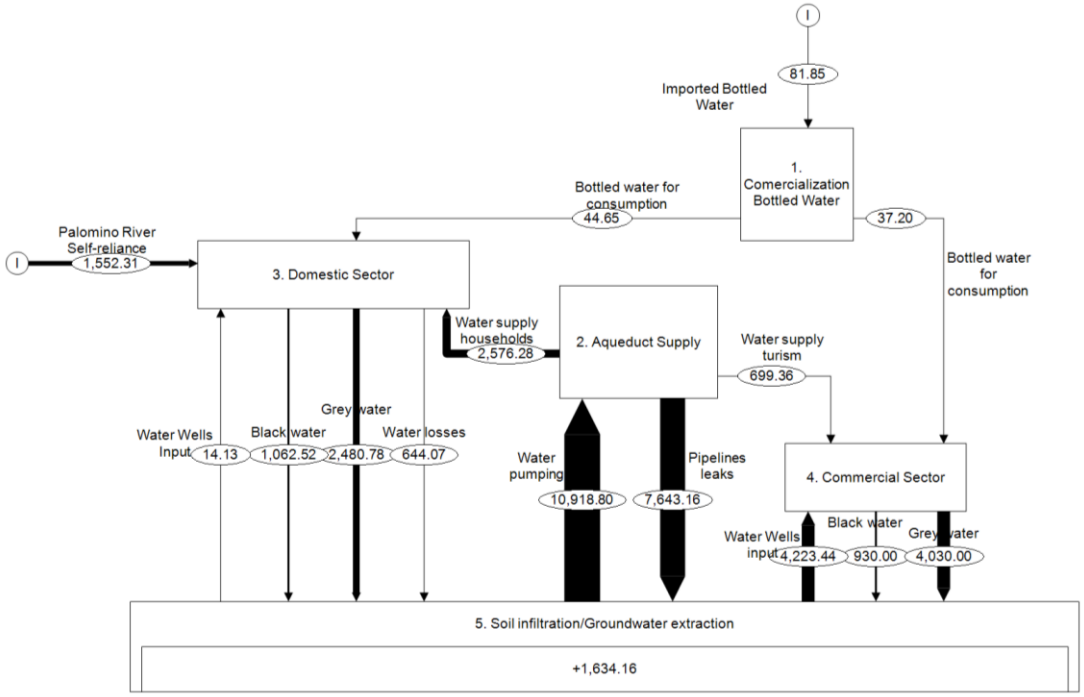
Scenario 1: Maximum losses with lowest water demand

Touristic Season: LOW, Hours without electric energy: 70h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 25%



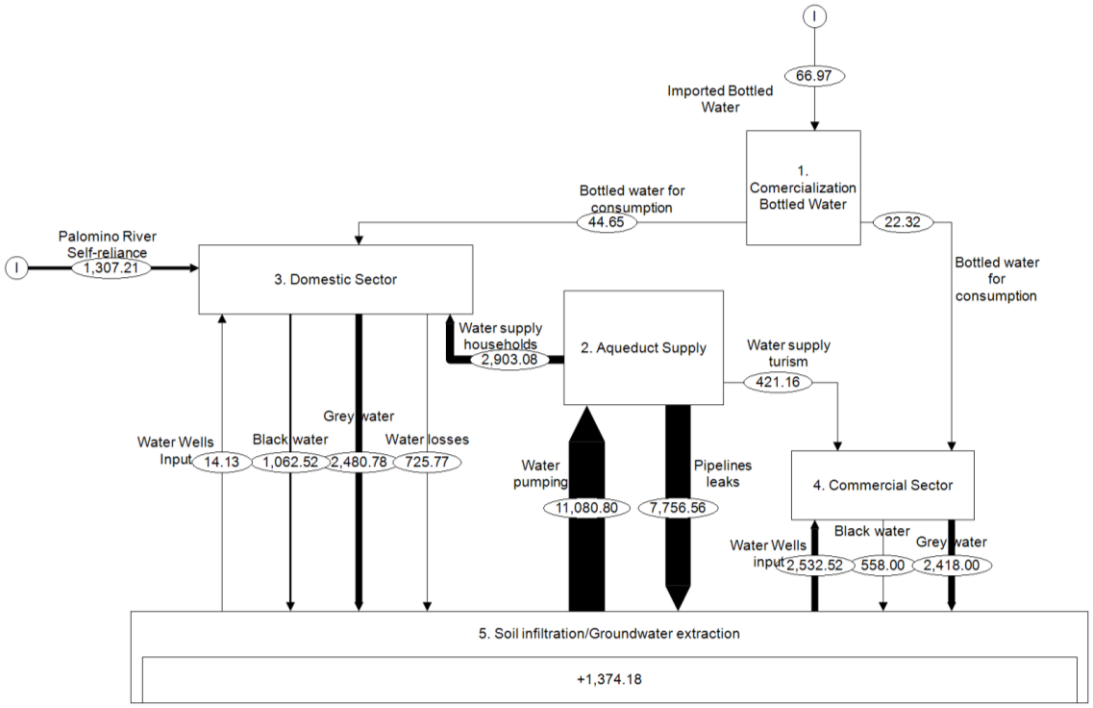
Scenario 2: Maximum losses with highest water demand

Touristic Season: HIGH, Hours without electric energy: 70h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 25%



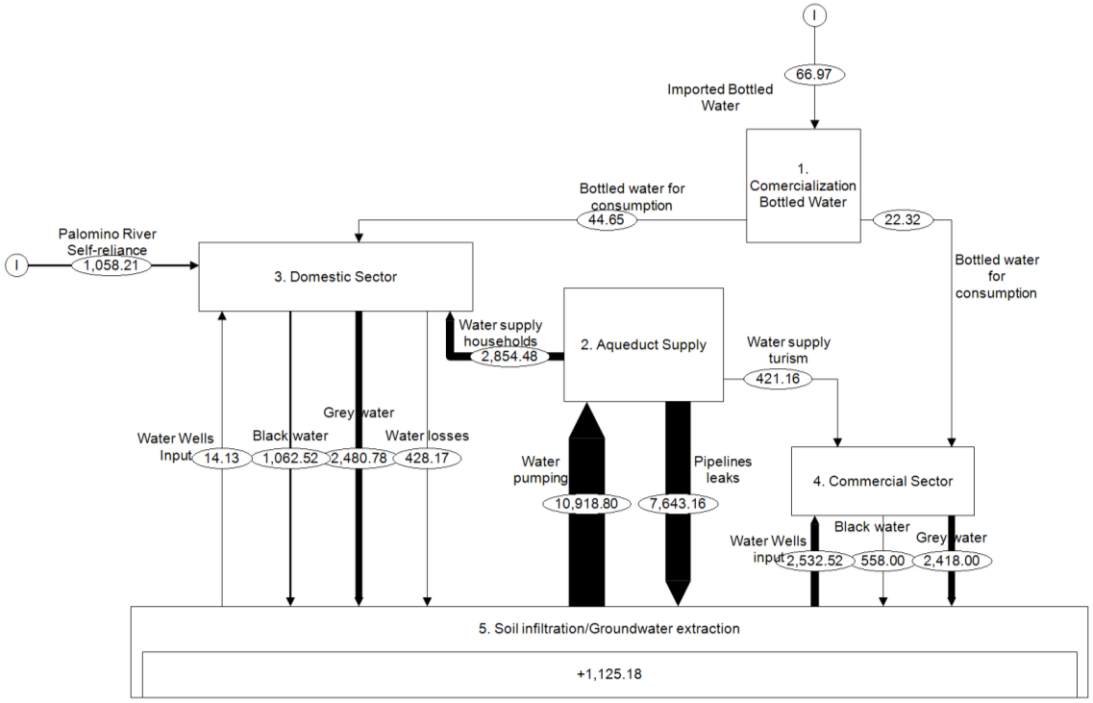
Scenario 3: Reduced 10 hours without electricity, maximum losses with lowest water demand

Touristic Season: LOW, Hours without electric energy: 60h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 25%



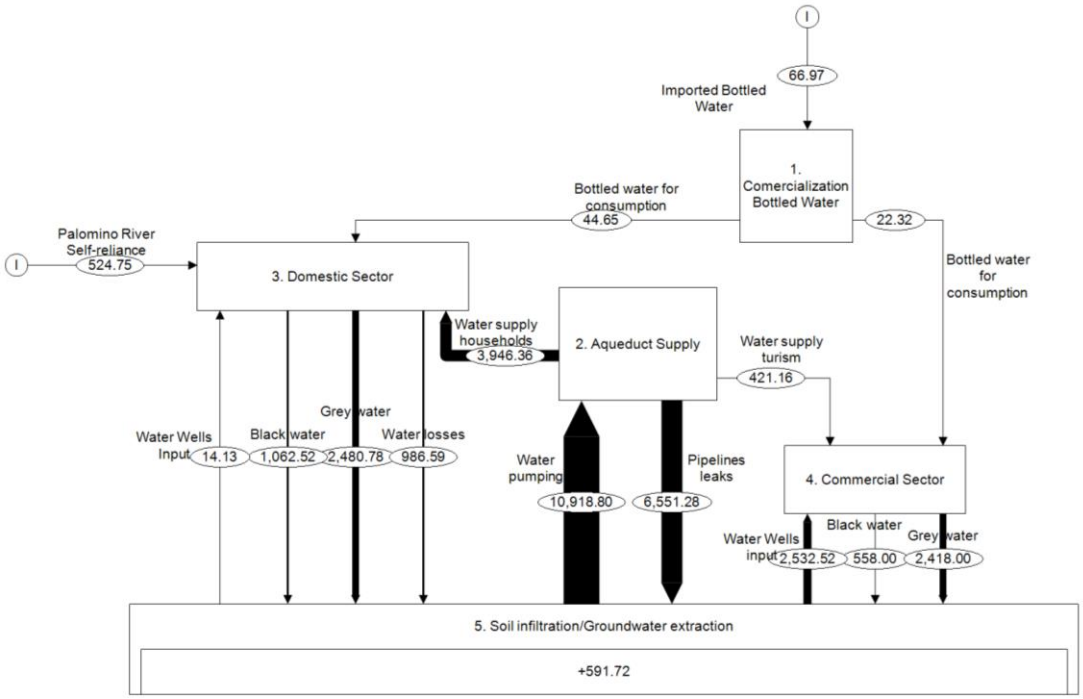
Scenario 4: Maximum losses for hours without electric and pipelines leaks, minimum losses for user's behavior with lowest water demand

Touristic Season: LOW, Hours without electric energy: 70h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 15%



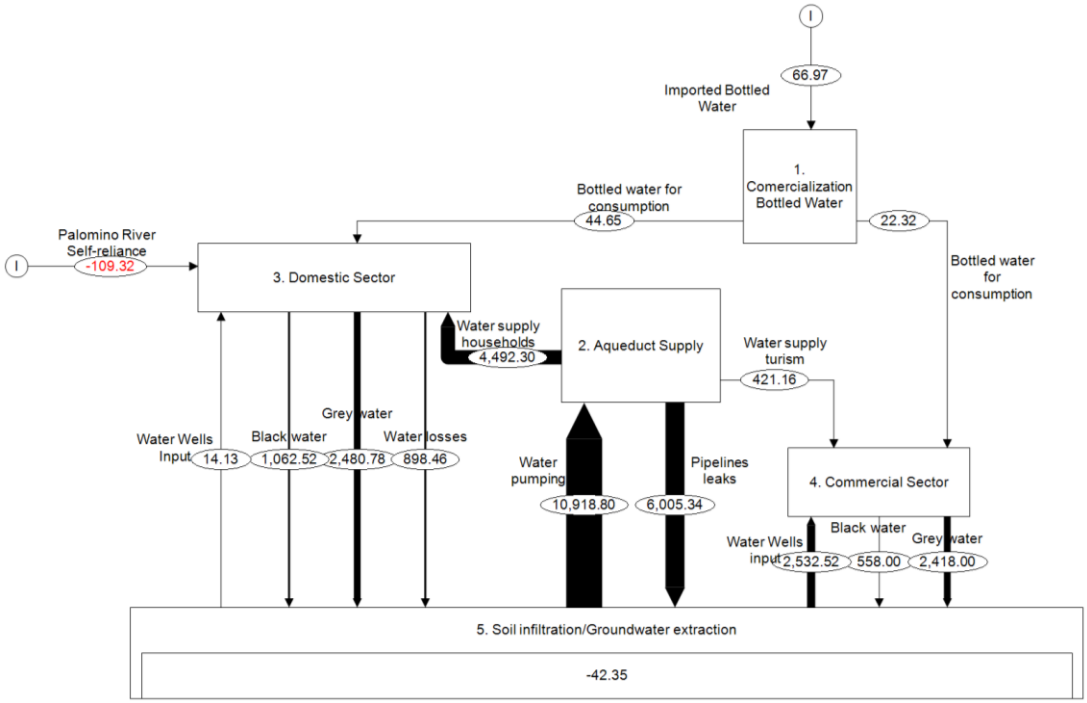
Scenario 5: Maximum losses for hours without electric and for user's behavior, reduced 10% for pipelines leaks losses with lowest water demand

Touristic Season: LOW, Hours without electric energy: 70h/month, Water losses pipelines leaks: 60%, water losses user's behavior: 25%



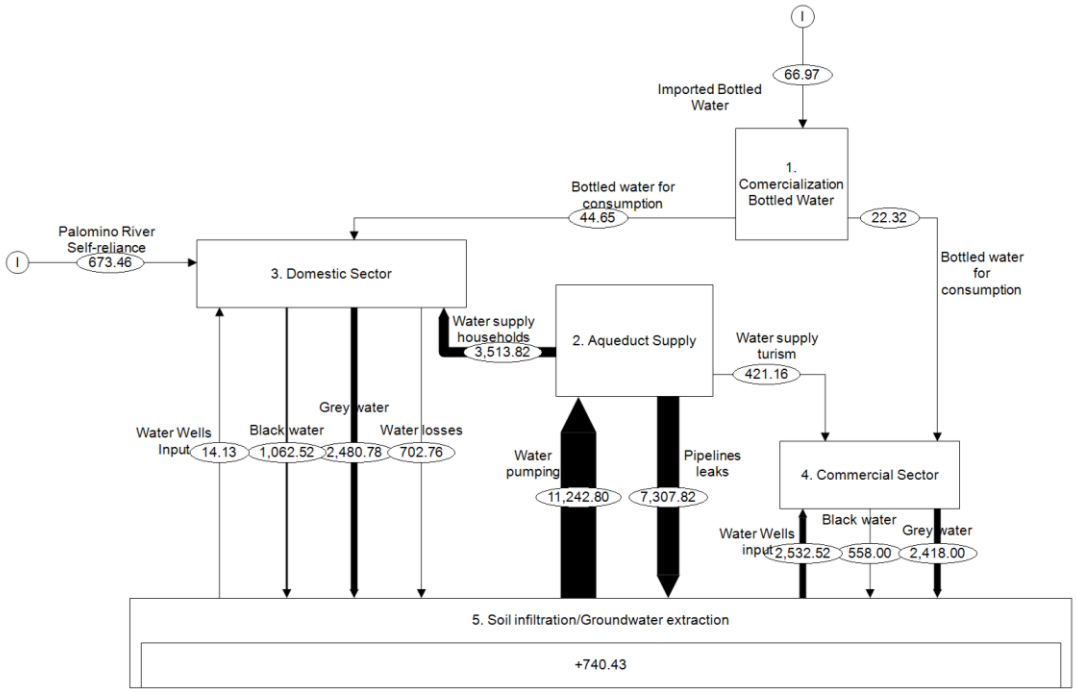
Scenario 6: Maximum losses for hours without electric, reduced 15% for pipelines leaks losses and 5% for user's behavior with lowest water demand

Touristic Season: LOW, Hours without electric energy: 70h/month, Water losses pipelines leaks: 55%, water losses user's behavior: 20%



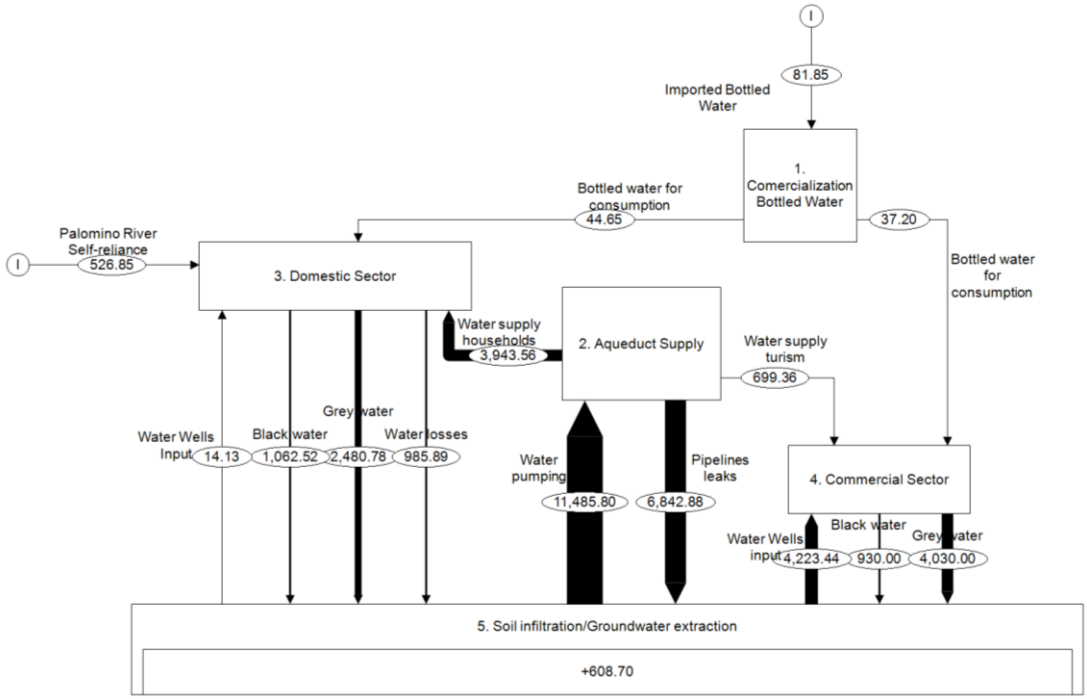
Scenario 7: Reduced 20 hours without electricity, reduced 5% for pipelines leaks losses and for user's behavior with lowest water demand

Touristic Season: LOW, Hours without electric energy: 50h/month, Water losses pipelines leaks: 65%, water losses user's behavior: 20%



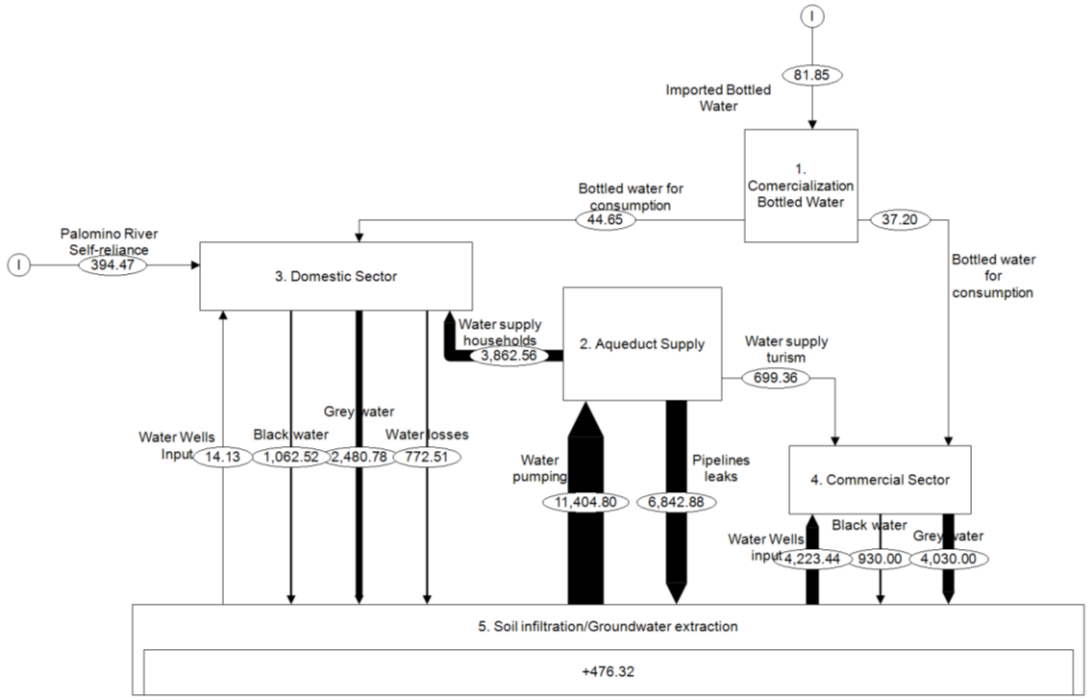
Scenario 8: Minimum losses for hours without electricity, maximum losses for pipelines leaks and for user's behavior with highest water demand

Touristic Season: HIGH, Hours without electric energy: 35h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 25%



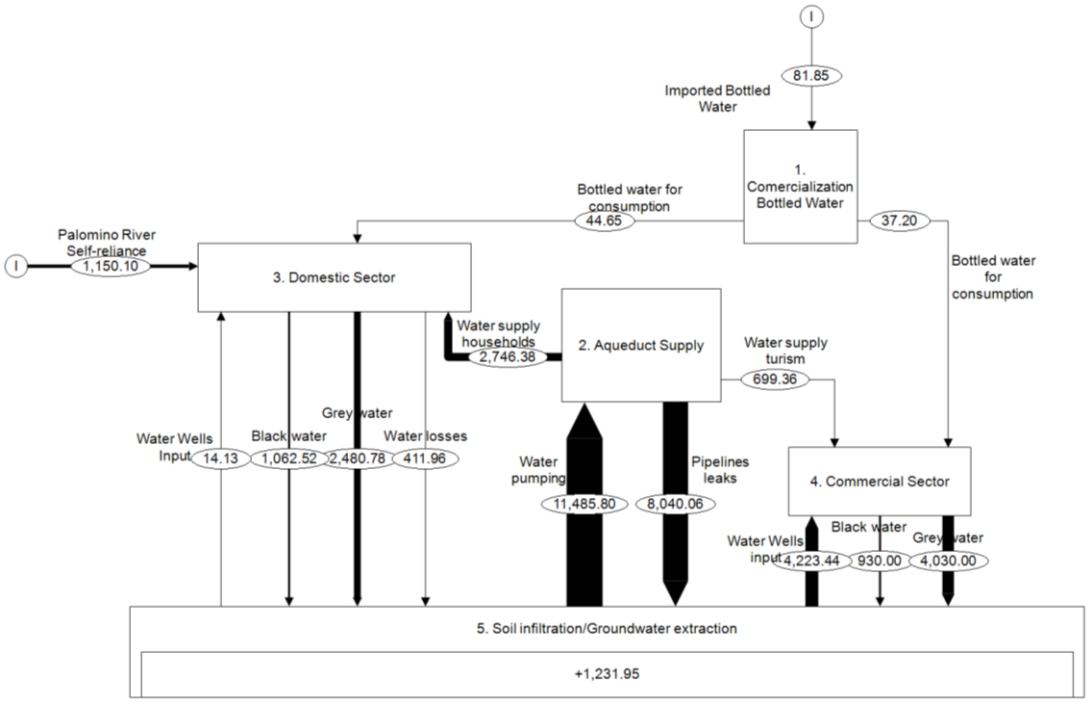
Scenario 9: Reduced 30 hours without electricity, reduced 10% for pipelines leaks losses and 5% for user's behavior with highest water demand

Touristic Season: HIGH, Hours without electric energy: 40h/month, Water losses pipelines leaks: 60%, water losses user's behavior: 20%



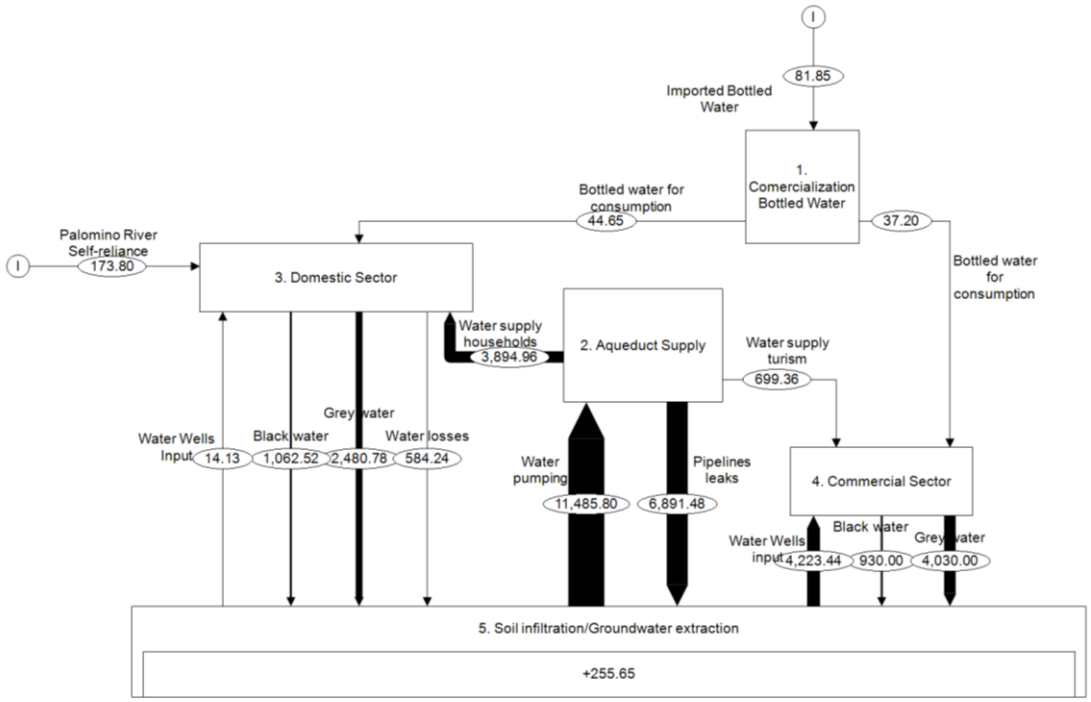
Scenario 10: Minimum losses for hours without electricity and for user's behavior, maximum losses for pipelines leaks losses with highest water demand

Touristic Season: HIGH, Hours without electric energy: 35h/month, Water losses pipelines leaks: 70%, water losses user's behavior: 15%



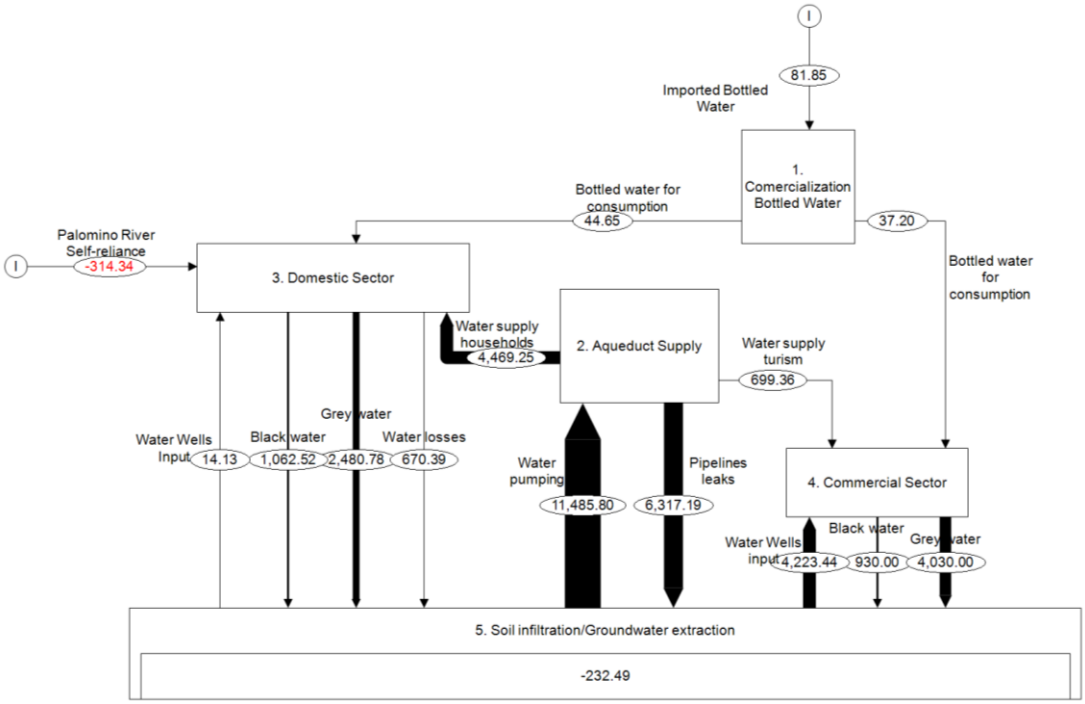
Scenario 11: Minimum losses for hours without electricity and for user's behavior, reduced 10% for pipelines leaks losses with highest water demand

Touristic Season: HIGH, Hours without electric energy: 35h/month, Water losses pipelines leaks: 60%, water losses user's behavior: 15%



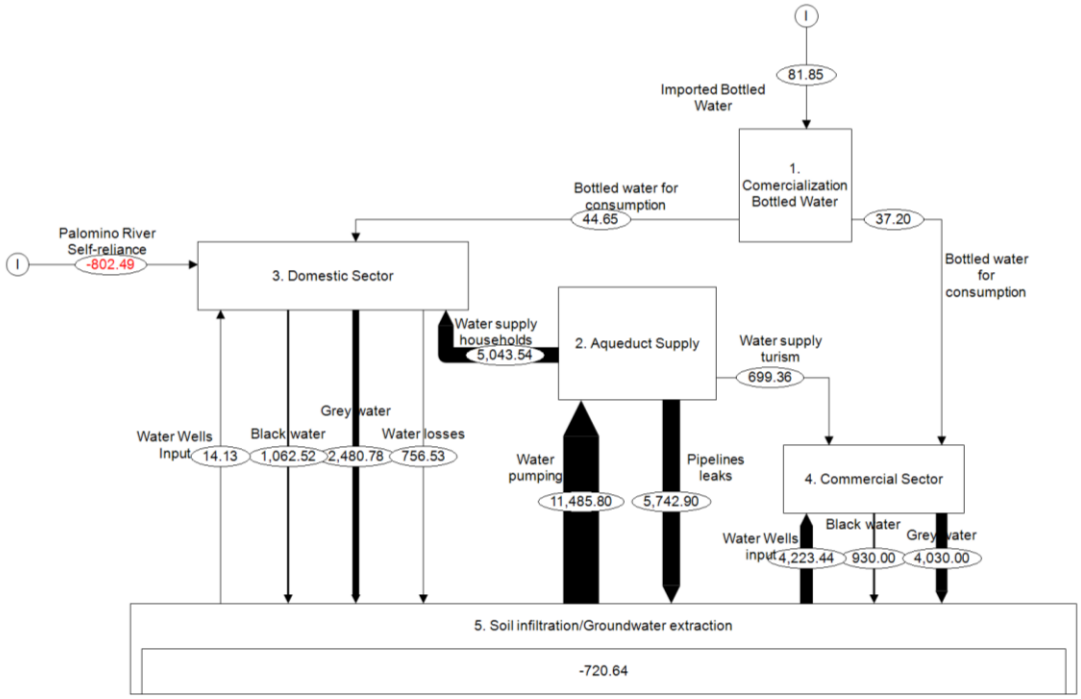
Scenario 12: Minimum losses for hours without electricity and for user's behavior, reduced 15% for pipelines leaks losses with highest water demand

Touristic Season: HIGH, Hours without electric energy: 35h/month, Water losses pipelines leaks: 55%, water losses user's behavior: 15%



Scenario 13: Minimum losses with highest water demand

Touristic Season: HIGH, Hours without electric energy: 35h/month, Water losses pipelines leaks: 50%, water losses user's behavior: 15%



Scenario 14: Minimum losses with lowest water demand

Touristic Season: LOW, Hours without electric energy: 35h/month, Water losses pipelines leaks: 50%, water losses user's behavior: 15%

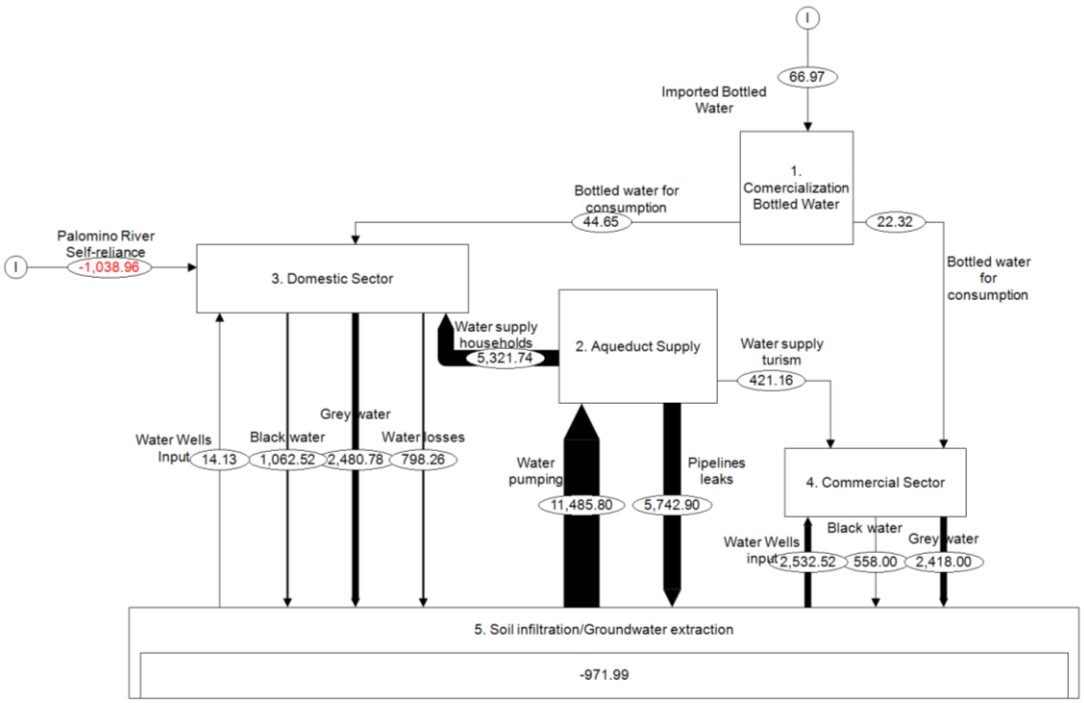


Figure 54: Results UWM model simulations from scenario 1 to scenario 14.

Table 13 provides a summary of the 14 scenarios developed, including the corresponding variables that characterize each scenarios and, finally, the results of the delta stock of the water system for each of the model simulations. The results of Table 13 can be visualized on Figure 55, which serves as a graphical representation of the UWM model simulations.

Table 13: Results of the stock for the UWM model simulation for the 14 scenarios

Variables /Scenarios	1. Touristic season	2. Hours without electric energy per month [Range: 70h/month-35h/month]	3. Percentage losses due to pipelines leaks [Range: 70%-50%]	4. Percentage of losses due to user's behavior [Range: 25%-15%]	Results Stock ΔS [m^3/month]
Scenario 1	LOW	70 h/month	70%	25%	1410.63
Scenario 2	HIGH	70 h/month	70%	25%	1634.16
Scenario 3	LOW	60 h/month	70%	25%	1374.18
Scenario 4	LOW	70 h/month	70%	15%	1125.18
Scenario 5	LOW	70 h/month	60%	25%	591.72
Scenario 6	LOW	70 h/month	55%	20%	-42.35
Scenario 7	LOW	50 h/month	65%	20%	740.43
Scenario 8	HIGH	35 h/month	70%	25%	608.7
Scenario 9	HIGH	40 h/month	60%	20%	476.32
Scenario 10	HIGH	35 h/month	70%	15%	1231.95
Scenario 11	HIGH	35 h/month	60%	15%	255.65
Scenario 12	HIGH	35 h/month	55%	15%	-232.49
Scenario 13	HIGH	35 h/month	50%	15%	-720.64
Scenario 14	LOW	35 h/month	50%	15%	-971.99

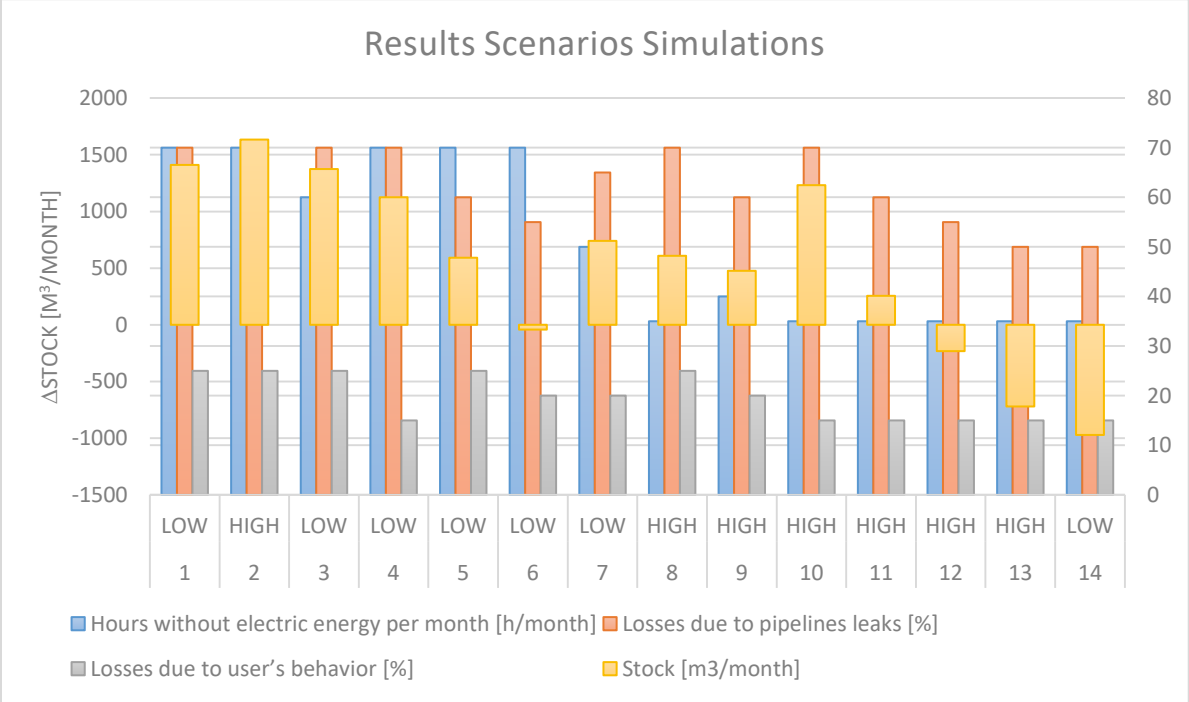


Figure 55: Graphical representation of the results for the scenario simulations.

3.2.2.6 Outcome analysis

The outcome analysis will be divided into main questions or discussion points which will guide the analysis from the UWM model results.

VARIABLES			
1. Touristic season	2. Hours without electric energy per month [Range: 70h/month-35h/month]	3. Percentage losses due to pipelines leaks [Range: 70%-50%]	4. Percentage of losses due to user's behavior [Range: 25%-15%]

What does the stock convey about the UWM model?

The stock of the system is perhaps the key parameter of the analysis to understand the results of the UWM model as a whole. The stock implies whether the system is importing water, or whether it has a surplus of water through its positive and negative value, correspondently. In mathematical terms, the UWM model is governed by the following system equation:

$$\Delta S = I_1 + I_3$$

If $\Delta S > 0$ the system is importing water. If $\Delta S < 0$ the system has a surplus of water.

What does the stock variation convey about the relevance of the variables?

Figure 56 displays the results of the scenarios simulations in the units *L/cap day* instead of m^3/month. The reason to display the results under this unit measure is because it gives the reader a better comprehension of the order of magnitude obtained by the simulations. The results in Figure 56 will be the basis for the analysis in this section.

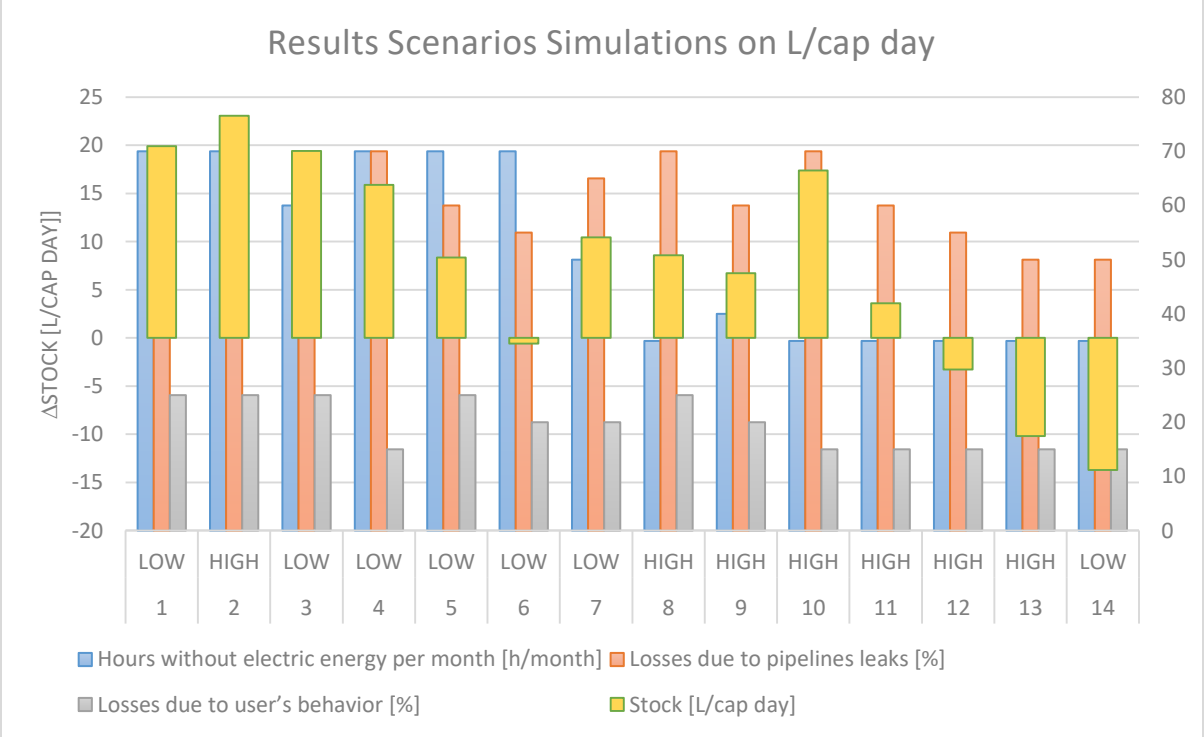


Figure 56: Results scenarios simulations [L/cap day].

Scenario 1 could be taken as the base scenario since it is a scenario that could represent a real setting (e.g., the month of October, in terms of days of the month and hours without electricity, as mentioned in the scenario development section). Scenarios 1 and 2 are the worst-case scenarios, in terms of the system presenting the highest loss levels for a low and a high tourist season water demand. As expected, the delta stock of the system between scenario 1 and 2 increases in proportion to the variation of the water demand per season. Thus, Scenario 2 presents the scenario with the highest water stress for the UWM, with a value of 23 L/cap day.

Based on scenario 1, a reduction in water losses through the variation of variables 2, 3, and 4 was performed for scenarios 2 through 6 (variable 1. Touristic season was constant on a low demand), wherein the system reaches its first negative value. For scenario 3, a reduction of 10 hours of electricity losses (approx. 14% from the maximal losses of 70 hours/month) lead to an improvement in the system of only 0.5 L/capday. Scenario 4 displays the maximum losses for variables 2 and 3, as variable 4 presents the minimum possible losses (a reduction of 10%), and the stock experiences a decrease of 15.9 L/cap day, or 20.2% from the result of scenario 1. Finally, a reduction of 58.1% in the stock is found from scenario 1 (19.9 L/cap day) to scenario 5 (8.4 L/cap day), in which the losses due to pipelines leaks is reduced in only 10%.

Scenario 6 is the first negative value that experiences the maximum losses in variable 2 (70 hours/month of no electric energy). A reduction of 15% and 5% in variables 3 and 4, correspondingly, results in a surplus of the system close to zero in terms of the stock. Scenario 7 sees a decline of 20 hours/month in variable 2 and a 5% reduction in variable 3 and 4 (variable 4 was maintained steady from scenario 6 to 7) lead to a water import requirement of 10.5 L/cap day. These representative variation gives a hint as to the significance of water losses due to pipeline leaks.

In scenarios 8 through 13 (and also, scenario 2), variable 1 is set to a HIGH touristic demand and variables 2, 3 and 4 are modified. If scenario 2 is taken as the base of the analysis, as it is the scenario with the highest water demand and the highest losses, a reduction from the maximum losses possible on variable 2 to a minimum loss of 35 hours/month results on a stock of 8.6 L/cap day, which is the equivalent to a reduction of 63% in the stock it is in scenario 8. This steep reduction sets some degree of relevance to the losses of the system by the lack of electric energy. In scenario 9, there is a reduction of 10% on variable 3 and 5% on variable 4, which, in addition to an increase of 10 hours/month on the losses on variable 2 from scenario 8, result in a stock decrease that is even more abrupt, having a value of 6.3 L/cap day, or a 71% reduction.

The results of the scenarios simulations mostly yielded scenarios with positive stock values, except in scenarios 6, 12, 13 and 14, in which a negative value was obtained, implying that the system could, in fact, potentially satisfy its metabolic needs. Scenarios 13 and 14 are the base scenario for the minimal losses of the system with a high and a low touristic season, correspondently. Here, it is important to indicate that negative values behave contrary to the positive values in the sense that, for positive values, when the water demand is higher (due to the high touristic season), the stock is higher; as for negative values, when the water demand of the system is lower (low touristic season), the result is a bigger negative value (Figure 56). This phenomenon makes physical sense, since the negative values represent a surplus in the system; therefore, the lower the demand, the higher the surplus, as arose in scenarios 13 and 14.

The negative values are interesting because they should be analyzed not by the stock value, but rather by the input value I_3 *Palomino River Self-reliance*, as it is the value that represents the actual surplus of the

system. This can be visualized in Figure 57, where the input flow I_3 has a higher negative value than the value of the stock. This phenomenon can be explained once more with the overall mathematical equation of the UWM system:

$$\Delta S = I_1 + I_3$$

Since the input flow I_1 *Imported Bottled Water* is a flow that exist not only due to the lack of water supply in the system, but also due to the water quality of the system, it is always present in the current UWM model, and always has a positive value in the model. I_1 depends, on one hand, on the economic conditions of the domestic sector to purchase water and, on the other hand, on the demand from the commercial sector; nonetheless, this flow remains constant during the scenarios simulations and varies only according to the increase or decrease in demand from the commercial sector, as determined by variable 1 (touristic season).

Accordingly, since I_1 is always positive, then I_3 must have a higher negative value, in order to balance this positive value in a surplus scenario; thus, I_3 is the actual surplus as the UWM system.

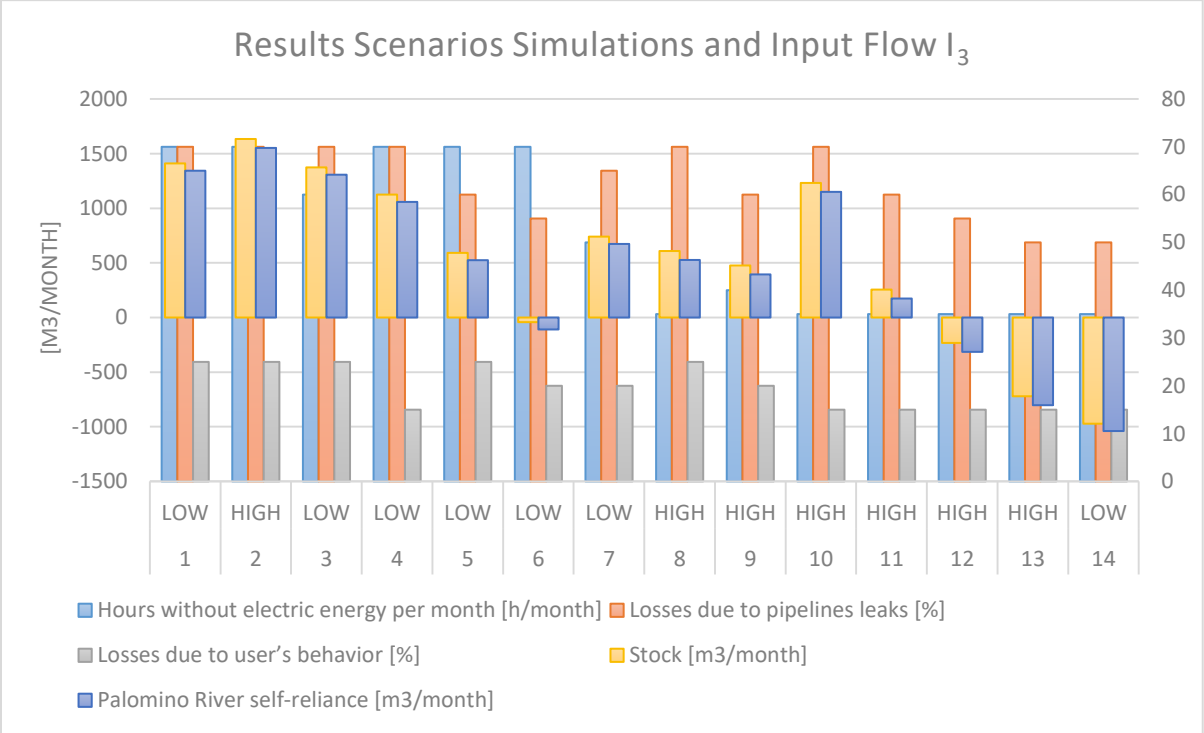


Figure 57: Comparative visualization of the UWM model stock results with the input flow I_3 for each scenario.

At this point, it is possible to suggest that variable 2 – Hours without electric energy per month [Range: 70h/month-35h/month] and variable 3 – Percentage losses due to pipelines leaks [Range: 70%-50%] are not critical variables for the UWM model. They strongly influence the metabolic behavior of the system and determine its ability to be *self-sufficient* from its own water supply. This means that the current aqueduct system and the groundwater extraction from water wells would satisfy the water demand of the UWM system, thus importation would no longer be required. On the contrary, variable 1 - Touristic

season and variable 4 - Percentage of losses due to user's behavior [Range: 25%-15%] affect the system in a more local and acute manner, though they do not have as much influence on the metabolism of the system as a whole.

The input flow I_3 *Palomino River Self-reliance* as a 'control value'

I_3 *Palomino River Self-reliance* is a key flow to analyze in the system, not only on negative stock value scenarios, but also because it represents a 'control flow' that guides the analysis to a comparative examination on an order of magnitude perspective. This flow gives a hint as to the potential for human agents to actually achieve this importation of water into the UWM system.

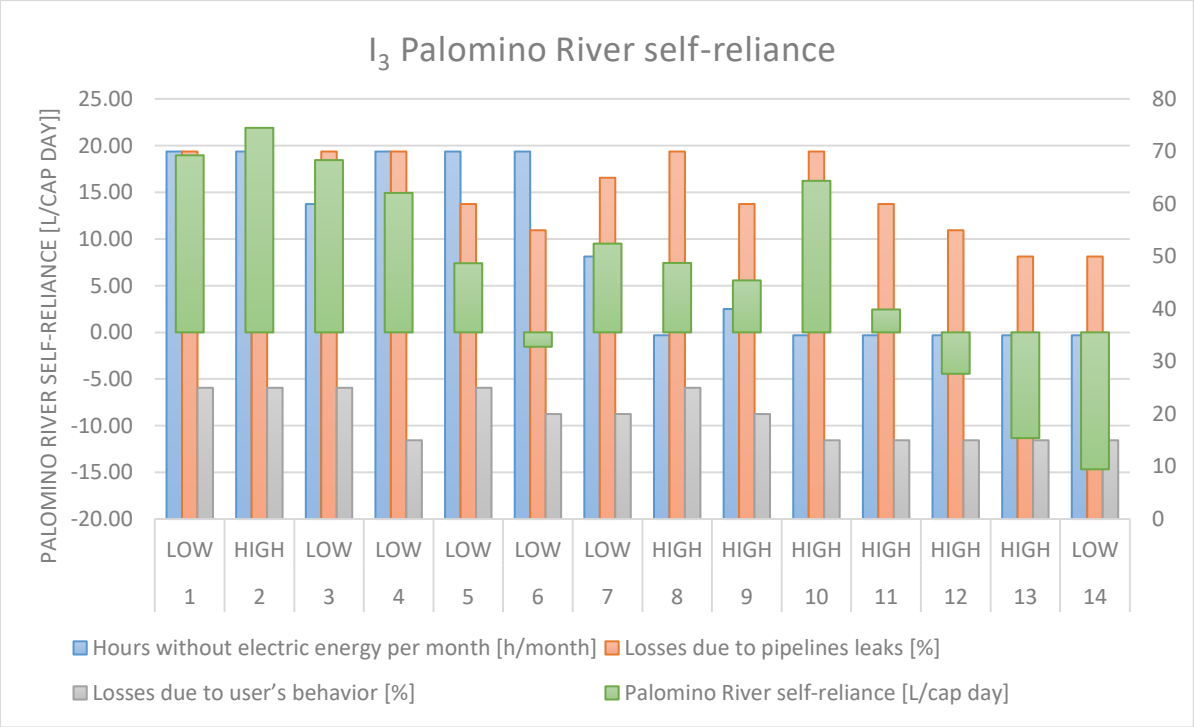


Figure 58: Results input flow I_3 [L/cap day] for the scenarios simulations.

As illustrated in Figure 58, the results of this flow vary between 22 L/cap day for scenario 2 to a minimum positive value of 2.45 L/cap day for scenario 11. These values are consequent to reality in terms of the inhabitants of the town needing to carry 22 L per day for their household supply. As a matter of fact, when we compare the result simulation for this flow with the field observations and the results presented in PART II – section 2.4 Water management households, the inhabitants claimed to collect up to 40 L/cap day on foot and almost 70 L/cap day with a transportation option (vehicle). This suggests that the results of the simulations give a lower value when compared to the survey results.

The inner flows and their variations in the UWM model

The analysis in the previous sections was focused more on a system analysis of the UWM model; here, some remarks about the inner flows of the system in relation to the scenario's variables will be made. The flow *F5,4 water wells input* varied drastically, according to variable 1 on a high or low touristic season; this is due to the fact that groundwater extraction is the main source of water supply for the commercial

sector. This fact also implies that the water supplied to the commercial sector from the aqueduct system does not significantly affect the water supplied to the domestic sector.

The flow of urban water to hostels is influenced only by the 40% increase from high to low tourist season; nevertheless, the bigger the losses in variable 2 for pipelines leaks, the bigger the proportion of this flow in relation to what enters the supply for domestic consumption (Flow F2,3 water supply households) (since the commercial sector has priority in the water supplied in relation to the domestic sector). The flow F5,3 of groundwater extraction for the domestic sector is insignificant in relation to the water supplied by the aqueduct service, which is the opposite for the commercial sector.

3.3 Part III Discussion

Based on the analysis of the results obtained through the scenario development for the current UWM in Palomino, it is clear that the flows *F2,5 – Pipelines leaks* (influenced by variable 3) and *F5,2 -Water pumped* for the aqueduct system (influenced by variable 2) affect the UWM drastically. As for variables 1 and 4, some of the inner flows are severely affected as it is the case for variable 1 and flow *F5,4- Water wells* for the commercial sector, though they do not influence the UWM system as a whole.

It is an encouraging result that some of the scenario simulations yield a negative stock value, meaning that, theoretically, the UWM system could satisfy its metabolic needs with the two available water supply sources: groundwater extraction and water supplied by the aqueduct service—even with a water system that presents high water losses. It is important to mention that the metabolic needs of the current UWM are bound to the water demand of the commercial and domestic sectors; therefore, if the demand were to increase, the UWM needs of system would not be met anymore, since the buffer from the negative stock values is low (max. 15 L/capday).

Another relevant flow is the input flow I_1 *Imported Bottled Water*. Even though this inflow is not significant in terms of its contribution to the UWM, it is important to highlight that it is the only flow within the system that exerts external pressures besides that on water resources. For a low season 66.97 m3/moth of water are bought, assuming a volume 600 cc per bottled water, this would mean a total of 111,616.6 bottles of water per month or the equivalent of 3.6 bottles per day and in weight (assuming each bottled water weight 5 grams) an equivalent of *558 kg of plastic per month*, which certainly represents a challenge for a town which waste management is already quite deficient.

The conceptual UWM model presented for the current UWM of Palomino is based exclusively on the economic flows (goods) of the metabolic processes within the system; therefore, no environmental flows are included in the system. This approach is valid in terms of understanding the urban metabolism within the socio-economical system; nonetheless, it assumes water resources to be endless sources, which could oversimplify the fact of the variations in the groundwater table and the impossibility of extracting these water resources. To explain these type of behaviors and interactions between economic and environmental flows, a system dynamics approach would be suggested, rather than a steady-state approach. Regardless, for the purpose of understanding the current UWM and identifying the critical flows and technical problems of the system, the UWM conceptual model and its simulations represent a successful and accurate approach.

Part IV: Sustainable urban water management system

4.1 Sustainable water management system

4.1.1 A brief literature review

4.1.2 Definition of sustainable urban water management system (SUWMS)

4.2 Sustainable solutions and urban synergies

4.2.1 Towards a sustainable future: Community engagement and sustainable initiatives in Palomino

4.2.2 Integrated Analysis: SWOT – Strengths, Weaknesses, Opportunities and Threats- of Palomino's water system and overview of the impacts of urbanization in water systems

4.2.3 Potential sustainable water technologies, solutions, and urban synergies for a future SUWMS in Palomino

4.3 Rainwater harvesting: A low tech, high impact technology to improve the UWM in Palomino?

4.4 Part IV Discussion

"Great things are done by a series of small things brought together."
Vincent van Gogh

At this point, the current state of Palomino's water system has been assessed in a qualitative and quantitative manner. The UWM of the current system has provided an analysis to determine where the main problems and difficulties of the UWM lay. Consequently, enough information about the current water system is available to begin the research of a sustainable water management system that could be applicable in the local context of Palomino. This chapter is divided into three main sections: the definition of a sustainable urban water management system (SUWMS), the analysis of sustainable technologies and initiatives that would enable the development of a SUWMS in Palomino, and finally, a quantitative analysis to assess the potential of one promising technology to improve the current UWM.

This chapter will address the following research sub-questions that will guide analysis:

4. *How could sustainable urban water management system (SUWMS) be defined?*
5. *Which technologies and initiatives are applicable in this local context for a sustainable urban water management system?*
6. *Which technology could potentially address the critical water flows of the current UWM?*
7. *How would this technology affect the UWM of the current system for a critical scenario?*

4.1 Sustainable water management system

4.1.1 A brief literature review

Sustainable water management system does not have a precise definition due to the fact that it is based on the broad concept of *sustainability*. The origins of sustainability, or sustainable development, arose in 1987 with the *Our Common Future* report by the United Nations Word Commission on Environment and Development (WCED). According to the report, "Humanity has the ability to make development sustainable – to ensure that it meets the needs of the *present* without compromising the ability of *future* generations to meet their own needs." From this definition, numerous efforts have been made to reach a clearer and more tangible definition for *sustainability*. Nonetheless, the question of how to achieve sustainable development and how to assess the sustainability of various systems is still under debate (Hellström, Jeppsson, & Kärrman, 2000).

Similarly, the concept of water management has changed with time. "Until the 1970s the field of water management was known by the term *water resources development*. In the 1980s it became more popular to refer to *water resources management* (WRM), and in the 1990s *to integrated water resources management* (IWRM). This change of names reflects the increasing recognition that water systems are not merely there to be exploited; rather, a balance should be sought between fulfilling human needs and sustaining ecosystems" (Savenije, Hoekstra, & van der Zaag, 2014, p. 320). Over time, a holistic approach towards sustainability has been developed, wherein social, economic, and environmental factors are taken into consideration in order to cover the so-called *triple bottom line* (people, planet, and profit).

Following this approach, in 1998 the American Society of Civil Engineers and UNESCO defined sustainable water resource systems as: "those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity" (American Society of Civil Engineers & UNESCO, 1998, p. 44). The concept of sustainable water resource

systems became more narrow, specifically referring to a sustainable *urban* development, when in 1999, Lundin stated that, "a sustainable urban water system should, over a long time perspective, provide required services while protecting human health and the environment, with a minimum of scarce resources" (Lundin, 1999, p. 25).

Moreover, the Swedish Foundation for Strategic Environmental Research (MISTRA) made an important contribution in this area with the research entitled *Sustainable Urban Water Management (SUWM)* (1999). The publication declared that, "every human being has a right to clean water. For urban areas, our vision is water management where water and its constituents can be safely used, reused and returned to nature" (Hellström, Jeppsson, & Kärrman, 2000, p. 312). This research greatly contributed to the field by defining a set of sustainability criteria, indicators, objectives, and requirements for a SUWM; this made it possible to assess the sustainability of urban water systems in a practical and quantifiable matter, since the use of criteria allows an evaluation to be operative and practical with regards to achieving sustainability objectives (Lai, Lundie, & N.J, 2008).

The report identified five sets of sustainability criteria: 1. Health and hygiene, 2. Social and cultural, 3. Environment, 4. Economic, and 5. Technical and functional, in addition to the following sustainability objectives: 1. moving towards a nontoxic environment; 2. improving health and hygiene; 3. saving human resources; 4. conserving natural resources; 5. saving financial resources. Finally, it included the following requirements of the system: (a) have a high degree of functional robustness and flexibility, (b) be adapted to local conditions, and (c) be easy to understand, and thus, encourage responsible behavior by the users (Hellström, Jeppsson, & Kärrman, 2000).

Sustainability indicators have the problem of requiring considerable amounts of data, which makes the research process time-consuming and expensive. Therefore, in most cases, simplifications must be made in order to complete the assessment within the available budget and timeframe. As an example, Table 14 offers comprehensive frame of sustainability criteria, which include quantitative and qualitative indicators; the inclusion of qualitative criteria could be an advantage regarding the data requirements as part of the assessment process.

Table 14: Set of criteria and indicators for assessing sustainability of urban water (Makropoulos, Natsi, Liu, Mittas, & Butle, 2008, p. 1449).

Capital	Criteria	Indicator
Environmental	Resource utilisation	Water usage (litres/use)
		Water loss (litres/use)
		Energy use (KWh/use)
		Chemical use (litres/use)
		Land use (m^2)
	Service provision	Service provision[a]
	Environmental impact	Environmental impact[a]
Economic	Life cycle costs	Life cycle costs[a]
	Willingness to pay	Willingness to pay[a]
	Affordability	Affordability[a]
	Financial risk exposure	Financial risk exposure[a]
	Capital cost (£)	Capital cost (£)
	Operational cost (£/l)	Operational cost (£/litre)
Social	Risks to human health	Risks to human health[a]
	Acceptability	Acceptability[a]
	Participation/responsibility	Participation/responsibility[a]
	Public awareness	Public awareness
	Social inclusion	Social inclusion[a]
Technical	Performance	Performance[a]
	Reliability	Reliability[a]
	Durability	Durability[a]
	Flexibility/adaptability	Flexibility/adaptability[a]

[a] These indicators do not have units as they quantify qualitative sustainability stock. Instead they are rated between 0 and 5 with 0 being the worst score and 5 the best score.

Lastly, it is interesting to highlight how the concept of sustainable urban water management is being directed to include goals and requirements for a resilient system that is adaptable to change and uncertainty, while the research contains a social dimension that explores the relation between water resources and changing societal systems through user's behavior. Adaptive management, social learning and engagement, transformation of knowledge and understanding of communities, decision-making throughout participatory processes and, in general, seeing sustainability not as "a state to be arrived at but a broad evaluative framework for understanding and justifying social practice" (Pearson, Coggan, Proctor, & Smith, 2010, p. 364) are all topics that are relevant to research in sustainable water management systems (Lundie,2005).

4.1.2 Definition of sustainable urban water management system (SUWMS)

Based on the literature review and the definitions of sustainable (urban) water systems presented in this masters thesis, it is clear that a sustainable water system should embrace the following characteristics: comply with the present needs, while guarantying that future needs can be met; guarantee the protection of the environment; promote human health and well-being; and strive for the conservation of resources. For this research, the definition of water services for a SUWM will be: "[a sustainable urban water management system] that includes collection, treatment and distribution of water, wastewater and stormwater" (Lai, Lundie, & N.J, 2008, p. 316). Figure 59, below, illustrates the proposed definition of sustainable urban water management system (SUWMS) for this master thesis research.

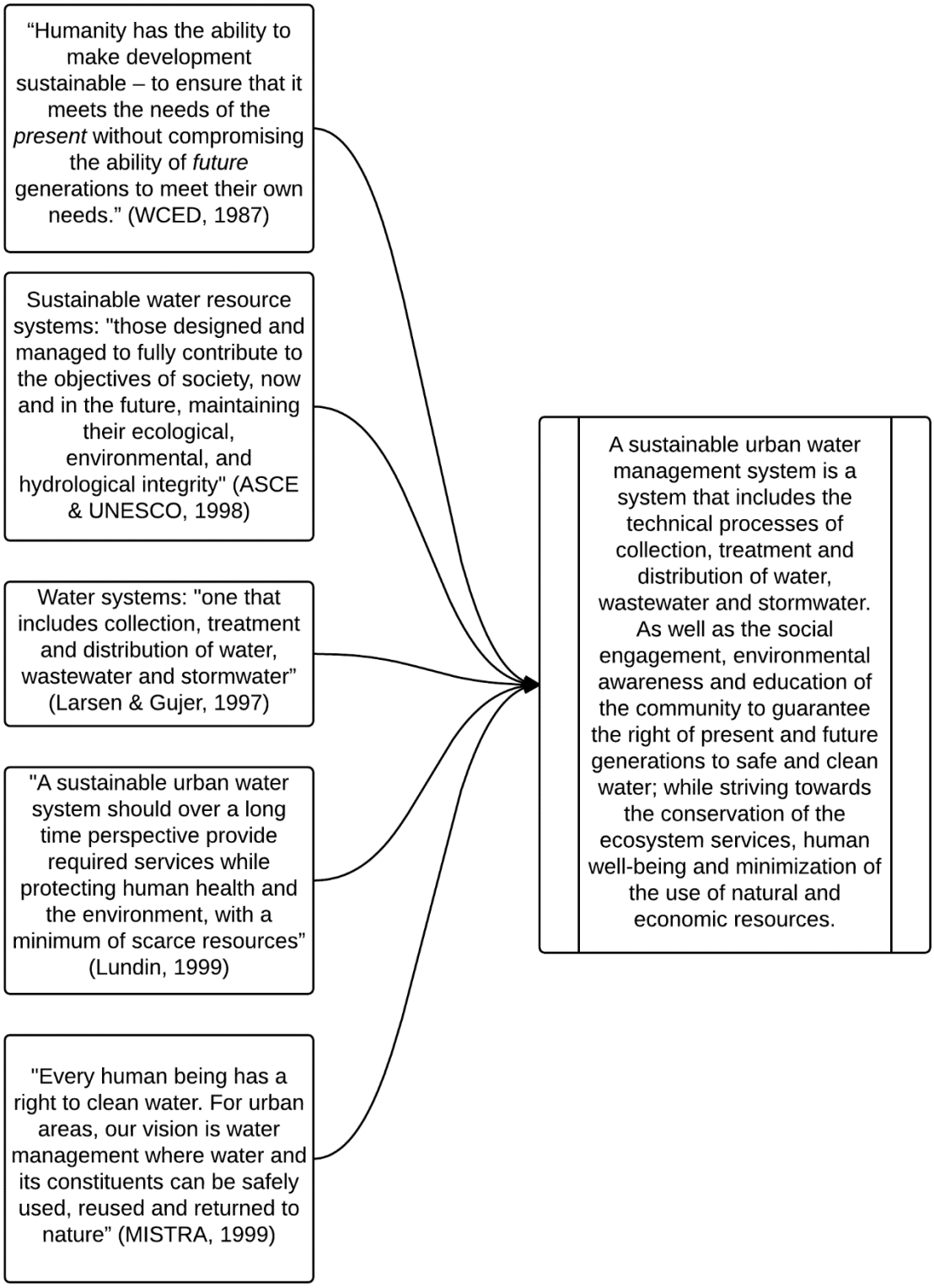


Figure 59: Definition of Sustainable Urban Water Management System (SUWMS).

The following goal oriented objectives complement the definition system just established and help to guide the implementation and management of a SUWMS.

Objectives:

1. Avoid pollution of natural ecosystems.
2. Conserve natural resources and ecosystem services.
3. Strive towards circularity of water flows and nutrients.
4. Improve human health, hygiene, and well-being.
5. Be adaptive to the local conditions, needs, and requirements of complex social—ecological systems.
6. Have a high degree of functional robustness and flexibility in order to be able to deal with changes and uncertainties.
7. Design the system to be easy to understand and thus, to encourage responsible behavior by the users.
8. Guarantee a minimum drinking water supply of 50 liters per day per person.
9. Minimize the use of natural and economic resources.

The objective 8 is oriented for the local context of Colombia: the current applicable Colombian Constitution from 1991, article 1, states the right of life is an inviolate right; based on this fundamental right the sentence T-740/11 from 2011 states that: since water is an indispensable resource to support life, accessibility to water resources is a fundamental right for every Colombian citizen. Therefore, the sentence obligates that the state guarantee a minimum drinking water supply of 50 liters per person per day through public services.

4.2 Sustainable solutions and urban synergies

4.2.1 Towards a sustainable future: Community engagement and sustainable initiatives in Palomino

This section gives an overview on the sustainable initiatives found in the town of Palomino. It is important to recognize these activities, since they represent the engagement and participation of the community towards a goal of local sustainable development. Additionally, they give a hint as to what the community has been working on thus far, where their interests lay, and whether or not these initiatives have improved their standard of living.

Palomino Cultural – Social Innovation in Practice

In early 2010, Palomino Cultural, a local collective of culture-oriented nonprofit organizations, started the eco-social project, *Palomino Sierra Nevada.* The objective of *Palomino Sierra Nevada* was simple—to identify, analyze, and address local people and problems through concrete proposals of design and architecture. Palomino Cultural is an association formed by 6 independent nonprofit cultural entities: Inteligencia Colectiva, Colecivo Mitín, Zoohaus, Zuloark, the community and the academia. This is the main project under the umbrella of the PEI, New Territories program from Javeriana University (Palomino Cultural - PEI, 2010).

With an initial investment of approximately $45.000 US, and using a participatory approach with the community, Palomino Cultural have designed and built several ecological projects. These include: dry toilets, cooking cars, a well for water supply, and the Culture House of Palomino. These projects have

been in used since their construction in 2011, and have been a successful example of social inclusion in the town of Palomino (Palomino Cultural, 2011).

Figure 60: Projects in Palomino by Palomino Cultural; including sustainable sanitation projects - dry toilets-. (Archive Colectivo Mitín, 2009).

Palomino Cultural was awarded second place in The Urban Development and Social Inclusion Contest (CAF 2013) from the Development Bank of Latin America. The project, *Bamboo: Planting of bamboo, education of the community and the construction of a school-workshop*, earned them this international recognition (González, 2013).

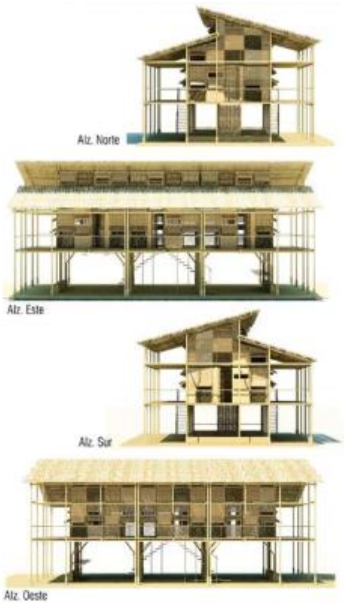


Figure 61: 'Bamboo: Planting of bamboo, education of the community and the construction of a school-workshop' (González, 2013)

Wild life conservation

Palomino has a unique conservation program, developed in collaboration with the governmental institution, Corpoguajira, to preserve the loggerhead sea turtle (*Caretta caretta*). The loggerhead sea turtle has been considered an endangered species by the International Union for the Conservation of Nature since 1978. The loss of nesting habitats are among the biggest threats to its conservation. In addition, the loggerhead sea turtle has a slow reproduction cycle: a loggerhead turtle reaches sexual maturity between 17 and 33 years, and lays 3 to 4 eggs per nesting season, in intervals of two to four

years. The eggs then hatch after 60 days of incubation (Sea Turtle Conservancy, 2015). After hatching the new born turtles are kept in nursing pools on the beaches of Palomino, where they are nursed for approximately six months, when they are released to the sea by local authorities and the community. In December 2015, a total of 550 loggerhead were introduced to their natural habitat by means of this program (Observation, September, 2015) (Guajira Hoy, 2015).

Urban agriculuture – RESA program

The RESA program (Red de seguridad alimentaria; in English: Food safety network) is a governmental initiative from the Department of Social Prosperity (DPS) that aims to achieve food security for families of low socio-economic status. The program is comprised of a series of courses in which, over a period of ten months, families are taught how to cultivate different crops using organic urban agriculture practices. For the municipality of Dibulla, in the townships of Mingueo, Palomino, and La Punta, 180 families have participated in the program (Guajira Hoy, 2014).

In Palomino, the program began in October 2014, and lasted ten months with 58 families participating. Upon completing the program, each family obtained one small water filter, one small cupboard, and one water storage tank of 250L (Orfelina, personal interview, September 17, 2015). Data from the survey process shows that 57% of the households interviewed were beneficiaries of the RESA program.

De cero a siempre

Since 2010, the Colombia's national government has been conducting an integrated development plan for children under the age of 6. The program reaches approximately five million children across the country; it aims to guarantee access to education, healthcare, and healthy food for mother and child, as well as the development of safe recreational and cultural areas in local neighborhoods (Gobierno de Colombia, 2014). A majority (57%) of the households interviewed were beneficiaries of the program 'De cero a siempre.'

Eco-tourism Committee

The Eco-tourism Committee is a new independent initiative, having started in January 2016. The committee is funded by six hotels in the Palomino area: Finca Escondia, Reserva Natural El Matuy, Hotel Eco-Sirena, Hostal Dreamers, Hostal Tikihut, and Hotel Hukumeizi. The committee is still in its initial stage of, and plans to tackle important issues for the development of Palomino, such as waste management, beach and urban area development, and the aqueduct (Uribe, V., personal interview, January 28, 2016).

4.2.2 Integrated Analysis: SWOT – Strengths, Weaknesses, Opportunities and Threats- of Palomino's water system and overview of the impacts of urbanization in water systems.

SWOT Analysis:

The SWOT analysis provides a simple overview on the integrated analysis for Palomino's current water system. This analysis is useful for the identification of potential water technologies. Especially interesting are the opportunities and weaknesses, because they provide hints on the possible solutions. As for the threats and strengths of the system, those are on a more general basis and require attention for future planning.

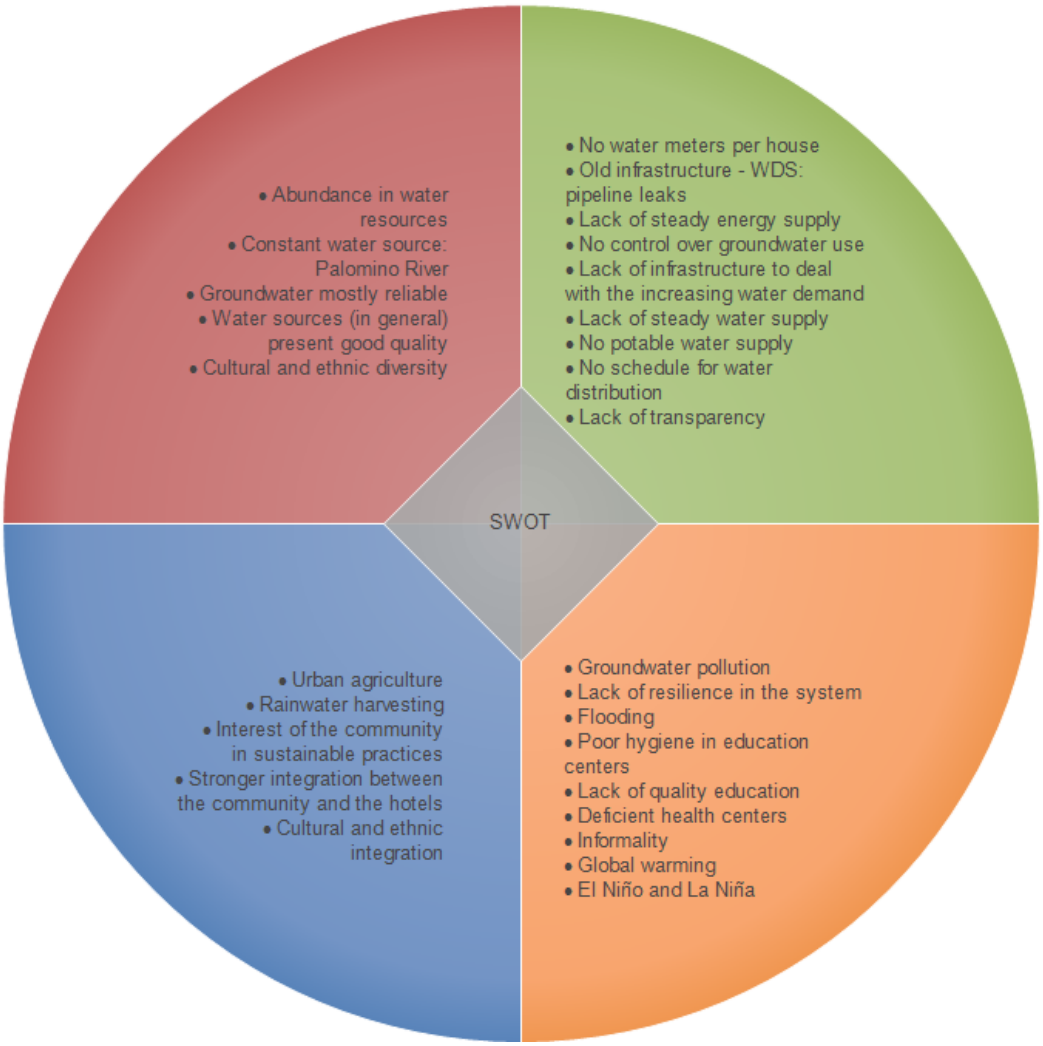


Figure 62: SWOT Analysis for Palomino's current water system

Figure 62 illustrates the main points for each section of the SWOT analysis: in the red quadrant are the strengths, followed by the weaknesses in green, opportunities in blue and threats in orange (clockwise rotation).

Urbanization and water systems:

Figure 63 presents an overview on some of the impacts that urbanizations generate on a water system. It is especially interesting to see how the figure is crafted to show the connections and dependencies of various impacts, showing some dynamics of complex problems in water systems. Figure 63 presents as an ultimate problem the loss of water resources for potential water uses. This would result on an unbalance water ecosystem, and possible water scarcity and water stress on the region. This representation was considered of special interest by the author since it is a good representation of a system thinking analysis characteristics of the industrial ecology discipline.

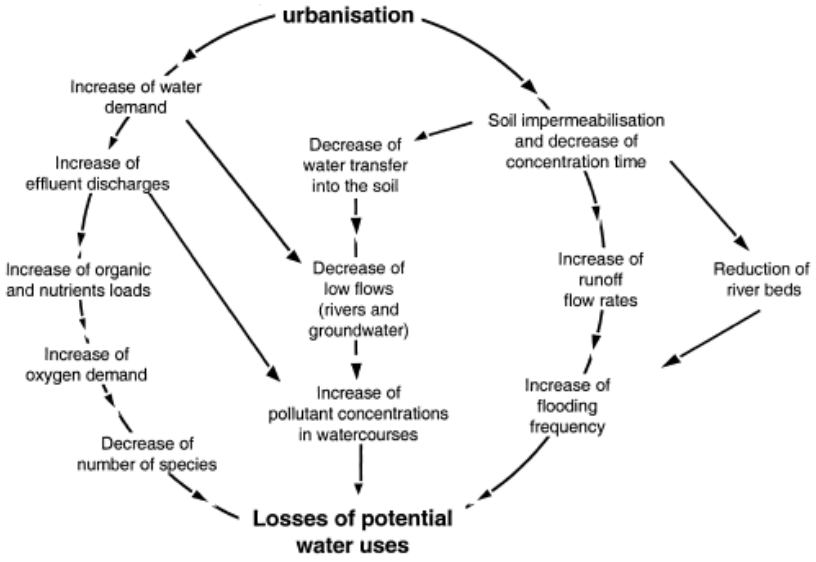


Figure 63: Impact of urbanization in water systems (Bertrand-Krajewski, Barraud, & Chocat, 2000, p. 324)

4.2.3 Potential sustainable water technologies, solutions, and urban synergies for a future SUWMS in Palomino

The solutions here presented will be guided by the SUWMS definition presented on the first section of this chapter:

A sustainable urban water management system is a system that includes the technical processes of collection, treatment and distribution of water, wastewater and stormwater. As well as the social engagement, environmental awareness and education of the community to guarantee the right of present and future generations to safe and clean water; while striving towards the conservation of ecosystem services, human well-being and minimization of the use of natural and economic resources.

It is important to highlight that the water technology solutions here presented are no more than a suggestion of technologies and initiatives that might be applicable for the local context of Palomino, based on the analysis done so far and the subsequent spatial analysis. The design of these technologies is not considered in this research, therefore it is understood that a deeper analysis and projections of future water demands are necessary in order to assess the validity of the technologies here presented.

The analysis will be based on the sub-division of the water services presented under the definition of SUWMS as follows: water supply, wastewater management, stormwater management, and management and governance.

As a final remark, the spatial analysis presented on this section is based on the cartography of Palomino from 2002 (Appendix B) and the mapping process performed during the field research.

Water supply

Figure 64 illustrates the spatial distribution in the urban perimeter of Palomino of the main infrastructure from the centralized water system: The pipelines networks of the WDS, the water storage tanks and the main water valve are visualized in dark blue. In addition, Figure 64 illustrates an overlay of the water supply coverage in relation with the contour lines, which give a general feeling of the terrain's topography, and the proximity to key water infrastructure.

Figure 64: Main infrastructure for the centralized water system (aqueduct) and water supply coverage in days per week.

As identified in the analysis of the critical water flows in PART III, the aqueduct's main failures are associated with the water losses in the WDS due to the leaks in the pipeline network and the lack of electric energy associated with the incapability of the water pump to function without electricity.

A solution to the centralized water supply could be to implement a parallel system that shares the existing infrastructure of the current centralized system, since the water well and pumping station are adequate to operate a new water pump of 3". As illustrated on Figure 65, the water distribution would then be divided in two main areas (blue and white polygon). The water supply will be by gravity as illustrated by the contour lines on Figure 67, providing enough water pressure to avoid the use of the individual water pump at a household level (or only use it for filling up elevated water tanks on the rooftop). The location of the water storage tank is strategic for two main reason: the first is the urban growth of the town; when comparing the cartography from two years—2002 and 2013— as visualized in Figure 66, the tendency of urban growth in Palomino is apparently towards the upper part of town. The second reason is the current water coverage in the urban area; as visualized in the previous Figure 64, the area that would be supplied by the parallel system is the most marginalized area in terms of water coverage.

Figure 65: Propose location for a parallel centralized water system supply (Google Earth, 2013; own figure).

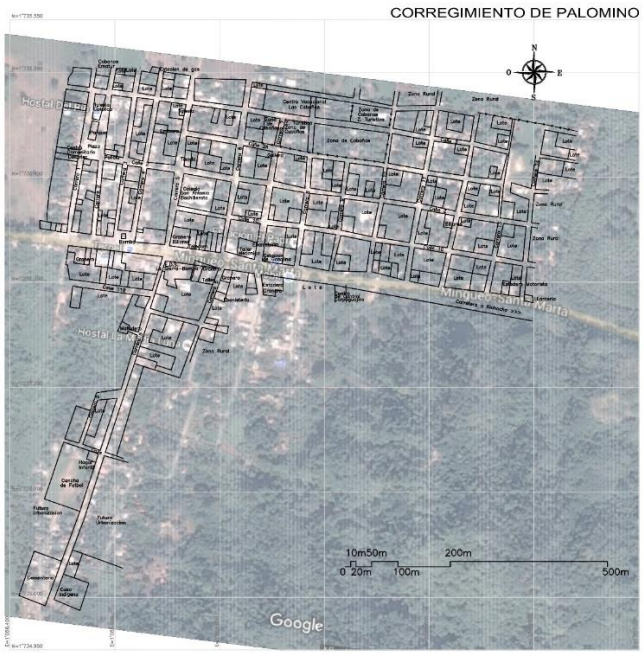


Figure 66: Palomino's urban growth from 2002 to 2013.

Figure 67: Overlay of water supply coverage water infrastructure and counter lines

The poor operation of the electric water pump due to the lack of electricity is major problem for the centralized system. This problem could be solved by a solution based on alternative energy sources. Installing of solar panels, as an addition to the electricity supplied by the main grid, would provide reliable and constant energy to the water pump station. As illustrated in Figure 68, Palomino has a substantial number of hours of sunshine per day (between 6 and 7 hours) even for the Colombian average, therefore making use of this renewable energy source is a promising, off-grid, sustainable solution.

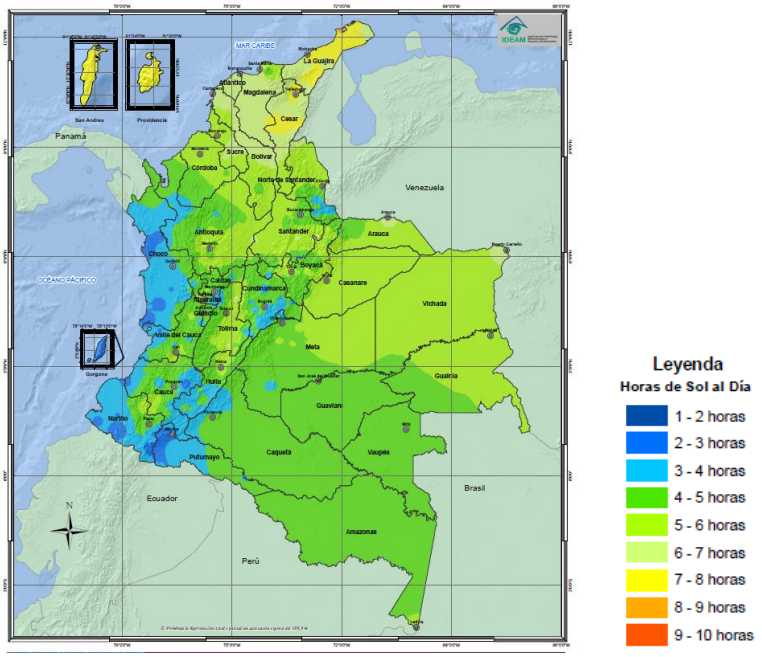


Figure 68: Sunshine hours per day in Colombia. Scale Colombia 1:9.000.000. Scale San Andrés y Providencia 1:600.000 (IDEAM, 2014)

Decentralized solutions for water supply are of special interest to Palomino, since they are often associated with low-cost water technologies with the potential for having a high impact on the current water system. For Palomino, two such solutions were identified: rainwater harvesting at a household level, and manual pumping wells, either for private or for collective use. Rainwater harvesting stands to have a large impact, since the community already performs rainwater collection to some extent and already has a degree of familiarity with this practice. For the manual pumping water wells, it is crucial to select effective locations based on the local topography. A high groundwater table is necessary for the wells be able to extract the groundwater; for this reason, the location for the construction should not simply be based on the water needs of the certain areas of the community. If properly implemented, these technologies could help to diminish the water scarcity in the town.

As a final remark that should be taken in consideration for future design, Figure 69 and Figure 70 show the area in the urban perimeter with the highest water demand according to the time of the day. This analysis is based on the household survey results (Appendix D), where it was asked the normal activities of the household members.

Figure 69: Areas of high water demand on the daytime (between 7:30 and 17:00)

Figure 70: Water demand on the nighttime (from 17:00 until 7:30am).

Wastewater

As exposed on PART II, Palomino present commonly basic-sanitation conditions. The most common practice for blackwater disposal is leach pits, which contribute greatly to the good hygienic conditions in the town. However, the leach pits present a risk of groundwater contamination and unbalanced loads of nutrients in the soil of the urban settlement. The education centers present a deficiency in WASH-related services, poor hygienic conditions in their bathrooms. In terms of greywater the infiltration is directly into the soil and large part of the population baths and washes clothes directly in the Palomino River, which generates direct contamination of cleaning products to the waters.

As potential solutions, the following practices might be implemented: ecological sanitation based on compost toilets. This technology has been implemented for different private households in the past, and has yielded successful results; the compost toilets are still in use after three to four years of construction. This technology provides a link between nutrients recovery from wastewater and urban agriculture practices at a household level, which would not only reduce the risk of groundwater contamination by avoiding the use of leach pits, but would also helped to increase the yield of crops for household consumption.

On locations of high discharge volume, like schools, the possibility of biogas production should be considered. An anaerobic digestion for biogas production is a valid option for wastewater treatment. The biogas produced could be use in the schools' kitchens.

For greywater treatment an effective solution for the community would be the construction of shared laundry rooms, which could be connected to rainwater harvesting for water supply and could lead to constructed wetlands for greywater treatment. This option would reduce the direct discharge of soap and different cleaning products into the Palomino River.

Stormwater

There is no stormwater management available in Palomino, therefore heavy flooding during the rainy seasons (during which water levels can reach up to fifteen centimeters above street level) is common. Figure 71 shows the areas more vulnerable for flooding according to the topography of the urban area, since there is no drainage system to evacuate the waters, the water tends to accumulate according to the conditions of the terrain. The flooding creates a high risk for human health because the flood water probably contains fecal matter from overflowing leach pits. Furthermore, stagnant water in a tropical climate generates ideal conditions for the spread of vector-borne diseases.

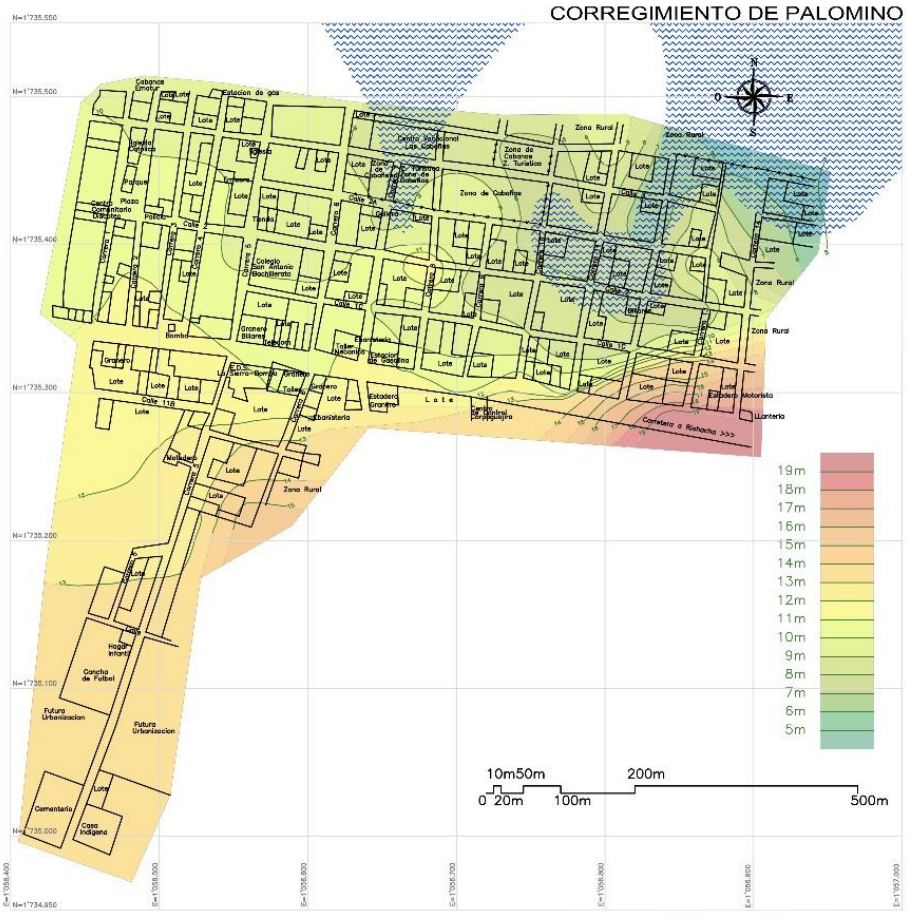


Figure 71: Topography and flooding area.

An advantage is the lack of paved roads in Palomino. This allows for a permeable surface through which the rainwater can infiltrate directly to the soil. Figure 72 shows the commonly observed roads and the land cover in Palomino's urban perimeter. The soil which is mainly permeable, with a high proportion of natural land.

Figure 72: Street in Palomino

Viable solutions for stormwater management include rainwater harvesting, and constructed wetlands, roads that use pervious pavements, and a drainage design based on infiltration trenches. These options reduce the water runoff in rain events and allow the water to infiltrate the ground and recharge the groundwater table.

Management and governance

The inhabitants of Palomino are normally not consulted on municipal nor governmental plans for development, which has led to general frustration and discomfort of the local population. Recently a new proposal has been made by the local government to transform the land use of the currently preserved littorals to an urban use that will benefit private investors. This lack of participation and consultation of the local community has resulted in protests (El Espectador, 2015). The water management in Palomino is no different. The water users are not consulted and the administration is failing in providing a satisfactory water service for years now.

Among the problems in management and governance found during this research are:

- Lack of schedule in water distribution.
- Lack of transparency in charging fees.
- No water fees related to the water consumption.
- Lack of maintenance of the infrastructure, especially of the WDS.
- Lack of integration with the community to solve water related conflicts.
- Lack of priority in the infrastructure development.

Lack of transparency, conflict resolutions and understanding of the water related problems:

- Most of the inhabitants do not pay for the water service anymore, since they have not receive the service for more than 10 months.
- Some inhabitants mentioned that the ‘fontanero’ might be paid to close the valves, so the inhabitants have to buy water at almost 5 euros per cubic meter.
- No available information from the local authorities and institutions.
- The population perceives high levels of corruption.
- No consistency when establishing the water fee per household.

The problems with the central administration are crucial and the high levels of corruption perceived by the local population makes the support of the local authorities more challenging. This is not uncommon in Colombia and it has been documented that corruption, and the absence of governance and strategic planning are the most common problems for proper water management systems.

An apparently successful management initiative in Colombia for rural water services are community-based management. This means that municipalities have the responsibility to ensure the delivery of the water services, but the community-based, either municipal, private or mix, are the actual responsible for the proper operation, maintenance and administration of the systems (Smits, Rojas, & Tamayo, 2013). This initiate could be applicable to Palomino: establish a water board, comprising of members for a community-based management, which would facilitate resolving water conflicts and managing the centralized water system. As additional management initiatives, it is necessary to improve the WASH sector in schools through effective programs on hand-washing, safe sanitation and consumption of potable water, in addition to hygiene education and de-worming programs

The management problems are among the hardest to resolve since they involve a considerable number of actors. The next section provides a short stakeholder analysis to identify the actors involved in the current urban water management system in Palomino.

Stakeholder analysis –how would strive for a SUWMS in Palomino?

The stakeholder analysis aims to analyze the key actors involved on the water system in Palomino in terms of their power and interests to influence the current state of the water system and strive towards a SUWMS. Figure 73 represents an overview of the key actors in the stakeholder analysis; they are divided into two categories either *organizations* (in turquoise color) or *person* (in purple color). The actors of the stakeholder analysis interact with each other according to the existing dependencies between one another, these interactions can be visualized as well in Figure 73- they are represented as connections between the actors.

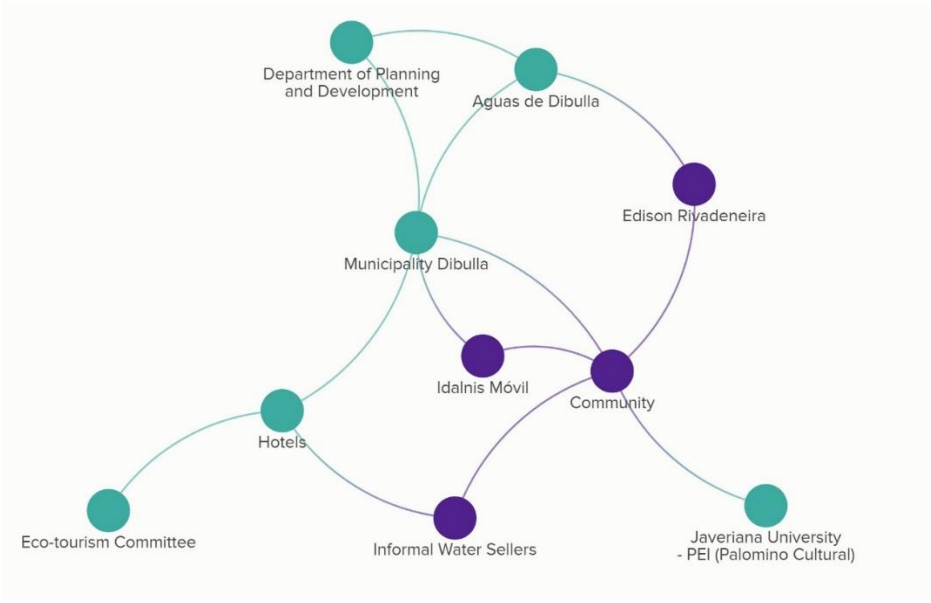


Figure 73: Stakeholders visualization and connections between actors

Organizations:

Javeriana University, Bogotá D.C. - PEI: Programa de Estudios Internacionales

The Program of International Studies (PEI – acronym in Spanish) is an initiative from the Javeriana University, Faculty of Architecture and Design in Bogotá D.C. The program was created in 1996 by the architect Carlos Hernandez Correa with the main objective to integrate interdisciplinary and international knowledge to create practical solutions based on research and social innovation for communities in need. This innovative approach is part of the framework 'New Territories', a living lab aimed towards research on contemporary cities understood as complex, adaptive living systems that present evolutionary processes embedded on social, technological and scientific context (PEI - Programa de Estudios Internacionales, 2010). The PEI program has been closely involved in developing various ecological projects with the community as it is the case of the dry toilets formerly presented.

Interest:

The interest of the Javeriana University – PEI program to improve the current state of the water system is high. This actor has been actively involved in improving the well-being of the community by different design project and collaboration on various research projects e.g. this master thesis.

Power:

The power of this organization to influence the current conditions is limitated, nontheless it can be considered high as it has been proven through past experinces. This actor is key in providing a direct communication with the community to understand and develop solutions according to their needs and posses an important knowleged and kown-how for applicable project.

Municipality of Dibulla

The municipality of Dibulla is the headquarters of the administration of the five townships: Las Flores, La Punta de los Remedios, Mingueo, Río Ancho and Palomino.

Interest:

The interest of the organization of high. As the local authorities it is obligate to provide to the community all the basic needs, including water supply and sanitation.

Power:

The power of this instructions is the highest since it is in charge of the central administration, and taxes and subsidies. The resources of this institution are high.

Department of Planning and Development

The department of planning and development is a sub-direction from the Municipality of Dibulla. The tariff per household is determined by the socio-economic condition, which is given by the Department of Planning and Development of the Municipality

Interest:

The interest of this institution could lie on facilitating the fees generation process and work with the municipality for an organized urban development.

Power:

The power of this institution is limited and link to the central administration of the municipality.

Aguas de Dibulla

The management and operation of the aqueduct system is the responsibility of the governmental institution Aguas de Dibulla.

Interest:
The interest for a proper function of the water services should be of high interest for this institution since it is its responsibility the proper functioning.
Power:
Linked to the central administration, nonetheless the power the make changes in the administration of the aqueduct service is relevant.

Hotels
This actors represents all the hotels present in Palomino, which represent the commercial tourism activity.

Interest:
The interest of hotels is great, since the water supply is linked to the development of this commerce activity. Especially for hotels in the urban perimeter, which are dependent from the centralized water supply.
Power:
The power is limited, nonetheless they represent the most important commercial activity in the town, therefore their economic muscle is important.

Eco-tourism Committee
The Eco-tourism Committee is a new independent initiative, funded by six hotels in the Palomino area: Finca Escondia, Reserva Natural El Matuy, Hotel Eco-Sirena, Hostal Dreamers, Hostal Tikihut, and Hotel Hukumeizi.
Interest:
The interest is high, since the committee strives towards sustainability
Power:
The power of the organization is, at this stage, limited. As an emerging initiative it still time to develop further.

Persons:
Edison Rivedeneira
Employee of Aguas de Dibulla and operator of the aqueduct system in Palomino.
Interest:
Slightly high. Interest in maintaining his job opportunities.
Power:
Low.

Idalnis Móvil
Idalnis plays an important role for the community, since she is a mediator for conflict resolution between residents of Palomino. She helps as well with the communication between the community and the local authorities or even the local hotels to transmit the community's concerns and problems in search for solutions that involve various parties. (Móvil, I, personal communication, September 17, 2015).
Interest:
As part of conflict resolution her interest in water related issues might be high.
Power:
The potential of Idalnis for aiding of water conflict resolutions is high.

Community

The community are the inhabitants of Palomino, mainly located in the urban perimeter of the town. The community are the main actor s water users and since the population is the more representative in term of quantity they are also the main water users of the water system.

Interest:

Very high. The community suffers greatly from water related problems.

Power:

Somehow low. Even though there has been many complains to the central administration, few changes are visible until the date.

Informal water sellers

Little is known about the informal water sellers, except that they provide a service to a certain degree required demand in Palomino. According to the interviews and survey performed, most of the household in Palomino collect water themselves from the Palomino River, since purchasing water is rather expensive and most households have a reduce income. No data is available about the amount of persons that performed vending of water for a living nor the range of age of 'employment' nor about the earnings of the sector.

Interest:

Very low. Theirs business is bound to water scarcity.

Power:

Low. Their influence might create some problem to achieve a proper water supply, but ultimately their power is low.

To finalize the stakeholder analysis, Figure 74 shows the power-interest gris, crafted according to the previous especification on the different stakeholders.

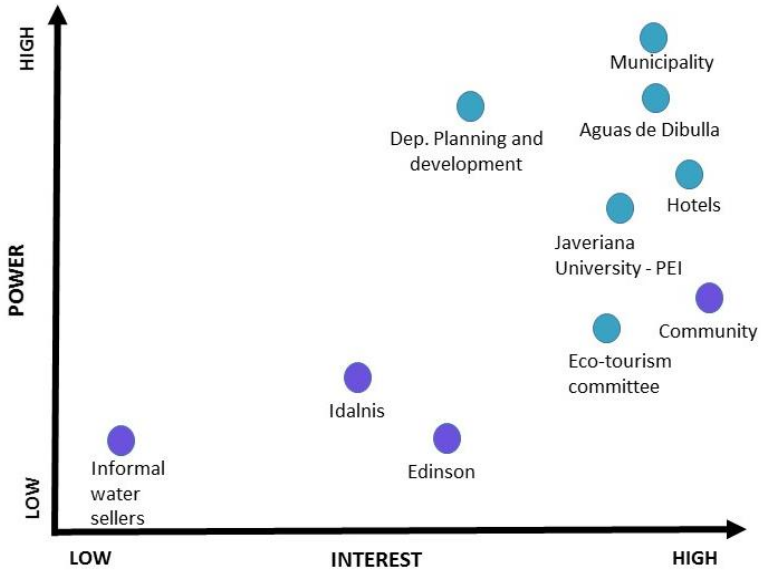


Figure 74: Power - Interest grid

4.3 Rainwater harvesting: Low tech, high impact technology to improve the UWM in Palomino?

The previous section gave an overview on different technologies and strategies that, if implemented, would contribute towards a SUWMS in Palomino. Even though the overview of this thesis is focused on the local conditions of Palomino, none of the technologies have been assessed in a quantitative manner. As shown in the literature review, some sustainability indicators have been proposed for an integrated assessment of technologies and practices in SUWMS, yet the lack of available data poses a challenge for a quantitative assessment in the present research.

In this section, an assessment will be made based on the UM approach, rather than on sustainability criteria. To start, PART III identified that two flows were critical for the UWM of the current water system in Palomino: the WDS losses linked to leaks on the pipelines networks, and the water pumped via the centralized system linked to significant losses due to the lack of electric energy.

From this information, we see that rainwater harvesting could be a promising technology to improve the UWM of the current system, since it is decoupled from these two critical flows: no electricity is needed for the capture and storage of rainwater, and no it is not necessary to use WDS from the centralized system if the rainwater harvesting is at a household level.

Using this hypothesis, we will explore the UWM of the water system by adding rainwater harvesting into the conceptual UWM model. By doing so, we will be able to make an analysis on the variations of the UWM and on the potential impact of rainwater harvesting to improve the UWM. To do this, we will assess the system using model simulations from different precipitation values, measured in Palomino's time series of 1691-2006. The method for the UWM analysis on this section is based on the method presented in PART III of this research, which is based on six steps: System boundary definition, Conceptual urban water metabolism model and definition of mass balance equation, Scenarios development, Data acquisition and/or estimation, Model simulations and results, and Outcome analysis.

4.3.1 System boundary definition

The system boundary will be maintained in the same manner in which it is presented in PART III (which is based on PART I). The spatial dimension corresponds an area of 4.83 km^2. Figure 75 illustrates the urban perimeter with an area of 0.54 km^2, which corresponds to 11% of the total area of the system. The urban area will be used to calculate the volume of rainfall entering the system. The time frame of the analysis is one month.

Figure 75: System boundary (red) and Urban area (purple) (Google Earth, 2013; own figure)

4.3.2 Conceptual urban water metabolism model and definition of mass balance system equation

The conceptual model for this analysis as based on the conceptual model in PART III, since the analysis is based on the evaluation of the changes to the UWM of the current water system through the adoption of rainwater harvesting practices in the community. Figure 76 illustrates the conceptual model for the analysis of the potential for improvements from rainwater to the urban water metabolism in Palomino.

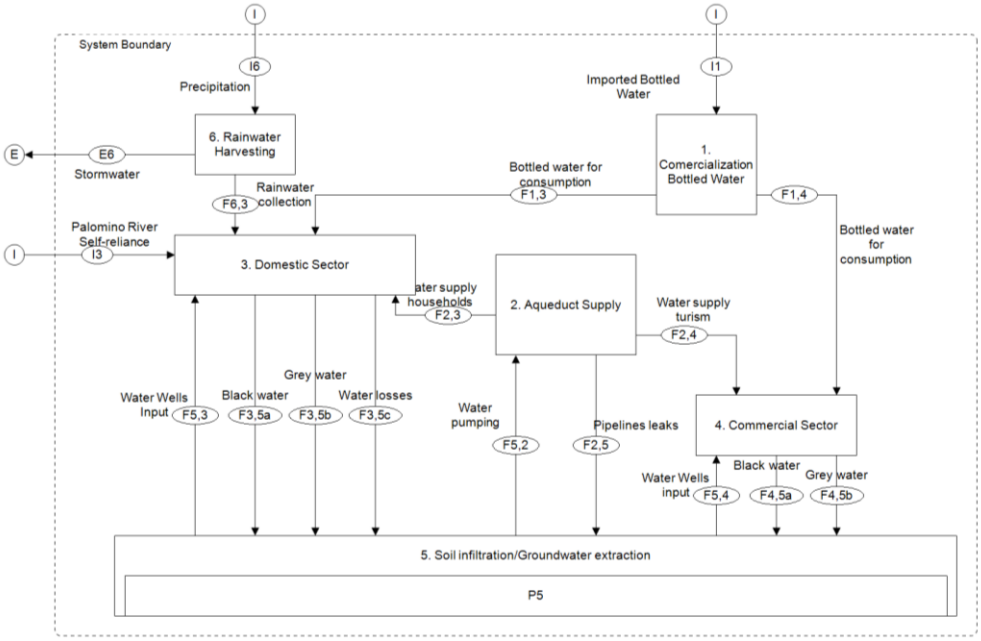


Figure 76: Conceptual UWM model including rainwater harvesting for Palomino's current water system

Here, all the assumptions made for the UWM model in PART III will be maintained, and only additional assumptions will be mentioned:

- Rainwater collection will be considered at the rate found from the survey's results on the household level, which corresponds to 57%. In other words, only 57% of Palomino households practice rainwater harvesting.
- Rainwater harvesting will not be included for the commercial sector. In the survey, none of the hotels reported performing rainwater harvesting, from which it is possible to infer that this practice is not common for the commercial sector.
- The precipitation that enters the system boundary and is not used for rainwater harvesting leaves the system in form of stormwater. In a physical sense, this is not accurate, since the precipitation should infiltrate the soil, feeding the groundwater levels and experiencing from evapotranspiration. As illustrated in Figure 77, the estimations for evapotranspiration, runoff and infiltration flows are based on the permeability of the land cover of the surface under study. Regardless, this phenomenon will not be considered, since the UWM of the current system contemplates only the economic flows of the water system.

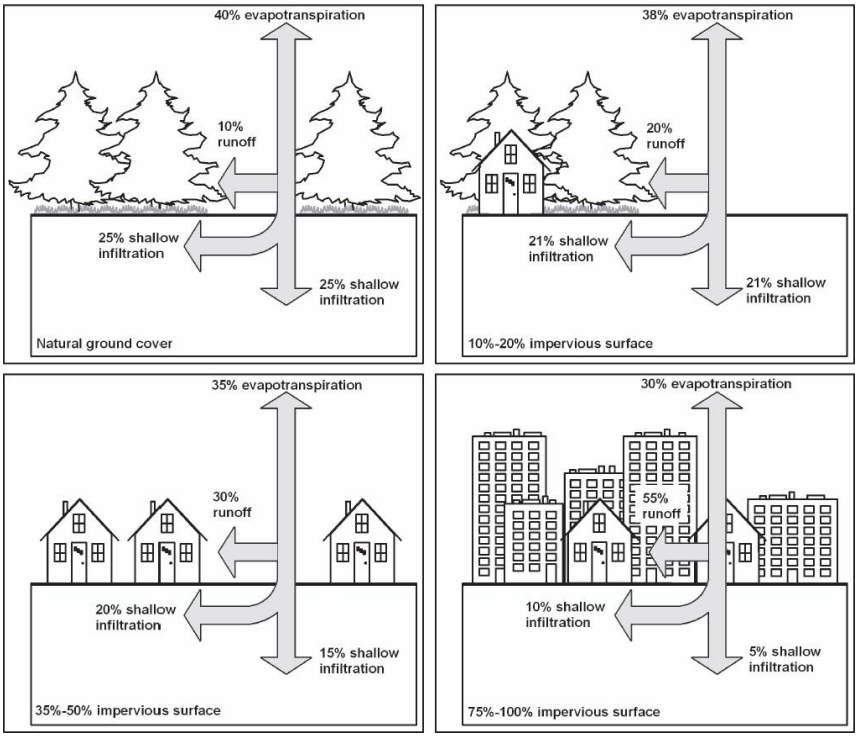


Figure 77: Evapotranspiration, runoff and infiltration coefficients in relationship of the degree of surface permeability (Thériault & Laroche, 2009, p. 260)

As illustrated in Figure 76, the UWM model is now formed by a total of six processes, three inflows, one outflow and 14 internal flows.

The nomenclature of the components of the model are maintained:

6 processes	P*i*, P= Process and *i*= number of the process.
3 Inflows	I*n*, I= Inflow and *n*= number of destination process.
1 Outflows	E*m*, E= Outflow (Export) and *m*= number of outsource process.
14 Internal flows	F*i,j*, F= Flow; *i*= number of source process and *j*= number of destination process.

The UWM model for rainwater harvesting—the overall equation that describes the system—is as follows:

$$\Delta S = I_1 + I_3 + I_6 - E_6$$

Where:
$\Delta S = Stored\ Water$
$I_1 = Imported\ bottled\ water$
$I_3 = Palomino\ river\ self - reliance$
$I_6 = Precipitation$
$E_6 = Stormwater\ (runoff)$

The following Table 15, will only describe the additions made to the UWM model due to rainwater harvesting process.

ADDITIONS TO THE UWM MODEL

Table 15: Description of the process of rainwater harvesting and associate flows

Nomenclature	Name	Description
P6	Rainwater Harvesting	This process represents the rainwater collection at a household level.
I6	Precipitation	Volume of rainfall entering the system boundary.
E6	Stormwater (runoff)	This outflow represent the volume surplus from the rainwater collection. The volume of rainwater that is not collected is assume to exit the system through this flow.
F6,3	Rainwater collection	Input of rainwater for use on households activities (e.g. cleaning) and animal husbandry. From process Rainwater Harvesting (6) to process Domestic Sector (3).

4.3.3 Scenario development - rainwater

The scenarios for the analysis of the UWM adding rainwater collection to the current UWM are based on the variation of the precipitation inflow. The values of the precipitation used in the model are a direct measurement from the database of the institute IDEAM through the measurement station, 15030020 Palomino, located at approximate at 11°14'N, 73°34W at an elevation 30 meters above sea level (m.a.s.l), as illustrated in Figure 78.

Figure 78: Geographical location measurement station (Google Earth 2013, own figure).

Figure 79 displays the annual rainfall in [mm] for a total of 45 years, which corresponds to the time series from 1961 until 2006. Here, years of abnormal rainfall, documented by the IDEAM, are classified in two phenomena: 'La Niña' in yellow and 'El Niño' in red. In short, 'La Niña' is associated with high levels of rainfall, while 'El Niño' is associated with extreme drought.

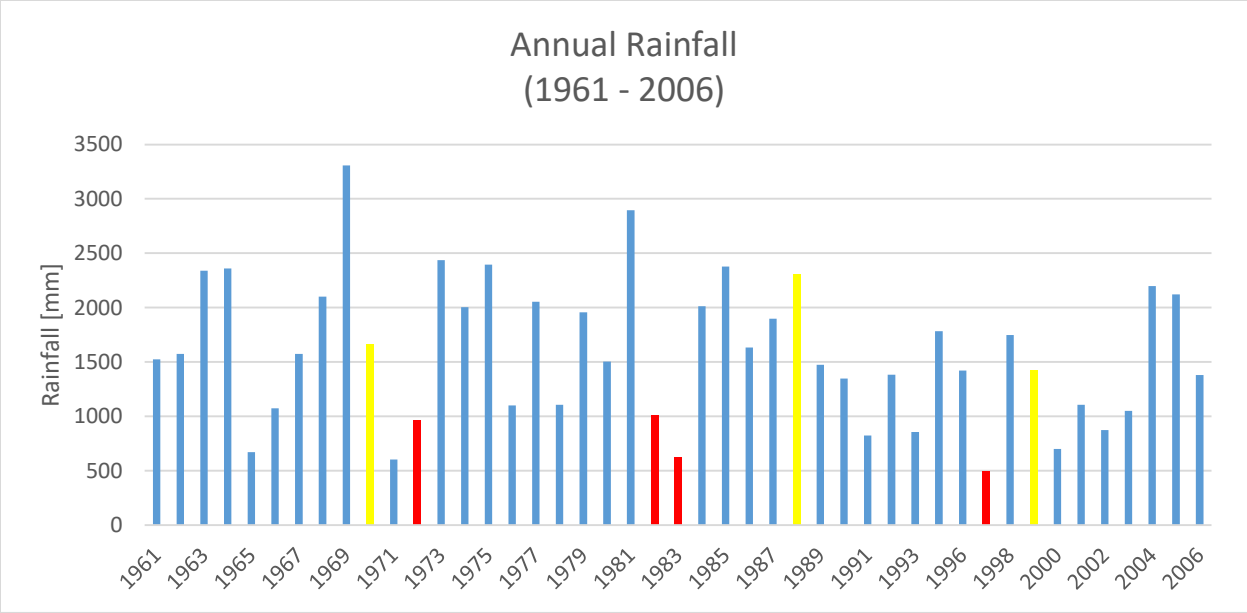


Figure 79: Annual rainfall time series 1961-2006. Including rainfall abnormalities. 'La Niña' (yellow), 'El Niño' (red). (IDEAM, 2015)

The registered anomalies in the rainfall volumes for La Niña and El Niño are cataloged according to their intensity as: mild, medium and strong. In Figure 79, only the strong events are shown. La Niña occurred in 1970, 1988 and 1999; El Niño occurred in 1972, 1982-1983, and 1997 (IDEAM, 2007).

The scenarios are developed on the basis of the most critical scenario found under PART III—Scenario 2—where the demand of the commercial sector is high, all losses are at maximum value, and therefore, the stock is the highest. Based on the demand and loss characteristics of Scenario 2, the monthly analysis will be performed for three years of reference, according to extreme annual rainfall values found in the time series of rainfall for Palomino.

The year with the highest recorded value is 1969 [3308.7 mm], and the year with the lowest recorded value is 1997 [492.5mm]. The year of 1997 corresponds exactly to a year of extreme drought associated with El Niño phenomenon; it was the strongest episode ever recorded in Colombia until 2015. Curiously, 1969 does not correspond to a year with La Niña phenomenon, which did occur one year later in 1970.

The difference in rainfall value between the two extremes in 1969 and 1997 corresponds to 2.8 m, a significant change in precipitation in the region. The intermediate value between these two events is 1900.6 mm (1.9m); the year is the closest to this value is 1987, which had a recorded rainfall of 1899.03 mm.

Based on these three rainfall events, three scenarios will be analyzed: one of extreme rainfall scenario (1969), one of extreme drought scenario (1997), and finally, one 'standard' scenario (1987), for a total of 36 model results. The analysis of these three scenarios should lend insight into the potential for rainwater harvesting and its influence on the UWM of Palomino.

Most of the principal assumptions of the UWM model remain the same as those made in PART III, along with additional assumptions being made for the process of rainwater harvesting. The subsequent list presents the assumptions of the UWM model in regards to rainwater harvesting.

Principal assumptions of the UWM model for rainwater harvesting:

- Water demand is proportional to water availability; the more water is available, the more will be expended. Therefore, water demand for the domestic and commercial sectors is based on result from the survey conducted during field research.
- Variations in water demand according to water availability are not taken into consideration. For the model simulations, the water demand remains constant at 50 L/cap day for the domestic sector and 160L/ cap day for the commercial sector.
- The domestic demand does not vary during the month of the analysis. This is true when calculating the standard demand on the basis of population, which can be considered constant during the time period of one month.
- The demand of the commercial sector remains constant throughout all scenarios with a high season value. The same is true for water losses, as is the result from Scenario 2 – PART III.
- The Palomino River is an endless water resource.
- The imported bottled water can be endlessly introduced to the system.
- The groundwater available in the system is modeled as a stock without the external influences of recharge by percolation and discharge by drainage.
- Rainwater harvesting is performed by 57% of the existing households in Palomino's urban perimeter.
- Since the data available is from one unique metering station instead of several, it is not possible to conduct geographical approximation of the rainfall using Thiessen Polygons[49]. Hence, it is assumed that precipitation is homogenous in all the urban area of Palomino.
- The flow *F6,3 rainwater collection* cannot have a value that is greater than the maximum storage capacity available at the household level.

4.3.4 Data acquisition and/or estimation

As previously mentioned, the values of the UWM model in Scenario 2 - PART III will be used as the base scenario. Scenario 2 was constructed on a monthly analysis of a 31 days; accordingly, the values of the model simulation for a yearly basis will be adjusted to reflect the varying number of days in distinct months. None of the three years under analysis is a leap year. In this section, only the additional data required by the inclusion of process 6 – Rainwater Harvesting will be presented.

I6 Precipitation:

The precipitation volume inflow is determined by the amount of rainfall throughout the month within the urban area in the system boundary. The volume of the rainwater inflow is estimated by the following equation:

$$I_1[m^3/month] = mean\ rainfall[m/month] * A[m^2]$$

[49] Definition of Thiessen Polygons on GIS applications can be found under: http://support.esri.com/en/knowledgebase/GISDictionary/term/Thiessen%20polygons

Where
$Mean\ rainfall = Value\ registered\ by\ IDEAM$
$A(urban\ area)[m^2] = 0.54\ km^2 = 541{,}760.6\ m^2$

The following Table 16 shows the mean rainfall values registered in the database of the IDEAM:

Table 16: Monthly Rainfall Mean Value [mm] (IDEAM, 2015)

Value	Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Value
Maximun	1969	173	141	202	188	155	409	182	256.4	448	497.9	478.8	177.5	3308.7
Minimun	1997	12.0	68.0	0.0	3.0	2.0	111.0	13.4	63.0	73.0	26.8	120.3	0.0	492.5
Intermediate	1987	44	50	0	183	488	94	84	58	232	202.03	132	332	1899.0

The calculated values of the input flow $I_6\ [m^3/month]$ per month are presented on Table 17:

Table 17: Results I_6 Precipitation [m^3/month] x10^3

Value	Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Volume
Maximun	1969	93.7	76.4	109.4	101.9	84.0	221.6	98.7	138.9	242.7	269.7	259.4	96.2	1792.5
Minimun	1997	6.5	36.8	0.0	1.6	1.1	60.1	7.3	34.1	39.5	14.5	65.2	0.0	266.8
Intermediate	1987	23.8	27.1	0.0	99.1	264.4	50.9	45.5	31.4	125.7	109.5	71.5	179.9	1028.8

E6 Stormwater and F6,3 Rainwater collection:
For the year of 2009, Palomino had an estimated population of 2,141 inhabitants in an average of 498 households; for 2015, the estimated population was **2,286 inhabitants** in the urban area in an average of 542 households (Departamento de La Guajira, 2012). Out of these 542 houses, it has been assumed that 57% performed rainwater harvesting, which corresponds to approximate **309 houses**.

Figure 80 illustrates the typology of houses in Palomino. Based on field observation, is has been determined that houses in Palomino have an average area of **55 m²**.

Figure 80: Different types of houses (facades) in Palomino. (Archive Colectivo Mitín, 2009)

$$F_{6,3}[m^3/month] = I_6[m^3/month] * TC_{6,3}$$

Where:
$I_6 = Precipitation$
$TC_{6,3} = Transfer\ Coeficient\ of\ the\ rainwater\ collection$

The transfer coefficient is calculated from the roof area of each household, since this figure represents the theoretical surface for rainwater harvesting of the system. For 309 households and an average roof area of **55 m²**, the theoretical area for rainwater collection (catchment area) corresponds to **16,991.7 m²**.

$$TC_{6,3} = \frac{Aroofs}{Aurban}$$

$$TC_{6,3} = \frac{0.01699\ km^2}{0.54\ km^2} = 0.031$$

$$E_6[m^3/month] = I_6[m^3/month] * TC_{e6}$$

$$TC_{e6} = 1 - TC_{6,3}$$

Where:
$I_6 = Precipitation$
$TC_{e6} = Transfer\ Coeficient\ of\ the\ precipitation\ leaving\ the\ system$

The flow $F_{6,3}$ *Rainwater collection,* is limited by two factors: first, the maximal storage capacity per household per day, and second, the maximal buffer capacity per household per month (also linked to the storage capacity). According to the water tanks available in local stores, the volume ranges from 250L to 10,000L. Though, as mentioned in PART II, water tanks of 250L are most common in Palomino, a volume of 2,000L will be chosen for this analysis, since 2,000L tanks have volumes and dimensions that are feasible to fit at a backyard area of a typical household in Palomino.

Condition 1: The rainwater collection per day cannot surpass the storage capacity of the household's water tank of 2,000L.

$$F_{6,3}[L/day\ household] \leq 2000\ L/day\ household$$

Here, it is assume that the rainfall levels are equally divided by the number of days it rained per month.

Table 18: Days of rain per month of year of analysis (IDEAM, 2015)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Days of Rain
1969	11	4	6	5	4	7	8	13	11	20	18	5	112
1997	2	3	0	1	1	7	1	2	9	8	3	0	37
1987	1	2	0	6	20	5	4	4	6	12	3	5	68

Table 19: Volume of rainfall collection per household [L]

Year	January	February	March	April	May	June	July	August	September	October	November	December
1969	854.8	1915.9	1829.8	2043.6	2106.1	3175.7	1237.2	1072.0	2213.6	1353.1	1445.7	1929.5
1997	326.1	1232.0	0.0	163.1	108.7	861.9	728.3	1712.1	440.9	182.1	2179.5	0.0
1987	2391.5	1358.8	0.0	1657.7	1326.2	1021.8	1141.4	788.1	2101.6	915.1	2391.5	3608.9

The results on Table 19 indicate which months of each year present a surplus in rainwater flow. The values marked in yellow represent months in which rainfall surpasses 2,000L per household.

Condition 2:

It is assumed that water tanks are empty at the beginning of the year; therefore:

$$F_{6,3}\ MAX[L/day\ household] = Dd * Households * \frac{day}{month} + 2000$$

Where:
$Dd = Demand\ domestic\ sector = 50 L/cap\ day$
$Households = 309$

If the theoretical F6,3 (3.1% of I_6) is divided into the number of days of rainfall, and is greater than the water demand between rainfall events, then the system presents a surplus. This surplus for each rain interval cannot be greater than 2,000L.

4.3.5 Model simulations and results

The thirty-six-model simulation results of this section can be found under Appendix A - Simulation results UWM Rainwater harvesting potential. Table 20 displays the results of the simulations in m^3 per month of analysis for key flows – Precipitation (I_6), Runoff (E_6), Rainwater Collection ($F_{6,3}$), Palomino River self-reliance (I_3), and the Stock of the system (*Process 5*).

Table 20: Results monthly simulations for the years: 1969, 1997 and 1987. Results in [m^3/month].

1969					
	Precipitation	**Runoff**	**Rainwater Collection**	**Palomino River self-reliance**	**ΔStock**
Base	N/A	N/A	N/A	1552.3	1634.2
Jan	93724.6	90903.4	2821.2	-1268.9	1634.2
Feb	76388.2	7439.3	1990.0	-588.0	1475.9
Mar	109435.6	107232.5	2203.2	-650.9	1634.2
Apr	101851.0	99718.9	2132.1	-630.0	1581.3
May	83972.9	81769.7	2203.2	-650.9	1634.2
Jun	221580.1	219448.0	2132.1	-630.0	1581.3
Jul	98654.6	96451.4	2203.2	-650.9	1634.2
Aug	138907.4	136704.2	2203.2	-650.9	1634.2
Sep	242708.7	240576.6	2132.1	-630.0	1581.3
Oct	269742.6	267539.4	2203.2	-650.9	1634.2
Nov	259395.0	257262.9	2132.1	-630.0	1581.3
Dec	96162.5	93959.3	2203.2	-650.9	1634.2
1997					
Jan	6501.1	6299.6	201.5	1350.8	1634.2
Feb	36839.7	35697.7	1142.0	259.9	1475.9
Mar	0.0	0.0	0.0	1552.3	1634.2
Apr	1625.3	1574.9	50.4	1451.7	1581.3
May	1083.5	1049.9	33.6	1518.7	1634.2
Jun	60135.4	58271.2	1864.2	-362.1	1581.3

Jul	7259.6	7034.5	225.0	1327.3	1634.2
Aug	34130.9	33072.9	1058.1	494.3	1634.2
Sep	39548.5	38322.5	1226.0	276.1	1581.3
Oct	14519.2	14069.1	450.1	1102.2	1634.2
Nov	65173.8	63153.4	2020.4	-518.3	1581.3
Dec	0.0	0.0	0.0	1552.3	1634.2
1987					
Jan	23837.5	23098.5	739.0	813.4	1634.2
Feb	27088.0	26248.3	839.7	562.2	1475.9
Mar	0.0	0.0	0.0	1552.3	1634.2
Apr	99142.2	96392.1	2750.1	-1247.9	1581.3
May	264379.2	262176.0	2203.2	-650.9	1634.2
Jun	50925.5	48728.8	2196.7	-630.0	1581.3
Jul	45507.9	44032.6	1475.3	77.0	1634.2
Aug	31422.1	30448.0	974.1	578.2	1634.2
Sep	125688.5	122938.4	2750.1	-1248.0	1581.3
Oct	109451.9	107248.7	2203.2	-650.9	1634.2
Nov	71512.4	69380.3	2132.1	-630.0	1581.3
Dec	179864.5	177661.3	2203.2	-650.9	1634.2

The following Figure 81, Figure 82 and Figure 83, display the results presented in the previous Table 20.

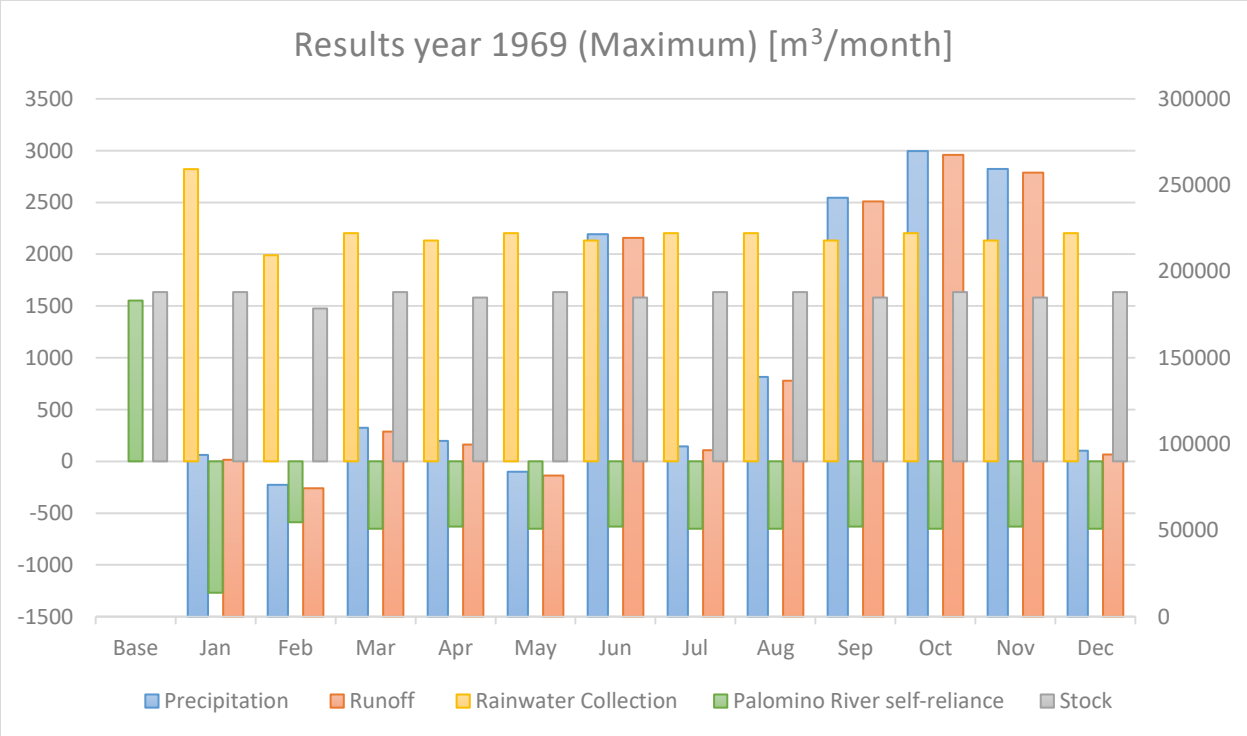


Figure 81: Graphical representation of the results for the year of maximum annual precipitation 1969

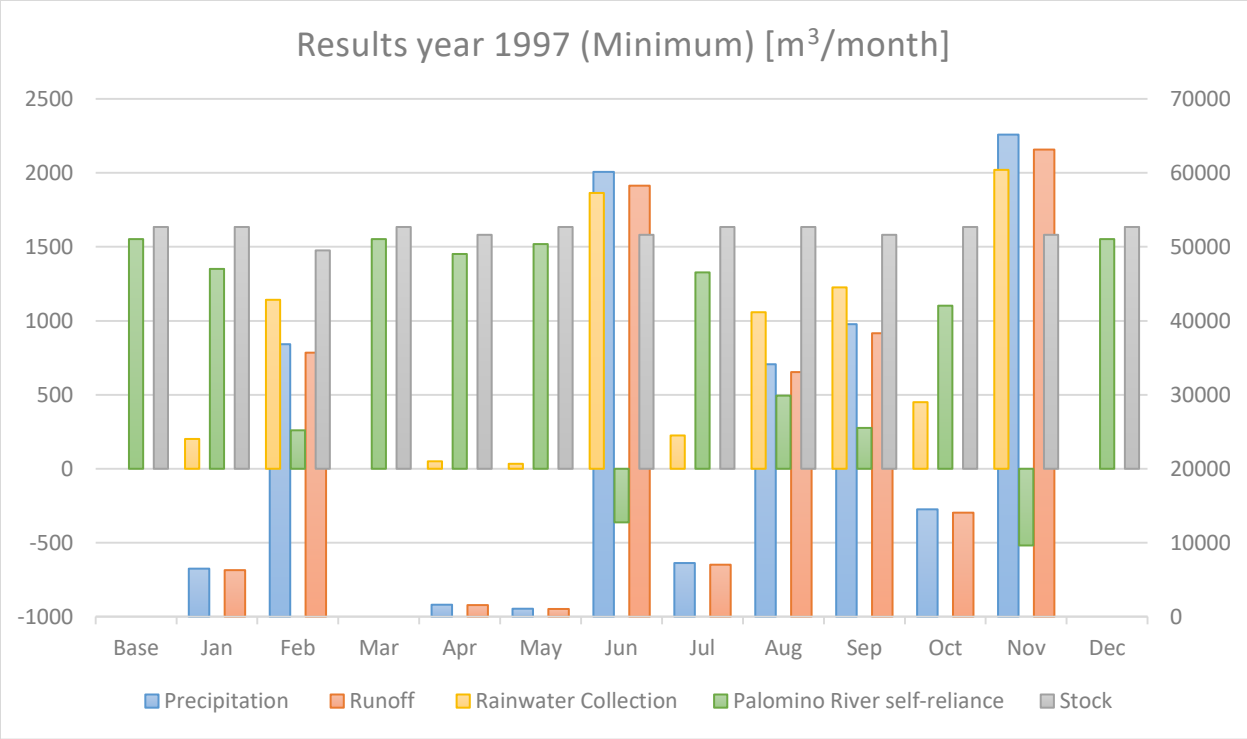


Figure 82: Graphical representation of the results for the year of minimum annual precipitation 1997

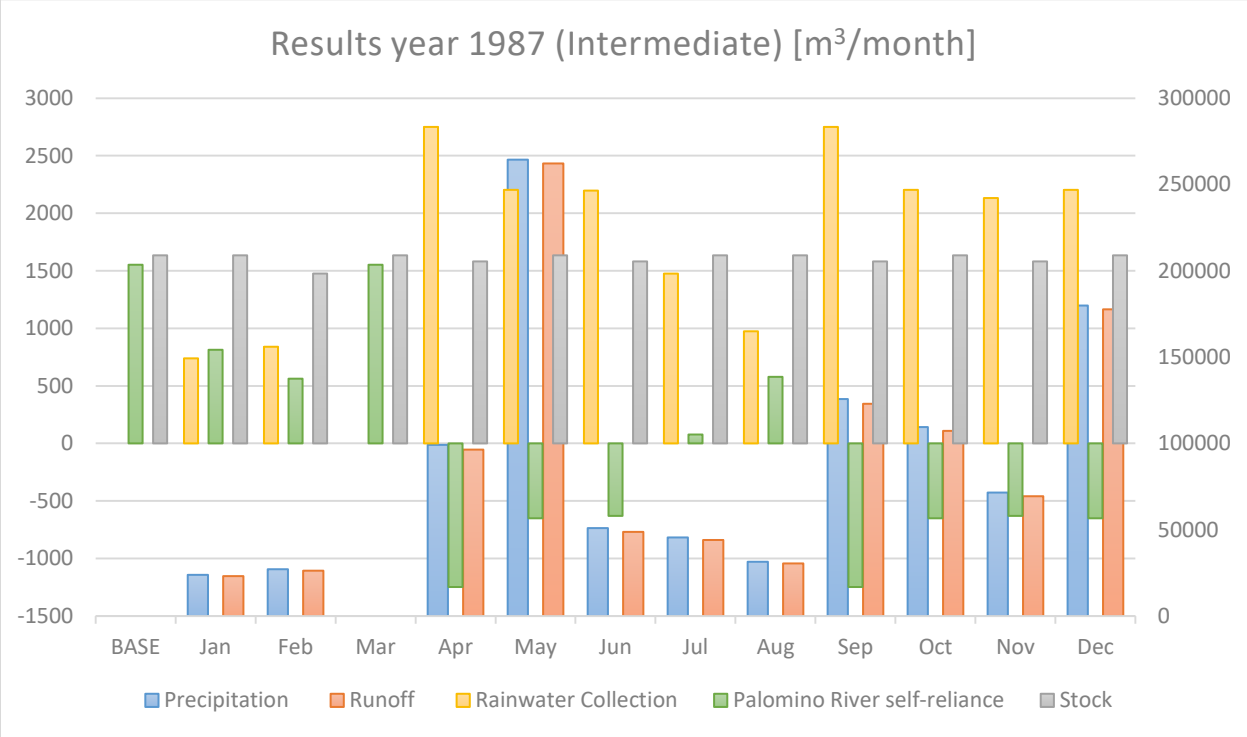


Figure 83: Graphical representation of the results for the year of intermediate annual precipitation 1987

4.3.6 Outcome analysis

As mentioned above, the critical scenario--with the highest water demand due to a high tourist season—was chosen for the analysis on the potential of rainwater harvesting to improve the current UWM in Palomino. For the base scenario, the obtained results correspond to a stock of *1634.16 m^3/month* and a volume of *22L/cap day* (*I_3 – Palomino River self-reliance*) to supply the daily water demand of the Domestics Sector (PART III). These values are the base for comparison analysis throughout this section.

As is evident from the results in Graphs 81, 82 and 83, the stock does not vary by the different years of analysis nor by the volume of precipitation entering the system. The variation of the stock is mainly dependent on the number of days per month of analysis, and on the water demand from both the domestic and the commercial sector. While the water demand is constant for both sectors throughout the analysis, the stock varies by the days of the month, as follows: for a 31-day month, the stock is 1634.2 m^3/month; for a 30-day month, the stock is 1581.3 m^3/month; and for a 28-day month, the stock is 1475.2 m^3/month.

The explanation for this variation in the stock is linked to the modeling process. The general equation of the overall system is as follows:

$$\Delta S = I_1 + I_3 + I_6 - E_6$$

When modeling, the stock is 'locked' by a constant value for the flows linked to this process (Process 5), whose values have been determined by the characteristics of the UWM (i.e., water demand per sector and number of days per month). The variations in the system are then better visualized by the flow *I_3 Palomino River self-reliance*.

The following Figure 84, Figure 85, and Figure 86 illustrates the results by month for each year of analysis, displaying the relationship between precipitation, rainwater collection, and self-reliance from the Palomino River. The two former values are calculated *per capita.* For the flow *I_3-Palomino River self-reliance,* the total population is considered (2,286 habitants). However, for the flow *$F_{6,3}$ Rainwater collection,* only the population that practices rainwater collection is taken into consideration: 309 households, each averaging 4.6 persons, yields a total of 1,421 people, or 62% of the population.

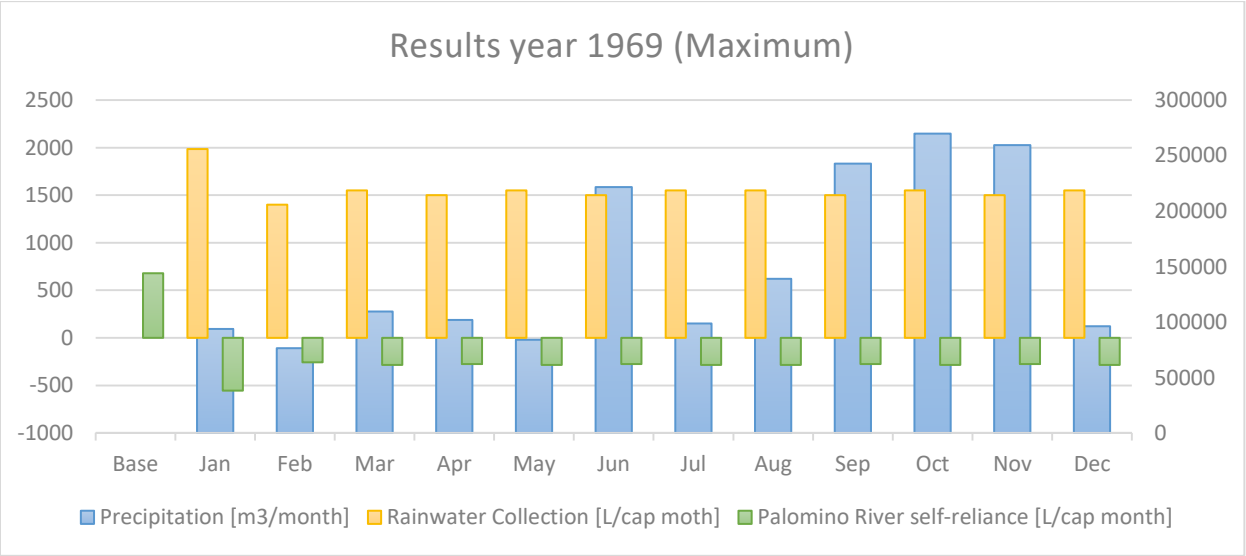


Figure 84: Results 1969 (I_6), Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

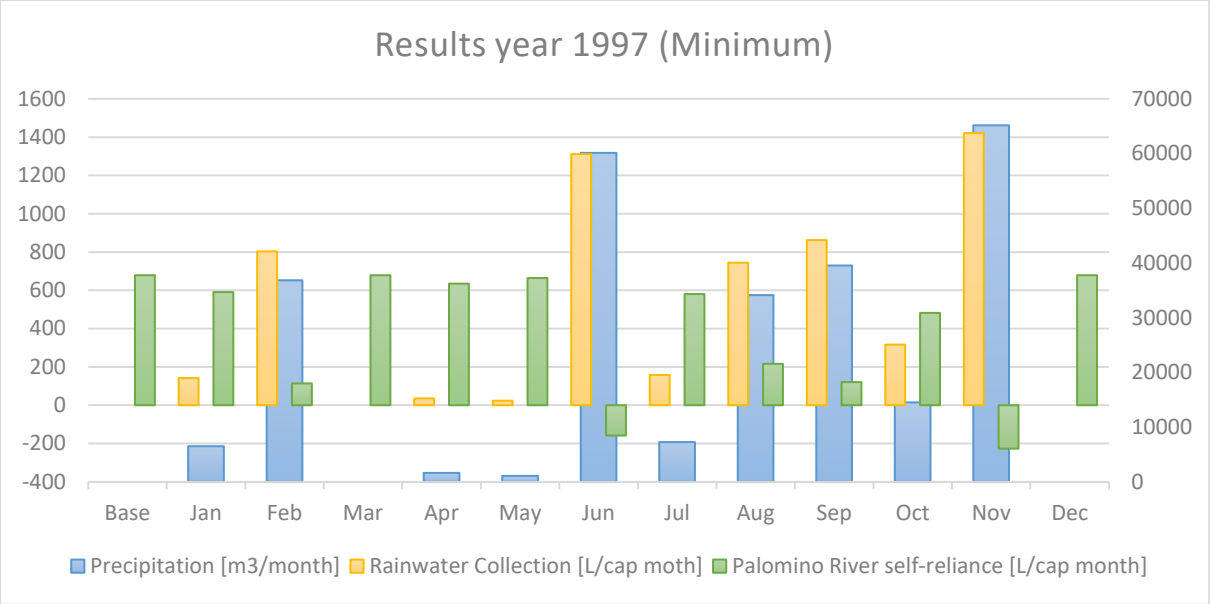


Figure 85: Results 1997 (I_6), Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

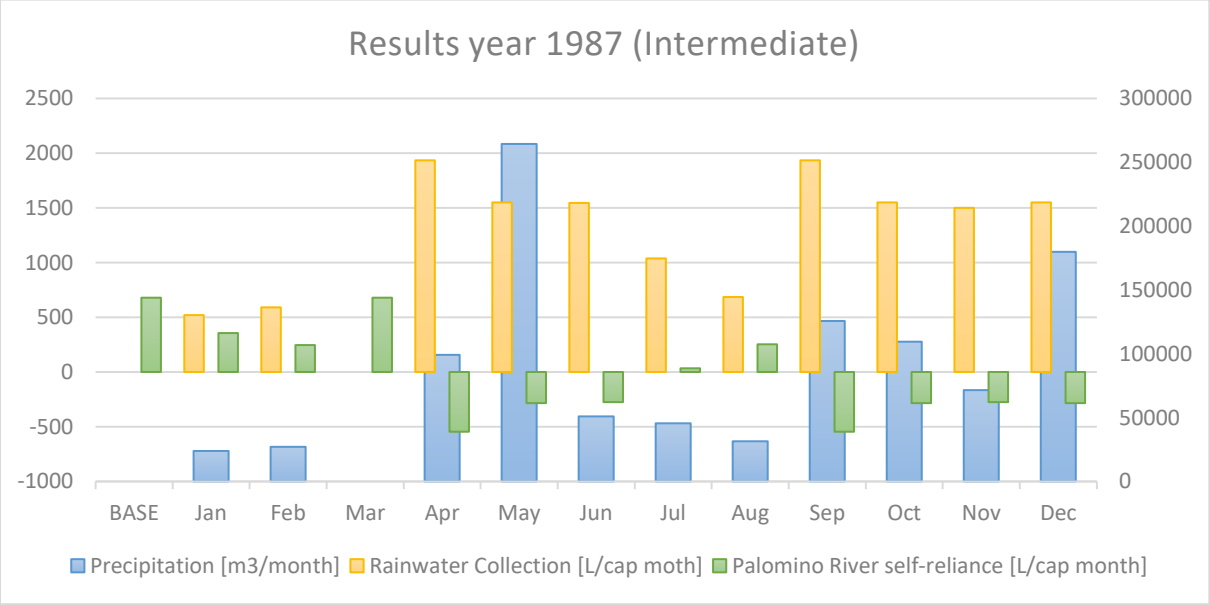


Figure 86: Results 1987 Precipitation (I_6), Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

As can be seen in the above graphs, 1969 does not present a strong variation between the different months, as is the case for 1997 and 1987. In 1969, January has an increased capacity of rainwater collection due to the 2,000L per household capacity of water storage tanks (as previously mentioned, it is assumed that each year starts with an empty water storage tank). Then, in February, as the precipitation inflow surpasses the capacity of the water tanks to store water, they maintain constantly full throughout the year. Perhaps the most important aspect to highlight for the year of 1969 is that the high levels of rainwater harvesting result in a water system that has a surplus of water; this is noticeable in the negative value on the inflow I_3.

For 1997, the system presents a surplus of water for only 2 months; for 1987, these episodes were present in 7 months. For both years, it is interesting to notice how the water harvesting functioned as a buffer for the system: the water demand for the domestic sector is partially drawn from this water source, therefore, the 2,000L water buffer decreases (is consumed) until the next precipitation event, when it can be refilled. This is strikingly evident in 1997, when, in the month of June, heavy precipitation fills the water tanks to its maximum capacity; the household water supply is then steadily consumed, and in the month of November, it is again refilled to its maximum buffer capacity.

The upcoming Figure 87, Figure 88 and Figure 89 display, in a higher level of detail, the relation between rainwater harvesting and the capacity of the system to be self-sufficient (judged by the need to import water from the Palomino River *I_3 inflow*).

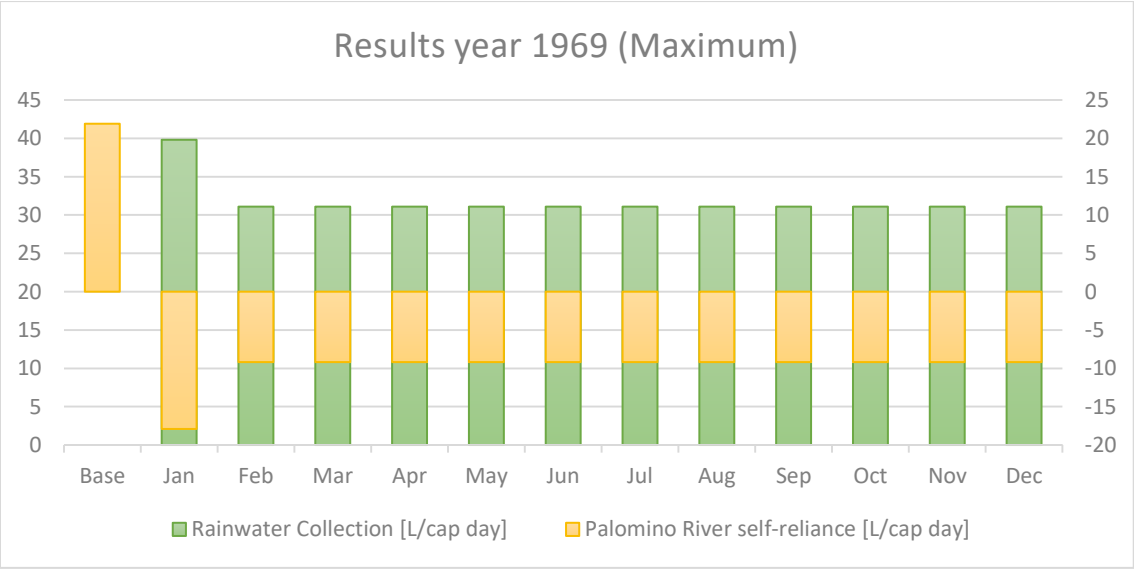


Figure 87: Results 1969. Comparison of Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

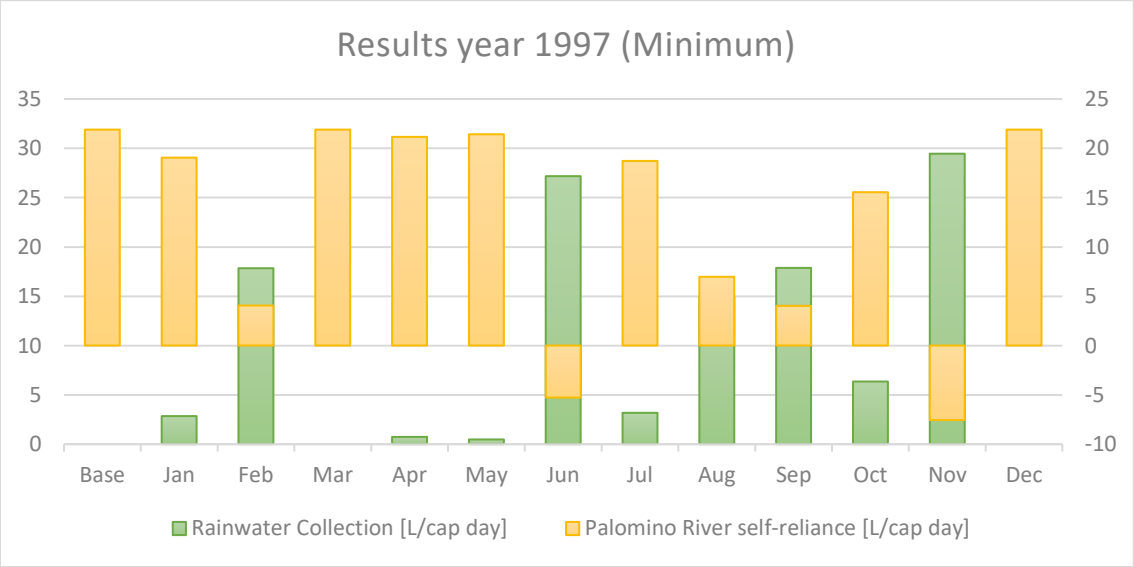


Figure 88: Results 1997. Comparison of Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

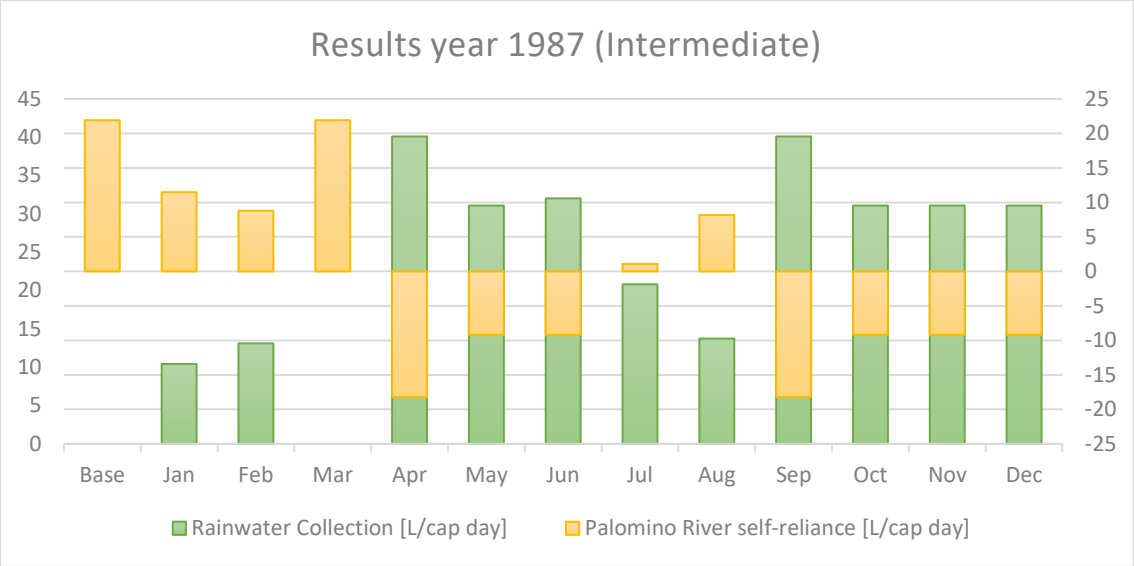


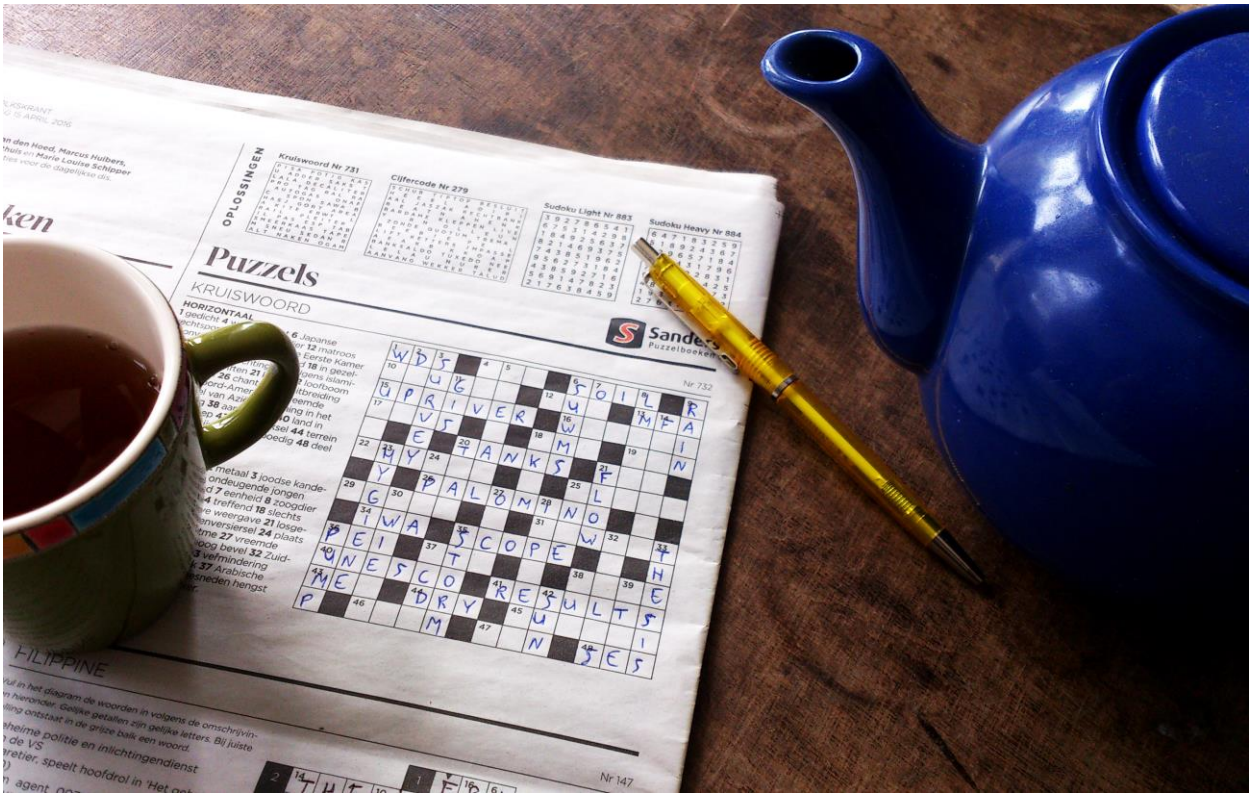
Figure 89: Results 1987. Comparison of Rainwater collection ($F_{6,3}$) and Palomino River self-reliance (I_3).

The relationship is straightforward: the more water is collected, the less water must be imported to the system. Basically, as indicated by the base scenario, a total of 22L/cap day is required to be imported to the system in the most critical conditions; for the system to be self-sufficient under these critical circumstances, the same volume, as a minimum, must be collected from rainwater.

At this point, it can be concluded that rainwater harvesting does have a meaningful affect on the UWM of the current water system in Palomino, offering great potential to be an alternative source of water supply to the system. The fact that it is decoupled from the two main critical flows of the system is a clear advantage in terms of the volume that can be captured, stored and used in the system. Finally, it is worth mentioning that even though this technology shows clear advantages, it also it is not a perfectly reliable water source. The case of 1997 (a year in which the rainwater collection only allowed the system to become self-sufficient on two occasions) showed that this decentralized water technology should be applied as a complementary water source--that is, one that enables to system to be more resilient--rather than the primary water source for the system.

4.4 Part IV Discussion

This section provided valuable information to enable a possible transition from the current water management system in Palomino towards a future SUWMS. Here some water technology and solutions were developed using a system thinking approach that would allow urban synergies between different urban clusters like water, energy and agriculture. For the potential technologies presented, the potential of rainwater harvesting as an alternative water source was assessed. For the influence of rainwater harvesting on the current UWM an order of magnitude of the rainwater potential was determined, here it is important to highlight that no distinction was made for the use of the rainwater collected in the system. This implies that this water could also be use as drinking water, which is no possible without a previous treatment.



Part V: Discussion, conclusions, recommendations and future work

5.1 Discussion

RQ1: What are the main qualitative and quantitative characteristics of the current urban water management system?
RQ2: How can the current urban water metabolism best be represented with a conceptual model?
RQ3: Which are the critical water flows of the current urban water metabolism in Palomino?
RQ4: How could sustainable urban water management system (SUWMS) be defined?
RQ5: Which technologies and initiatives are applicable in this local context for a sustainable urban water management system?
RQ6: Which technology could potentially address the critical water flows of the current UWM?
RQ7: How would this technology affect the UWM of the current system for a critical scenario?
What are the main barriers and opportunities for the implementation of a sustainable urban water management system in Palomino?

5.2 Conclusions

5.3 Recommendations and future work

"Experience is one thing you can't get for nothing"
Oscar Wilde

Part V is the last chapter of this masters thesis, wherein the research questions are answered. This chapter presents a discussion about each research question, focusing on the method used and the application to the specific case of study in Palomino. Following the discussion, the chapter continues with the key conclusions that have arisen from this research project. Additionally, this chapter contains recommendations for future work that might build on the inquiries and knowledge developed in this research.

5.1 Discussion

The research was guided by a total of seven research sub-questions, each one enabling the next to be answered. The answers to each research question were developed in the corresponding chapter (i.e., PART II, PART III, and PART IV), along with a brief discussion at the end of each chapter.

In PART II – Palomino a town rich in water resources, yet poor in water availability, the following research question was developed:

RQ1: What are the main qualitative and quantitative characteristics of the current urban water management system?

This chapter's method was based mainly on different tools to collect primary data in order to obtain enough information to develop and answer the research question. For data gathering during the field research, three tools were used: semi-structured interviews, survey processes, and mapping, using GIS tools and field observations. These tools have some limitation in terms of precision, time and subsequent data analysis, yet they proved to be useful in collecting relevant primary data to outline the study area and understand the water system in a very short period of time.

It was found that Palomino's water supply operates on both centralized and decentralized systems. The centralized water system is the primary water source for the population within the urban perimeter. Its coverage varies greatly according to the spatial distribution of the households within the urban area. None of the households receive an entirely steady service— at maximum, the water is supplied for one or two days a week, and only for a few hours per day. A large majority (79%) of interviewees claimed not to receive the water service on a weekly basis. The water distribution system (WDS) infrastructure is old and without water treatment, so the water it supplies is not potable. The system lacks resilience and flexibility since its operation relies on a single electric water pump. The electricity provided is mostly intermittent, and fluctuations in service are extremely common, generating variabilities in the volume of groundwater extracted to feed the centralized water supply.

The deficiencies in the centralized water supply have forced the community to rely on alternative water sources, i.e., the decentralized water systems: water collection directly from the Palomino River, water purchasing from informal sellers, rainwater collection, and wells for groundwater extraction. Groundwater extraction is the main water source for the hotels in Palomino; only a few wells are found for household use. The groundwater table is high, due to the porous condition of Palomino's soil, its proximity to river, and abundant rainwater in rainy seasons; no water well surpasses the eight meters

depth. Rainwater collection is a common practice among the community, although none of the households have the necessary technical infrastructure to maximize the water they harvest.

The amount of water collected directly from the Palomino River varies greatly for each household, according to: the water supplied by the centralized system, the transportation means and carrying capacity, and the location of the household in the urban area. The volumes of water collected range from 1 liter per day per household to 67 liters per day per household. Transporting water on foot, a household can collect up to 40 liters per day. Furthermore, the community spends a substantial amount of their time collecting water from the river, ranging from thirty minutes to two hours per trip. This condition affects women the most, whose main duty as homemakers is to wash clothing in the river and collect the water from the river on an almost daily basis.

Within the community, the water demand per household variates greatly. Generally, there is an observed correlation between the volume of water available to a household and the water consumption of the household. The survey results showed water demands ranging from 33 L/day cap to 90 L/day cap; the highest value is almost three times the lowest water demand. Most of the households with the highest water demand were also supplied by wells. As a general remark, it can be noted that the water demand per household can be considered somehow low. One explanation for this – besides the low volume of supplied water – is the habits of water use relating to households activities. 92% of households in Palomino do not own a washing machine, and 96% of households do not have a shower directly connected to the central pluming of the house. It is common for inhabitants to bathe in the Palomino River and to wash clothing directly in the river, thus reducing the demand for extracted water.

A major part of the adversity faced by the inhabitants of Palomino with relation to water is the price of water. Each household invests a considerable amount of its income in purchasing water from informal water sellers, paying for the centralized water supply (central administration), and purchasing of bottled water for consumption in stores and commerce centers. In an apparently contradictory manner, it was observed that many water users, including students in education centers, lack water sensibility and awareness in regard to preserving the water resources; water spills from water storage tanks and bathroom sinks are common. Simply put, user behavior increases the water losses in the current water system.

In terms of sanitation, the most common practice for blackwater disposal is leach pits, which contribute greatly to the good hygienic conditions in the town. However, the leach pits present a risk of groundwater contamination and unbalanced loads of nutrients in the soil of the urban settlement. Heavy flooding during the rainy seasons (which can reach up to fifteen centimeters) creates a high risk for human health, since the flood water probably contains fecal matter from overflowing leach pits. Furthermore, stagnant water in a tropical climate generates ideal conditions for the spread of vector-borne diseases (e.g. Chikungunya, Dengue fever, Yellow fever, and Zika). The education centers present a deficiency in WASH (Water, Sanitation and Hygiene)-related services, poor hygienic conditions in their bathrooms, and an utter lack of cost-free potable water available to students.

The results herein show a great deal of volatility (specifically, with regard to the supply and demand of water) in the current water system of Palomino. The volume of supplied water varies considerably due to a host of factors that include the socio-economic conditions of a given household, the location of each household inside the urban perimeter, the coverage of the water supply in the urban area, and the fluctuation of electricity that feeds the centralized system. The differences between households are large,

indicating a high level of system dynamics, interactions and dependencies within the urban water system; this leads to the question of whether working with averages of water demands and supply is an accurate way to handle research and models for this type of system.

In PART III – Urban water metabolism, the subsequent research questions were developed:

RQ2: How can the current urban water metabolism best be represented with a conceptual model?
RQ3: Which are the critical water flows of the current urban water metabolism in Palomino?

The methodology for this chapter was based on the implementation of steady-state models for material flow analysis (MFA) under the urban metabolism (UW) framework. The methodology was selected to analyze the current water system in Palomino in a quantitative manner, and to determine the critical water flows (i.e., identify the water flows that significantly affect the metabolic functions of the urban water metabolism (UWM)). The method uses variations of four key variables identified in Palomino's water system: 1. Touristic season (variation in high and low touristic season), 2. Hours without electric energy per month (variation between 70 hours/month and 35 hours/month), 3. Percentage of water losses due to pipelines leaks (variation between 50 and 70 percent), and 4. Percentage of losses due to user behavior (variation between 15 and 25 percent of the water supplied). Through the variations of these variables a set of fourteen scenarios was developed. The use of scenarios allowed a systematic modification each of the four variables to analyze the influence of these variations on the behavior of the UWM system.

The chosen methodology contains six steps: definition of the system boundary (to delineate the space and timeframe for the analysis of the UWM model), development of the conceptual model and the main mass balance equation, scenarios development, data acquisition and estimation, model simulations and results, and outcome analysis. The results of the scenarios are analyzed in terms of signals in the UWM system and in terms of order of magnitudes that make physical sense. All variables (except variable 1, which is linked to the water demand) represent water losses in the system, and their variations characterize the changes between each scenario. This method provides the possibility of using steady-state models in order to obtain, to some extent, a dynamic analysis of the system.

The baseline study for Palomino, developed in Part II, outlined the urban water system and study area, which in turn, allowed for the development of the conceptual model representation of the UWM. The conceptual model is based on economic flows linked to anthropogenic processes, therefore, no environmental flows related to urban hydrological process were included. The model is built of five processes, two inflows, and thirteen internal flows; it is visualized in Figure 50 (PART III, page 51). The general mass balance system equation is determinate by the equation: $\Delta S = I_1 + I_3$. Here, ΔS is the change on the stock of the system (input of water to the system), I_1 is the imported bottled water, and I_3 represents the net extraction of water collected by the community directly from the Palomino River.

The model makes use of certain assumptions that allowed a specific model simplification:

- Water demand is proportional to water availability: the more water is available, the more will be expended; therefore, water demand for the domestic and commercial sectors is based on the results of the surveys from the field research.
- A standardized water demand was used: 50L per capita per day for a total of 2286 inhabitants, and 160 L per tourist per day for the commercial sector (tourism), ranging between 600 and 1000 tourists per low and high season, respectively.
- Domestic demand does not vary during the month of the analysis. This is true when calculating the standard demand on the basis of population, which can be considered constant during the timeframe of each scenario.
- Commercial demand differs only between high and low touristic seasons, but it is constant for the duration of each season.
- The Palomino River is assumed to be an endless water resource.
- Imported water bottled can be introduced to the system on an unlimited scale.
- The groundwater available in the system is modeled as a stock, without the external influences of recharge by percolation and discharge by drainage.

According to the previous system equation, the model yields two main results parameters: the water imported to the UWM urban system in order to satisfy the water demand of the current water system (ΔS) and the net extraction of water from the Palomino River by the process of the community collecting water directly from this source (I_3).

The model simulations resulted mainly in a need to import water to the UWM system. A total of nine scenarios yield that result. Scenario 2, catalogued as the critical scenario because of the fact that it represents the highest water losses and highest water demand, resulted in a net extraction of the Palomino River of 22L/cap day. This result, although high, makes physical sense in terms of it being an amount of water that would be possible for one person to carry in one day. In fact, when comparing this result with the field observations and the results presented in PART II, Section 2.4 - Water management households, the model simulation results are lower than the volume estimated by the community, though within the same order of magnitude. Inhabitants claimed to collect up to 40 L/cap day on foot and almost 70 L/cap day with a transportation option (vehicle). This would suggest that the results of the simulations give a lower value when compared to the survey results; since the data obtained is very rough, it is not possible to determine if some flows in the model are underestimated, or if the primary data obtained is overestimated. Then again, it is important to highlight the fact that these values were proven during the field research to be, by some means, aligned with reality.

An encouraging result is that the water scarcity is not directly related to the tourism and hotels water demand. This is meanly due to the fact that most hotels extract groundwater as their main water supply and that not many hotels are present in the urban perimeter to 'compete' for the water supplied by the centralized system. Another encouraging simulation result was that some of the scenario simulations (scenario 6, 12, 13 and 14) yield a negative stock value (ΔS), meaning that the UWM system has a surplus of water. This implies that the system is importing or producing (within its system boundary) more water supply than it theoretically needs to satisfy its water demands. This denotes that the UWM system could

satisfy its metabolic needs with the two available water supply sources: groundwater extraction and water supplied by the aqueduct service—even with a water system that presents high water losses (50% losses in the WDS, 15% losses due to user behavior, and approximately 5% of losses due to lack of operation of the water pump). It is important to mention that the metabolic needs of the current UWM are bound to the water demand of the commercial and domestic sectors; therefore, if the demand were to increase, the current UWM supply might no longer meet the demand.

The final result of this section was the identification of the most critical flows of the UWM system. Here, it was found that the flow *F2,5 – Pipelines leaks* (associated with the water losses throughout the water distribution system (WDS)) and the flow *F5,2 - Water pumped* (associated with the volume of groundwater extracted by the electric water pump to supply the centralized system) affected the UWM drastically, these flows can altered the UWM easily if variated. Both of these flows are linked to the centralized water supply.

Finally, it is worth discussing some of the methodological implications of the UWM model. The UWM is the basis for the quantitative analysis of the local urban water system, and its conceptual model is based on processes and flows that are directly associated with the influence of socio-economic relations between the built environment and the water transformations in the urban water metabolism. This approach is interesting in terms of understanding the urban metabolism within the socio-economical system; nonetheless, it assumes water resources to be infinite sources, which oversimplifies depletion of water resources and variations in the groundwater table that might make it impossible to extract water in certain periods of time. To explain this behavior and associated interactions between economic and environmental flows, one might employ simulations based on a system dynamics approach, rather than the steady-state approach presented in the present research. Regardless of this limitation, for the purpose of understanding water systems under the UM framework, and for identifying the critical flows and technical problems of a water system given a data poor location, the use of an UWM conceptual model and a scenario simulations approach did represent an effective, informative, and insightful method.

In PART IV – Sustainable urban water management system (SUWMS) - the next research questions were developed:

RQ4: How could sustainable urban water management system (SUWMS) be defined?

RQ5: Which technologies and initiatives are applicable in this local context for a sustainable urban water management system?

The definition of sustainable urban water management system (SUWMS) is based on a literature study. From this literature study, five definitions regarding water systems and sustainability were selected to develop the definition of SUWMS for this research:

> *A sustainable urban water management system is a system that includes the technical processes of collection, treatment and distribution of water, wastewater and stormwater, as well as the social engagement, environmental awareness and education of the community to guarantee the right of*

present and future generations to safe and clean water; while striving towards the conservation of ecosystem services, human well-being and minimization of the use of natural and economic resources.

This definition embraces a holistic perspective that embodies basic sustainability concepts: satisfy present needs, while guarantying that future needs can be met; guarantee the protection of the environment, human health, and well-being; and strive for the conservation of resources.

Guided by this definition, an overview on potential water technologies and initiatives is provided with the goal of envisioning the possibilities for a transition from the current water system to a SUWMS. These potential solutions are based on the problems identified for the water system and the local conditions of Palomino. They cover the following water services specified in the definition: water supply, wastewater treatment and stormwater management.

For the centralized water supply, the poor operation of the electric water pump could be solved by installing of solar panels that, as an addition to the electricity supplied by the main grid, would provide reliable and constant energy to the water pump station. Since Palomino has a substantial number of hours of sunshine per day (between 6 and 7 hours) making use of this renewable energy source is a promising sustainable solution. The present research has exposed the problem of the pipelines leaks from the current water distribution system as a critical water loss in the UWM of Palomino. However, this problem requires a more rigorous solution—since the existing network is in need of serious attention with regard to maintenance and upgrading of components, any proper fix for this issue would involve major material and economic investments.

As Palomino does not have an organized urban development plan established by local authorities, it is very difficult to provide a future vision for the development of centralized water supply. Despite this, on this research a spatial analysis has been conducted comparing the cartography from two years—2002 and 2013—in order to visualize the tendencies of urban growth in Palomino. From this spatial analysis, it is possible to draw ideas for alternative solutions, such as a parallel water supply system that makes use of the existing infrastructure (i.e. water well and pumping station from the centralized system) in order to supply to the neighborhoods that currently do not have water services (like 'El Centro' neighborhood) (Refer to Figure 64, page 89; Figure 65and Figure 66, page 90).

Decentralized solutions for water supply are of special interest to Palomino, since they are often associated with low-cost water technologies with the potential for having a high impact on the current water system. For Palomino, two such solutions were identified: rainwater harvesting at a household level, and manual pumping wells, either for private or for collective use. Rainwater harvesting stands to have a large impact, since the community already performs rainwater collection to some extent and already has a degree of familiarity with this practice. For the manual pumping water wells, it is crucial to select effective locations based on the local topography. A high groundwater table is necessary for the wells be able to extract the groundwater; for this reason, the location for the construction should not simply be based on the water needs of the certain areas of the community. If properly implemented, these technologies could help to diminish the water scarcity in the town.

The sanitation and treatment of waste could be improved through the implementation of ecological sanitation for nutrients or energy recovery. One very promising option is compost toilets. This technology has been implemented for different private households in the past, and has yielded successful results; the compost toilets are still in use after three to four years of construction. Furthermore, the use of compost

toilets is a reinforcement of agriculture projects that could be supported on the government program, RESA, which advocates for urban agricultural practices. The link between nutrients recovery from wastewater and urban agriculture practices at a household level, would not only reduce the risk of groundwater contamination by avoiding the use of leach pits, but would also increase the yield of crops for household consumption.

For the education centers, which have much larger discharge of wastewater per day, an anaerobic digestion for biogas production is a valid option for wastewater treatment. The biogas produced could be use in the schools' kitchens. For greywater treatment on a household level, implementation would be difficult. Since it is common to bathe on the back garden of the households and have separate leach pits for the kitchen discharge, the construction of pipelines and discharge structures in constructed wetlands might be expensive and challenging. Perhaps a more effective solution for the community would be the construction of shared laundry rooms, which could be connected to rainwater harvesting for water supply and could lead to constructed wetlands for greywater treatment. This option would reduce the direct discharge of soap and different cleaning products into the Palomino River by reducing the practice of washing clothes directly in the river. It would also reduce the time and effort that homemakers invest in these households obligations.

For stormwater management—currently an important issue in Palomino due to the extreme flooding in the rainy seasons—there are several viable solutions, including rainwater harvesting, and constructed wetlands, roads that use pervious pavements, and a drainage design based on infiltration trenches. These options reduce the water runoff in rain events and allow the water to infiltrate the ground and recharge the groundwater table. Such a drainage system would be designed to not allow water to stagnate, thus avoiding the risk of spreading tropical diseases.

For management initiatives, it is necessary to improve the WASH sector in schools through effective programs on hand-washing, safe sanitation and consumption of potable water, in addition to hygiene education and de-worming programs. It would also be important to establish a water board, comprising of members for a community-based management, which would facilitate resolving water conflicts and managing the centralized water system.

These solutions also strive to achieve certain goals aligned with the definition of SUWMS: avoid pollution of natural ecosystems; conserve natural resources and ecosystem services; strive towards circularity of water flows and nutrients; improve human health, hygiene and well-being; be adaptive for the local conditions, needs and requirements of complex social—ecological systems; have a high degree of functional robustness and flexibility to deal with changes and uncertainties; be easy to understand thus, encouraging responsible behavior by users; and minimize the use of natural and economic resources.

These options should only be taken as a starting point for subsequent analysis and design. None of these potential solutions are based on future scenarios on water demand, population growth and urban development; rather, they are suggestions of potential practices and technologies that could contribute to a future SUWMS for Palomino. Hence, a more detailed analysis, in terms of design and feasibility of implementation, is needed if any technologies are to be implemented in the town. Though they are thought of as part of the integrated water system, these technologies—if implemented in a simultaneous manner—hold the possibility of amplifying urban synergies between the urban water system, and the agriculture, energy and tourisms development clusters.

As a final remark, the definition of SUWMS does compromise key aspects for urban water development and sustainable development in a general manner; therefore, this definition is applicable to any urban water system in any settlement that strives for sustainability.

RQ6: Which technology could potentially address the critical water flows of the current UWM?
RQ7: How would this technology affect the UWM of the current system for a critical scenario?

In PART III – RQ3, it was identified that two flows are critical for the UWM of the current water system in Palomino: first, the water losses due to leaks in the pipelines networks of WDS and second, the water pumped to supply the centralized system, linked to significant losses in the water supplied due to the lack of electricity for the operation of the electrical water pump. Based on these two water flows and the set of potential solutions found under the research question 5 (RQ5), a promising technology to improve the UWM of the current system is rainwater harvesting. The main advantage of this water technology is that it is decoupled from the two critical flows: the capture and storage of rainwater does not require no electricity, nor does it require the use of the WDS from the centralized supply.

On the other hand, rainwater collection is already a commonly-used practice in the community—57% of interviewees claim to practice rainwater harvesting in some capacity. The recognition of the importance of rainwater is apparent, though few households have the technological solutions needed for an integrated rainwater harvesting system that makes use of the roof surface as the catchment area and a direct conduction of rainwater into water storage tanks. Rather, the most common rainwater collection practice among the community is to place a collection tank outdoors while it is raining. The awareness of the community towards rainwater collection is encouraging; the fact that they are familiar with the concept and the importance of rainwater collection as a valuable water source would facilitate the implementation of this technology at a household level.

The influence of rainwater harvesting practices on the UWM of the current water system is assessed by adding the additional process of rainwater harvesting to the conceptual UWM model. This process is linked to three additional flows: an input flow for precipitation, an output flow for stormwater (runoff), and an inner flow for the rainwater collected by the domestic sector. Now, the conceptual model is constituted by six processes, three inflows, one outflow, and fourteen internal flows, as visualized in Figure 76 (PART IV, page 101). The general mass balance for the system is: $\Delta S = I_1 + I_3 + I_6 - E_6$ where, ΔS is the change on the stock of the system (input of water to the system), I_1 is the imported bottled water, I_3 represents the net extraction of water collected by the community directly from the Palomino River, I_6 is the precipitation, and E_6 is the volume of rainwater that has not been collected and leave the system as stormwater (runoff).

This UWM model for the assessment of the influence of rainwater harvesting in the UWM of Palomino makes use of the same model assumptions from the previous UWM scenarios based analysis, in addition to the following specific model simplification:

- Rainwater collection will be considered at the rate found from the survey's results on the household level, which corresponds to 57%. In other words, 57% of the households in the urban perimeter perform rainwater harvesting.

- Rainwater harvesting will not be included for the commercial sector. In the survey process, none of the hotels performed rainwater harvesting, from which it is possible to infer that this practice is not common for the commercial sector.
- The precipitation that enters the system boundary and it is not collected in the rainwater harvesting process leaves the system in form of stormwater. In a physical sense, this is not accurate, since the precipitation should infiltrate the soil, feeding the groundwater levels as well as experiencing evapotranspiration. These phenomena of urban hydrology will not be considered, since the UWM model only contemplates the economic flows of the water system.
- The rainfall is considered homogenous in the urban area of 0.54 km^2.
- The monthly precipitation is equally distributed, according to the number of days with rain per month.
- The rainwater collected per rain event at a household level cannot surpass the storage capacity established at 2,000L per household.
- At the beginning of each year, it is assumed that the water storage tank is empty.

The analysis was performed for three years: 1969, a year previous to La Niña phenomenon and characterized for extreme rainfall; 1997, a year characterized by extreme drought due to El Niño phenomenon; and 1987, a year of 'normality', chosen by the median value of precipitation between the annual values of 1969 and 1997. The analysis of the rainwater harvesting potential was based on the critical scenario (scenario 2)—the scenario with the highest water losses and highest water demand.

The region of Palomino presents large differences in annual rainfall; extreme conditions, like the ones assessed in this analysis, are not uncommon. The difference in the annual rainfall between the year 1969 (3308.7mm) and 1997 (492.5mm) is 2.8 meters. The total (annual) rainfall in 1987 was 1,899.03mm. For each of the three years, a monthly analysis was performed, resulting in total thirty-six models simulations.

An interesting feature of this analysis is the inclusion of conditions based on the storage capacity for rainwater collection at a household level and based on the water demand. The first conditional is established by the storage capacity per household set at 2,000L, which indicates that for each rain event the water collected cannot surpass this volume. The second consideration is that between rain events, the collected water will be consumed at a rate of 50L/day per person. If, between rain events, the volume of water stored is greater than the volume of water consumed per household, then a surplus of water will be kept in store for the next rain event. Then, on a monthly basis, the volume of the surplus cannot exceed the 2,000L storage capacity. This condition implies that, even though the analysis was based on steady-state modeling, a semi-dynamic analysis was performed based on the variations of the stored rainwater volume (ΔV) during the time intervals (Δt) determined by the rain events per month.

The results are analyzed on the basis of one key parameter of the UWM model: the net extraction of water collected form the Palomino River (I_3). For the critical scenario (as found on under RQ3) without rainwater collection, a total of 22L/cap day needs to be imported to the system. So, for the system to be self-sufficient under these critical circumstances, the same volume, at a minimum, should be collected from rainwater. Even though the relationship is straightforward—the more water that is collected, the less

water that will need to be imported to the urban water system—the collection of this rainwater is not so simple.

For the year 1969, the volume of collected rainwater reached maximum capacity, with a volume of 40 L/cap day for the first month, and 31 L/cap day for the remaining months. The surplus of water—believed to be an input of water collected from the Palomino River—ranges from -18 L/cap day for the first month to -9 L/ cap day in all subsequent months. The fact that the net extraction of the Palomino River is negative indicates the surplus of water in the system, which can be interpreted as a buffer for households. The water storage was at its maximum capacity for all months in 1969, which would suggest that rainwater harvesting is a reliable water source for the system in these conditions.

On the contrary, for the year 1997, the extreme drought limited the volume of water that could be stored per month. Here, in only two months (June and November) is the collected rainwater sufficient to obtain a surplus of -5 L/cap day and -7 L/cap day, respectively. For this year, the monthly rainwater collected is very limited, and so, rainwater harvesting does not affect the UWM as drastically as it did for the year of 1969. For this year, rainwater does not provide a reliable source of water; only a few times during the year does the UWM have a sufficient influence so that the community does not have to collect water directly from the river.

Lastly, in 1987—a year that represents a 'standard' rainfall—a surplus of water was obtained for a total of seven months, with a maximum value of -18 L/cap day. For this year, it is interesting to notice that the volume of collected rainwater can present strong variations from one month to the next, jumping from zero to 40 L/cap day from March to April, for example. It is encouraging that despite the strong variations, the system is able to satisfy its metabolic needs almost every month of the year.

It is not surprising to find that rainwater harvesting is not a reliable and sufficient water source to satisfy the metabolic needs of the current water system, since rain events tend to have a high degree of variability. Nonetheless, it is worth mentioning that rainwater harvesting does affect the UWM in a positive manner and would, theoretically, reduce the burden for homemakers in Palomino to collect and carry water from the river. In fact, as shown in the results, rainwater harvesting would even generate a buffer of water (although small) for household use.

It should also be noted that the analysis per capita is based on the total population of Palomino, though rainwater harvesting has been considered already by only 309 households, or 62% of the population. Thus, a much greater volume of rainwater can be collected if rainwater harvesting practices are implemented in as many households as possible. This would reduce the water imports and increase the influence of rainwater harvesting on the UWM.

Another way to increase the influence of rainwater is to change the water storage tanks for ones with a larger volume. However, this is not considered to be feasible for many households because of the limited amount of space in the backyards of houses. Even disregarding these measurements, water scarcity in Palomino cannot be solved by rainwater collection alone, mainly due to the strong variations in precipitation, both on monthly and annual bases. Furthermore, the location of Palomino makes it vulnerable to strong climate variations like the Niño and Niña phenomenon. In fact, from the time series analyzed of almost 50 years, six of these events were present. This implies strong variations on the precipitation, and the external threats like population growth and informal urban development also imply more water challenges to the region.

As final remark, no distinction was made for the use of the rainwater collected in the system, since the analysis is simply intended to predict the potential the influence of rainwater collection in the UWM system. This implies that this water could also be used as drinking water, which is not possible without water treatment methods.

Rainwater harvesting does affect the UWM of the current water system in Palomino and it offers significant promise as an alternative source of water supply to the current water system in Palomino, and has the potential to mitigate the water scarcity that currently exists in the urban water system. The fact that it is decoupled from the two main critical flows of the system is a clear advantage in terms of the volume that can be captured, stored and used in the system. Nevertheless, despite the advantages of this technology, rainwater collection has certain vulnerabilities as a reliable water source.

What are the main barriers and opportunities for the implementation of a sustainable urban water management system in Palomino?

The barriers identified in Palomino are a mix a variety of problems: social, technical, environmental and economic as can be expected for any complex problem setting. The problems stemming from poor administration have caused Palomino's community to suffer greatly with regards to its water supply. The lack of governance, building of new infrastructure, and maintenance of the central water infrastructure, in addition to unorganized urban growth are undoubtedly some of the main issues affecting the water supply in Palomino. The responsible institutions seem to be uncoordinated in terms of understanding the needs of the community and prioritizing their investments accordingly. The level of informality is a great barrier when it comes to regulate water uses and sanitation measurements. As research quantitative by the use of the UWM approach, the current metabolism is affected by the centralized water supply system the most and the central administration should concrete its efforts on improving the noticeable problems with the WDS.

The opportunities to implement a SUWMS in Palomino are noticeable from many perspectives. One perspective that is important to highlight is the common vision of the community and commercial sector on the importance of tourism for the economic development of the town. Due to the biological and cultural diversity of the region, Palomino is a destination known for 'natural-tourism', which has enable the community and hotels to aim for a common vision of eco-tourism. Though many efforts are yet to be made for this vision to come true, it is an opportunity for the community to develop a sustainable growth and economic development which would allow for the community's economic empowerment. The touristic sector cannot continue to increase without a proper infrastructure that allows a fair and just development with strong bonds between the community and the hotels sector, and obviously water availability is one of the first problem to tackle if the tourism sector is set to increase in the upcoming years.

Stronger bonds between the tourisms sector and the community would facilitate private investment and private funding to enable the implementation of sustainable water solutions. As shown during this research the community and the hotels are willing to invest in improving the water system in Palomino.

In terms of water resources Palomino is a location rich in water resources, which facilitates the implementation of different technologies to supply the water demand of the population.

5.2 Conclusions

When researching water systems, it is common to find analysis based on average approaches. Aiming to understand and describe the water systems based on average values could lead to biased conclusions, since the reality of water systems tends more towards complex systems with many dynamics and dependencies. Furthermore, it is difficult to understand the vulnerabilities of a water system under an average values approach; systems are likely not to fail under average conditions.

Since the beginning of this research, it was unequivocal that water systems should be understood under a system-thinking approach that shows the dynamics and interdependencies of water systems in a social-ecological system setting. Consequently, during this research, the current water system of Palomino was continuously researched with a lens that tried to uncover the dynamics underlying the apparently 'homogenous' and average system behavior of the water system and water users.

The results obtained during the field research relating to water demand and supply showed great variance among the households found within the urban perimeter of Palomino, where most of the population suffers from water scarcity. The lack of water supplied from the centralized system and alternative water sources, such as water wells, forces the community to collect water directly from the Palomino River. Moreover, it underscored the inability of the current urban water system to satisfy the population's water demand.

In order to understand the problems that burden the current urban water system of Palomino, a material flow analysis (MFA) under the urban metabolism (UM) framework was applied. The conceptual urban water metabolism (UWM) model of the current system was analyzed by stepping out of the averages and using a scenarios based approach. The analysis was performed with a signal-based approach that allows, once more, to step out of the averages and research the system using model simulations. Despite the use of a steady-state model, the scenarios-based approach made it possible to check the vulnerabilities of the system with a semi-dynamic analysis.

The results of the simulations and analysis were promising. They showed that the current water system could—from a water supply perspective—theoretically, have the ability to be self-sufficient, even with the current mix of water supply technologies and a slight decline in water losses within the system. It also was found that the increasing tourism is not the root of the of the water scarcity issues in Palomino, since most of the hotels are supplied by water wells. Finally the two critical water flows for the current UWM were identified: *F2,5 – Pipelines leaks,* associated with the water losses from the water distribution system (WDS),; and *F5,2 -Water pumped,* associated with the volume of groundwater extracted to supply the centralized system.

Rainwater harvesting was chosen from the set of potential sustainable solutions to be assessed as a potential technology to improve the current UWM of Palomino and aid on the transition from the current urban water system into a sustainable urban water management system (SUWMS). This technology was

selected for two main reasons: first, it is a technology that is decoupled from the critical flows of the current UWM system, and second, and it is already a common practice among the community.

The impact of rainwater harvesting on the UWM was analyzed with data from three non-consecutive years—one of extreme rain events, one of extreme drought, and one of 'normality' or standard annual precipitation. This analysis was crafted to include even more the dynamics of the system by establishing conditions on the volume of rainwater collected given by the storage capacity and rain events. The influence of rainwater was assessed in comparison with a critical scenario of the UWM corresponding to the highest water demand the highest water losses. It was concluded that the rainwater harvesting could, as a complementary water source, influence the UWM in a positive and substantial manner, so that the water system would then be capable of satisfying the urban water metabolic needs, while even providing a small water buffer for household consumption. It was also found, however not surprisingly, that the patterns of the precipitation in Palomino challenge the reliability of rainwater collection as a water source, even in years of 'normality' or standard precipitation. This means that the water supply issues in Palomino cannot be solved solely by the collection of rainwater, and that this technique should be used as a complementary water source in order to increase the resilience of the water system and mitigate the water scarcity the that community faces.

From the research—and especially from the way the MFA analysis was handled under the UWM framework some interesting methodological conclusions can be drawn. The applied methodology proved to be successful in terms of understanding water systems—not by the traditional approach of modeling based on average values, but rather by using scenarios that explain the variations and dynamics in the water systems. Understanding model simulations through a signal analysis approach allows the analysis to be less dependent on exact values, and rather, to focus on both orders of magnitude that make physical sense and on signals (positive and negative values), in order to determine whether or not the UWM system satisfies its metabolic needs.

In conclusion, this research presents how to address a material flow analysis (MFA) that goes beyond a material accounting method using the urban metabolism framework. The research shows how to understand changes in the urban water metabolism (UWM) through the use of signals that enables to determine the metabolic changes and water needs of urban water systems by means of a semi-dynamic analysis. This methodology could be applied in a larger context to other study cases; it is highly recommended for developing countries and local conditions where limited data—or resources for collecting relevant primary data—are available to undertake a statistical analysis.

5.3 Recommendations and future work

Throughout the model simulations it was found that the software STAN is quite useful in terms of providing an easy to use, easy to understand software, which has the necessary tools to perform a material flow analysis successfully. Nonetheless, it was also found that this software lacks the availably to include any type of dynamics in it. The impossibility of include any conditionals as part of the transfer coefficient calculations, limits its flexibility. The conditionals included on the simulations during this research had to be calculated separately and then introduced manually to the program. This resulted in a very time consuming process. It is important then to understand the limitations of this tools and perhaps considering using another software that deals better with system dynamics, such as MATLAB Simulink.

An important methodological implication of the model simulations is the development of models that only include economic flows. This showed to be extremely useful when understanding changes in the UWM by focusing only on anthropogenic related processes, however the environmental depletion of water resources is completely excluded. Assuming endless water resources is problematic when failing to predict the behavior of water resources and possible ecosystem unbalances that may threat urban water systems. For these proposes it would be recommended to expand the system boundary to identify and research the impacts of the urban water system outside the urban settlement.

Recommendations for future work are abundant in an emerging field as it industrial ecology and the urban metabolism framework. In this research, the first approach of an urban metabolism study in Palomino was performed, which could serve as a stepping stone to complement the water flow analysis with an energy, nutrients and material flow analysis that expands the understanding of the transformation of resources in this urban settlement. The use of model simulations and results obtain via MFA under the UM framework can be used to identify opportunities for urban policy makers where resources exploitation and UWM studies can be linked to enable sustainable urban designs.

The UWM study can be complemented by directing the scope towards the inclusion of different frameworks, such as the ecological networks analysis. This analysis could complement the understanding of urban water systems by research degrees of relationships and mutualism in network structures in water systems (Zhang, Yang, & Fath, 2012). In addition, the analysis on UWM can be expanded by including social behavior patterns where sustainable consumption and life styles could influence the UWM towards a less resource intensive urban water system.

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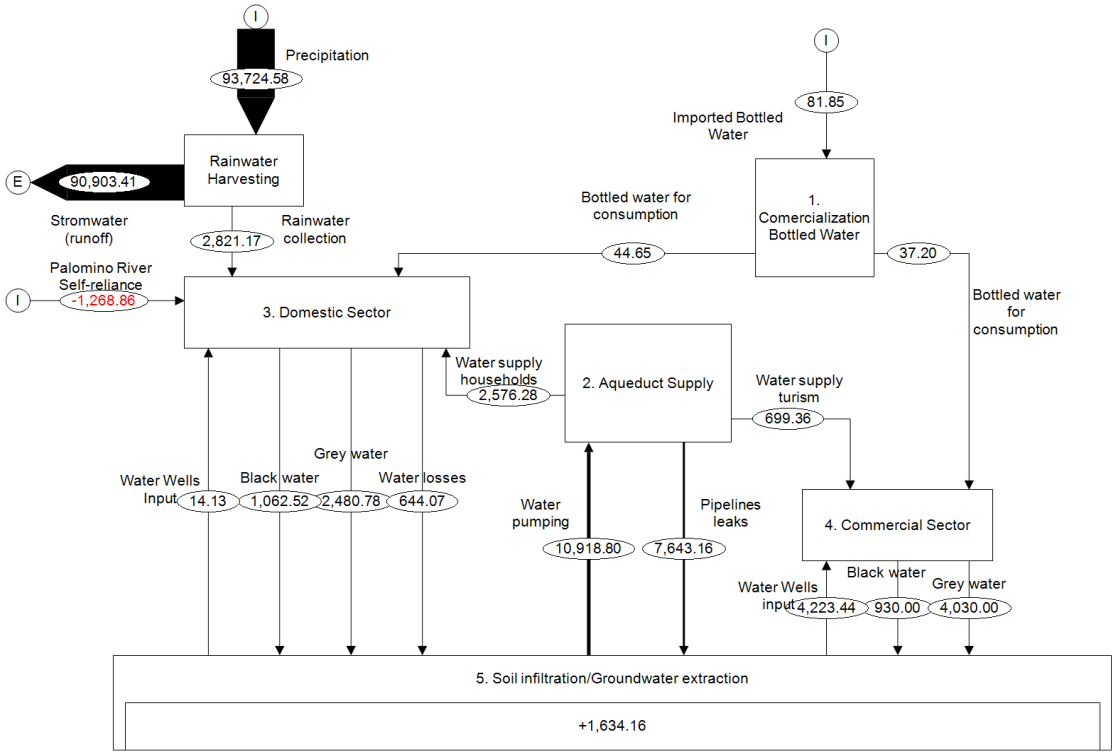
Appendices

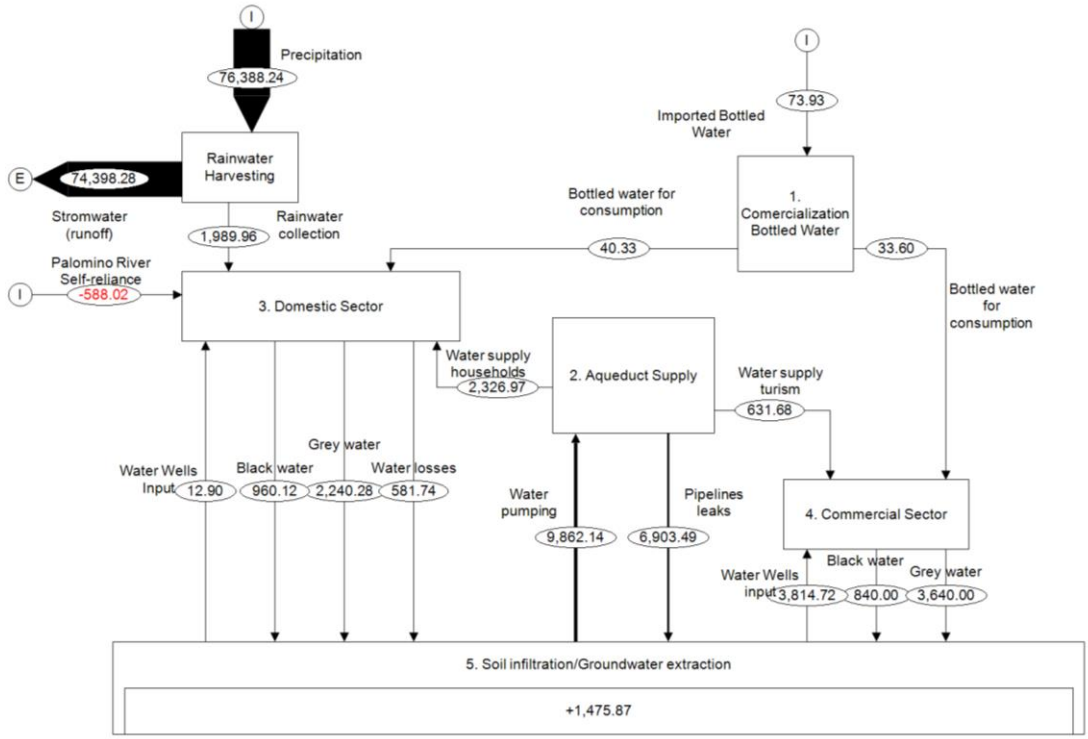
Appendix A: Simulation results UWM - Rainwater harvesting potential

Year 1969: Maximum rainfall

January



February



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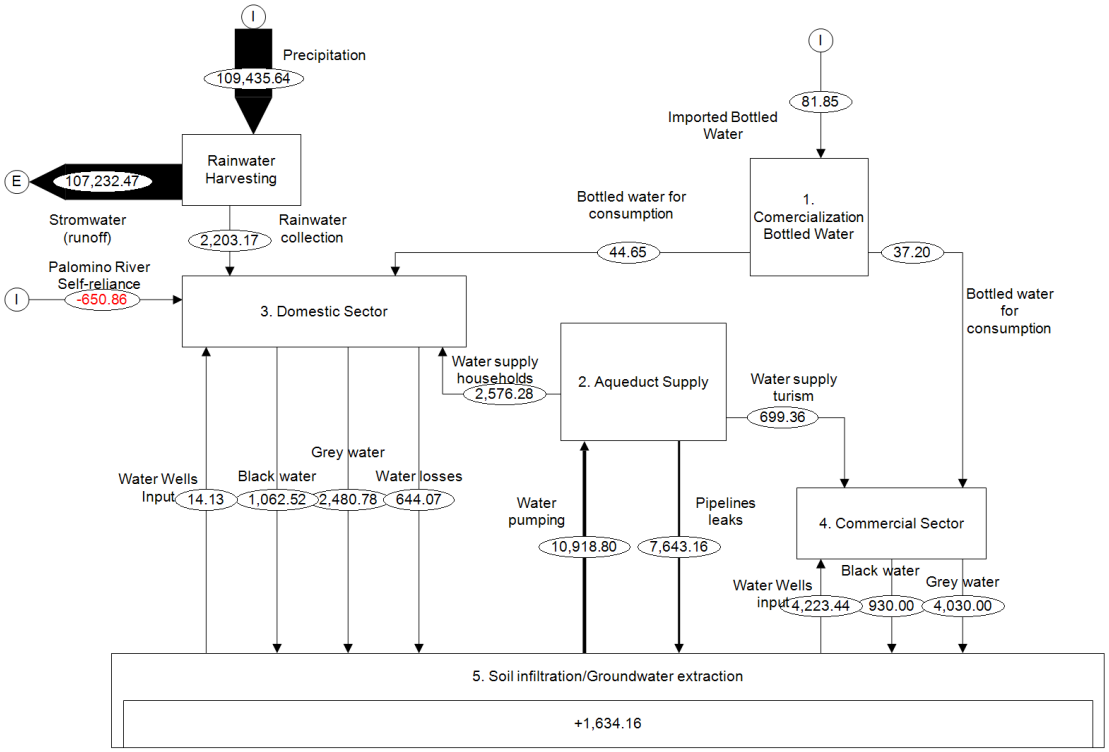
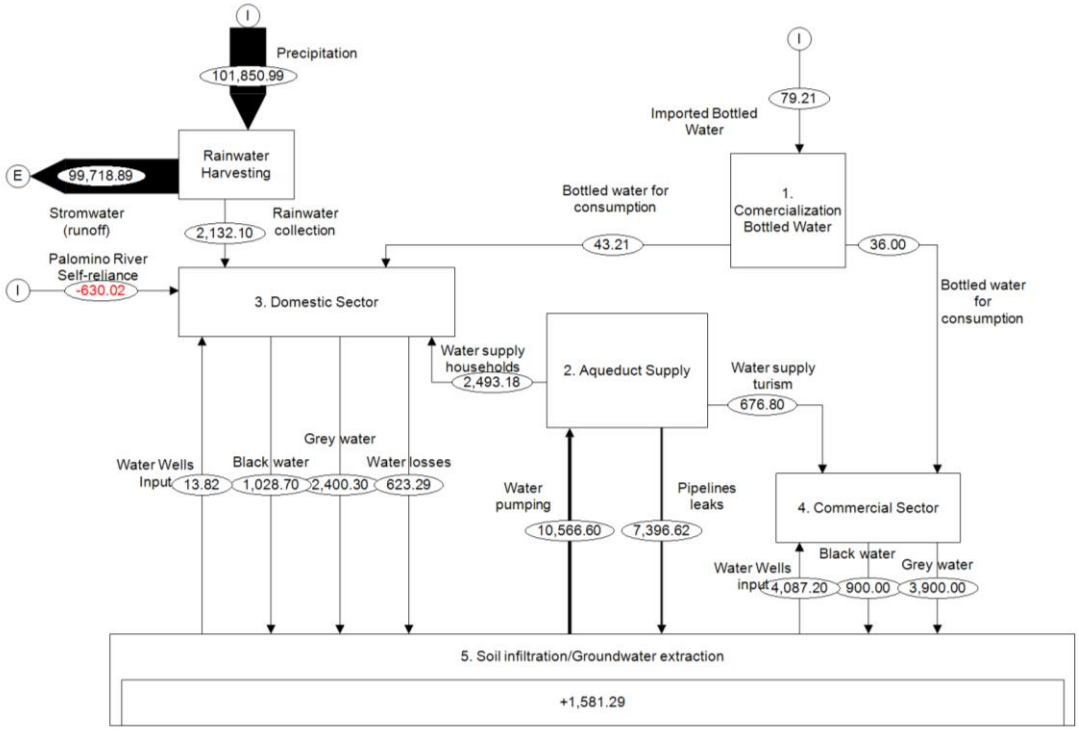

I
Precipitation
109,435.64
Rainwater Harvesting
E
107,232.47
Stromwater (runoff)
Rainwater collection
2,203.17
Palomino River Self-reliance
I
-650.86
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
Water losses
2,480.78
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

April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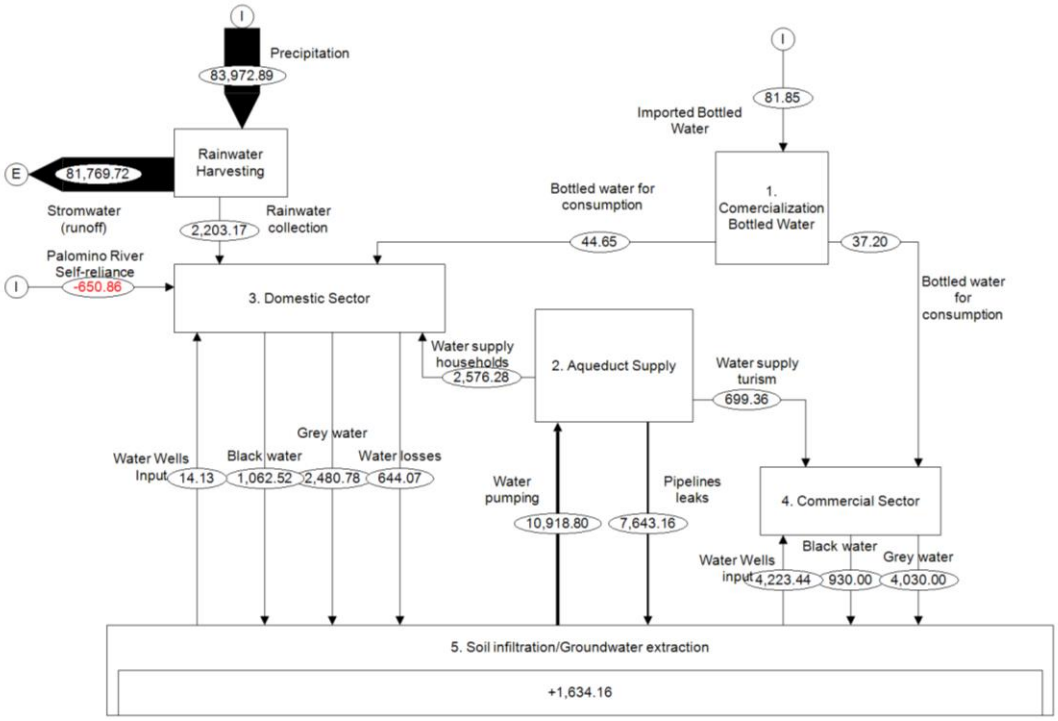
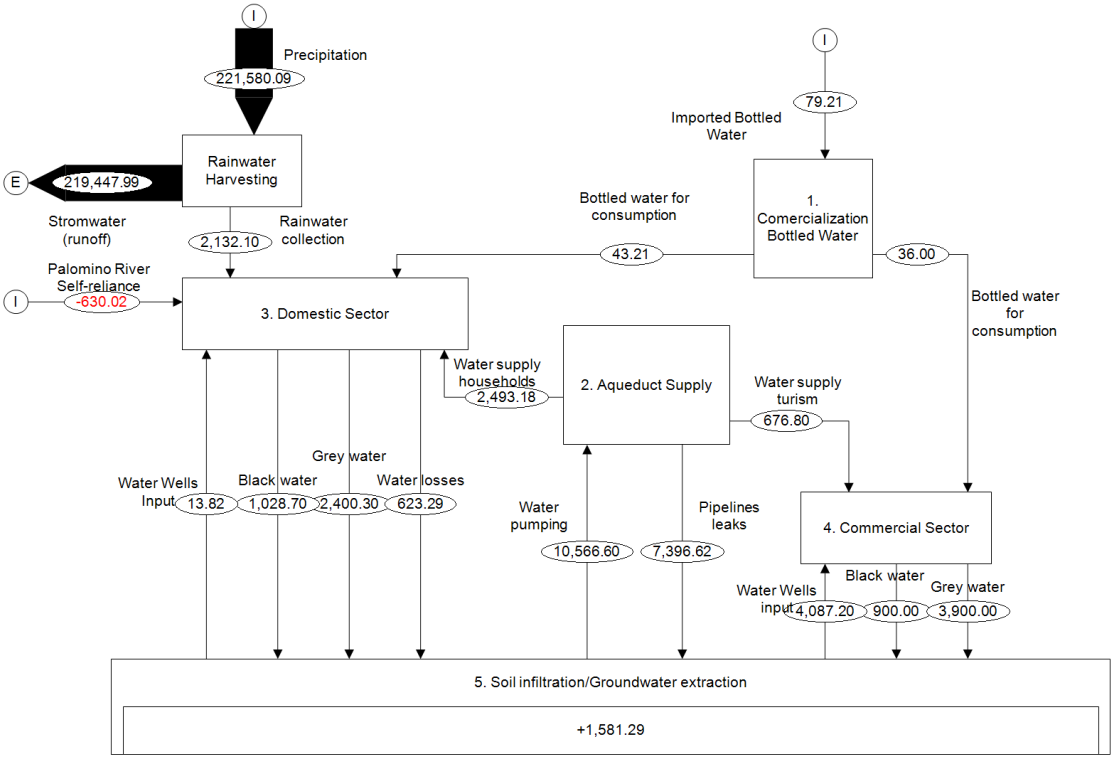
Rainwater Harvesting
E
99,718.89
Stromwater (runoff)
Rainwater collection
2,132.10
Palomino River Self-reliance
I
-630.02
3. Domestic Sector
I
79.21
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
Grey water
Water Wells Input
13.82
Black water
1,028.70
Water losses
2,400.30
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
Water Wells input
4,087.20
Black water
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

May


I
Precipitation
83,972.89
Rainwater Harvesting
E
81,769.72
Stromwater (runoff)
2,203.17
Rainwater collection
Palomino River Self-reliance
I
-650.86
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
Water losses
2,480.78
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Black water
Water Wells input
4,223.44
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

June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Precipitation
221,580.09
Rainwater Harvesting
E
219,447.99
Stromwater (runoff)
2,132.10
Rainwater collection
Palomino River Self-reliance
I
-630.02
3. Domestic Sector
I
79.21
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
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13.82
Black water
1,028.70
Water losses
2,400.30
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
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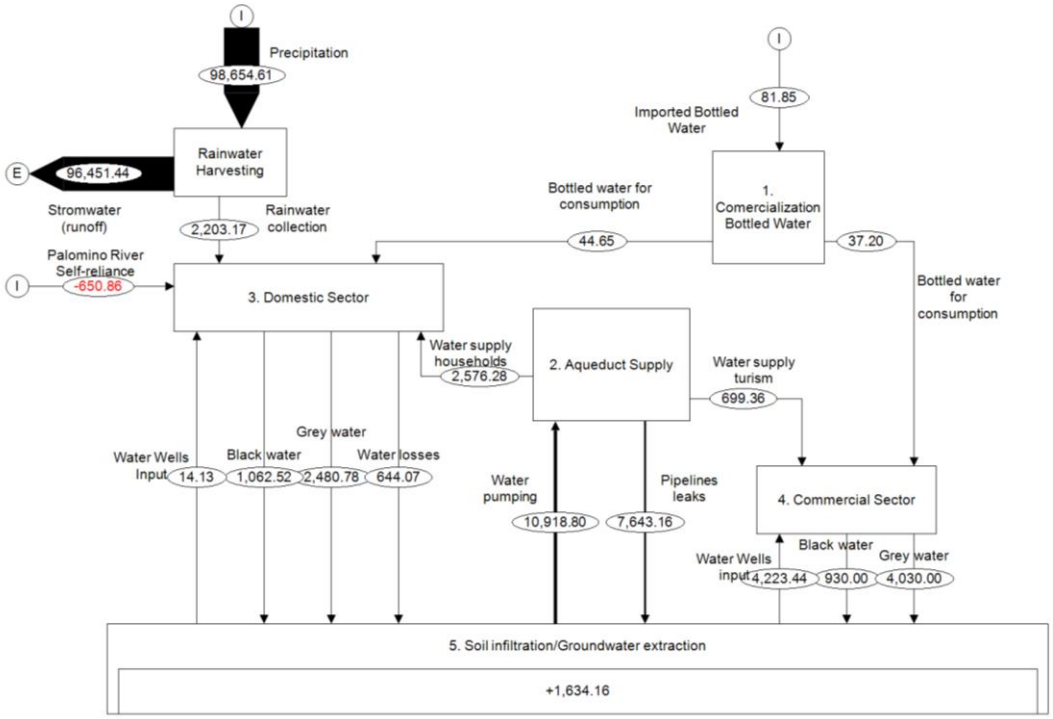
Water Wells input
4,087.20
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

July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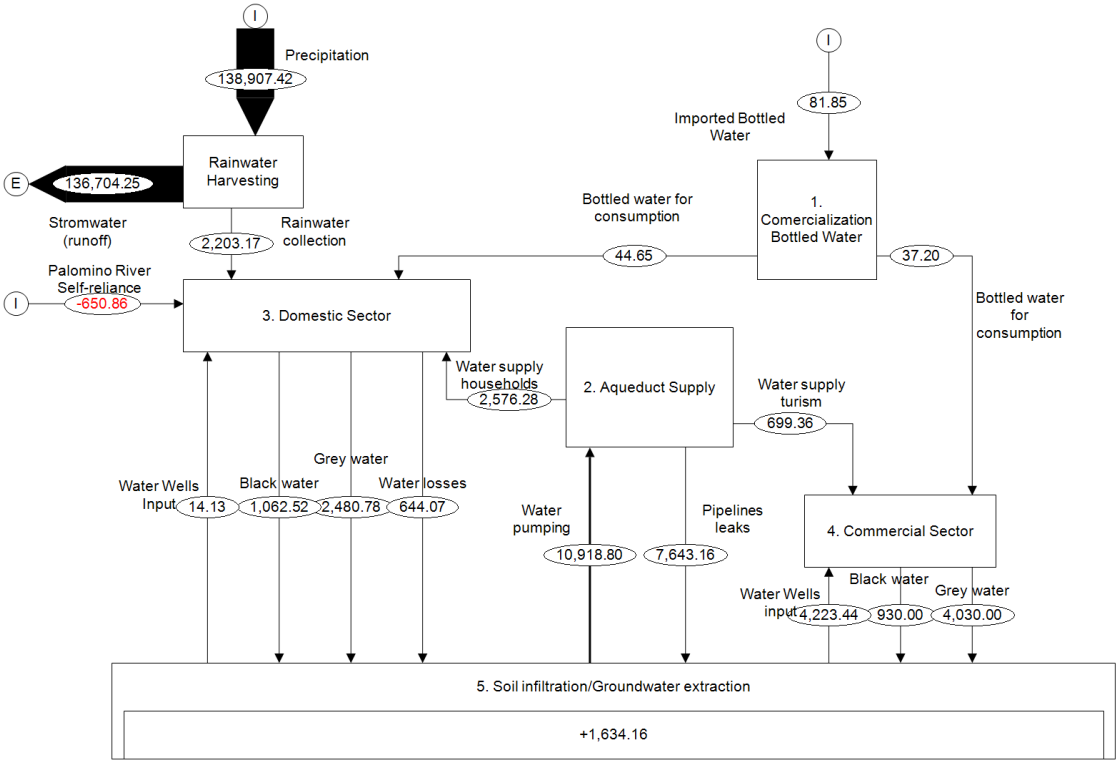
Rainwater Harvesting
96,451.44
Stromwater (runoff)
Rainwater collection
2,203.17
Palomino River Self-reliance
-650.86
3. Domestic Sector
Imported Bottled Water
81.85
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
Water losses
2,480.78
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
Black water
4,223.44
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

August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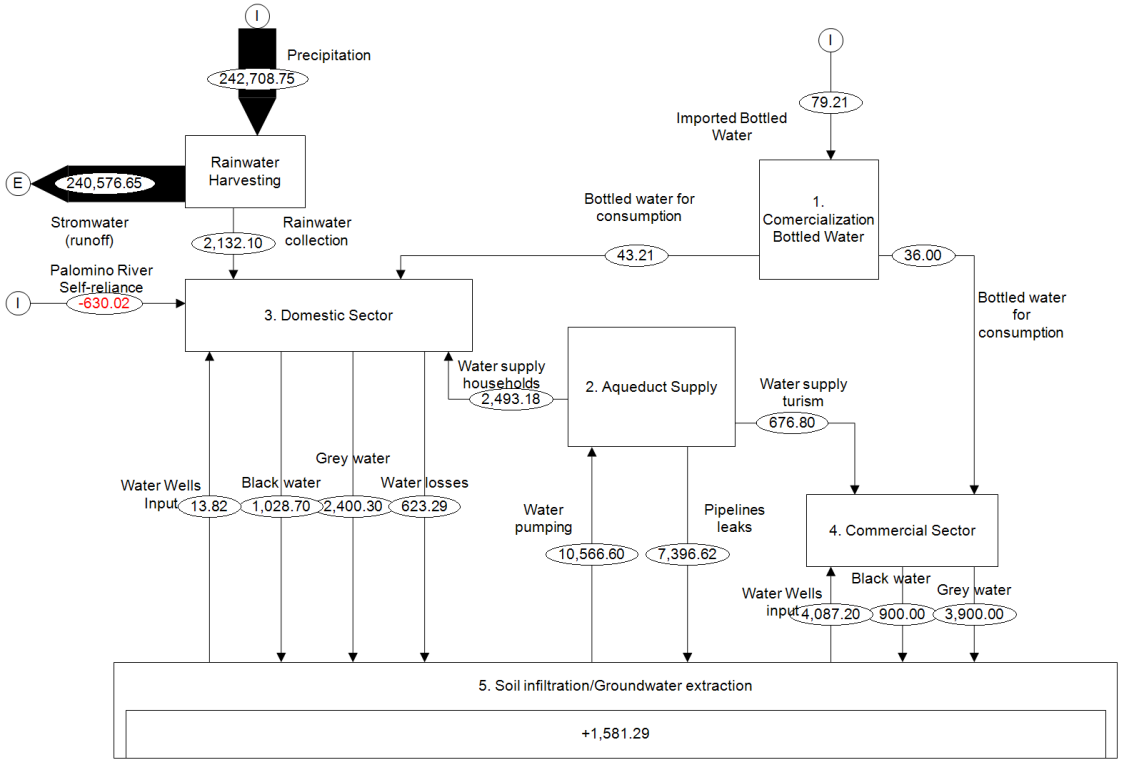
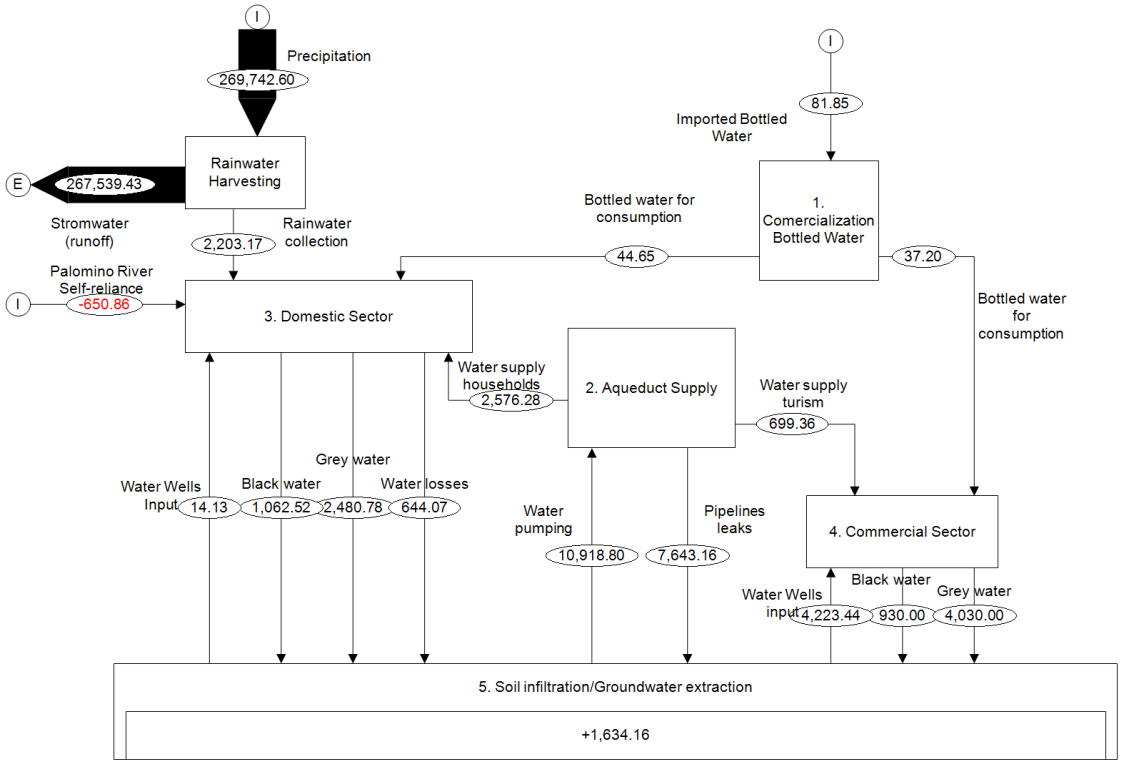
Rainwater Harvesting
136,704.25
Stromwater (runoff)
Rainwater collection
2,203.17
Palomino River Self-reliance
-650.86
3. Domestic Sector
Imported Bottled Water
81.85
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
Water losses
2,480.78
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
Black water
4,223.44
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

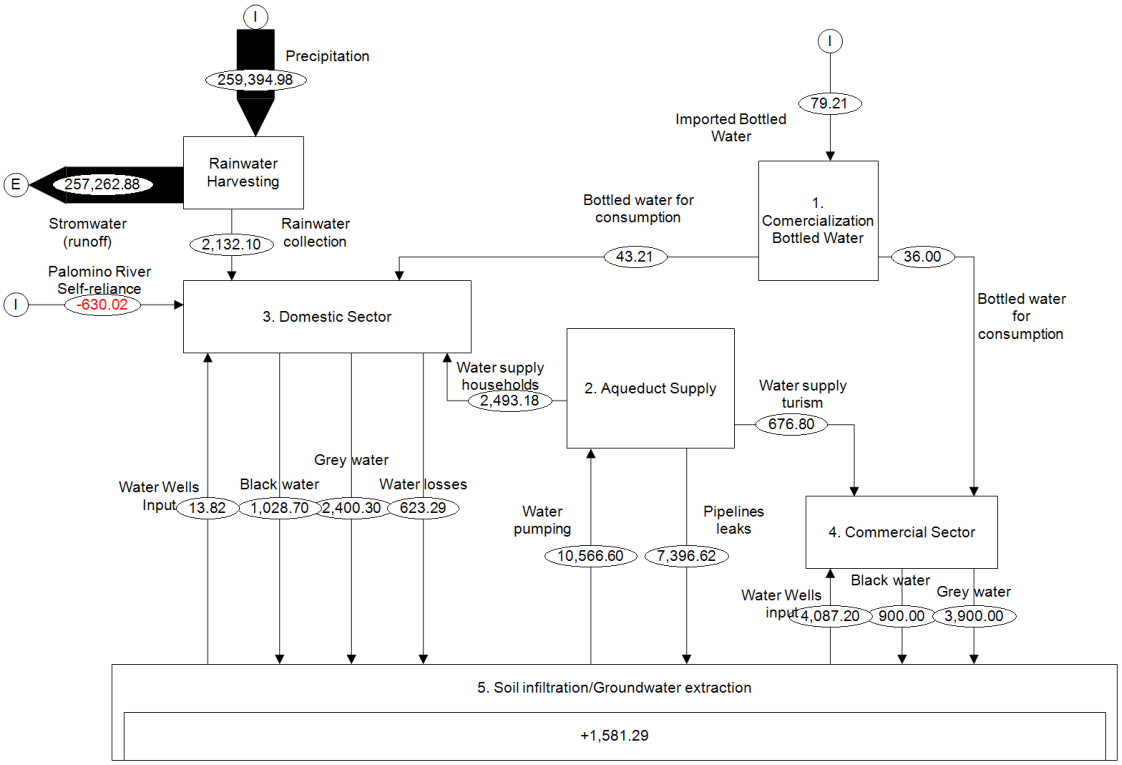
September



October



November



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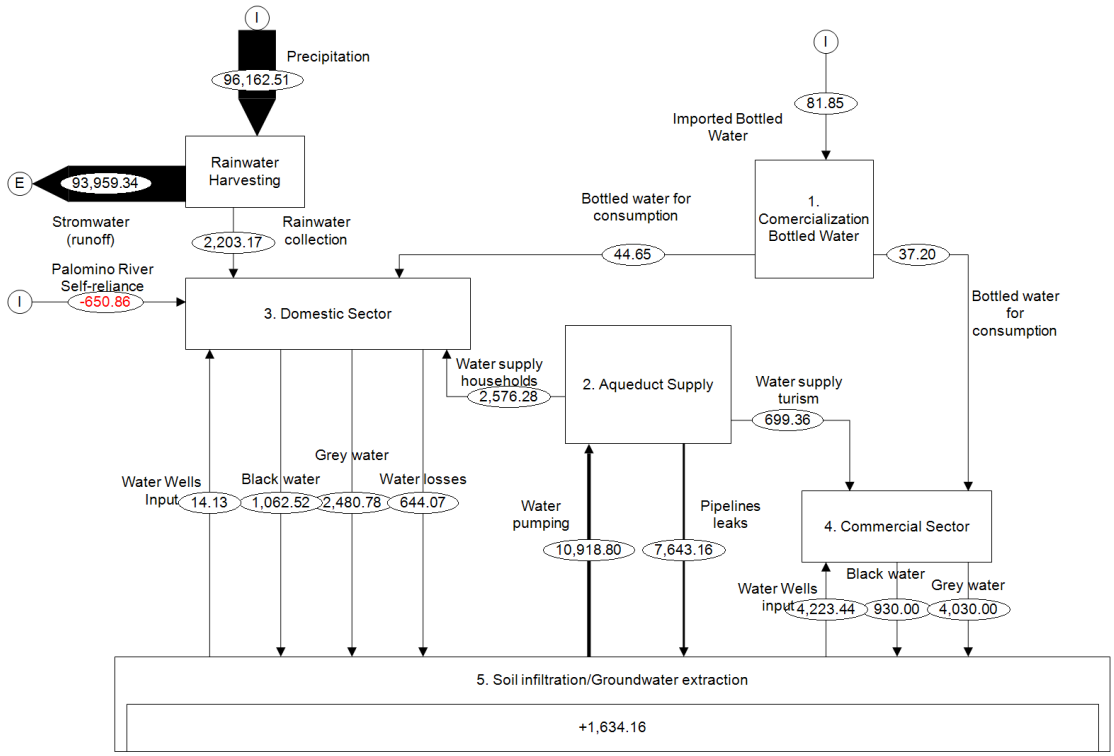
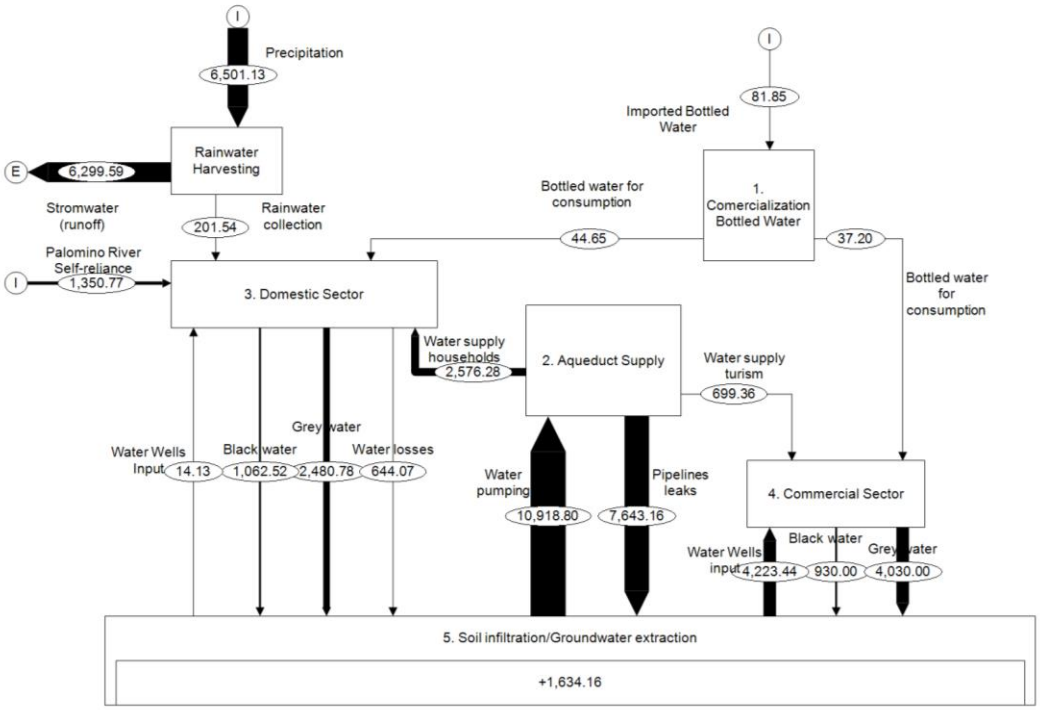
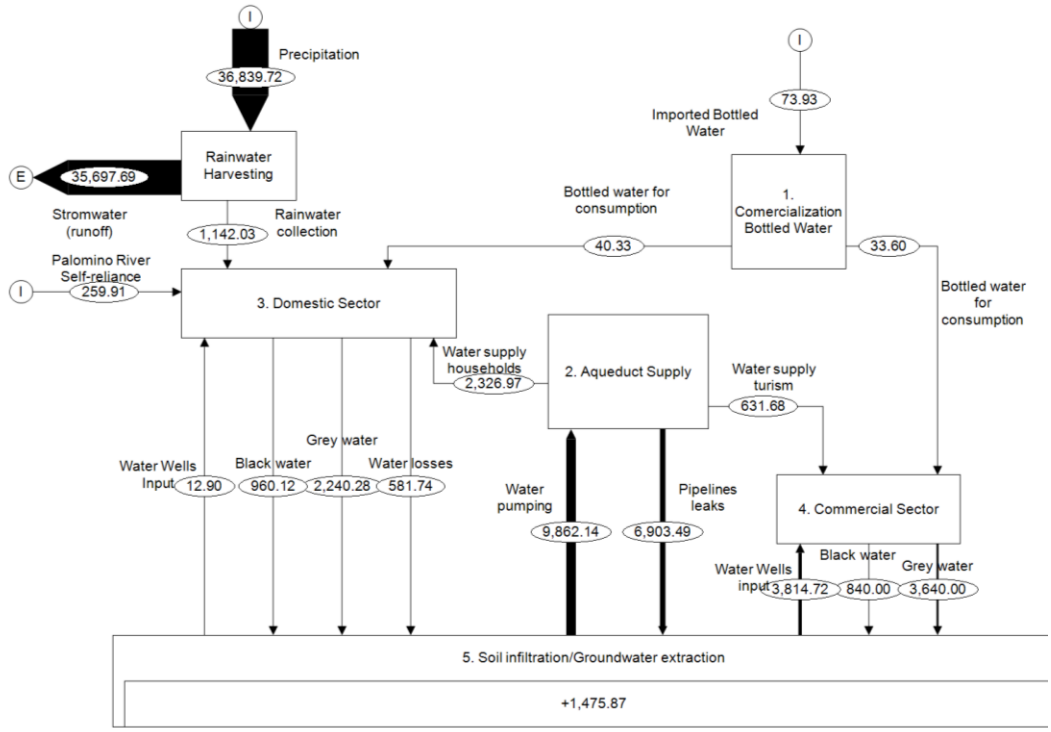


Year 1997: Minimum rainfall

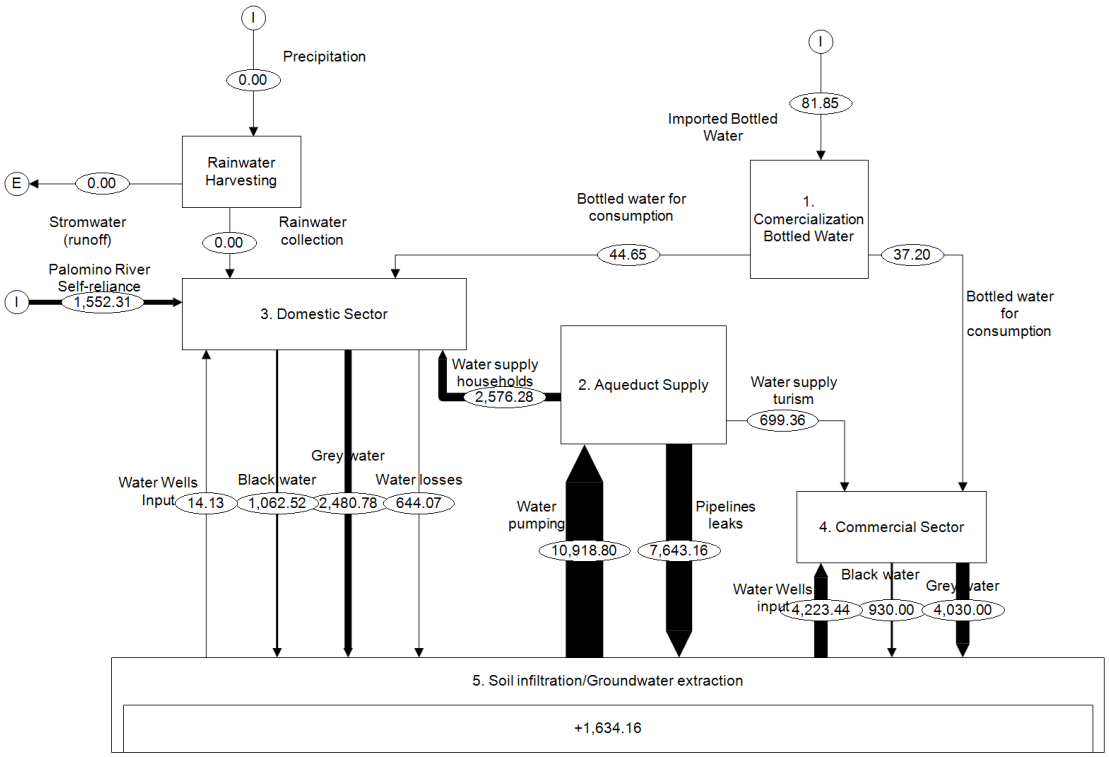
January



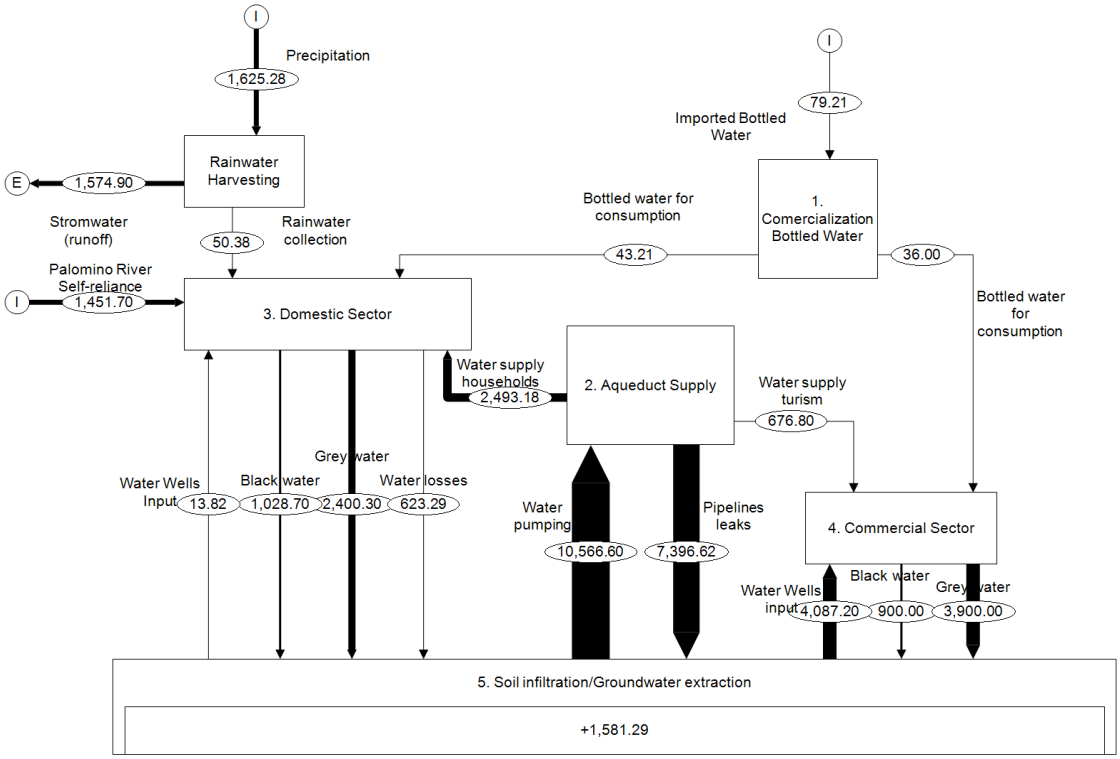
February



March


I
Precipitation
0.00
Rainwater Harvesting
E
0.00
Stromwater (runoff)
0.00
Rainwater collection
Palomino River Self-reliance
I
1,552.31
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

April


I
Precipitation
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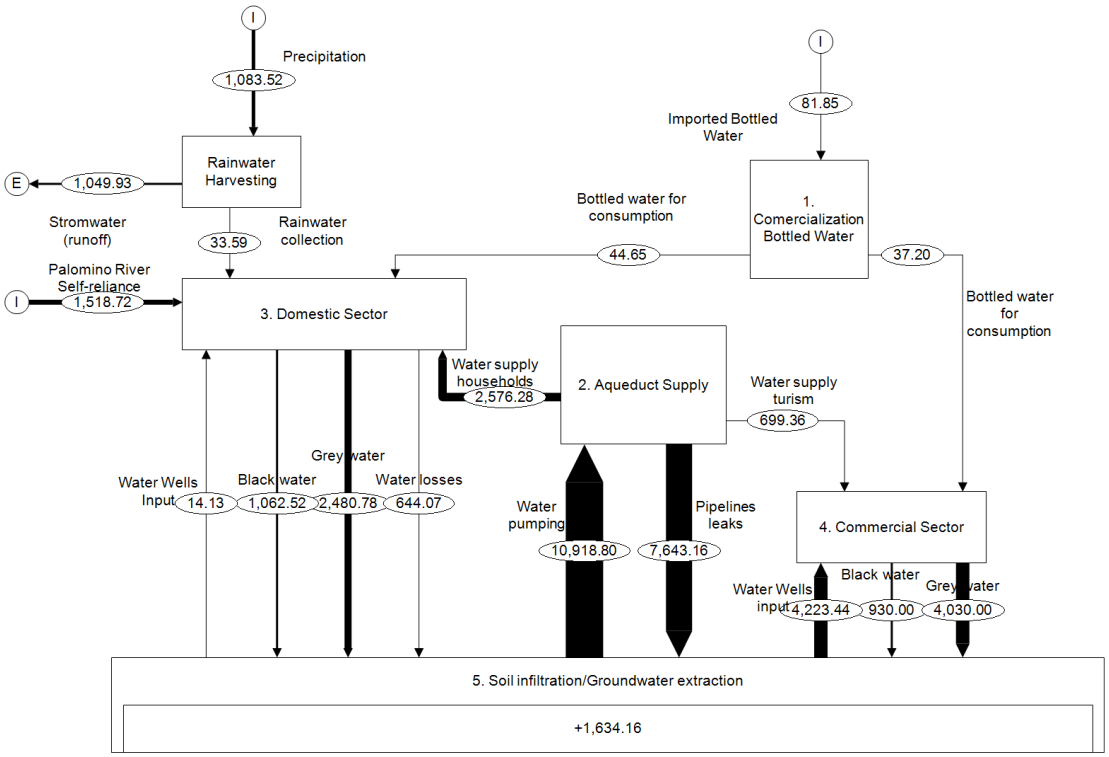
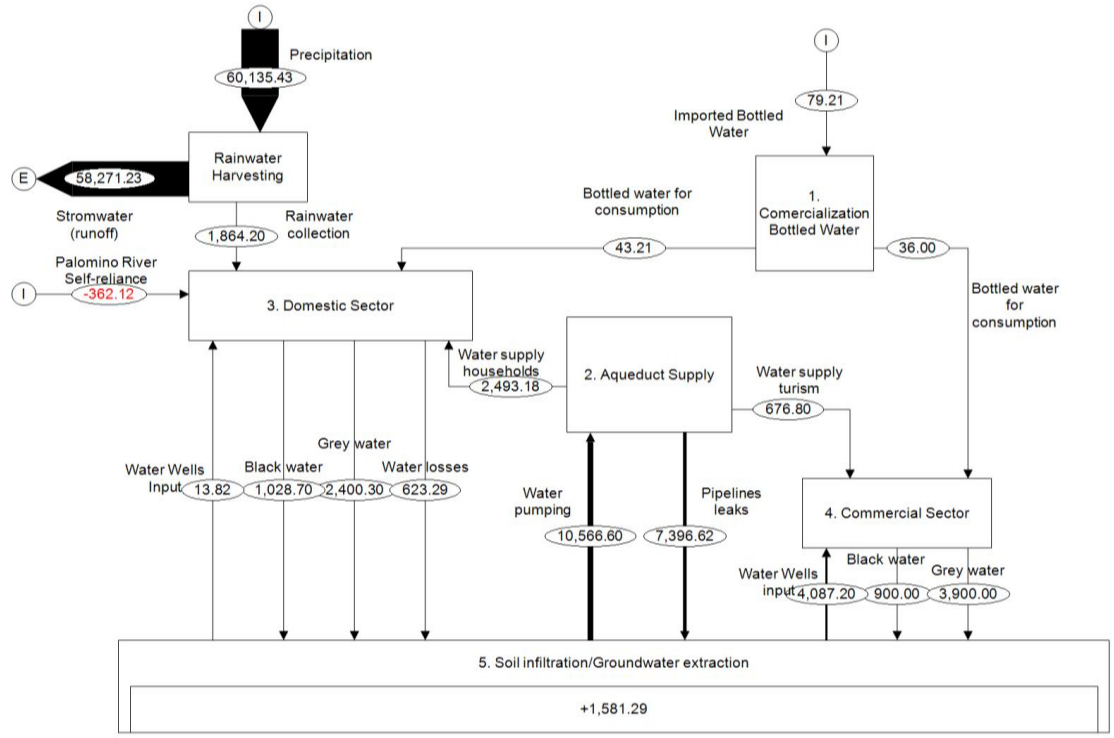
Rainwater Harvesting
E
1,574.90
Stromwater (runoff)
50.38
Rainwater collection
Palomino River Self-reliance
I
1,451.70
3. Domestic Sector
I
79.21
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
Grey water
Water Wells Input
13.82
Black water
1,028.70
2,400.30
Water losses
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
Water Wells input
4,087.20
Black water
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

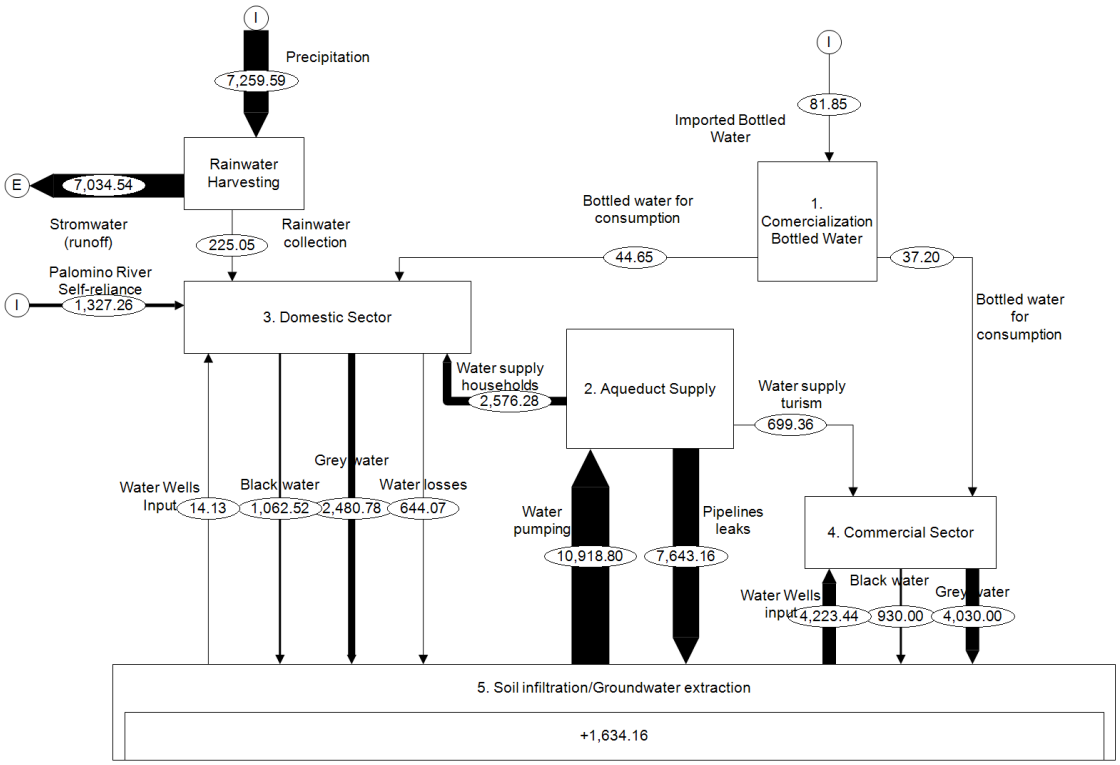
May


I
Precipitation
1,083.52
Rainwater Harvesting
E
1,049.93
Stromwater (runoff)
33.59
Rainwater collection
Palomino River Self-reliance
I
1,518.72
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

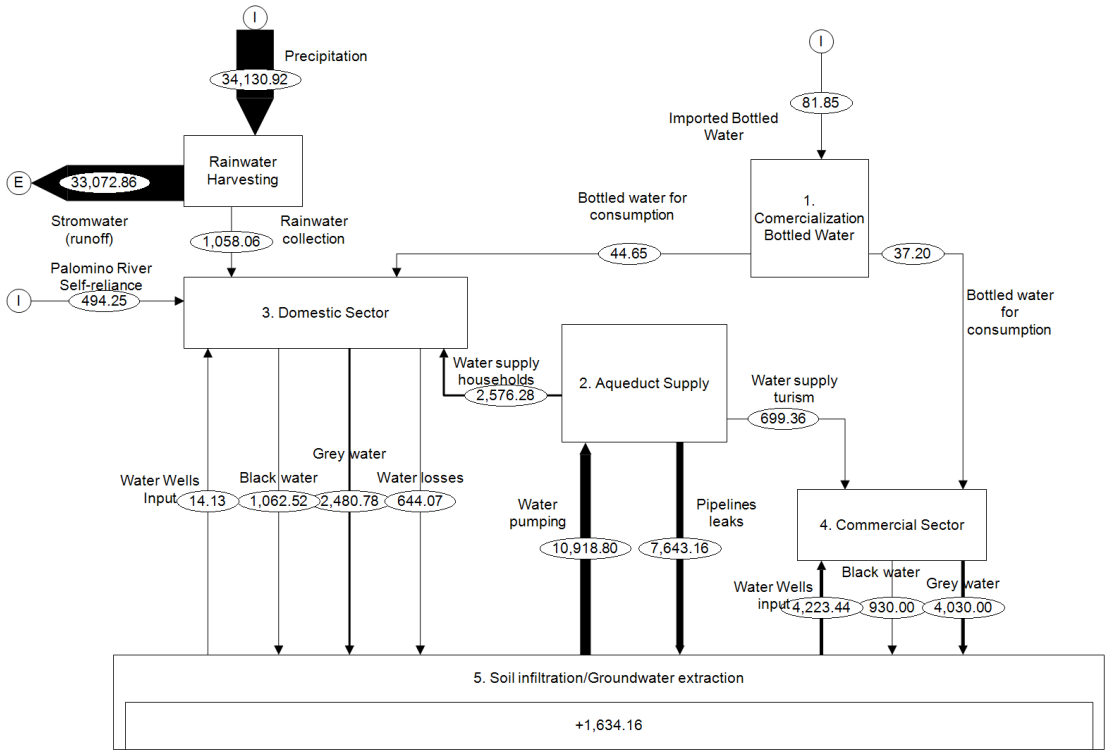
June


I
Precipitation
60,135.43
Rainwater Harvesting
E
58,271.23
Stromwater (runoff)
1,864.20
Rainwater collection
Palomino River Self-reliance
I
-362.12
3. Domestic Sector
I
79.21
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
Grey water
Water Wells Input
13.82
Black water
1,028.70
2,400.30
Water losses
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
Water Wells input
4,087.20
Black water
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

July


I
Precipitation
7,259.59
Rainwater Harvesting
E
7,034.54
Stromwater (runoff)
225.05
Rainwater collection
Palomino River Self-reliance
I
1,327.26
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

August


I
Precipitation
34,130.92
Rainwater Harvesting
E
33,072.86
Stromwater (runoff)
1,058.06
Rainwater collection
Palomino River Self-reliance
I
494.25
3. Domestic Sector
I
81.85
Imported Bottled Water
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Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
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Water pumping
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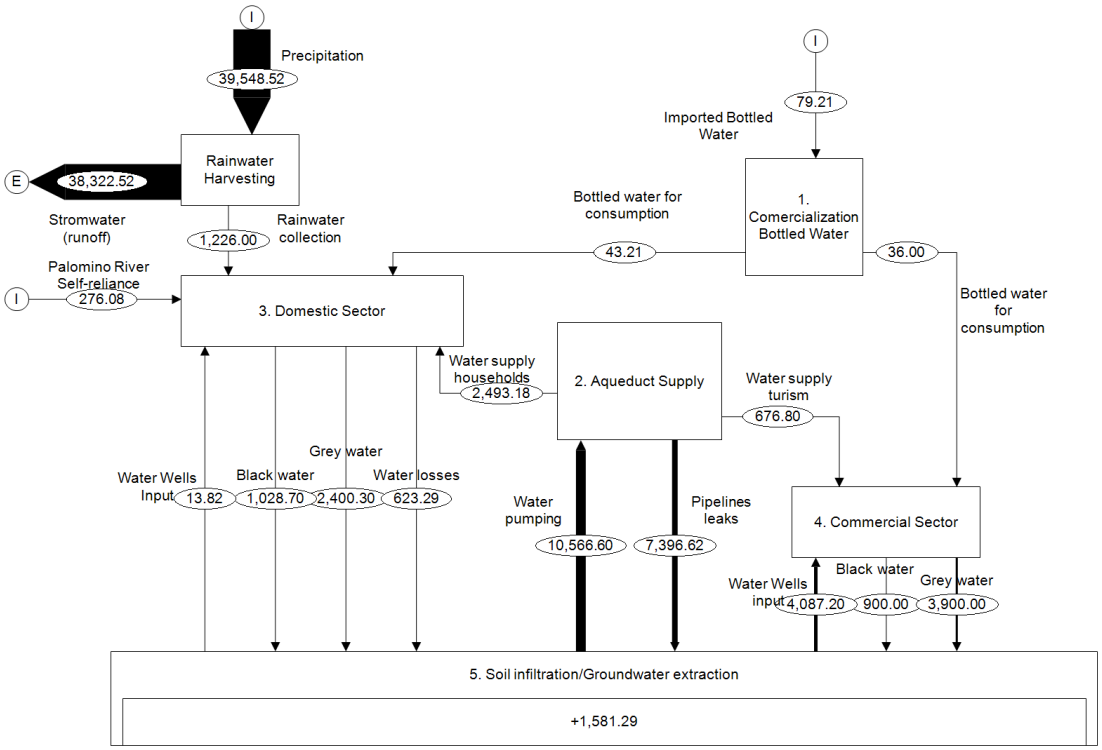
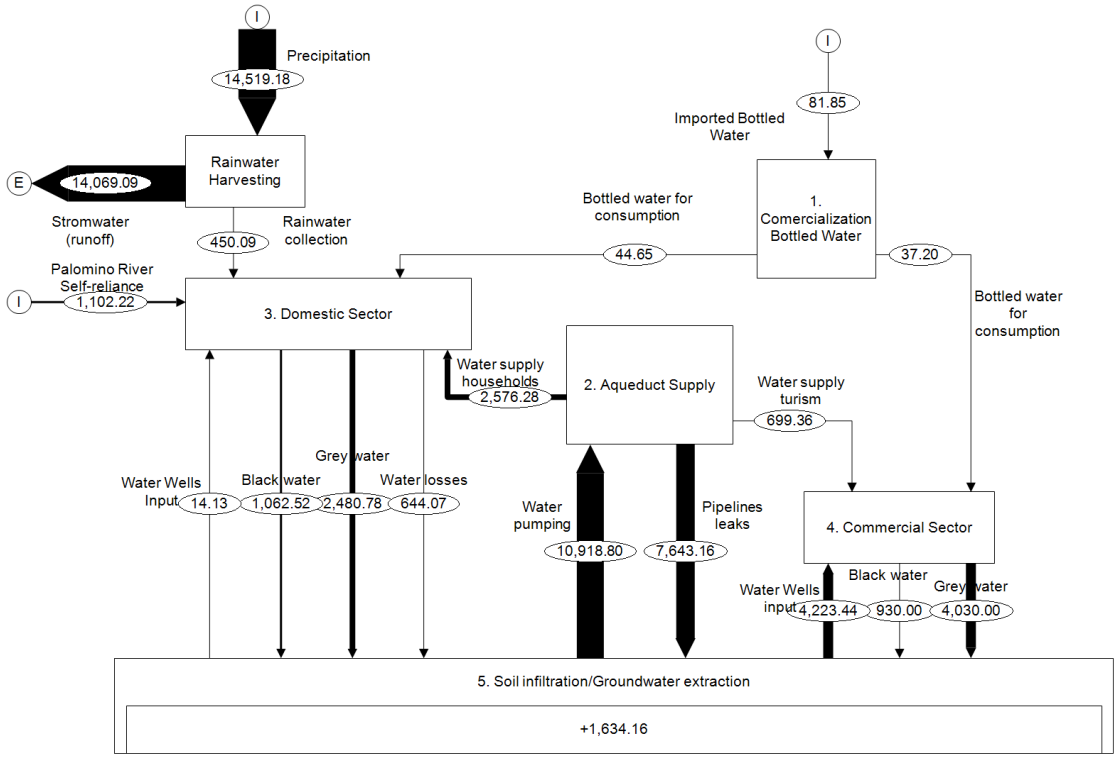
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

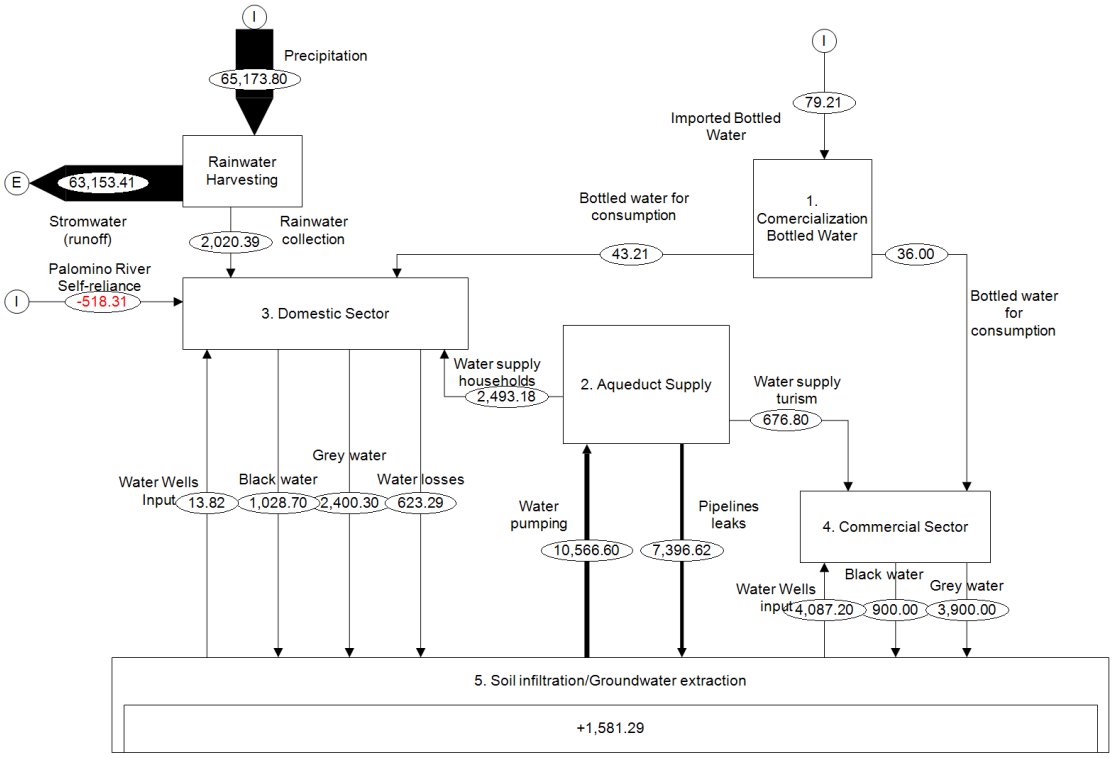
September



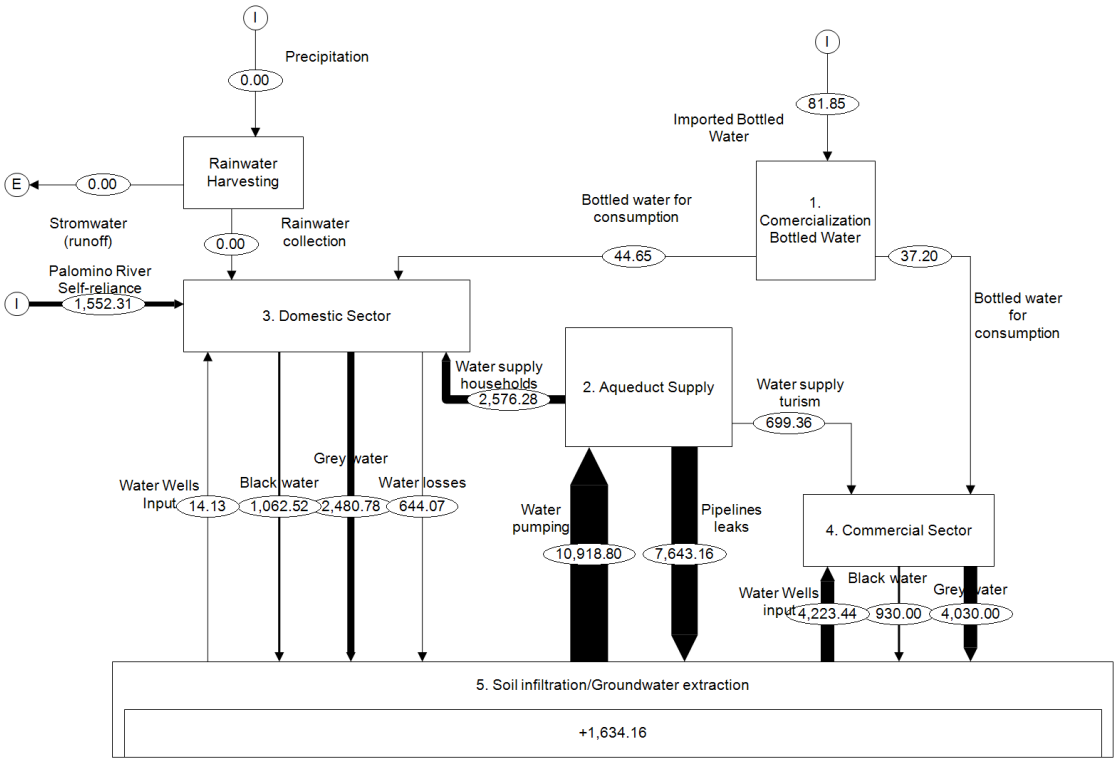
October



November

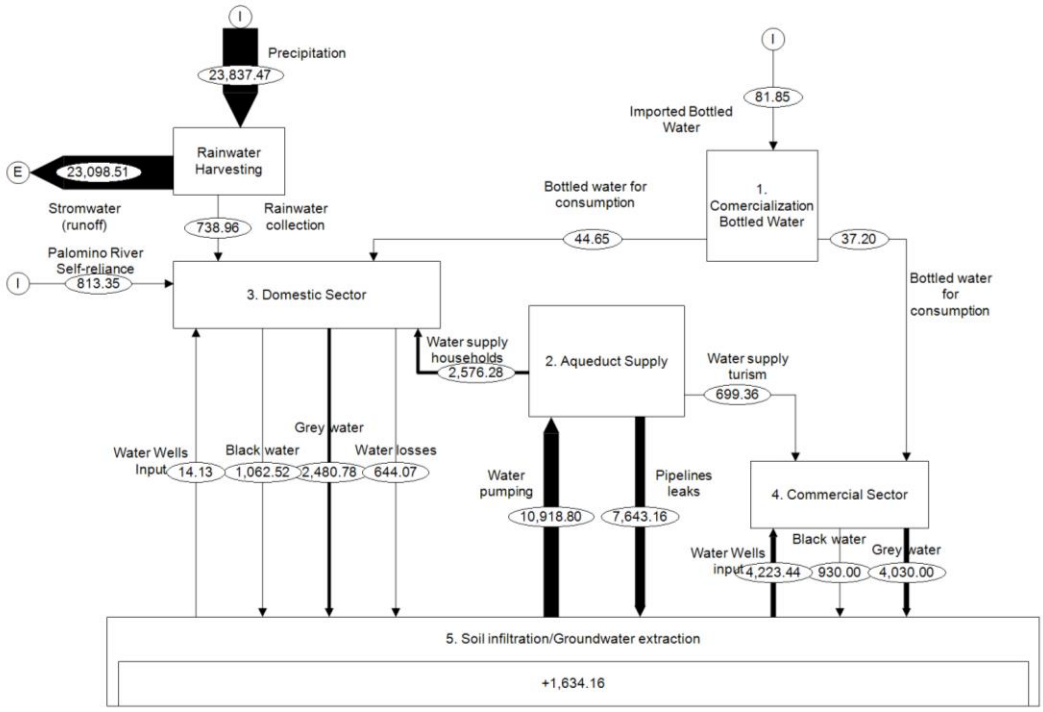


December

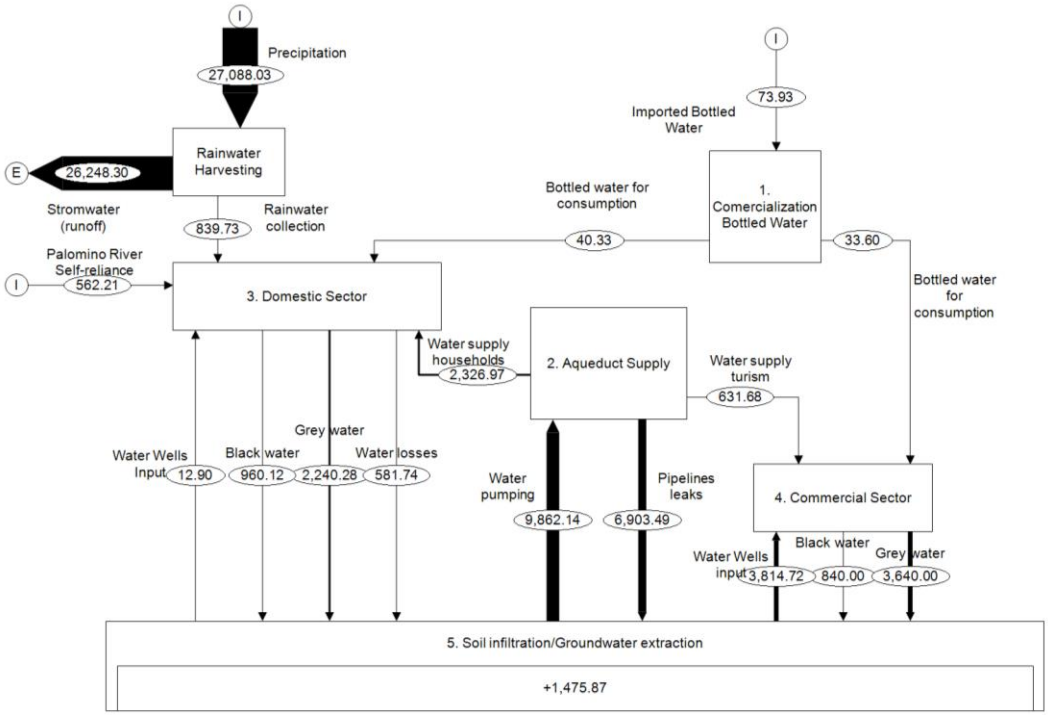


Year 1987: Intermedium rainfall

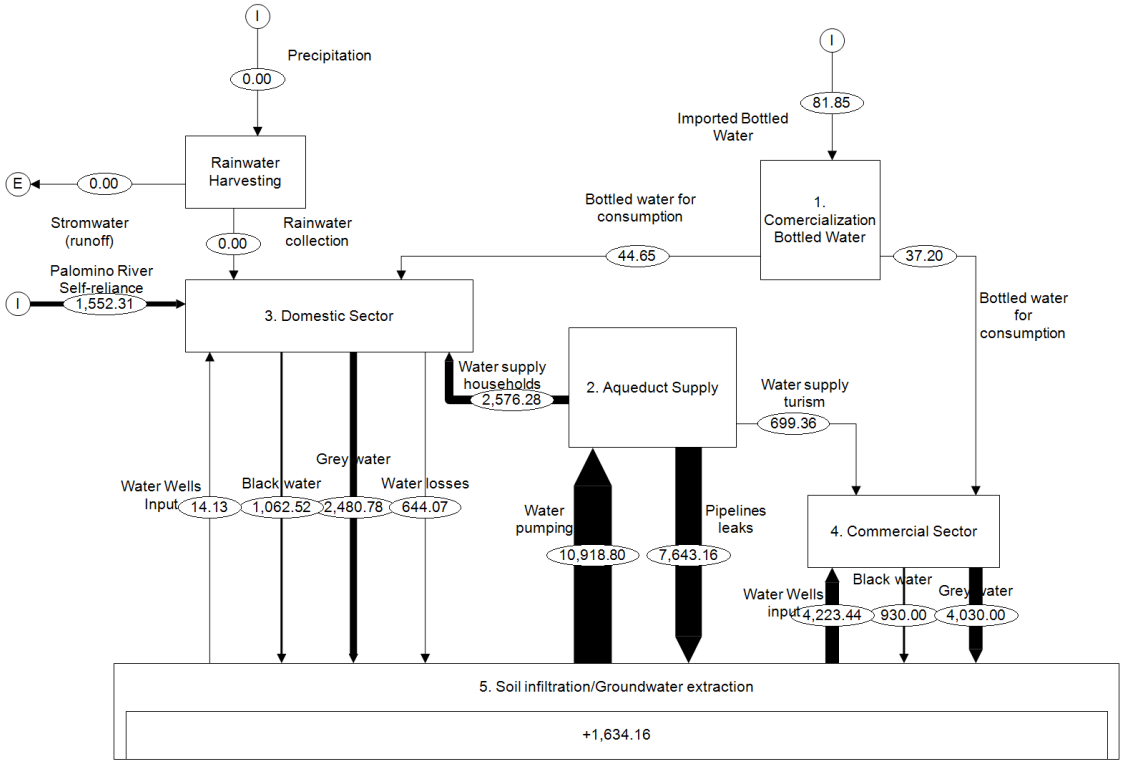
January



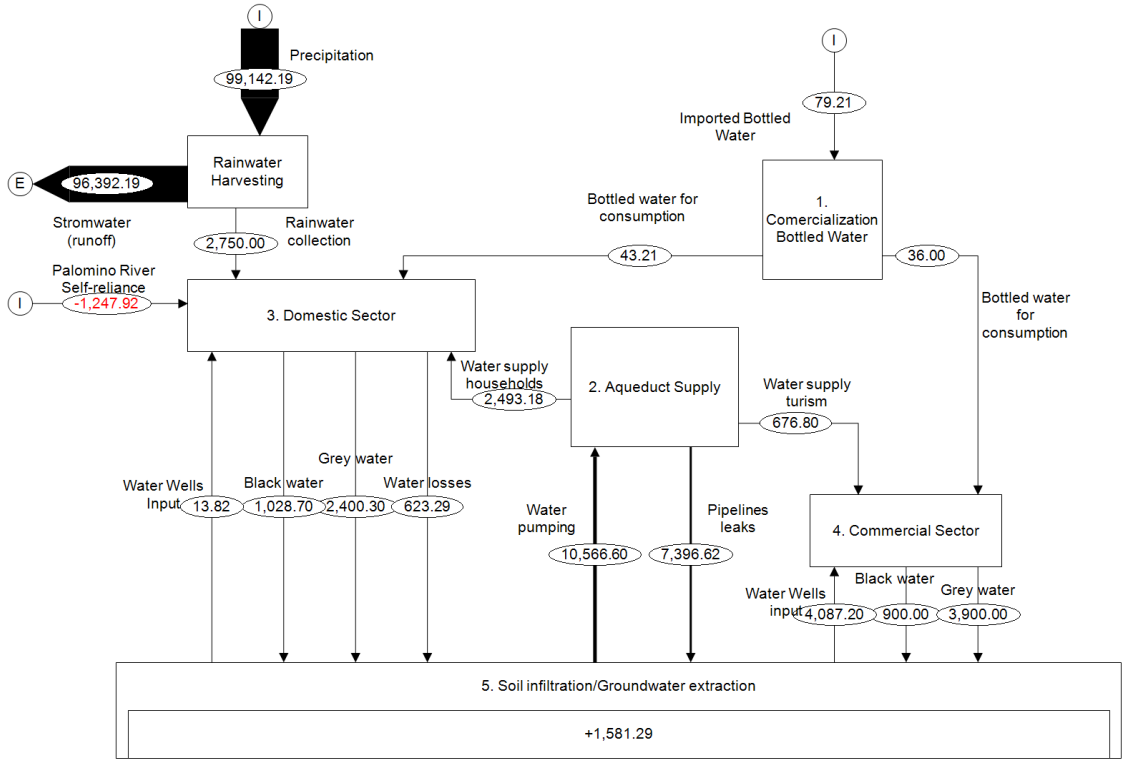
February



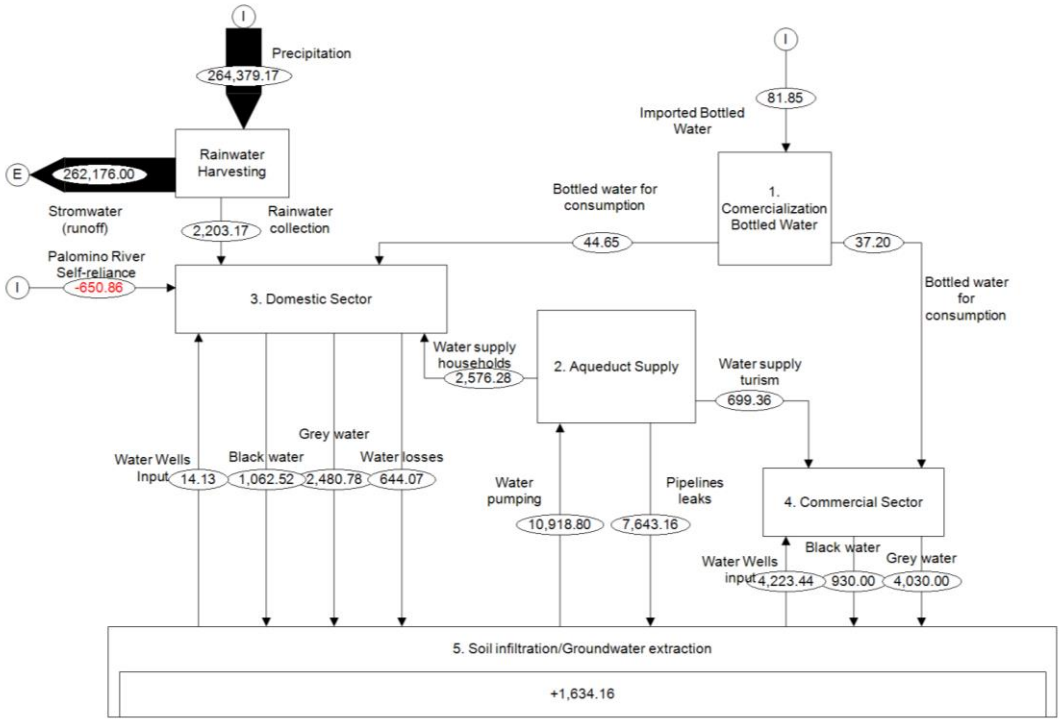
March


I
Precipitation
0.00
Rainwater Harvesting
E
0.00
Stromwater (runoff)
Rainwater collection
0.00
Palomino River Self-reliance
I
1,552.31
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

April


I
Precipitation
99,142.19
Rainwater Harvesting
E
96,392.19
Stromwater (runoff)
Rainwater collection
2,750.00
Palomino River Self-reliance
I
-1,247.92
3. Domestic Sector
I
79.21
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
Grey water
Water Wells Input
13.82
Black water
1,028.70
2,400.30
Water losses
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
Water Wells input
4,087.20
Black water
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

May


Precipitation
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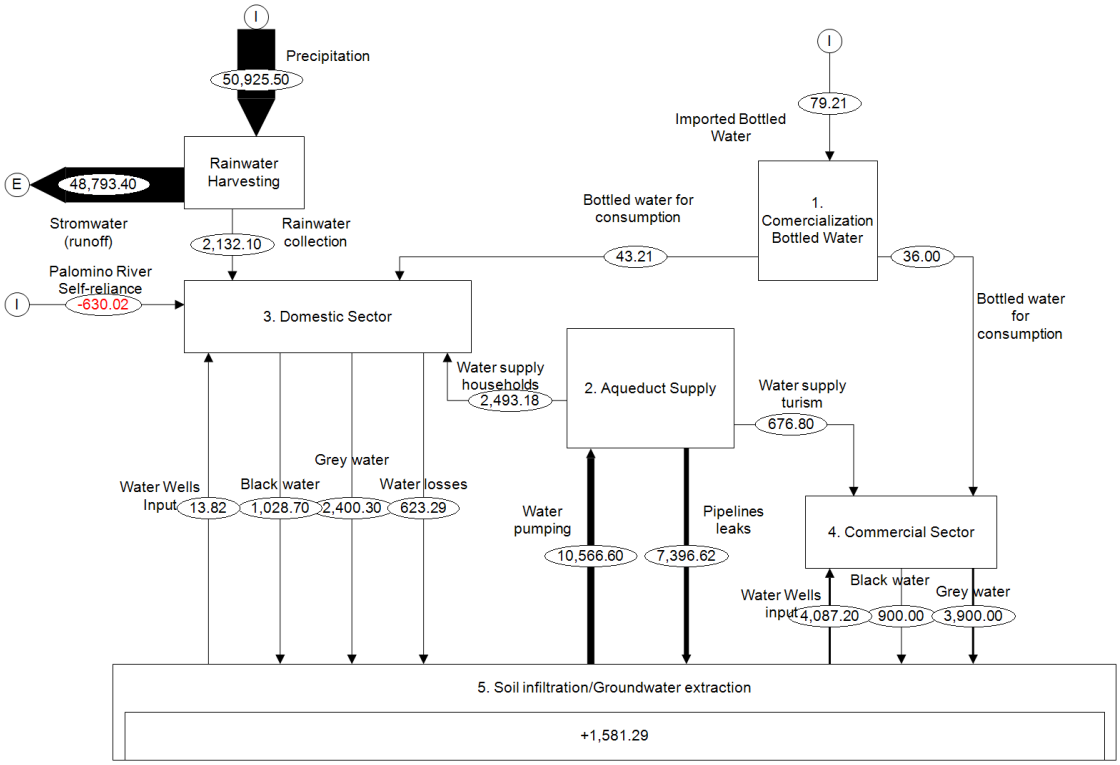
Rainwater Harvesting
E
262,176.00
Stromwater (runoff)
Rainwater collection
2,203.17
Palomino River Self-reliance
-650.86
3. Domestic Sector
Imported Bottled Water
81.85
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
Water losses
2,480.78
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

June


Precipitation
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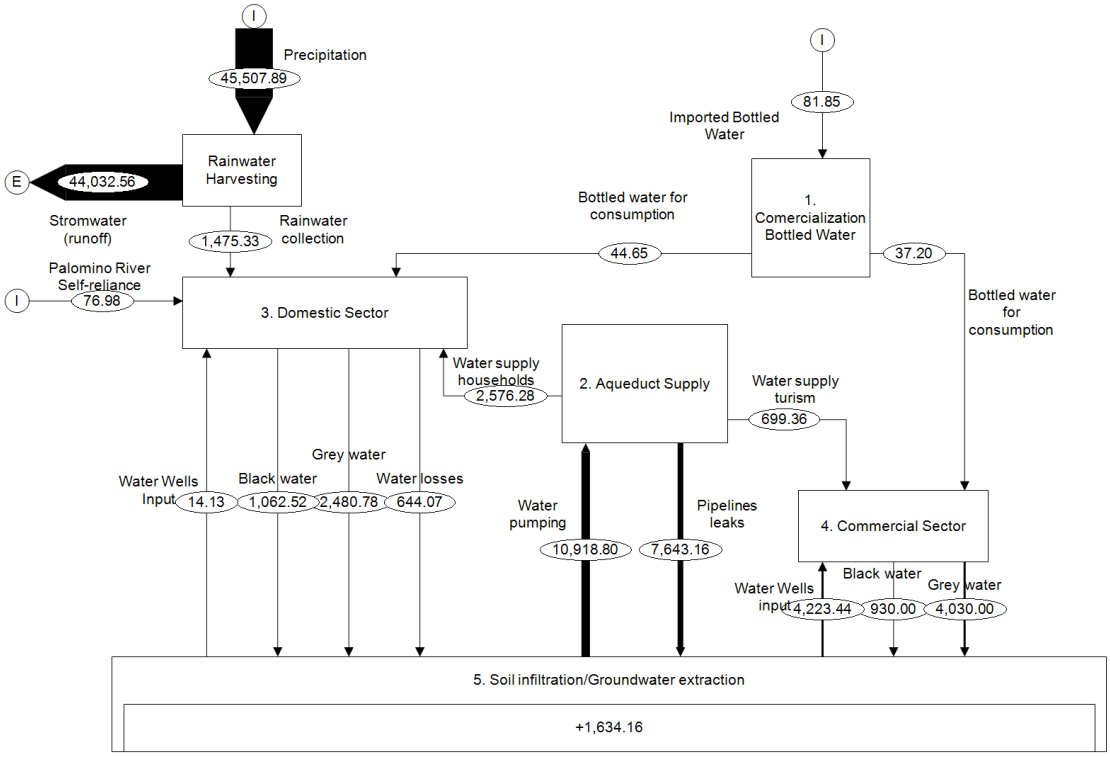
Rainwater Harvesting
E
48,793.40
Stromwater (runoff)
Rainwater collection
2,132.10
Palomino River Self-reliance
-630.02
3. Domestic Sector
Imported Bottled Water
79.21
1. Comercialization Bottled Water
Bottled water for consumption
43.21
36.00
Bottled water for consumption
Water supply households
2,493.18
2. Aqueduct Supply
Water supply turism
676.80
Grey water
Water Wells Input
13.82
Black water
1,028.70
Water losses
2,400.30
623.29
Water pumping
10,566.60
Pipelines leaks
7,396.62
4. Commercial Sector
Water Wells input
4,087.20
Black water
900.00
Grey water
3,900.00
5. Soil infiltration/Groundwater extraction
+1,581.29

July


I
Precipitation
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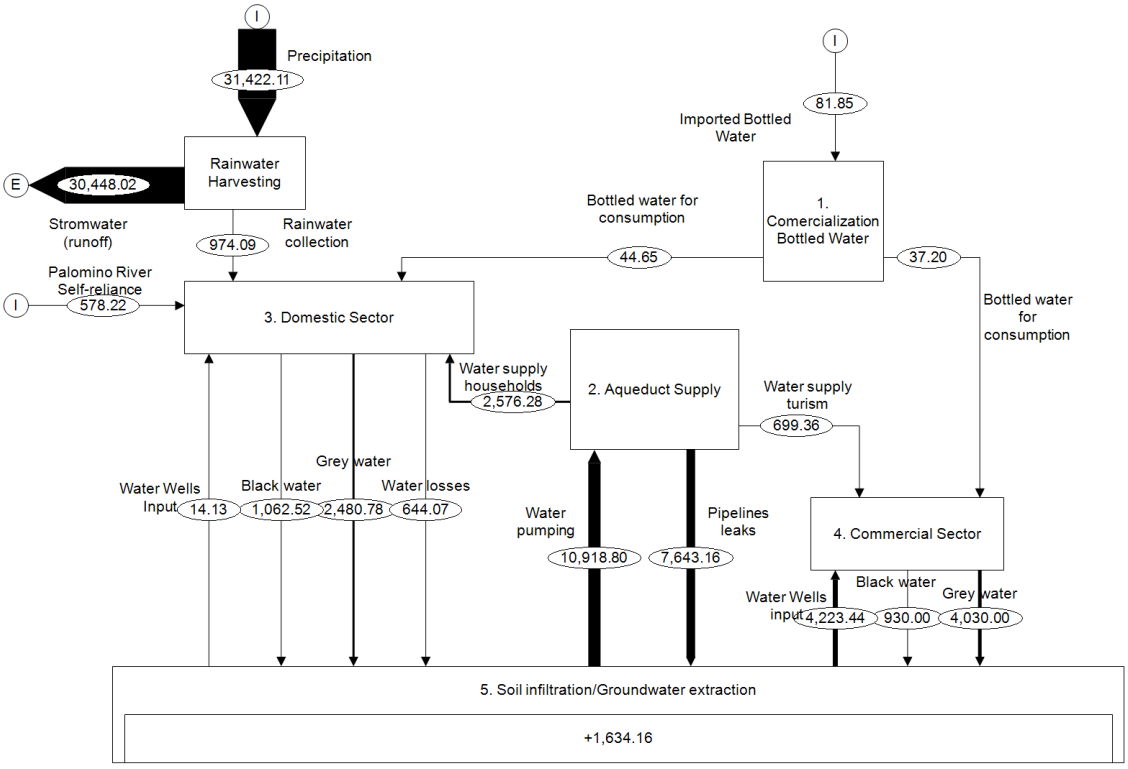
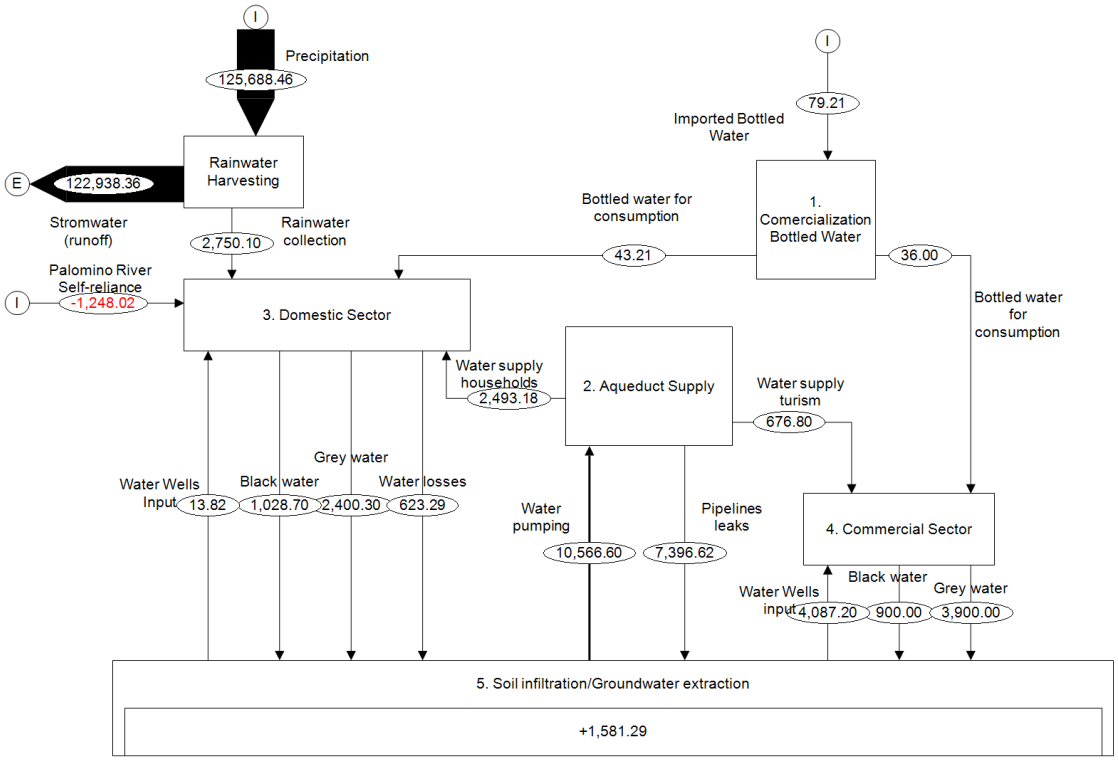
Rainwater Harvesting
E
44,032.56
Stromwater (runoff)
Rainwater collection
1,475.33
Palomino River Self-reliance
I
76.98
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

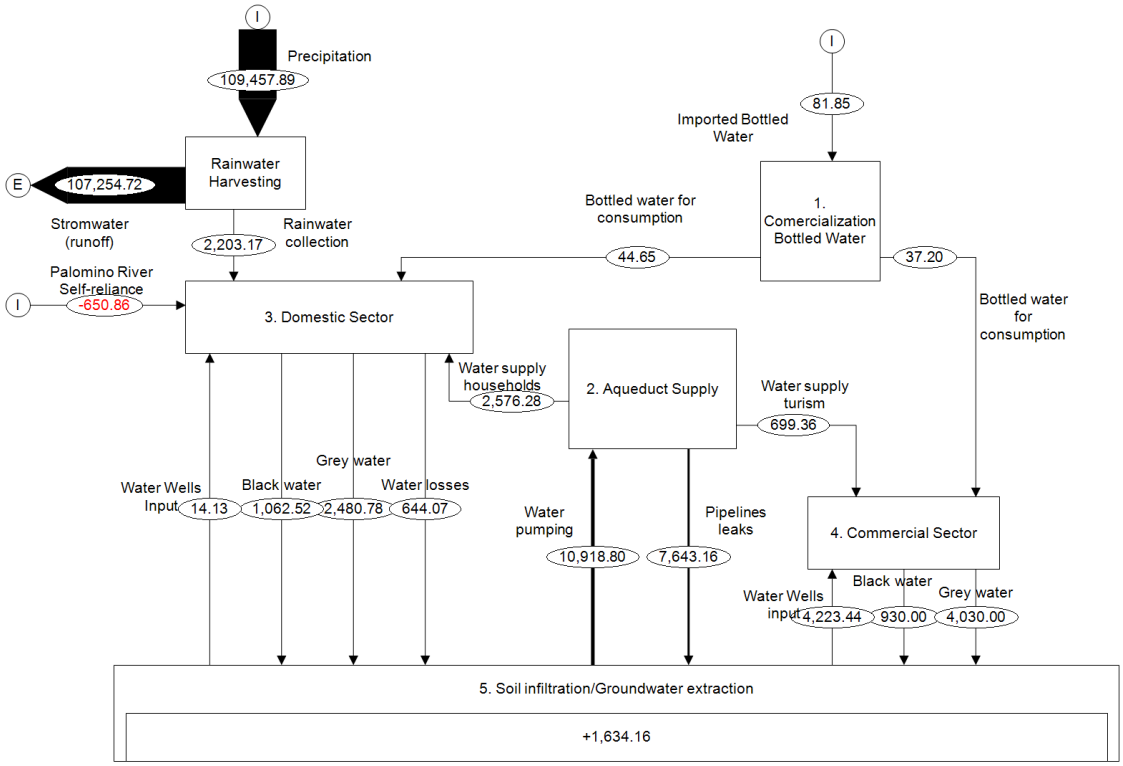
August


I
Precipitation
31,422.11
Rainwater Harvesting
E
30,448.02
Stromwater (runoff)
Rainwater collection
974.09
Palomino River Self-reliance
I
578.22
3. Domestic Sector
I
81.85
Imported Bottled Water
1. Comercialization Bottled Water
Bottled water for consumption
44.65
37.20
Bottled water for consumption
Water supply households
2,576.28
2. Aqueduct Supply
Water supply turism
699.36
Grey water
Water Wells Input
14.13
Black water
1,062.52
2,480.78
Water losses
644.07
Water pumping
10,918.80
Pipelines leaks
7,643.16
4. Commercial Sector
Water Wells input
4,223.44
Black water
930.00
Grey water
4,030.00
5. Soil infiltration/Groundwater extraction
+1,634.16

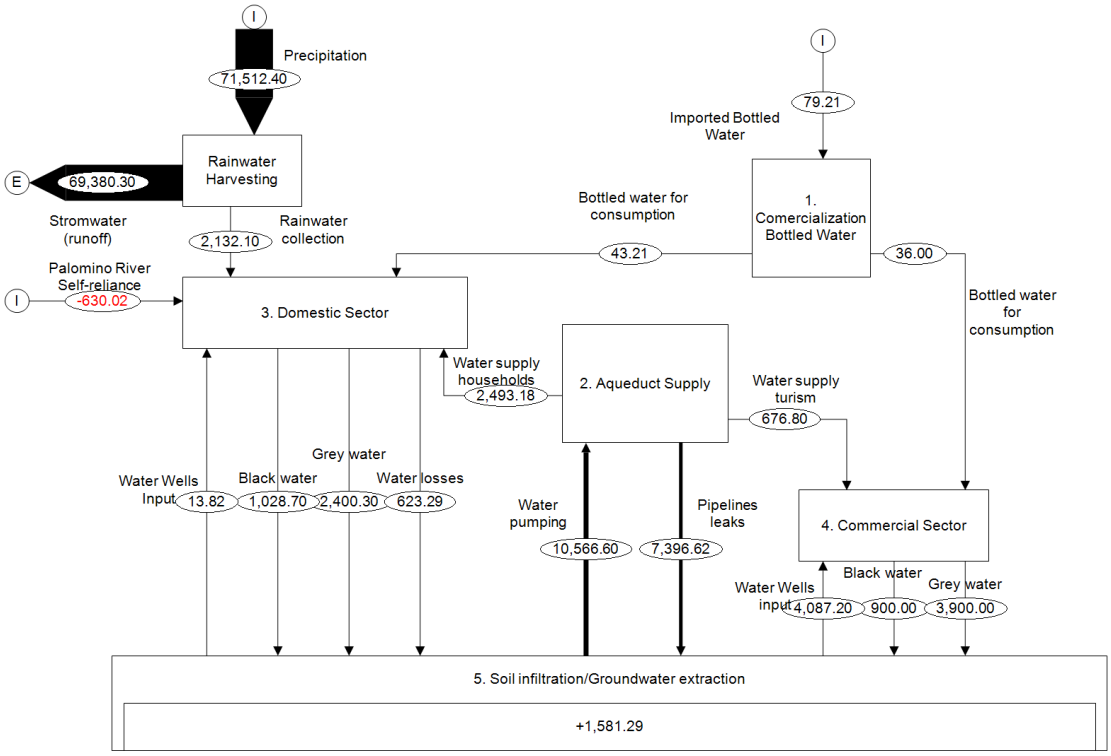
September



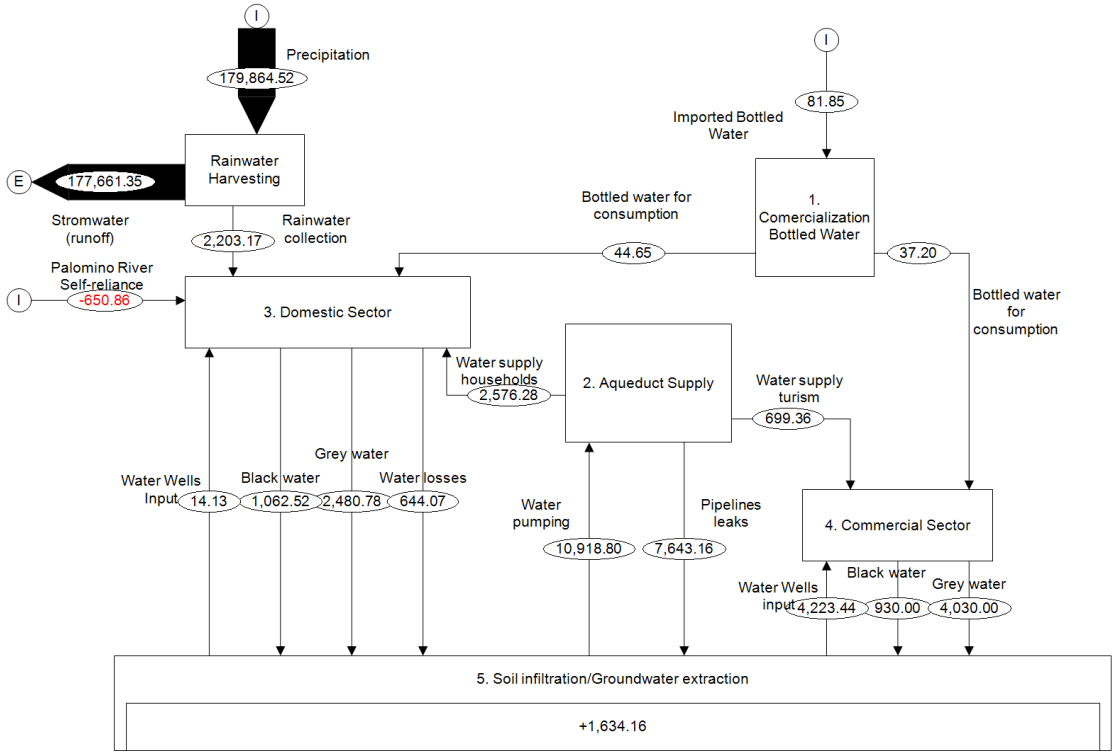
October



November

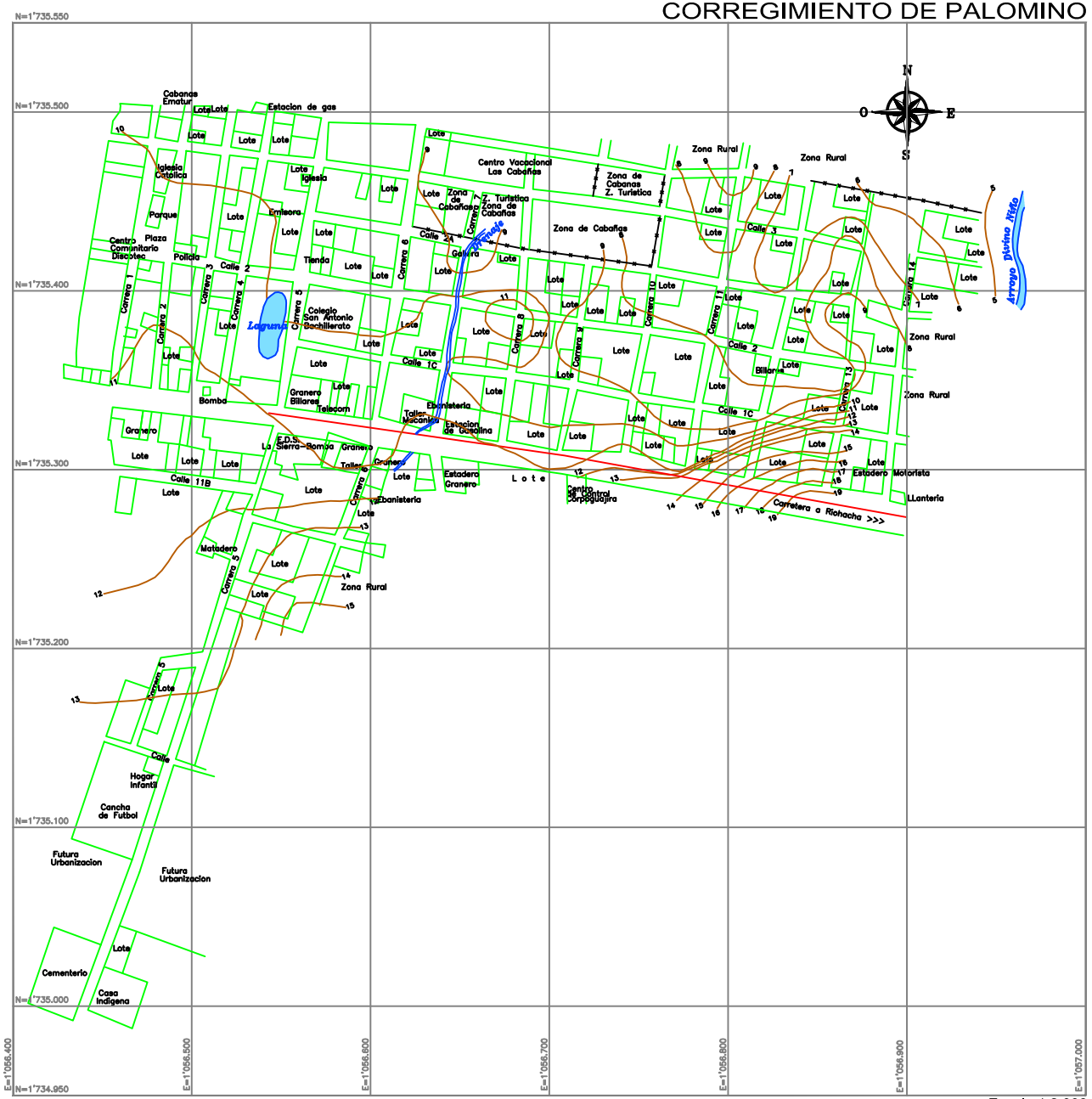


December



Appendix B: Palomino's cartography 2002

CORREGIMIENTO DE PALOMINO



Escala 1:2.000

FUENTE: Base Topográfica Tomada del Ing. Sergio Barrera S. Octubre de 1999. Ajustada parcialmente por Ing. Milag Freddy Sarmiento B.

ALCALDÍA MUNICIPAL DE DIBULLA

República de Colombia

Gobernación del Departamento de La Guajira

ESQUEMA DE ORDENAMIENTO TERRITORIAL DEL MUNICIPIO DE DIBULLA - LA GUAJIRA

APOYO Y ASESORÍA TÉCNICA PARA EL AJUSTE DEL E.O.T.

Ing. Milag Freddy Sarmiento B.
CONSULTOR GOBERNACIÓN

Fecha:	Digitalizó: COAMBIENTE LTDA.	Archivo:	Mapa No.
Enero de 2002	Revisó: Ing. Milag Freddy Sarmiento		

Appendix C: Interviews

Date: Friday 11, September 2015
Interviewee: Carlos Hernandez
Origen: Bogotá D.C.
Short description: Director of PEI, Javeriana University. Third supervisor IE thesis Natalia Uribe Calvo

Talking about ´Palomino Cultural' and the projects that the PEI has done previously in Palomino.
General views and concerns from Carlos are based on the lack of community liders. Palomino's society suffers from disarticulation and this represents a difficulty for the development of the projects. Of future projects as well of the maintenance of the previous projects done.
Now a day, the territory where the 'house of culture' project was built is facing a legal process. Apparently the 'owner' of the territory recently showed up and he wants some financial compensation.
From the water management side, the aqueduct is fed from the 'río ancho'. The river is losing its water flow and the watershed is facing droughts.
Part of the upper territory in the Sierra Nevada is being burned for plantations; this is contributing to the loss the water retention capacity of the watershed and loss of native plants and biodiversity. This is also applicable the water retention capacity on the Sierra Nevada, where all the water bodies originates and climate change has become a treat since the glaciers are melting faster. The Sierra Nevada contributes to an order of magnitude of 10 million liters of water each year.
Carlos gave me some important contacts: Juan Rodriguez – owner of a dry toilet, actively involved in in conservation projects and apiculture. Orfelina: community lider. Agua Ayuda: NGO for water management in the department of 'La Guajira'

SUMARY:

- Lack of community liders
- Lack of appropriation from the community to the projects done
- Loss of water retention capacity from water bodies and loss of biodiversity – conservation issues
- Climate change
- People and organizations: Juan Rodriguez, Orfelina and Agua Ayuda

Date: Friday 11, September 2015
Interviewee: Silvia Amado
Origen: Bogotá D.C.
Short description: Bachelor student, Javeriana University, Faculty of architecture and design. Thesis project on bamboo and education.

Silvia was in Palomino in June 2015 doing her field research. As general impressions she transmitted to me: the hostels and hotels don't have many locals working for them. A new 'hippie' era has arrived to Palomino were lots of traveller and volunteers work for 'free' and in return they are allowed to stay in the hostels and eat there. A lot of new commerce, probably due to the increased tourism and the locals are also gaining from it with basically the following activities: moto-taxi, bird watching excursions, surfing and travels to the river (people are taken high in the mountain with motorbike then they walk and finally they gown down the river in tires) the trip cost 18.000 pesos. She met Emma, who actually studied with me in school. She now lives close to Palomino, has a child with an indigenous from the Sierra and sells organic coffee and chocolate.

SUMARY:

- Hotels don't hire locals – only volunteers
- Local economy benefits from tourism by providing special activities like surfing, river trips and excursions
- People: Emma Gaskill - Organic shop of coffee and chocolate from indigenous communities.

Date: Monday 14, September 2015
Interviewee: Gregorio Rojas
Origen: Bogotá D.C.
Short description: Graduate student from Industrial Design, Javeriana University. As a student he was involved with the PEI on the construction of the dry toilets and the house of culture.

Gregorio was part of the second group of students that came to Palomino. They worked closely with 'Zuluart' a collective group from Spain. The PEI program wants to link the academia with the local and traditional knowledge; aiming towards local development.
The dry toilets had three governance approaches: public – by the house of culture, public/private – in the house of Juan De Dios Rodriguez and private – in the house of Bacilia. The problems in the town and for the development of the projects are mainly the lack of appropriation and sense of belonging from the community to the town itself as well as the projects done.
In terms of water management, the extraction wells are close to the septic tanks, which represents a risk of water contamination. Most of the houses have tanks for water storage and carro-tanques (truck with water storage capacity) come into town to fill the tanks.

SUMARY:

- Zuluart – stakeholder on the PEI program. Local knowledge for development with help of the academia.
- Three model of governance for the dry toilets – public, public/private and private
- Problem of appropriation from the community
- Possible drinking water contamination due to septic tanks
- Apparently drinking water is being transported into town

Date: Tuesday 15, September 2015
Interviewee: Esteban, 23 years old
Origen: Pereira
Short description: Esteban studied mechanical engineering, but didn't complete the graduation. He works doing handcrafts and sells them to tourist on the Palomino beach. He is married with a German women and has 1 child. He lives close to Palomino in the next town of Río Ancho (also part of the municipality of Dibulla).

Esteban knows well the town of Palomino, he claims that the service of water comes only on Wednesdays and Saturdays, if it comes at all. There is a competition between the town (inhabitants) and the hotels. The town has access to a pipeline of 1", while the hostels have accesses to a pipeline of 4". In ´puente bomba' by the 'río ancho' the riverbed was detoured to provide fresh water to a plantain plantation.

SUMARY:

- Water supply only twice a week – if it comes; service is not regular
- Resource competition – private interests seems to have priority over the community.
- Better public infrastructure for private investors
- Poor management of the water resources

Date: Tuesday 15, September 2015
Interviewee: Abelaido, 9 years old and Deiner, 10 years old
Origen: Palomino
Short description: Both are school students. Abelaido (right) lives with his mother and 18 siblings in 'El Divino Niño' neighborhood, Deiner (left) lives with his father and 7 siblings in 'Los Pinos' neighborhood.

Both children complained about leakages in the roofs of the houses and some flooding in the streets. They said the water to their houses comes from the aqueduct. They didn't have any especial complains about stomachache due to water consumption. They said that Palomino has 3 schools, divided in kindergarten, primary school and high school. Palomino has 3 parks and they were satisfied with the amount of playgrounds. They couldn't remember the name of their school.

SUMARY:

- Water supply in their houses
- No especial complain about diseases due to water consumption
- No good infrastructure of their homes
- 3 schools in Palomino
- 3 playgrounds
- They didn't know the name of their school – level of education in Palomino?

Date: Wednesday 16, September 2015
Interviewee: Dionisio
Origen: Bogotá D.C.
Short description: Dionisio comes originally from Bogotá. He has live in Palomino for around 1 year. He works in different activities, including fishing. He did a documentary about the Koguis in la Sierra Nevada called: Visita de los Iku.

When asked why Palomino doesn't have a strong fishing economy, Dionisio mentioned that the main reason why Palomino, being a coastal town, is not a fishermen's town is because of the lack of fishes in the water bodies. Due to the intense summer, the river fishes have diminished, also the destruction of the natural habitat, especially of the mangroves had negative effects on the fish population. Next to this issues, nearby there is a new port 'Puerto de Buena Vista', apparently the construction process and the dredging had a negative influence on the fish population in the Caribbean Sea in Palomino. There is also some influence of industrial fishing nearby in Mingueo and Santa Marta.
About the water management in Palomino, Dionisio mentioned that most of them buy plastic water bags for consumption or consume the water supplied to their homes after boiling it. Most homes have private pumps to obtain the water from the main distribution lines; this creates a lower pressure in different area and it has basically become a 'fight' over the resource.

SUMARY:

- Diminish of fish population: intense summer, destruction of mangroves, construction and dredging process of Buena Vista port, industrial fishing.
- Water supply: 'fight' over the resource using pumps. Every house has their own pump. Unequal pressure in the water distribution lines. Plastic water bags and boiling water is common for consumption.

Date: Thursday 17, September 2015
Interviewee: Orfelina
Origen: Palomino
Short description: Orfelina (44) lives with her husband (35) and two young (15 and 14). She works with the governmental institution DPS (Departamento para la Prosperidad Social / Department for Social Prosperity). She is one of the community leaders and a main actors during the construction process of the 'Culture House'
Coordinates: 11º11'44"N; 73º31'43"O
Neighborhood: El Centro

Orfelina mentioned some main characteristic from Palomino, such as the lack of access to internet (WiFi) and no public library. She helped with the program RESA from the DPS and an intermediate organization CEFIN, which was based on food security by means of organic urban agriculture. The program ended on August, 2015 and lasted 10 months. It comprehended the education and supply of seeds and plants for 58 families in Palomino, where they learned about different vegetables, compost systems and how to start cultivating in their backyard. The program benefited an estimated of 1.000 families from the municipality of Dibulla (including the towns of Mingueo, Campana, Dibulla, Flores and Palomino). After the program was complete, each family obtained one small water filter, one small cupboard and one water storage tank of 250L.

As for the water management, Orfelina said that there are three water wells in Palomino: one in La Sierrita, one in the 'Culture House' and one in 'El Divino Niño'. There has been an intense summer over the past two year, therefore Palomino is facing high levels of droughts. Orfelina and her family go to the Palomino River to shower and take water for the normal household activities; her household hasn't received water supply from the public infrastructure for over 10 months. She also buys plastic water bags to supply drinking water for her family; no especial complains about stomachache. Curious quotation: *"Thanks God there is no politics".*

SUMARY:

- Poor levels of education in Palomino: no access to internet and no public library.
- RESA program: organic urban agriculture for food security. Benefits: education to families on urban agriculture for 10 months, water filter, water storage tank of 250L and one cupboard.
- 3 water wells in Palomino: one in La Sierrita, one in the 'Culture House' and one in 'El Divino Niño'.
- Orfelina's household hasn't receive water supply from the public infrastructure for over 10 months.
- Her family goes to the Palomino River to shower and take water for the normal household activities. They also buy

- Plastic water bags for drinking water supply

Date: Thursday 17, September 2015
Interviewee: Adriana Mariño
Origen: Palomino
Short description: Adriana (33) lives with her husband Enrique (44) and three children (18, 12, and 9). Adriana works as a farmer in a rented farm and her husband works in construction. The children go to school.
Coordinates:
Neighborhood: Divino Niño

Adriana works in a rented farm where she and 4 more colleagues cultivate a variety of products, such as: eggplant, papaya and soursop. They are in charge of the whole production process including: land preparation, cultivation, harvest and distribution. The payment agreement with the owner of the farm is 10% of the overall profit and it is subsidized by the UCB (Reforestation project - Edgar Rueda). The yield has been low due to the intense summer.
She and her family are beneficiaries of the RESA program; the tank has no direct connection and it is use just for storage. Some people take a picture from the neighbor's garden and they claim they do their own urban gardening to obtain the benefits of the RESA program.

As for the water supply, it comes every 4 days and now she uses the water filter to treat the water for consumption. Water comes with a lot a chlorine sometimes; once she had four fishes in the 'cement tank' to eat the 'guasarapo' (mosquito larva) and the water came and kill them all. When the water supply doesn't come, she has to go to the Palomino River, it takes her at least 1 hour. There is no public sewage system, they use septic tank and until the day they haven't have problems with it. She complains about the lack of service. The household pays 8.000 pesos for the water service and she thinks this value is ok. There is no water metering. The receipt comes from Dibulla and it is payed to Edinson the 'fontanero' (name given to the operation and maintenance person).

On the weekend there is no health service. The doctor only comes into town on Monday, Wednesday Thursday and Friday. Palomino is big enough, there is the need for a proper hospital and not only a health center. Once one child of Adriana got seriously sick, they had to go to Mingueo and there is no ambulance, so they have to pay for particular transportation until Mingueo and then in Mingueo there was no service so they had to go the Riohacha (90km away); the trip was made in a particular car with no medical emergency equipment.
As for the 'public order', Palomino is a quiet and safe town for the time being. There is no more internal displacement; a big number of families came to Palomino in 2002 when the paramilitary had control over the Sierra Nevada.

SUMARY:

- Agriculture program part of the UCB (Reforestation project)
- Beneficiaries of the RESA program.
- Water quality high in chlorine. Once it killed all her fishes. Fishes are used for mosquito larva control in water storage.

- Water supply every 4 day. When the water received is not enough they go to Palomino River
- Household pays $8.000 pesos for the water service, including waste collection.
- 'Edison' is the "fontanero" (person in charge of operation and maintenance of the aqueduct)
- Palomino has no hospital only a basic health center. No ambulance
- Palomino received high volume of displaced families in 2002.
- Now the town and surrounding areas are 'war free'.

Date: Thursday 17, September 2015
Interviewee:: Mara Zambrano alias Margó
Origen: Palomino
Short description: Margó (44 years old) lives with her husband Joel and two children (Yarly and Abel)
Coordinates: 11º14'14"N; 73º33'22"O
Neighborhood: Divino Niño

Water supply in the morning and afternoon. Once they were over 2 months without water, apparently due to a malfunction in the water pump; also the droughts might have created water scarcity in the main water well.
Bathroom is not directly connected to the pipe lines, they have to fill the tanks with buckets of water. This also applies for the kitchen and shower. They store water in one 'alberca' and the 250L plastic tank obtained as beneficiary of the RESA program. Margó was told that the water filter is supposed to last from 8 months to 1 year with regular use of a family of 4. She doesn't know how much it would cost to replace the filter.
She says that in Palomino there is no public sewage system, but everyone has their own septic tank. She has 2 septic tank and it is an investment of her household. It works quite well and only in heavy rains sometimes the first septic tank gets full, so they didn't use it anymore. It does not present over flooding.

Margó is quite informed about the projects done from PEI. She thinks they have done a great job and they have worked very hard for the community. She mentioned that now there is a legal issue with the territory; the mayor doesn't want to buy the land to preserve the culture house for the community, but instead she wants to do a police station. Margó disapproves that public investment have not a priority of investment in a project for the youth, she believes that the culture house and the workshops done there can help to avoid that the young take drugs and go into illegal armed groups.
Palomino has change a lot and now is extremely peaceful. She doesn't feel insecure at all. She never has been rob, even though there is no much police around.

Date: Friday 18, September 2015
Visit to the Municipality of Dibulla
Interviewee: Geovannys Marbello
Shor Description: Employee Aguas de Dibulla. Governmental institution in charge of management and operation of the aqueduct system in Palomino.
Palomino's water supply is based on a water well in the proximity of the river with a pumping station (electric energy) of 4", then water is transported to storages tanks and to be distributed to the community through gravity. Treatment through choline disinfection. There is not enough capacity to supply to the town, therefore the water is not store long in the storage tanks. Edinson Riva is an employee of Aguas de

Dibulla, he is in charge of the management of the aqueduct system and charging and collecting the payment from water user. The rate depends on the socio-economic condition of each household. The socio-economic level is define by the Department of Planning in Dibulla. There are no blueprints and cartography for the aqueduct infrastructure in Palomino. The infrastructure is a responsibility of the municipality. There it can be found 'Plan maestro de acueducto y alcantarillado – 2010'. It includes various water systems from the municipality, where the current state of aqueduct system and possible solutions to the systems is analyzed.

Date: Wednesday 23, September 2015
Interviewee: Johana
Origen: Palomino
Short description: The Coordinator Palomino's preschool 'Hogar de Primera Infancia'
Coordinates: 11°14'43.63"N; 73°33"24.88"O
Neighborhood: Divino Niño

For 1.5 years the preschool is part of the program CID – Centro de Desarrollo Infantil managed by the organization 'Fundación un mejor vivir' from La Guajira. National policy 'De cero a siempre' - The school provides breakfast and lunch to students.
Nowadays, the school has 150 children enrolled and 21 personnel (including security and nursery). The aqueduct services comes every 8 to 10 days, the institution has a well for water storage, the water is then pump to elevated tanks where it is distributed to the bathrooms and sinks and kitchen. When there is no electricity, the personnel suffers greatly, especially due to the toilets: water has to be taken manually to fill each toilet's tank.
When the water supply from the aqueduct is not enough to fulfill all activities, the school has to buy water from the river. They pay per trip from 12.000 to 20.000 Colombian pesos for 1 to 1.5 m^3 of water. During this year (2015) the school bought at least one trip per month.
Palomino Cultural built a vertical garden for the school, unfortunately due to its proximity to the emergency exit, the structure is not functional and now it serves as part of the recreation and to provide shadow. Urban farming is performed is part of the pedagogical activities.

Date: Monday 28, September 2015
Interviewee: Angel Pinto
Origen: Palomino
Short description: Coordinator Palomino's primary school and secondary school ' Institución Educativa Rural San Antonio de Palomino' and 'Divino Niño'
Coordinates: 11°14'43.63"N; 73°33"24.88"O
Neighborhood: Centro and Divino Niño

The schools has between 870 to 980 students enrolled, counting the student from San Salvador. In Palomino, the student attending the secondary school (also serves as primary school in the mornings) are around 450 and students attending the primary school 'Divino Niño' are around 70-80. The institution has 18 teacher, 2 cleaning personnel and one coordination.
The water supply from the aqueduct is available every 1 to 2 days a week the school has several storage tanks where the water is store and then pump to the elevated tanks for a distribution by gravity the

bathrooms, kitchen and sinks. When no electricity service is available the water used for toilet flushing has to be carried manually. When the water supply is deficient the school has to buy water from the Palomino River at least twice a month.
This bring sanitary problems. The school supplies sometimes lunch for students. It depends on external aid from NGOs. Water bags / bottles for consumption are sold to teachers and students for consumption.

Date: Monday 28, December 2015
Interviewee: Edinson Rivadeneira
Origen: Palomino
Short description: Operator of the aqueduct system in Palomino. Employee of Aguas de Dibulla

There are 7 sectoral valves in Palomino: Divino Niño (2), Carmen Garzon, Centro, Sierrita, La loma. The principal valve is open from 10:30am until 14:00 and from 18:00 until 6am. The distribution is made 1 neighborhood per day.
When the tariff is charged he receives a prove of payment sign and the user stay with one also.
For water quality normally 3 samples are taken, one at the main water well, one at the storage tanks and one at the household level. He does not have the results. No information was given regarding the location of the valves.

Information from anonymous sources:
Due to the character of the information, the source wants to remain anonymous.

A1: The government in the department of La Guajira and subsequently the municipality of Dibulla is extremely corrupt. The aqueduct and the sewage system have been paid at least twice. Official contracts have been made and the construction of the infrastructure is not done.

A2: Politicians make studies and studies and the aqueduct is still does not work in Palomino; politicians come with the project plan but they never fulfil the projects they claim they would do if they get elected.

Appendix D: Surveys per household

Survey for the community

General Information

Household #	1		13m	Name of the interviewed:	
Coordinates				Anauris Pertus Hernández	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	40,72	El Centro / Pavimentada	
O	73	33	44,06	Estrato / SISBEN	3,38 - no es de familia en acción niños no reciben ayuda del gobierno

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

6

How old are they? / ¿Cuántos años tienen?

Miles Hernandez 62, Jose Gregorio Rmoero 37, Anaris Pertus 35, John Jairo Laru 17, Jonathan 15, Milady 13.

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

Colegio Bachillerato 7 - 13:00 vinen a la casa fútbol a la plaza, Jose trabajan en playa 7 - 12.00 - 14:00 17:00, cuidandero. Playstation administran. 4; 1 xBox 360

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

NO HAY SERVICIO

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

NO HAY SERVICIO NO HAY PRESIÓN

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

NO HAY SERVICIO, DE 1 AM A 6 AM

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	PEQUEÑA 1/2"; ELECTRICO
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	9 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

Comprar al señor con timbos y tanques 1000L por 15.000 pesos compra 2 $30.000: Van a lavar al río Palomino, agua Palomino

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

15 min 20 min vuelta

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

3 viajes

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

8 tanques 20 L; 2 días de actividades

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 1 3500L

Tank (plastic) / tanque 1 1000L _ 90L

other tina de 80 L hace rato no llena

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

40L

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		TOMATE AJÍ Y COL; SEMBRADO DE MADERA SEMILLERO MONGO GUNÁBANA, CERCA VIVA YA CASI NO
Animals / Animales	X		1 PERRITO: DOBBY

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

$8.000 incluye aseo; $5.000 sólo agua

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

Alto porque no llega el sevicio. Este año se pusieron de acuerdo para no pagar el servicio en señal de protesta

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7 cuando llegaba

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			**X**	
Turbidity/Turbidez			**X**	**CUANDO LLUVE ES TURBIA**

Chlorine levels / Niveles de Cloro	**X**			MUCHO CLORO, OLOR Y SABOR. PESCADOS SE MUEREN PARA COMERSE EL GUSARAPO

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro	X	SÁBANA PARA COLARLA

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

1 PACA DE 3.000 DURA 1 DÍA. Es parte parte del diario, ahí veces no se tiene

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	x	virosis gripa, dolor de cabeza, mareo, quemando por dentro, amigdalas
Cholera / Cólera	-	
Diarrhea / Diarrea	-	
Other / Otro	x	chikungunya. A todos les dio. Dolor en los pies

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público	No hay acá	
Septic tank / Poza séptica	X	1 POZA, PATIO DE ARENA FILTRA
Latrine / Letrina	-	
Open air / aire abierto	-	
Other/Otro	-	

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO HAY REBOSE

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí		
No	X	SI ALGO SACAN EL TANQUE

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

ANTERIORMENTE MARZO, ABRIL Y MAYO. AGOSTO SEPTIEMBRE OCTUBRE, NOVIEMBRE Y DICIEMBRE LAGRIMERO// DESDE HACE 4 AÑOS EL FENOMENO DEL NIÑO- SOLO LLUEVE ESPORÁDICAMENTE. CAE PARA LA SIERRA.

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE SECÓ FALTA DE LLUVIA Y SE EMPEZÓ A ECHAR BASURA PIEDRAS

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO LO SUFICIENTE PERO HAY INICIATIVAS: RESFORETANDO EN LA PLAYA, UVITA ICACO PLAYERO, PUEBLO SE SIEMBRA. CORPO GUAJIRA AYUDA CON REFORESTACIÓN EN SAN SALVADOR A 7KM HACE 6 AÑOS.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO HAY MOTOBOMBA ADECUADA, MANTENIMIENTO TUBERIA, HACE AÑOS (HACE MÁS DE 37 AÑOS) METIERON TUBOS, PALOMINO HA CRECIDO MUCHO, NO HAY PRESIÓN. ABREN PARA METER ALCANTARILLADO Y NO FUNCIONA, PESIMA ADMINISTRACION

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

EN REUNIÓN COMUNAL, POR LA FINCA EL ALTO, COMPRAR ENTRE TODOS 1000 METROS A 100.000 PESOS + 300.000 DE MOTOBOMBA. HACE UN MES // en un total de 15 casas

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

NO. Resa la gusta por las hortalizas. Cursos del Sena, hortalizas, refostrestación

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

Beneficia a aquellos que tienen las cabañas. Turista y no turista. - hippie, a meter vicio hace como dos años. Bañándose desnudos. Preocupación con la juventud. Patrullaje de tortugas acabo el contrato hace 1 año y medio (sobrino) - se ha llenado terrible.. Si no se ponen las pilas va a quedar esto como Taganga.

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

claro. Sin los hostales se sirven de Palomino, deben darle la mano a Palomoni. No hay salud. Ni agua. No hay médico de viernes a lunes. No hay sala de maternindad. Hospital no da abasto. Con médico permante. Hay que coger pa mingeo.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

pozo ahora no funciona, están secos. Motobomba no da basto. Y dejora 40 min para llenarse la alberca y 15 min se desocupa.

32. Other comments / Otros comentarios

Dónde está la plata del acuedocto se devolvió … A sus bosillos -- Palomino si no votara.

Survey for the community

General Information

Household #	2 14M			Name of the interviewed:	
Coordinates				Eduardo	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	43,07	El Centro / Pavimentada	
O	73	33	44,06	Estrato / SISBEN	2

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

4

How old are they? / ¿Cuántos años tienen?

47, 41, 7, 34 días

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

8 meses de trabajando construcción. Concreto fincan la Arborada. Colegio - 14.30-16.30 Primaria.en casa

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

AHÍ VECES 2 VECES POR SEMANA. SE TURNAN POR BARRIO

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

4 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

1 AM - 5 AM

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2 "**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	COMO 3 AÑOS, 9 MESES DE ESTE AÑO

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

25 MIN 7 30 MIN. LLENAR

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

2

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

4 PIPINAS 20L , 1 25L - CADA 2 DÍAS

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	0	MUCHO GUSARAPO
Tank (plastic) / tanque	1 1 GALON	TAPADO POR SANCANDO
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales		X	1 GATA

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

$7.000 - 10.000 // AGUA Y BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

EL PRECIO ES BIEN . MÁS BARATO QUE COMPRAR EN LOS CARROS

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

6

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			**X**	
Turbidity/Turbidez		**X**		**CUANDO LLUEVE, HAY QUE ESPERAR A QUE SE ASIENTE**
Chlorine levels / Niveles de Cloro			**X**	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)* CUANDO SE ACABA HERVIDA
Other / Otro		

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

1000 PESOS

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	X	CUANDO ES CRUDA
Cholera / Cólera	-	
Diarrhea / Diarrea	X	CUANDO ES CRUDA
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público	
Septic tank / Poza séptica	X
Latrine / Letrina	
Open air / aire abierto	
Other/Otro	

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	CANELECTA , TANQUE DE PLASTICA DENTRO DEL MISMO TANQUE DEL GALON
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

AGOSTO Y SEPTIEMBRE OCTUBRE Y NOVIEMBRE, FENÓMENO DEL NIÑO - YA NO LLUVE 3 VECES EN EL AÑO

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE RELLENÓ Y SE COMPRÓ EL TERRENO. (ALGO RPIVADO), GENERABA MOSQUITO, LAGUNA SUCIA

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. SE CUIDAN AL NO CUIDAR LOS ÁRBOLES DE LAS ORILLAS. EL PALOMINO SE CUIDA. MADERERO ARRIBA EN LA SI

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

SE DAÑAN TURBINAS. NO HAY SUFICIENTE FUERZA, SE ROMPE TUBOS Y DESCUIDO DE LOS TUBOS VIEJOS.

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

ESTOY DISPUESTO A PAGAR MÁS POR EL SERVICIO. POR SERVICIO 24/7 HASTA 15.000 PESOS (DEPENDE DE LO QUE TENGA). PROYECTO DE CONSTRUCCIÓN DESDE RÍO ANCHO -- - EN EL PALOMINO CUANDO DEJA DE LLOVER HAY CAPA VERDE EN PALOMINO. PASO DEL EJÉRCITO. ESTANCAMIENTO RÍO ENTRA POR LA CAÑADA

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

SÍ PRIMERA INFANCIA. AYUDAN DE ALIMENTO PARA LA CASA PAQUETE DE ALIMENTO MENSUAL. AGUANTA COMO PARA DOS DÍAS. DEPENDE DE LA EDAD DE LA BEBE LACTANTE.

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. GENERA EMPLEO. VENTA DE COMIDAS. TURISTA COMPRAN, HACEN CABAÑAS.

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. SERÍA MEJOR. MEJOR COMUNICACIÓN Y ACERCAMIENTO. ELLOS SEPAN LAS NECSIDADES DEL PUEBLO-…

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

CONSTRUCCIÓN DE ACUEDUCTO. ALCANTARILLADO SE HIZO Y NO FUNCIONA. GENTE EMPEZÓ A USAR AL ALCANTARILLADO SIN ACABAR. DEJARON ASÍ EL PROYECTO.

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	3			Name of the interviewed:	
Coordinates				Ana Pertus	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	48,80	El Centro	
O	73	33	43,69	Estrato / SISBEN	no sabe

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

4 + 1 por venir

How old are they? / ¿Cuántos años tienen?

25, 39, 12, 8

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

Colegio Primaria (7.00- 14.30), vendedor ambulante carretera carne asada (8.00 - 20.30) ama de casa

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

2

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

18.30 - 12-00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ	X		
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	1 - 2 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RIO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

20 MIN

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

5 CANECAS - 20L -- 5 DÍAS

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1 2 X 1,20
Tank (plastic) / tanque	0
other	xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

AHÍ VECES CUANDO LLEGA EL AGUA

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales	X		2 POLLITOS, 1 PERRITO Y UNA COTORRITA

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

$11.000 POR MES NO INCLUYE BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

SÍ PORQUE NO LLEGA EL AGUA

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

6

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor	X			**SALADA**
Color	**X**			**AMARILLA**
Turbidity/Turbidez		**X**		
Chlorine levels / Niveles de Cloro			**X**	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	AGUA DEL RÍO. ES AGUA QUE CORRE

Boiling / Hervida	-	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	NO	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

-

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	X	AGUA DEL ACUEDUCTO, RÍO NO
Cholera / Cólera	-	
Diarrhea / Diarrea	-	
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público	
Septic tank / Poza séptica	X
Latrine / Letrina	
Open air / aire abierto	
Other/Otro	

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO, HASTA EL MONTO, CUANDO LLUVE, SE ESTÁ REBOSANDO. SE DEJA DE USAR. USAR EL DEL VECINO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	SACAR EL BALDE O GOTEO DEL TECHO
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

NO SABE SÓLO VIVEN ACÁ DESDE HACE 9 MESES

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NO SABE SÓLO VIVEN ACÁ DESDE HACE 9 MESES

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. LLUEVE VIENE LIMPIANDO; TODO DE RESTO ESTÁ LIMPIO

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO SABE

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

NO SABE

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

Sí. Alimentación todos los meses. Está satisfecho. Van 1 vez a la semana. Y cuando hace actividades. O mandar excusa. De 9.00 a 11.00 - en Palomino por la tienda de Jaminto.. Tiene que hacer el trámite de control. RESA NO

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

NO SABE

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

NO SABE

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

NO SABE

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	4	14M		Name of the interviewed:	
Coordinates				Yulaidy Quintero	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	42,40	El Centro	
O	73	33	39,84	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

7

How old are they? / ¿Cuántos años tienen?

38, 35, 8, 7, 11, 16 ,17

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

3 primaria (7.00-12.30) - bachillerato 7.00 -13.00 -- en la casa. Mamá ama de casa. Trabajos various. (6.30 - 12.00 - 14.00 - 18.30)

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

2

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

MÁXIMO 1 HORA

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

DEPENDE CUANDO LA PONGAN 9.00--

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	1-2 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

20 MIN

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

2-3 VIAJES EN MOTO

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

2 PIMPINAS DE 5 L - TODOS LOS DIAS

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1	4000L
Tank (plastic) / tanque	3	1 TANQUE ELEVADO 250L 50L
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales		X	

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

13.000 PESOS INCLUYE BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

ES JUSTO

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez		X		**CUANDO SE CRECE EL RÍO**
Chlorine levels / Niveles de Cloro	X			**A VECES LLEGA CON UN OLOR Y SABOR MUY FUERTE**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X
Boiling / Hervida	-

Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

1 PACA -- 2.500 PESOS

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Cholera / Cólera	-
Diarrhea / Diarrea	-
Other / Otro	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público	
Septic tank / Poza séptica	X
Latrine / Letrina	
Open air / aire abierto	
Other/Otro	

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

HA CAMBIADO MUCHO. YA NO HAY TEMPORADAS

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NO SABE

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. SE BOTA BASURA, MUCHA BASURA.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO SABE BIEN. ADMISTRACIÓN Y FALTA DE GESTIÓN, FALTA QUE QUEJA CIUDADANA

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

NO PAGARÍA MÁS

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

SÍ. HACE DOS AÑOS. MERIANDES Y COMIDA. RESA NO

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. COMPRAN EN EL PUEBLO. PLAYA. COMPRAR EMPLEO. POR AHORA SIGUE SANO

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. INTERES POR LOS SERVICIOS DE PALOMINO

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

GRAVEDAD PARA AUMENTAR LA PRESIÓN

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	5			Name of the interviewed:	
	Coordinates			Edison	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	31,19	La Sierrita	
O	73	33	38,73	Estrato / SISBEN	no forma parte del sisben

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

12

How old are they? / ¿Cuántos años tienen?

2, 6, 7, 13, 12, 44, 40, 57, 42, 27, 19,33

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

niños al colegio - 3 (7:00 - 12:30), 1(12:30 - 17.00), 2 dueños acá en el restaurante, 1 acá. Resto trabaja 7.00 - 17:00

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

2 - 3 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

10.00 PM

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	4-5 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO, CARRO TANQUE

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

1 HORA

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

20 VIAJES EN MOTO

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

2 PIPINITAS 20L

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1	500L	
Tank (plastic) / tanque	1	1500L	250L
other	xx		

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

NO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		PARA EL JUGO BOLSA DE AGUA
Irrigation / irrigación	X		CULTIVOS, 50 MAIZ, 10 CAÑA 50 PLÁTANO, 2 MANGO , 2 MANOCILLO, GUANABANA
Animals / Animales	X		10 GALLINAS, 7 POLLITOS, 3 PERROS, 1 TORTUIGA

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

10000 - BASURA COBRAN EN LA LUZ

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

ALTO PORQUE NO LLEGA, CUANDO LLEGABA ERA 4.000

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez		X		**ARENA DEL RIO**
Chlorine levels / Niveles de Cloro	X			**MUY FUERTE. SE PASAN DE CLORO**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	-	
Water Filter / Filtro de Agua	X	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

TODOS LOS DÍAS 5 BOLSAS DE 5 L, MAS QUE TODO RESTAURANTE. CLIENTES POR DÍA. RELATIVO -- 10

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	-	
Cholera / Cólera	-	DESDE 90's NO HAY
Diarrhea / Diarrea	-	
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	3 BAÑOS 2 POZOS
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO, RESPIRADERO PARA ESCAPE

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	SACAN CANALETA, 3 TANQUES 1500L 250L 120L
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

HACE UN AÑO QUE NO LLUVIA, ANTES ERA JULIO, NOVIEMBRE. AHORA COMIENZA EN SEPTIEMBRE.

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NUNCA FUE LAGUNA, MÁS CHARCO

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. SIEMPRE, SE HA CUIDADO. 2 ÑOS DE SE SEMBRO GUADUA COTADA (NO ES NATIVA) Y MACANA, ÁRBOLES DE RÍO, SOLO SE LAVA ROPA, NO CARROS, UNA BANANERA A LA ORILLA DEL RÍO PASANDO EL RÍO

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

TUBERÍA, TIENE AÑOS, MANTENIMIENTO, SI SE ROMPE TUBERÍA EL BARRIO MISMO ARREGLA.

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

100,000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

CLARO. ALIMENTO, LECHE, NUTRILO, HUEVOS, SÓLO UN SEMANA. TODOS LOS MIÉRCOLES. SÍ RESA

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ SIRVE, PORQ DAN TRABAJO A LA GENTE DEL PUEBLO. PERO LA GENTE DE LOS HOSTALES NO LES GUSTA QUE VAYAN LOS DEL PUEBLO. SE APROPIAN DE LA PLAYA

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. AYUDEN A LOS DEL PUEBLO. AYUDAR A ARREGLAR CALLES A DARLES TRABAJO. ESTAR TODOS UNIDOS.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

MOTOBOMBA GRANDE, ACUEDUCTO DEL RÍO, PLANTA DE TARTAMIENTO, Y DESDE ARRIBA. ESTUDIOS Y POCA ACCIÓN.. 2.000 MILLONES PESOS EN ESTUDIOS DE AGUA EN PALOMINO

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	6			Name of the interviewed:	
	Coordinates			Arely Vide	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47,96	Divino Niño	
O	73	33	14,88	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

3, mantenemos 6

How old are they? / ¿Cuántos años tienen?

4 niños. 15, 16, 13, 8. 55, 39

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

colegio (7:00 - 13:00) llegan a la casa, mamá y ella en la casa, (por ahora por enfermedad). Normalment ella trabaja (7:00-18:00)

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X
*NO / NO	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuantas horas al dia tiene ud suministro de agua?

4-5 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

NO HAY HORA. SE TIENE QUE ESTAR PENDIENTE

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply comes regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ	X		
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	MÁS DE UN MES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ	*(jump to question 11)*
NO / NO	X

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO DE CARÁCTER PRIVADO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

NADA

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

-

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 0

Tank (plastic) / tanque 2 250L cada 8 días

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ POR EL POSO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		TOMATE, AJÍ CILANTRO, MAIZ, PLÁTANO
Animals / Animales	X		1 PERRO, 10 GALLINAS

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

12.000 PESOS CON EL ASEO

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

NORMAL

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

9

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor	X			**ACUEDUCTO , POSO BIEN**
Color			**X**	
Turbidity/Turbidez			**X**	
Chlorine levels / Niveles de Cloro	**X**			**MUCHO, HUELO A LIMPIDO, ARDOR DE OJOS**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	DEL ACUEDUCTO
Boiling / Hervida	-	

Water Filter / Filtro de Agua	X	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

2 PACAS - 12.000, NO ES BIEN 20 BOLSAS POR PACA

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Cholera / Cólera	-
Diarrhea / Diarrea	-
Other / Otro	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO,

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

MAYO, Y OCTUBRE - DICIEMBRE, MUCHO. YA NO HAY INVIERNO.

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE RELLENÓ. FUE MEJOR, MUCHO SANCUDO, PATIO INUNDADO

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. HAY QUE CUIDAR LOS RECUSOS, ESPECIALEMNTE LOS ÁRBOLES

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

POR LA TURBINA QUE SE DAÑA MUCHO. LA TURBINA ES MUY VIEJA.

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. 200.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

NO; SÍ

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. TRABAJO EN 'LAS MARÍAS' ASEO GENERAL, CAMARERA

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. PARA ESTAR RODEDAOS DE TURISMO. NO HAY PARQUES, NIÑOS DE TURISTAS Y NO HAY PARQUES PARA LOS NIÑOS DEL TURISMO. APROVECHAR LA INFRAESTRUCTURA DEL PUEBLO PARA EL TURISMO.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

MUCHAS CALLES INUNDADA POR TUBERÍA ROTA, PATIOS INUNDADOS BOTANDO AGUA. GENTE NO ESTÁ PENDIENTE DE CERRAR LAS LLAVES. INFRAESTRUCTURA MALA.

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	7			Name of the interviewed:	
Coordinates				William Murga Ruedas	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47,07	Divino Ñiño	
O	73	33	20,32	Estrato / SISBEN	no sabe

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

10

How old are they? / ¿Cuántos años tienen?

26, 25, 23, 22, // 17, 15, 14 //3,5 AÑOS // 71, 43,

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

COLEGIO (7:00 - 12:30 - 13:00); TRABAJAN ARBAÑILERÍA (6:00 - 7:00 - 12:00 -14:00 17:00) POR LA PLAYA. BEBÉ Y DOS PADRES EN LA CASA

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

2

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

DÍA 1 HORA, CUANDO DEPUÉS DE LAS 18:00 TODO LA NOCHE (NO SE SABE POR QUÉ)

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

NO TIENE HORA. CUANDO LE INFORMAN

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	SÓLO CUANDO QUEMA TURBINA -15 DÍAS A 1 MES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO; SUFRE MUCHO CUANDO NO HAY LUZ

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

NADA

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

0

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1	125L	
Tank (plastic) / tanque	1	250L	6 DE 20L
other	xx		

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ CON POSO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		SIEMBRA TOMATES, CILANTRO
Animals / Animales	X		10 GALLINAS

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

27.000, 25.000, 18.000

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

AGUANTA

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

5

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor		X		**POSO BIEN**
Color	X			**AMARILLOSO, POSO BIEN**
Turbidity/Turbidez	X			**CON ARENA Y SUICIO, NO HAY MANTENIMIENTO**
Chlorine levels / Niveles de Cloro	X			**MALO, MUCHO CLORO MATÓ TODOS LOS PECES**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	X	PARA PREVENIR PARÁSITOS
Water Filter / Filtro de Agua	X	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much manoy do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

CUNDO HAY COMO, 2 PACAS. DE BOLSITAS. SE USA MÁS PARA HACER HIELO

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	X	AGUA CRUDA
Cholera / Cólera	-	
Diarrhea / Diarrea	-	
Other / Otro	-	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO, NADA

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

22 AÑOS, EL TIEMPO MEJOR, MEJOR AGRICULTURA, NO HAY AGUAS LLUVIAS AHORA, TANTO EN LA SIERRA, CASI 3 AÑOS. 2000- 2001 EXCESOS DE AGUA AHORA SEQUÍA

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

CERCA DEL MAR MADRE VIAJE LAGUNAS Y MUCHAS AVES, , LIMONCITO, DUEÑOS DE LA TIERRA, HACE LO QUE QUIERAN CON LAS LAGUNAS

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. MUCHA DEFORESTACIÓN. RÍOS CERCA CORPOGUAJIRA LOS MANDÓ REFORESTAR. HA PARADO LA DEFORESTACIÓN. HA BUSCADO ARBOLIZACIÓN

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

PERSONAL DE OPERACIÓN, FALTA DE ADMINISTRACIÓN, ANTES SE PENSÓ TRAERLO DESDE RÍO ANCHO, CAÑO DE LA CAE AL PALOMINO QUE SE LLAMA MANAICE. DE RÍO ANCHO PARA ACÁ ES MÁS ECONÓMICO PORQUE NO HAY QUE ABRIR. TURBINA DAÑADA, POSO EXAMINADO

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

CLARO. 20.000 PESOS

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

AHORA CON EL NIETO. RESA SÍ, CILANTRO QUE LE DIERON ERA MALO

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

POR UN LADO ES BUENO POR EL TRABAJO QUE ENTRA, POR OTRO LADO NO ES BUENO, PORQUE VIENE MUCHO VICIO. 100 HACEN 10 DESHACEN. MALANTROS

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ SERÍA BUENO. CREAR LAZOS SOCIALES

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

MEJORANDO EL ACUEDUCTO. TENIENDO UN ACUEDUCTO POR GRAVEDAD.

32. Other comments / Otros comentarios

MEDICO NATURISTA DEL PUEBLO. BASES DE PLANTAS. CONTADOR DE LUZ. AYUDA A LOS VECINOS NUEVAS REDES DE LUZ Y CONTADOR. TODO EL BARRIO DIVINO NIÑO. CONTADOR COMMUNITARIO

Survey for the community

General Information

Household #	8			Name of the interviewed:	
	Coordinates			Nancy Helena Díaz Álvarez	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	51.27	Alto donai // Divino Niño	
O	73	33	14.83	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

11

How old are they? / ¿Cuántos años tienen?

5, 8,7, 16, 17, 13, 42, 6, 22, 18, 59

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

colegio (7:00-12:00) todos menos el de 5 años. 1 ama casa. 59 incapacitado (7:00 - 16:00) -- oficios varios playa.

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

6 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

18:00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	8 DÍAS

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

2 HORAS

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

3 VIAJES

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

CANECA EN CARRETILLA 20L X4 -- 1 DÍA

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca

Tank (plastic) / tanque 1 300L

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

DEPENDE , AHÍ VECES NO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		MATAS, MATAS DECOARTIVAS
Animals / Animales	X		20 GALLINAS

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

NO

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

-

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

3

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor	X			**HUELE A PODRIDO**
Color		X		**MUGRE O CLARA**
Turbidity/Turbidez			X	
Chlorine levels / Niveles de Cloro			X	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	-	*(jump to question 18 b)*
Other / Otro	-	

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

-

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	X	BASTANTE
Cholera / Cólera	-	
Diarrhea / Diarrea	-	
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público	
Septic tank / Poza séptica	X
Latrine / Letrina	
Open air / aire abierto	
Other/Otro	

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

MUCHA INUNDACION - HASTA 15CM HAY OLORES, MUCHO MOSQUITO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	EN BALDES PINPINETAS
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

15 AÑOS--- AGOSTO - DICIEMBRE, SÍ MUCHO. HACE 9 MESES NO LLUEVE ESTE AÑO

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

LA ENTERRARON, NO HACE FALTA, MUCHO MOSCO ANTES

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. SE CUIDAN RECURSOS

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

PORQUE NO HAY ACUEDUCTO. NO HAY TUBERÍA MANGUERA SE CONECTA DESDE ARRIBA

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. 5.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

SÍ ANTES. SÍ PERO SÓLO UN TANQUE COMO DE 20L LES FALTO RECIBIR EL FILTRO DE AGUA

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SI PORQUE ES LA FUENTE DE TRABAJO. ENTRA PLATA AL PUEBLO POR EL TURISMO

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. PODRÍA ASOCIARSE MÁS LOS DE LAS PLAYAS NO REQUIEREN NADA CON LA GENTE DEL PUEBLO. YA NO DEJAN NI ENTRAR A LAS PLAYAS. ELLOS NO DEJAN ENTRAR

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

QUE HAYA INFRATESRUCTURA Y ACUEDUCTO

32. Other comments / Otros comentarios

DESPLAZADOS DEL SAN SALVADOR HACE 10 AÑOS

Survey for the community

General Information

Household #	9			Name of the interviewed:	
Coordinates				Adriana Mariño	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	45.82	Divino NiÑo	
O	73	33	30.96	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

5

How old are they? / ¿Cuántos años tienen?

17, 12, 9, 31, 35

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

colegio bachillerato (7:00-15:00) (primaria 7:00 -12:00)- 17 trabaja de ayudante (6:00 - 16:00). Arriba san salvador (6.30-11.00) trabaja en la casa con el bloque y oficios varios

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

2 /CADA 4 DIAS

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

1 A 2 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

12:00 O 16:00 O 18:00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	2 SEMANAS

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

1 HORA

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

PIMPINAS 5L 4 O 250L Y PAGA -- POR VIAJE COBRAN 25.000 -- DURA 5 DÍAS PORQUE TB SE HACE BLOQUE

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1 3 CHICHES
Tank (plastic) / tanque	2 250L
other	xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

NO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		
Animals / Animales	X		3 PERROS Y 20 GALLINAS

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

11,000

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

BIEN

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

6

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez		X		
Chlorine levels / Niveles de Cloro	X			**SABOR LIMPIDO Y MATÓ A LOS PECES.**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	-	
Water Filter / Filtro de Agua	X	
Bottled water / Agua en bolsa	-	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much manoy do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

ANTES DE TENER EL FILTRO

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	X	HACE 1 AÑO A LA NIÑA
Stomach ache/ Dolores de estómago	-	
Cholera / Cólera	-	
Diarrhea / Diarrea	-	
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

SI LLUEVE SUBE POR LO MENOS 15 CM. OLORES EN LA CALLES

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	CANELATE AL TANQUE
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

OCTUBRE, NOVIEMBRE Y DICIEMBRE. HA CAMBIO MUCHA SEQUÍA.

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE RELLENO. ERA UN CHARCO LLENO DE SAPOS Y MOSCOS

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. TIRAN MUCHA BASURA EN EL RÍO.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

SÓLO SON DOS ALBERCAS Y PALOMINO HA CRECIDO MUCHO

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. 200.000 Y PONER TIEMPO Y EXPERTICE

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

RESA

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ, NEGOCIOS Y TIENDAS, MUEVE DINERO.

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

CLARO. POR EJEMPLO LAS HORTALIZA, QUE COMPREN LOCAL. CADENA DE PRODUCTOS ORGÁNICOS ((--100.000 BEJERENJA 1LIBRA 1.500))

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

SE BOTA MUCHA AGUA, LAS MANGUERAS ESTÁN ROTAN Y SE RIEGA AGUA EN LAS CALLES.

32. Other comments / Otros comentarios

HAY PROBLEMAS CON LA BASURA. QUIERE ARREGLAR EL FUNCIONAMINETO PORQ ELLA HACE ABONO ORGANICO

Survey for the community

General Information

Household #	10			Name of the interviewed:	
Coordinates				Antonio Hernandez Urango	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47.04	Divino Niño	
O	73	33	22.43	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

4, 5

How old are they? / ¿Cuántos años tienen?

13 meses, 4 años, 6, 7, 73, 64, 31, 39, 37

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

6, 7 colegio sede divino niño (7:30-11:30), 31 trabaja en bloquera, 39 agricultor campo, (7:00-14:00) , 37 ama , en casa

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

1-2 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

9.00 - 10.00 AM // 19.00-20.00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	3 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

COMPRAR O AL RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

3 HORAS

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

PIMPINETAS 4 - 5 GALONES 20L - 1 DÍA

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 1

Tank (plastic) / tanque 3 200L // 10 GALONES

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ ALCANZA A LLENAR -- MÁXIMO 2 DÍAS

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales	X		1 PERRO MONCHI

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

NO SE PAGA ESTABLE. INCLUYE BASURA - $8.000

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

MUY ALTO PORQUE NO LLEGA EL AGUA

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez			X	RÍO CUANDO LLUEVE ES TURBIA
Chlorine levels / Niveles de Cloro	X			PASADO DE CLORO

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-

Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro	-	

18b. How many bottles do you buy per week? How much manoy do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

2 PACAS NO DURA NADA, ES NECESARIA, 2 DÍAS. 50 BOSITAS. 2.500 PESOS. ES COSTOSO.

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-	
Stomach ache/ Dolores de estómago	X	
Cholera / Cólera	-	
Diarrhea / Diarrea	X	AHÍ VECES
Other / Otro		

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

MUCHO - 20 CM, AHÍ VECES SE LLENAN LOS POZOS. CON MUCHO OLORES

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

18 AÑOS OCTOBRE - NOVIEMBRE -DICIEMBRE; MARZO, Y FEBRERO, ESTE AÑO PURO VERANO

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE RELLENÓ. HABÍA CAIMAN DE AGUJA. SE COMPRÓ Y SE RELLENÓ CON ESCOMBRO, TUMBARON Y SE VEIA DIBULLA LOMA. ERA MUY FEO, MOSQUITO, PELIGROSO CON LOS NIÑOS

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. SE SIEMBRA MUCHO ÁRBOL PARA REFOSRESTAR EL RÍO

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

MAL ADMINISTRACIÓN, ALCALDÍA NO HACE ACUEDUCTO BUENO, FALTA ADMISTRACIÓN GESTIÓN Y VOLUNTAD, AGUA HAY BASTANTE. FALTA DE RECURSOS

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ PERO DEBERÍASER CUESTION DE LA ADMINISTRACION. MAL DE RECURSOS. 50.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

SI; BIENESTAR, HOGAR INFANTIL, ENTRAN A LAS 8 - 15.30. EDUCACIÓN COMIDA, ALIMENTO. RESA NO

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

CLARO QUE SÍ, DA TRABAJO. SE BENEFICIA A ALGUNOS, FALTA DE DINERO PARA EMPEZAR UN NEGOCIO

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

TURISMO SE BENEFIA MÁS LA GENTE DE AFURA Y NO DEL PUEBLO. APROBAR LO SE HACEN ELLOS Y LO QUE SE HACE EN EL PUEBLO.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

MOTOBOMBA. // HAY ALTOS DE NIVEL DE CORRUPCION. CONTRATOS FALSOS. QUE FUNCIONE POR GRAVEDAD. PROYECTO DESDE RÍO ANCHO Y NO LLEGÓ. DESDE NARAJAL, DESDE HACE 4 AÑOS ESTAN HABLANDO DE MEJORAR EL ACUEDUCTO

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	11			Name of the interviewed:	
	Coordinates			ISABEL SAN MARTÍN	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47	Divino Niño	
O	73	33	22	Estrato / SISBEN	1

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

10 HIJOS + 7

How old are they? / ¿Cuántos años tienen?

48, 27, 29, 26, 24, 21, 19, 17, 15, 14 ++ 1 4 MESES, 8, 7, 5, 5, 4, 3

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

19, 15, 14 (COLEGIO (7:00-13:00) SAN ANTONIO DE PALOMINO. POR LA LAGUNA. A CASA; PREESCOLAR Y PRIMARIA. (7:30-12:00) // EL RESTO TRABAJO Y LA DE 21 NO TRABAJA. (6.30-16.00) TRABAJAN POR LAS CABAÑAS-ESTACION DE POLICIA

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

1-2 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

9.00 - 10.00 AM // 19.00-20.00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	X

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	3 MESES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

3 HORAS

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

UNA LATA 18L EN LA CABEZA

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 1

Tank (plastic) / tanque 3 200L // 10 GALONES

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

LACANZA A LLENAR (MÁXIMO 1 SEMANA)

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales		X	

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

INCLUYE BASURA - $8.000

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

MUY ALTO PORQUE NO LLEGA EL AGUA

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

5

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez		X		RÍO CUANDO LLUEVE ES TURBIA
Chlorine levels / Niveles de Cloro	X			MUCHO CLORO

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	-	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro	-	

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

2-3 BOLSAS DE 5 L -- CADA BOLSA VALE 2.000 DURA 2 DÍAS, costoso

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	X
Cholera / Cólera	-
Diarrhea / Diarrea	X
Other / Otro	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

MUCHO - 20 CM, AHÍ VECES SE LLENAN LOS POZOS. CON MUCHO OLORES

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	PONE TANQUES CUANDO LLUEVE. DURÓ UN DÍA APROX.
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

SI. ESTE AÑO PURO VERANO

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

SE RELLENÓ.

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. SE SIEMBRE MUCHO ÁRBOL PARA REFOSRESTAR EL RÍO

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

MAL ADMINISTRACIÓN, ALCALDÍA NO HACE ACUEDUCTO BUENO, FALTA ADMISTRACIÓN GESTIÓN Y VOLUNTAD, AGUA HAY BASTANTE. FALTA DE RECURSOS

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ PERO DEBERÍA. MAL DE RECURSOS. 50.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

SI A AMBOS

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

CLARO QUE SÍ, DA TRABAJO.

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

TURISMO SE BENEFIA MÁS LA GENTE DE AFURA Y NO DEL PUEBLO.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

MOTOBOMBA. // HAY ALTOS DE NIVEL DE CORRUPCIÓN. CONTRATOS FALSOS. QUE FUNCIONE POR GRAVEDAD. PROYECTO DESDE RÍO ANCHO Y NO LLEGÓ. DESDE NARAJAL

32. Other comments / Otros comentarios

Survey for the community

General Information

Household #	12			Name of the interviewed:	
	Coordinates			Alva Luz García	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47	El Centro	
O	73	33	40	Estrato / SISBEN	-

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

6

How old are they? / ¿Cuántos años tienen?

4, 6, 10, 8, 28, 25

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

Primaria (2) (7:00 - 12.30), (1) 14:30-17.30-18.00. trabaja finca escondida 6.00-16.00. 6.30-12.00//14-17.00 contrucción

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

2

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

1-2 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

MAÑANA O NOCHE //18.00-19.00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ	X		
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	CUANDO SE DAÑA LA TURBINA O SE VA LA LUZ 1 SEMANA O SEMANA Y MEDIA.

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ	X	*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

-

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

-

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

-

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

-

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca	1	1*1,5*0,5
Tank (plastic) / tanque	3	100L
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

SÍ

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales		X	

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

8000 + BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

INCONFERME CON LA BASURA AGUA ES JUSTO

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

10

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez			X	
Chlorine levels / Niveles de Cloro			X	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	
Boiling / Hervida	-	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro	-	

18b. How many bottles do you buy per week? How much money do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

3 PACAS // 24 BOLSITAS// O 5 L -- UNA SEMANA // POR PCACA 2.200 // AGUANTA

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Cholera / Cólera	-
Diarrhea / Diarrea	-
Other / Otro	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

HACE TRES AÑOS MUCHA OCTUBRE Y NOVIEMBRE;SÍ MUCHA SEQUÍA

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NO, LLEVAN ACÁ 2 AÑOS

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

ULTIMAMENTE SE ESTÁ CUIDANDO, NO SE TIRA BASURA, TURISTAS NO TIREN BASURA.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO SABE

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. No se gana tanto pero se colaboraría . Unos 20.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

No. No

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

sí. Yo trabajo en el turismo. Empleo. Hace unos años que no había tanto turista era más difícil obtener empleo. Ahora hay contsrucción y compras de turistas a tiendas locales. Palomino tiene reconocimiento internacional

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

sí. Hacer aportes a las escuelas. Ayudar a la inspectora.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

no sabe

32. Other comments / Otros comentarios

La niña de 4 no estudia.no tenía quien la recogiera. Tiene que ser un adulto.

Survey for the community

General Information

Household #	13			Name of the interviewed:	
Coordinates				Jody Estéfany Narvaes	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	47	Los Pinos	
O	73	33	37	Estrato / SISBEN	-

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

6

How old are they? / ¿Cuántos años tienen?

7,9, 28, 5, 44, 47,

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

colegio (13:00 -18:00), aca en la casa. (28) - 6:00 - 10:00 13:00-18:00, pescador (4:00 - 16:00)

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X	
*NO / NO		*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

1

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

9:00 Y 18:00

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	1 MES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ		*(jump to question 11)*
NO / NO	X	

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

VAN A BAÑARSE AL RÍO, 30 MIN; COMPRAR

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1 - -- 8.000 // SÍ MY ALTO

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

10 TANQUES DE 5 L -- 1 DÍA

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 2

Tank (plastic) / tanque 2 250L

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

NO

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		YUGA, PATILLA TOMATE,CEBOLLIN
Animals / Animales	X		PERRO

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

12.000 SIN BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

POR EL SERVICIO ES MUY ALTO

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

6

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor		X		**SALUBRE**
Color			X	
Turbidity/Turbidez		X		**ARENITA**
Chlorine levels / Niveles de Cloro			X	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	X	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much manoy do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

1 PACA CADA 2 - 3., NO MUCHO

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Cholera / Cólera	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	CANECAS AFUERA
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

NOVIEMBRE Y DICIEMBRE ; SÍ MUCHA SEQUÍA

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NO SABE

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. NO SE ARROJA BASURA.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO SABE, SE DAÑA TURBINA

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ SE HACE. 20.000

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

NO , SÍ

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

HAY MÁS TURISMO HAY MUCHO GENTE DE AFUERA y HAY MÁS TRABAJO

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. UNIRNOS A BUSCAR TRABAJOS, TRABAJADORES DE PALOMINO

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

REUNIONES COMMUNALES PARA TRABAJAR EN EL ACUEDUCTO

32. Other comments / Otros comentarios

INUNDACIONES, CALLE HUELE MAL.

Survey for the community

General Information

Household #	14			Name of the interviewed:	
Coordinates				Carlos, Nelsy y Wilmer	
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	49	El Centro	
O	73	33	41	Estrato / SISBEN	-

General Questions

How many people live here? / ¿Cuántas personas viven en esta casa?

6

How old are they? / ¿Cuántos años tienen?

40, 37, 17, 11, 9 ,7

What are the main activities of the inhabitants from the house? / ¿Qué hacen los habitantes del hogar?

niños para el colegio - 12.30 - 17.00, 1 casa. Trabajo 7:00-12:00 14:00-18:00

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X
*NO / NO	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

2 -3 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

A CUALQUIER HORA - CUANDO LLEGA

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	1 MES

6. The water received each week is enough to fulfil the household activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores de la casa?

*YES / SÍ	*(jump to question 11)*
NO / NO	X

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

RÍO PALOMINO; COMPRAR 10.00O o 16.000 DE 20L

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

COMPRAR

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

1 SEMANA , 1 DIA Y MEDIO

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

-

11a. Where do you storage the water? / ¿Dónde almacena el agua?

Tank (cement) / Alberca 1 1 4000L

Tank (plastic) / tanque 2 2 250 1 500

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

A VECES

12. What are the main uses for the water in your house? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	x		
Cooking and cleaning / Cocinar y limpiar	x		
Irrigation / irrigación		x	
Animals / Animales		X	

13. Does your house has a water metering? / ¿Tiene su casa un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

$12.000 incluye basura. Hay veces llega y ahí veces no

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

NO. Mucha plata para poco servicio

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			X	
Turbidity/Turbidez			X	
Chlorine levels / Niveles de Cloro		X		**BASTANTE PERO YA HA NORMALIZADO**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata	X	
Boiling / Hervida	X	
Water Filter / Filtro de Agua	-	
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per week? How much manoy do you spend per week? Is this a lot of money for you?/ ¿Cuántas bolsa de agua compra ud por semana? ¿Cuánto gasta ud por semana? ¿Es harto o poco para ud este gasto?

AGUA CLANDESTINA EN BOLSA DE PUERTO NUEVO….

19. Have you or your family suffered from the following diseases in the last year? / ¿A sufrido ud. O su familia de las siguientes enfermedades en el último año?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Cholera / Cólera	-
Diarrhea / Diarrea	-
Other / Otro	

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	MIN 2 METROS
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	SACAR EL TANQUE
No		

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en las últimos años?

OCTUBRE. CLIMA ESTÁ LOCO

24. In Palomino's map from 2002 a lagoon is showed, what happened to it? Why did it get dry? / En el mapa de Palomino en el 2002 , hay una laguna. Qué pasó con ella?

NO SABE

25. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ. RÍO PALOMINO BIEN CUIDADO Y SIERRA TB.

26. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

MAL GOBIERNO FALTA DE ADMINISTRACIÓN

27. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

NO PORQ NO CUMPLEN. HASTA 20.000 AL MES -

28. Have you been a beneficiary of the program: de cero a siempre or resa? / ¿Ha sido ud beneficiario del programa de cero a siempre o resa?

NO

29. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SEGÚN EL TURISMO. TURISMO FORMAL Y TURISMO DE MOCHILERO VICIOSO MARIHUANERO. EL PUEBLO SE ESTÁ VOLVIENDO TAGANGA. HOTELS EMPLEAN EN RESTAURANTE Y HOSTALES. PLAYA LLENA DE VICIO. IMAGEN DE PALOMINO. PROSTITUCIÓN. PROBLEMA DE SEGURIDAD..

30. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. CADA CUAL TIRA PARA SU LADO. NADIE SE PROCUPA POR NADIE. LOS HOSTALES TIENEN SERVICIOS PROPIOS Y NO LES INTERESA EL SERVICIO DEL PUEBLO.

31. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

POZO SÉPTICA CONTAMINACIÓN DE POZOS DE AGUA.

32. Other comments / Otros comentarios

**LAGUNA DE OXIDACIÓN POR EL BASURA

Appendix E: Surveys per hotel

Survey for the hotels and hostels

General Information

Survey #	1			Name of the interviewed:	Name of the hotel:
Coordinates				Ernesto Uribe	El Matuy
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	15	10	La Playa	
O	73	32	43	Hotel x	Hostel
Area	12 hectaria (120.000m2/hec)				

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

6 años

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

10 cabanas 4 personas por //35 personas

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

si

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

diciembre, enero, abril, juni, julio, agosto

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

3600

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	X	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO ARTESANAL DE 13M DIAMETRO 1,2M , nivel freatico es muy alto// comprar agua del rio palomino o san salvador -- 2 m3 por 55.000 (cada 2 dias hay que hacerlo) // es un gasto muy alto para el hotel

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

LAGUAN AGUA VAE POR GRAVEDAD

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca		
Tank (plastic) / tanque	4 2000L	CADA CABANA TIENE SU PROPIO TANQUE DURA 1/2 DIA CUANDO HAY 35 PERSONAS
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

sí, PERO EN SEQUIA NO

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	PA QUE NO MUERAN LAS PLANTAS
Animals / Animales	X		3 PURO CRIOLLOS

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

-

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

-

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

10

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			**X**	
Turbidity/Turbidez			**X**	

Chlorine levels / Niveles de Cloro				**NO HAY**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

80 GARRAFONES - 18l POR GARRAFON + BOTELLAS DE AGUA POR HUESPED BOTELLAS POR DIA //POR GARRAFON 6.000 Y PACA DE BOTELLAS CON 24 BOTELLAS OR 15.000 // 1' AL MES // SI PERO ES OBLIGACION

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	14
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	X	CON RECOLECCION DE LA POSA Y AGUAS SUBTERRANES
No		TECHOS DE PALMA

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

ABRIL MAYO JUNI Y SEPT OCTUBRE Y NOVIEMBRE; SI MUCHO NO HAY LLUVIA DESDE HACE 9 MESES NO LLUEVE

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

RIO PALOMINO MUY DEFORESTADO, SIERRA ES MEDIO VIRGEN

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hotel comprometido con el medio ambiente? ¿Cómo?

SI. NO HAY TAL, CLASIFICACION DE BASURA. FORMAN PARTE RENATUR. MIEMBRO ACTIVO. VEGETACION NATIVA. RESERVA DE AGUA NO HAY FUMIGACION, SOLO SACUNDOS. BABILLAS, ARDILLAS PAJAROS CONEJOS

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

NO. LAINFRAESTRUCTURA NO FNMENTA EL TURISMO, NO HAY AGUA, NO HAY LUZ, NO HAY CARRETERAS. NO HAY FIBRA OPTICA. NO HAY COMUNICACION

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

CLARO. COMUNICACION PARA BUENA OFERTA DE EMPLEO. BANCO DE DATOS DE PERSONAL DEL PUEBLO. EL TURISMO DE TRABAJO Y EL PUEBLO DEBE BENEFICIARSE DE éL

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

CLARO. TRABAJO AL PUEBLO. TIENDAS Y GRANEROS SON PROVEEDORES DE LOS HOTELES, AUMENTA LA DEMANDA DE PRODUCTOS Y EMPLEO

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

SANTA MARTA PRINCIPALMENTE Y EN TIENDA DE LEOPOLDO AL MENOS 1.5' AL MES. FERRETERIA. FRUTAS.

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

10 5

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

8 5

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

Falta de boca toma y gravedad, no hay acueducto, aca pura bomba

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

construir acueducto bocatoma y 3km de sanja para meter tubos de conducción y cae por gravedad. Acuducto eficiente donde la gente pague su cuota mensaul. El acuducto podria generar recursos para su manejo y utilidad para futuras inversiones

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

Claro. Si todos invierten yo invertiria 3 millones

34. Other comments / Otros comentarios

Survey for the hotels and hostels

General Information

Survey #	2			Name of the interviewed:		Name of the hotel:	
Coordinates				Rosa Barreto		Tiquihout	
	Grades	Minutes	Seconds	Name of the neighbourhood:			
N	11	15	13	Playas Don aire			
O	73	33	25	Hotel	x	Hostel	
Area	50x60 m						

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

1, año y 6 meses

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

45

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

15 diciembre a 15 de febrero, 15 de junio a 30 de julio.

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

9125

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	X	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO PRIVADO ; NO SABE PROFUNDO ES EL POSO

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca		
Tank (plastic) / tanque	500L	DIARIMENTE EN CAPACIDAD MAXIMA SINO CADA 2 DIAS
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

PROBLEMAS CUANDO SE VA LUZ

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		SI PERO ES AGUA RECICLADA DE LAS LAVADORAS, TODAS LAS AGUAS GRISES SALEN
Animals / Animales	X		PERRO Y GATO

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

X

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

X

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor				**N/A**
Color			**X**	
Turbidity/Turbidez			**X**	

Chlorine levels / Niveles de Cloro			-	**N/A**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

6 DE 5L A DIARIO, 2.500 POR BOLSA, ES UN GASTO IMPORTANTE, PERO NECESARIO

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	4
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO,

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

SEPTIEMBRE A DICIEMBRE; SI HA VARIADO MUCHO

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

70/30 SE CUIDA PORQUE SON LOS LUGARES MÁS LINDOS PARA LOS TURISTO, LOS TURISTAS CUIDAN?. No hay un seguimiento a ellos

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

Sí. Hostal ecológico. No se patrocinan las drogas, todas las habitaciones tienen un ventidalor, y música baja para evitar contaminaciíon auditiva

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

sí. El pueblo deja que los dueños de los hostels hagan los hostales, y conozcan Palomino

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

Sí. Cultural. Más recreaciones cultural.

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

hasta cierto punto y desarrollo dan oportunidad para construcción pero no necesariamemnte mejora la calidad de vidad del pueblo

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

Santa Marta todo lo de Makro, Hierbabuena, cereal -- proveedor mayorista., cosas de Palomino dos variadades el pepe distriaves paloamino y ferreteria, Marquetalia

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

12; 8

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

6, 6 --
riohacha

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

falta de administración. Poca gestion y olvido del estado. Falta de recursos básico

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

mejorar la administración. Implementación, proveer!

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

Sí. ++ no sabe porque no es el dueño

34. Other comments / Otros comentarios

Hotel con Piscina - 12 m *4*1,40(80) // promover lo que maneja la región. Ciudad perdida - magic tour. Tubing -- 18.000 sin guía y 25.000 con guía. Falta capacitación del personal. Guias funcionana como cuidanderos y no como guías

Survey for the hotels and hostels

General Information

Survey #	3			Name of the interviewed:	Name of the hotel:
Coordinates				Rodrigo	Dreamers
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	15	16	Playa don Aire	
O	73	33	25	Hotel	Hostel x
Area	6.000 M2				

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

3 años

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

80

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

diciembre - agosto

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

27740

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	X	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO, PROFUNDIDAD NO SABE

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

-

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca			
Tank (plastic) / tanque	5	1000L	DIARIMENTE
other	xx		

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		PLANTAS Y JARDÍN
Animals / Animales		X	

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

X

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

X

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

4 - NO SE PUEDE BEBER

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor				
Color			**X**	
Turbidity/Turbidez			**X**	

Chlorine levels / Niveles de Cloro				**N7A**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

150L // 7-8 CADA UNO DE 20 L

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	3
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

AFUERA SÍ ACA NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

OCTUBRE NOVIEMBRE, NO SABE

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. TODOS LOS DESECHOS ESTANS EN EL RÍO DEL PUENTE AL MAR Y SEDIMENTO Y EL SEDIMENYTO APESTA

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

SÍ. CAMPAÑAS CON LOS OTROS HOSTALES SOBRE EL DÍA DEL AGUA. ACTIVIDADES ESPORADICAS REDUCCION DE RESIDUAS (VASOS DE VDRIO)

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

NO. HAY NO HAY INFRASESTRUCTURA ADECUADA

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. FUNDACIÓN SENA CON PARA DAR CLASES DE INGLÉS. RIGHT TO SMILE

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. CREA TRABAJO OPORTUNIDADES, DESARROLOO DE HABILIDADES

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

DESDE RIOHACHA O SANTA MARTA EN PALOMINO (DISTRIAVES) Y MINGUEO.

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

20

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

18

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NI IDEA

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

NI IDEA

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

DEPENDE AL SER UN SERVICIO PUBLICO. CUALES SON LAS CAPACIDADES DEL PRIVADO?

34. Other comments / Otros comentarios

Survey for the hotels and hostels

General Information

Survey #	4			Name of the interviewed:		Name of the hotel:	
Coordinates				Delia		Villa Delia	
	Grades	Minutes	Seconds	Name of the neighbourhood:			
N	11	15	19	La Playa			
O	73	33	22	Hotel	x	Hostel	
Area							

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

2 años

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

21+17+12

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

15 diciembre - enero, abril, junio

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

3650

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	X	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO PRIVADO, 4 M

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

0

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca

Tank (plastic) / tanque 4 DE 2000L Y 1 DE 1000L

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

DIARIO , PROBLEMA DE LA LUZ

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		JARDIN
Animals / Animales	X		1 PERRO

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

X

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

X

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

9

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor				
Color			**X**	
Turbidity/Turbidez			**X**	

Chlorine levels / Niveles de Cloro				**N7A**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

12/24;

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	1
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO, CUANDO LLOVÍA, HACE COMO 7-8 AÑOS

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

MARZO, ABRIL, TIMEPO DE MÁS LLUVIA; SEPTIRMEBE OCTUBRE Y NOVIEMBRE. HA CAMBIADO EL AÑO ENTERO SIN LLOVER

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

SÍ, CON LA RESFORESTACIÓN A LA ORILLA DEL RÍO. DESCUIDAO DE LAS ORILLA DEL RÍO CREA SEQUÍA

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

SÍ. CON CORPOGUAJIRA. VIENE Y REVISAN, SE RECOJEN BASURA Y ESO, SI EL ÁRBOL PERJUDICAN.

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

SÍ. UTILIZA LA INFRESTRUCTURA DE PALOMINO

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ YO SOY AMIGA DE TODOS LOS AMIGOS DE PALOMINO.

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. TURISMO LLEGA EL BILLETE, SIN TURISMO NO HAY PLATA

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

CADA DOS DÍAS A RIOHACHA Y SANTAN MARTA Y BARRANQUILLA. PORQUE VIAJA Y LOS ARTICULOS SON BARATOS ALLÁ

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

7.5

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

5

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

NO SABE, LLEGA MUY POCAS VECES Y LLEGA POR SECTORES, Y SE VAN PARA EL RÍO

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

NO SABE

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

ESO LE TOCA A LA ALCALDÍA COMO GASTO PÚBLICO.

34. Other comments / Otros comentarios

Survey for the hotels and hostels

General Information

Survey #	5			Name of the interviewed:	Name of the hotel:
Coordinates				Milena Beleño	San Sebastia´n
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	15	20	Playa	
O	73	33	23	Hotel	Hostel x
Area	1,5hec				

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

3 años

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

25

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

abril, 15 diciembre y enero, febrero

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

1825

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	X	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

POSO PRIVADO - 5 METROS

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

0

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca

Tank (plastic) / tanque 3 1000L

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

TURBINA AUTOMÁTICA - 5 VECES AL DÍA

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación		X	
Animals / Animales	X		1 PERRO

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

X

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

X

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			-	
Color		**X**		
Turbidity/Turbidez		**X**		

Chlorine levels / Niveles de Cloro				**N7A**

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

CADA QUIEN COMPRA BOTELLA // 2 GARRAFONES QUE DURAN 2 SEMANAS SON 3

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	X
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	3
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

SI LLUVE MUCHO SE INUNDA, SÍ CLARO SE FILTRAN AGUAS. HACE UNOS 5 AÑOS QUE NO PASA ESO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

OCTUBRE, NOVIEMBRE ABRIL. SÍ. YA NO LLUEVE

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. MUY MAL MANEJO DE BASURAS.

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

SÍ PERSONALMENTE, PERO SÓLA ES MUY DÍFICIL. LOS TRISTAS NO AYUDAN TAMPOCO. EXTRANJERO ES MAS CONSIENTA FLATA DE CULTURA

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

MÁS QUE TODO DE LAS TIENDAS

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ. HAY UN RECELO. MUCHOS HOSTALES TRAE GENTE DE AFURA NO HAY PRERACIÓN DE LA GENTE DEL PUEBLO. PUEBLO ESTÁ ABANDONADO.

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SI SE SABE MANAJAR. SE PUEDE CONVERTIR EN UN CHOQUE. HAY MUCHO VICIOSO. MUCHO EXTRANJERO. PERJUDICA O BENEFICIA?

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

MAYORÍA ES DE AFUERA. TIENEN COCINA. Y ELLOS COMPRAN DE ACÁ. EN CAMBIO EL GRANDE COMPRA.

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

5.2

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

todos

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

falta de conciencia y administración, siempre ha sido un problema con el agua. Agua se está vendiendo a los hostales grande en el pueblo.

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

debe haber inversión para acueducto y alcantarillo. Atención del municipio

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

sí. Diuficil decir cuanto porque no está el duenño.

34. Other comments / Otros comentarios

EL HOTEL ES MUY CONCIENTE DE LOS BENEFICIOS QUE PUEDE TENER EL PUEBLO.

Survey for the hotels and hostels

General Information

Survey #	6			Name of the interviewed:	Name of the hotel:
Coordinates				Pablo Mariño	Cabañas Brava
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	15	19		
O	73	33	21	Hotel x	Hostel
Area	2 hectares				

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

3 años

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

108

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

diciembre y enero, smeana semana abril, juni y julio

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

19710

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ		
*NO / NO	x	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	
NO / NO	

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO		If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ		*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

Poso privado; prfundidad 2 m

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

0

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

0

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

0

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca

Tank (plastic) / tanque 6 1000L diarimente, planta propia propia

other xx

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

sí

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	x		
Cooking and cleaning / Cocinar y limpiar	x		
Irrigation / irrigación	x		Jardín, cultivos, frutales, platano y yuca, autosuficiente
Animals / Animales	x		3 perros y gatoos

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	x

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

x

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

x

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

7

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			-	
Color			**x**	
Turbidity/Turbidez			**x**	

Chlorine levels / Niveles de Cloro				

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

GARRAFON DIARIA // DIARIAS 10 PACAS 24 UNIDADES / SEMANA // GASTO IMPORTANTE (VENTA)

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	-
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	2 3 M
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO, NO

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

ABRIP Y MAYO; YA NI SE SABE , VERENO CUNATINUO

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. FALTA DE EDUCACIÓN DEL PUEBLO, NO HAY CONCIUENCA

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

SÍ, RECOLECCION DE BASURAS, COMPOST,

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

NO. LA GENTE VIENE A LA PLAYA EL PEUBLO LE FALTA CUIDADA, NO HAY CALLES,

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

SÍ, EDUCACIÓN RECURSOS DE CAPACITACIÓN PUEBLO VIVE DEL TURISMO. Y QUE PALOMINO ES EL UNICO PUEBLO. HAY SER COMPETENTES, ATENDAR BIEN AL TURISTA, ETC

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

SÍ. NEGOCIOS ALREDEDOR DEL TURISMO, TRANSPORTE HAOTSLEM RECRECIÓN . EDUCACIÓN. CONSERVACIÓN BILÓGICA

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

SANTA MARTA AL POR MAYOR. POCAS COSAS EN PALOMINO.

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

6, 2

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

TODOS	2 NO	SI NO DA EL RENDIMIENTO

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

FALTA DE ADMINISTRACIÓN. PEUBLO SIN AGUA Y DOS DOS RÍOS

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

POLITICOS HONESTO QUE HAGAN ALGO POR LA COMUNIDAD.

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. DEPENDE DE LA NECESIDAD Y EL PLAN. MÁXIMO 5'

34. Other comments / Otros comentarios

PISCINA - DIMENSIONES 15*4*1 …INVERTIR EN LA INFRAESTRUCTURA BÁSICA PERO SALVAVIDAS DEL PERSONAL.

Survey for the hotels and hostels

General Information

Survey #	7			Name of the interviewed:		Name of the hotel:	
Coordinates				Jasnim Guzman		Nakua	
	Grades	Minutes	Seconds	Name of the neighbourhood:			
N							
O				Hotel		Hostel	x
Area	19m*30m						casa

General Questions

How long has the hostel been functioning? / ¿Hace cuánto funciona el hotel?

1 año

What is the maximal capacity of the hotel? / ¿Cuántos huespedes puede alojar?

14

Is the hotel at its maximal capacity during the 'high season'? / ¿Está el hotel en su máxima capacidad durante la temporada alta?

sí

Which months represent the 'high season'? / ¿Qué meses son de temporada alta?

todo el año hay extranjero. Diciembre y semana santa

How many hosts do you estimate you recieve per year? / ¿Cuántos huéspedes estima ud que hospeda por año?

1022

Aqueduct / Water Supply (Quantity)

1. Do you have connection to the aqueduct service? / ¿Tiene ud. Conección al servicio de acueducto?

YES / SÍ	X
*NO / NO	*(jump to question 7)*

2. How many days per week do you have water supply? / ¿Cuántos días a la semana tiene ud. Servicio?

1

3a. How many hours per day do you have water supply? /¿Por cuántas horas al día tiene ud suministro de agua?

2-3 HORAS

3b. At what hours do you receive the service? / ¿ A qué horas recibe el servicio?

SERVICIO SORPRESA// EL RPOBLEMA CUANDO UNO NO ESTÁ NO PUEDE RECOGER

4a. Do you use a pump to obtain the water supply? Which capacity? [HP, L/s] / ¿Usa ud motobomba para la obtención del servicio? ¿Capacidad? [HP, L/s]

YES / SÍ	X	**1/2"**
NO / NO		

5. Does the water supply come regularly (every week)? / ¿Es el servicio de acueducto regular (todas las semanas)?

YES / SÍ			
NO / NO	X	If no/ for how many days(weeks) have you been without water supply? /si no ¿por cuántos días (semanas) máximo no le ha llegado el servicio?	1 MES

6. The water received each week is enough to fulfil the hostel activities? / ¿Con el agua que recibe semanalmente, es suficiente para realizar las labores del hotel?

*YES / SÍ	X	*(jump to question 11)*
NO / NO		

7. From which water source do you collect water? / ¿De qué fuente recoge agua?

8. How long does the trip takes for you to take water? /¿Cuánto tiempo se demora el viaje para recoger el agua?

9. How many trips do you have to do daily? /¿Cuántos viajes debe hacer por día?

10. What type of container do you use? /¿Qué contenedor usa? \\(quatification in L)

11a. Where do you storage the water? - How many days does it last with the hostel at the maximal capacity?/ ¿Dónde almacena el agua? - ¿Cúantos días le dura el agua recolectada con el hotel en su máxima capacidad?

Tank (cement) / Alberca	1 10000L	cuando está lleno 500L al día (14 perosnas)
Tank (plastic) / tanque	1 6000L	
other	xx	

11b. Do you manage to fill the storage tanks per day of supply? / ¿Alcanca a llenar sus tanques de almacenamiento?

si

12. What are the main uses for the water in the hotel? / ¿Cuáles son las actividades principales que realiza con el agua?

	Yes/Sí	NO	Observations
Daily shower / Ducha diaria	X		
Cooking and cleaning / Cocinar y limpiar	X		
Irrigation / irrigación	X		JARDÍN
Animals / Animales	X		2 GATOS

13. Does your hotel has a water metering? / ¿Tiene su hotel un medidor de agua?

YES / Sí	
NO	X

14. How much do you pay for the aqueduct service? / ¿Cuánto paga por el servicio de acueducto?

20.000 INCLUYE BASURA

15. Do you think the price is fair? Is it high/low? / ¿Piensa ud que el precio es justo? ¿Alto, bajo?

LEY 142 RECAUDO LEGAL NO HAY SOPRTE DE PAGO. HAY PROBLEMA DE PAGO

Water Quality

16. In a scale from 1 to 10 being 10 the best 1 the worst, how would you rate the water quality? / En una escala de 1 a 10, siendo 10 el mejor puntaje, ¿cómo calificaría la calidad del agua?

5

17. How would you rate the following characteristics of the water quality? / ¿Cómo calificaría las siguientes características de la calidad del agua?

	Bad/Malo	Regular	Optimal	Observations / Observaciones
Taste / Sabor			X	
Color			**X**	
Turbidity/Turbidez			**X**	

Chlorine levels / Niveles de Cloro			**X**	

18a. How do you treat the water for consumption? / ¿Cómo trata el agua para el consumo?

No treatment/ No la trata		
Boiling / Hervida		
Water Filter / Filtro de Agua		
Bottled water / Agua en bolsa	X	*(jump to question 18 b)*
Other / Otro		

18b. How many bottles do you buy per month? How much money do you spend per month? Is this a lot of money for you?/ ¿Cuántas bolsa de agua/garrafón compra ud por mes? ¿Cuánto gasta ud por mes? ¿Es harto o poco para ud este gasto?

2 6L DIARIO // (2-3)

19. Have you or your host complained about any of the following diseases? / ¿Se ha quejado ud. o sus huéspede de alguna de las siguientes enfermedades?

Skin rush / Brotes en la piel	-
Stomach ache/ Dolores de estómago	X
Diarrhea / Diarrea	-
Other / Otro	-

Wastewater and Sanitation / Aguas residuales y saneamiento básico

20a. The sanitary service used is: / El servicio de sanitario usado en la casa es

Toilet with sewage connection / Inodoro con conexión al alcantarillado público		
Septic tank / Poza séptica	X	2 SE TRATA CON BACTERIA
Latrine / Letrina		
Open air / aire abierto		
Other/Otro		

20b. Have you had any floodings and/or malfunctinig issues? / ¿Ha sufrido ud de inundaciones y/o malfucionamiento del servicio sanitario?

NO,

21. Do you pay for this service? / ¿Paga por este servicio?

Yes /Sí	
No	X

Other Questions / Otras preguntas

22. Do you do rain water harvesting? / ¿Tine ud recolección de aguas lluvias?

Yes /Sí	
No	X

23. Which months represent the rainy season? Has it been modified in the last years? / ¿En qué meses es invierno? ¿se han alterado las lluvias en los últimos años?

24. Do you think that water resources are being taken care of? (Palomino river, sierra nevada) / ¿Cree ud que cuidamos de nuestros recursos naturales?

NO. INCONCIENCIA TOTAL, TUABN LAS MADRES VIEJAS. DEFORESTACIÓN

25. Have you and your hotel a compromise with the environment? How?/ ¿Está ud y su hostel comprometido con el medio ambiente? ¿Cómo?

SÍ, RECOGE BASURA DE TODOS LOS VECINOS MANEJO DE AGUAS GRISES Y RECUPERACIÓN DE AGUAS

26. Do you think that turism benefits from the infrastructura of the town of Palomino? / ¿Cree ud que el turismo se benefia de la infraestructura del pueblo de Palomino?

maso menos, cada hostal brindar comodidad de acuerdo a la comidad del cliente. De lo que el cliente busque

27. Do you think there should be a closer integration between the hostels and the town of Palomino? / ¿Cree ud que debería haber una integración más cercana entre los hostales y el pueblo de Palomino?

sí. Trabajo de tejido social, conscientisación. Y no mas barraes integración

28. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

siendo un turismo sostenible

29. Where do you buy the main supplies for the hostel (in terms of food, cleaning supplies, etc.)? / ¿Dónde compra ud los suministros principales para el hotel (en términos de comida, productos de aseo, etc.)?

SANTA MARTA. ME GUSTARÍA QUE HAYA UN MERCADO MAYORISTA. COMERCIENTES LOCALES CÁMARA DE COMERCIO PARA PRECIOS ESPECIALES EN HOTELES

30a. How many employers do you have in the high season, in the low season? / ¿Cúantos empleados contrata ud en temporada alta, en temporada baja?

1

30b. How many of your employers are locals (people who live in Palomino)? / ¿Cúantos de sus empleados son locales (gente de Palomino)?

0

31. What do you think are the main problems for water supply in Palomino? / ¿Cuáles cree ud que son los problemas principales en el suministro de agua en Palomino?

32. How do you think the water management (supply and sewage system) could be improved in Palomino? / ¿Cómo cree ud que se puede mejorar el manejo de agua (agua potable y aguas residuales) en Palomino?

AUNTONOMÍA DE LA COMIDAD RESPECTO A UN ACUEDUCTO PROPIO

33. Would you be willing to invest to improve the water supply? How much? / ¿Estaría dispuesto a invertir para mejorar el servicio del suministro y calidad del agua? ¿Cuánto?

SÍ. FORMA DE PAGO. 1 MILLÓN

34. Other comments / Otros comentarios

FONTANERO?? // NEGOCIO EXTERNO DE VENTA DE AGUAU // AGUA DE DIBULLA SE APROPIO DE LA TURBINA // COMITÉ PREOCUPADO POR EL CRECIMIENTO DESMEDIO Y FALTA DE CUIDADO DE RECURSOS NATURALES. TURISMO DE BIODIVERSIDAD// COMITÉ TURISTICO AMBIENTAL HACE 6 MESES. 24 DE JULIO 2015 SE CONFORMA OFICIALMENTE.. LAGUNAS DE OXIDACIÓN DENTRO DEL PUEBLO ?? DEFORESTACIÓN..BASURAS A LAS 3.30 AM//

Appendix F: Surveys per store and commerce

Survey for local stores

General Information

Survey #	1			Name of the interviewed:	Name of the stre:
Coordinates				Laura	Renacer
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	44.69	Centro	
O	73	33	39.32		

General Questions and quantification of water

1. How long has the store been functioning? / ¿Hace cuánto funciona esta tienda?

5 años

2. Which one is the product you sell the most? / ¿Cuál es el producto que más vende?

arroz, aceite, queso, y huevos

3. How many bottled water do you sell per week? - How much does it cost?/ ¿Cuántas botellas/pacas de agua vende por semana? ¿Cuánto cuestan?

4 a 5 pacas -- 100, 200 600cc; pacas 24 2-3

4. Do you sell water to hostels / hotels? - How much?/ ¿Le vende ud. Agua por encargo a los hoteles? ¿Cuánta?

no

5. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

sí porque compran en la tienda.

6. Other comments / Otros comentarios

Survey for local stores

General Information

Survey #	2			Name of the interviewed:	Name of the stre:
Coordinates				Sofía	Jalayur
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	44.93	El Centro	
O	73	33	42.73		

General Questions and quantification of water

1. How long has the store been functioning? / ¿Hace cuánto funciona esta tienda?

hace 1 semana

2. Which one is the product you sell the most? / ¿Cuál es el producto que más vende?

dulces, gaseosa

3. How many bottled water do you sell per week? - How much does it cost?/ ¿Cuántas botellas/pacas de agua vende por semana? ¿Cuánto cuestan?

bolsa // 3 pacas de 24 al día -- a 100 pesos 300cc

4. Do you sell water to hostels / hotels? - How much?/ ¿Le vende ud. Agua por encargo a los hoteles? ¿Cuánta?

no

5. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

sí, porque traen planta. Aca solo compran locales

6. Other comments / Otros comentarios

Survey for local stores

General Information

Survey #	3			Name of the interviewed:	Name of the store:
Coordinates				María Beatriz	el descuento
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	25.82	La Sierrita	
O	73	33	40.06		

General Questions and quantification of water

1. How long has the store been functioning? / ¿Hace cuánto funciona esta tienda?

1 mes

2. Which one is the product you sell the most? / ¿Cuál es el producto que más vende?

Agua

3. How many bottled water do you sell per week? - How much does it cost?/ ¿Cuántas botellas/pacas de agua vende por semana? ¿Cuánto cuestan?

2 pacas de 24 al día -- 300 pesos

4. Do you sell water to hostels / hotels? - How much?/ ¿Le vende ud. Agua por encargo a los hoteles? ¿Cuánta?

no

5. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

claro. No vende mucho a turista más a locales. El turismo ha ayudado a crecer el desarrollo economico en la playa. Antes trabajaba en la paya.

6. Other comments / Otros comentarios

Survey for local stores

General Information

Survey #	4			Name of the interviewed:	Name of the stre:
Coordinates				Madeleine Moscote	La chiquilla
	Grades	Minutes	Seconds	Name of the neighbourhood:	
N	11	14	27.47"	La Sierrita	
O	73	33	39.65"		

General Questions and quantification of water

1. How long has the store been functioning? / ¿Hace cuánto funciona esta tienda?

10 años

2. Which one is the product you sell the most? / ¿Cuál es el producto que más vende?

pan, gaseosa y agua

3. How many bottled water do you sell per week? - How much does it cost?/ ¿Cuántas botellas/pacas de agua vende por semana? ¿Cuánto cuestan?

3 pacas 300cc - 2.500; 2 pacas200cc - 2.000; 5L 3 pacas de 3 bolsa - 2.000 por día

4. Do you sell water to hostels / hotels? - How much?/ ¿Le vende ud. Agua por encargo a los hoteles? ¿Cuánta?

no

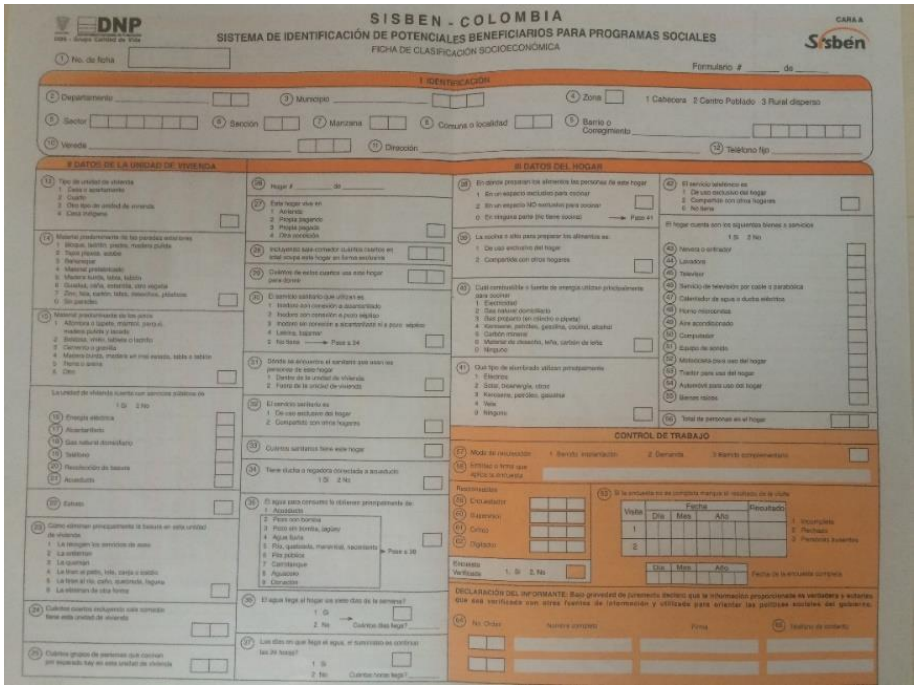
5. Do you think that tourism benefits the economy and development of Palomino? / ¿Piensa ud que el turismo beneficia la economía y el desarrollo de Palomino?

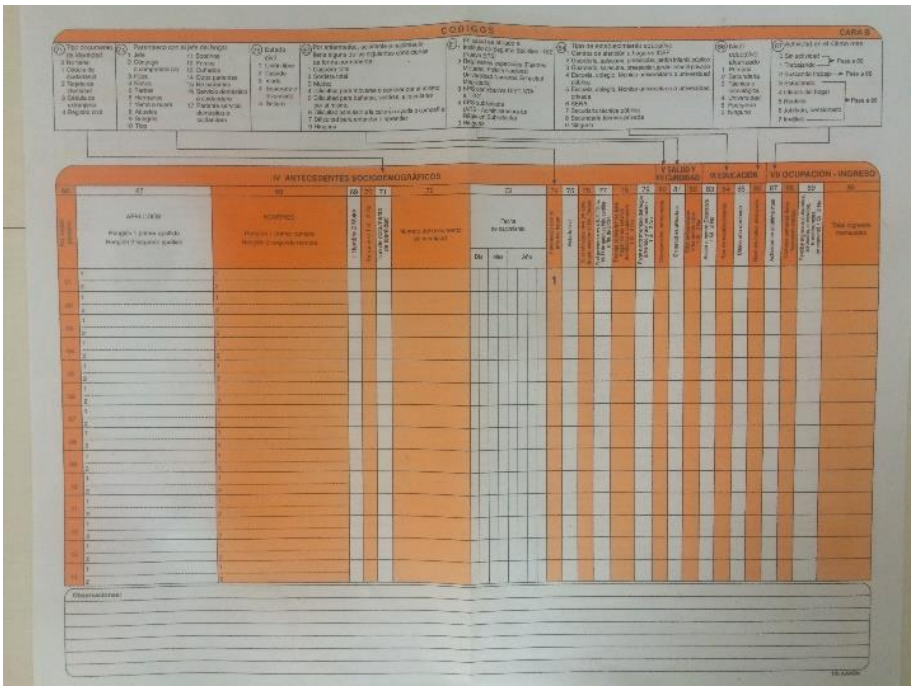
sí. Sin el turismo no hay increso.

6. Other comments / Otros comentarios

Appendix G: SISBEN database

SISBEN (acronym in Spanish for: Sistema de Identificación de Potenciales Beneficiarios de Programas Sociales) is the database used by the governmental institution Department of National Planning (DPN – Departamento de Planeación Nacional) to assess to possible beneficiaries to social programs., such as subsidies in public services, health insurance and education. The SISBEN performs periodically interviews per household with a specific form containing a total of 90 questions to determine the social-economic status of each individual.





Appendix H: List of registered hotels at chamber of commerce

#	Name	ID	Addressee	Link to the chamber of commerce
1	Reserva Natural El Matuy	14609	TRONCAL CARIBE 2.5 KM PALOMINO-RIOHACHA	http://rntguajira.confecamaras.co/detalle-establecimiento/8723/reserva-natural-el-matuy
2	ECO-HOSTAL JAGUAR AZUL	26734	BRR LA SIERRITA-PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/126/eco-hostal-jaguar-azul
3	THE DREAMER HOSTEL S.A.S	41994	DIAG 32 N 151 LOS TRUPILLO MAMATOCO	http://rntguajira.confecamaras.co/detalle-establecimiento/45031/the-dreamer-hostel-s-a-s
4	HOTEL HUKUMEIZI	22770	VIA LA PLAYA KM 2 CRR PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/14710/hotel-hukumeizi
5	RESERVA NATURAL CHUNDWA	27028	CRA 5 NO. 4-68 PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/18591/reserva-natural-chundwa
6	AITE PALOMINO S.A.S	27165	CARRET VIA A MINGUEO KM 2-2 FINCA LA TERRAZA VIA PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/18443/aite-palomino-s-a-s
7	PLAYA LAS MARIAS	27385	CORREGIMIENTO PALOMINO_LA PLAYA	http://rntguajira.confecamaras.co/detalle-establecimiento/19490/playa-las-marias
8	POSADA VILLA MARLEN	32348	CRA 6 CL 4-202 PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/43609/posada-villa-marlen
9	casa surf mar azul palomino	32356	palomino guajira area rural via a la playa, sector los pinos	http://rntguajira.confecamaras.co/detalle-establecimiento/43634/casa-surf-mar-azul-palomino
10	HOSTAL Y BALNEARIO VILLA DELIA	32520	PALOMINO VIA A LA PLAYA	http://rntguajira.confecamaras.co/detalle-establecimiento/43920/hostal-y-balneario-villa-delia-4
11	HOSTAL ALUNA.BUNKUA-SE	33110	CR 6 N 2A-3 CORR PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/44480/hostal-aluna-bunkua-se
12	FINCA ESCONDIDA S.A.S.	34457	PLAYA PALOMINO KM 72	http://rntguajira.confecamaras.co/detalle-establecimiento/45036/finca-escondida-s-a-s
13	ECO HOTEL LA SIRENA	35091	FINCA LA SIRENA-PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/45045/eco-hotel-la-sirena
14	TIKI HUT HOSTEL	35092	PLAYA DONAIRE - PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/45046/tiki-hut-hostel
15	PALOMINO BREEZE S.A.S	36226	VIA PRINCIPAL FERRETARIA PALOMINO GUAJIRA	http://rntguajira.confecamaras.co/detalle-establecimiento/45057/palomino-breeze-s-a-s
16	CABAÑAS PRABA	38450	FINCA BRIGADA 2 RURAL PALOMINO SECCIÓN PLAYA CABAÑAS PRADA	http://rntguajira.confecamaras.co/detalle-establecimiento/45088/cabanas-praba-4
17	CASA SILVESTRE	39501	CL 1C # 6 - 15 PALOMINO	http://rntguajira.confecamaras.co/detalle-establecimiento/45100/casa-silvestre
18	ECOGARDEN	41347	CRA 29A # 69-56	establecimiento/45111/ecogarden-cabaa-as-