Waste Management System Assessment in the North of Argentina

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Abstract

During the last decades, solid waste management has been going through a lot of changes regarding, regulation and applications of models and systems. New practices to solve environmental problems have been approached in different scenarios, situations and in different countries. Today the problem of waste management requires the application of broader approach including new methodologies, systems, practices and models to continue the development toward sustainable systems.

The objective of this thesis to assess the waste management situation in the Provinces of Jujuy (Municipality of San Salvador de Jujuy) and Salta (Municipality of Salta Capital) located in the north of Argentina and to provide technical recommendations to implement or improve their waste management system. To carry out the technical and environmental assessment of the waste situation in the municipalities in Jujuy and Salta, the Integrated Waste Management (IWM) approach from UN-HABITAT and UNEP, Global Waste Management Outlook is applied; as well as the chronological and practical methodology WHAT (Waste Holistic Assessment Tool) from the Municipal Association in Sweden “Gästrike Återvinnare” based on ten (15) aspects that, according to praxis in Sweden, are considered relevant in order to assess the waste management system in a municipality. The Province of Jujuy and Salta are facing environmental problems as contamination of soil and groundwater, landfills producing greenhouse gas emissions and social problems of people living at the landfill that need to be addressed.

The result of this thesis shows that in the province of Jujuy the waste management situation need to be prioritized. At the capital of Jujuy, there are produced 400 tonnes of household waste per day. The level of knowledge of the system perspective is very low and they need the creation of goals, objectives and policies for the implementation of a sustainable system. It is also necessary the assessment of the type and quality of the waste produced, to have a picture of the situation based on facts. The collection and transport need improvements on infrastructure and regarding the workers at the landfill. There is a lack of sorting system or sorting stations. Sorting of waste and recycling is only based on the activity of the informal workers living at the landfill. The construction of a sorting plant at Chanchillos is positive but the lack of separation system limit the usefulness of the equipment. Regarding the financing aspects, there is a system in place for charging the customers for services provided regarding collection of waste, but there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities etc.

In conclusion, the most important aspects with high priority In Jujuy to start with the implementation of an integrated waste management system in Jujuy are: system goals, source and quality of waste, waste sorting, waste treatment, cooperation, planning, financing, knowledge, socio economic aspects and environmental aspects. The results with lower priority are collection and transport, law and regulations, public awareness and business opportunities.

On the other hand, the legislative framework shows that the legislation is in place concerning the issues of waste and environmental protection as well the legislative framework at national and provincial level. However, it is necessary to develop a specific legislation, regarding waste management practices, considering, waste hierarchy as well as the development guidelines regarding extended producer responsibility (EPR). In relation to the technical aspects of the landfill, the results show that there is a potential to implement two different solutions for waste treatment a) The capturing of the landfill gas to
reduce gas emissions from the landfill. b) Possibility to build up a biogas plant with electricity generation or biodiesel production taking advantage of the raw material of the place as manure.

The results in the Province of Salta shows the implementation of an integrated system is in place but it is necessary the improvement of the system. At the capital of the Province of Salta, there are produced 600 tonnes waste a day, that is deposited in a controlled landfill with biogas extraction and only a small percentage of the waste is sent for recycling. Regarding the waste collection and separation there are similarities with the problems of infrastructure described in the Province of Jujuy, such as the lack of trash cans, that makes the collection difficult and the lack of a separation system is a common deficit. The municipality does not have an update data of the quality and quantity of waste since 2003.

In relation to public awareness there is a cooperative in cooperation with a private company that oversees the waste sorting. This program is a good initiative but it only covers 2000 blocks of the city and 14 000 households representing only the 10% of the total area. Regarding the financing there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities, etc. The waste is transported to the landfill, which is using the cell method and is well constructed, considering important aspects as the size of the cells, quantity and variation of rainfall, the absorptive capacity of the waste as well as the control of the capacity of the cells for high degree compaction. However, the controlled landfill has technical problems during the extraction of biogas with leachates and oxygen that ingress into the holes where methane gas is extracted.

In conclusion, the aspects with high priority in Salta are: classification of source and type of waste, cooperation, planning, financing, business opportunities and socio-economic aspects. The aspects with low priority are: system goals, collection and transport, waste treatment, law and regulations, public awareness, knowledge, environmental aspects. This shows that the government strategy is working positively regarding instruments and legislation. However, the control and financial system need improvement to afford the costs of the waste management system. The controlled landfill has technical problems during the extraction of biogas with leachates and oxygen that enter the holes where methane gas is extracted. There is also a potential to a) upgrade the biogas to biofuel or b) for generation of energy which is highly demanded in the Province.

The conclusions of the assessment show that today the problem of waste management requires a broader approach and new methodologies to understand the situation of the decision makers in the area of waste management. Where not only the physical or technical aspects on a waste management system are considered but also broader and deeply oriented aspects that include other factors that describe the cause of the problems. The methodology applied in this thesis called WHAT (Waste Holistic Assessment Tool) can be used as a practical assessment tool in the future, for the analysis of the conditions for the establishment and development of integrated waste management system in a municipality. After the application of the WHAT methodology in this thesis it can be noticed that there is a potential of future improvements of the methodology as a) the inclusion of the Swedish knowledge and knowhow in the area. b) potential to development of a software to provide a quick assessment in a municipality. c) the inclusion of a database for the implementation of waste management. d) potential to include a financial tool with cost and benefits of the investments. According to the concept of sustainable waste management, the system needs to ensure health and safety aspects but in addition it must also be environmentally, effective, economically affordable and socially acceptable.
Key words: Integrated waste management; solid waste, methodology; waste management; waste treatment; landfill; organic waste; biogas.

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Symbols/Abbreviations

CAF Development Bank of Latin America
DIPEC Direction of Census and Statistics of the Province of Jujuy
DGE Direction General of Census and Statistics of the Province of Salta
EPR Extended producer responsibility
GWMO Global Waste Management Outlook
IDB Inter-American Development Bank
INDEC National Institute of Statistics and Census
ISWM Integrated Sustainable Waste Management
IWM Integrated Waste Management
LFG Landfill Gas
SWM Solid Waste Management
UNFCCC United Nation Framework Convention on Climate Change
UNEP United Nations Environment Program
UN-HABITAT United Nations Human Settlements Programme
UNJU University of Jujuy
WHAT Waste Holistic Assessment Tool from Gästrike Återvinnare

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INTRODUCTION

Production of household waste has increased dramatically in recent years, especially in industrialized emerging countries such as Argentina. According to the UNEP (United Nations Environmental Programme), Argentina needs to address institutional, legislative and technological challenges in the area of waste management as well as the need to improve capacity building in the area. (UNEP Global Partnership on Waste Management, 2015).

The target areas for this study are the principal municipalities in the Provinces of Jujuy and Salta in the north of Argentina. The differences between Salta and Jujuy are primarily based on the different stages of implementation of a waste management system as well as the technical, economical and the social aspects. In Jujuy, all the waste generated ends up in the open landfill that does not comply with the technical and sanitary standards, and the deficiency of the waste system is remarkable. In the Province of Salta, the waste is deposited in a controlled landfill with biogas extraction and only a small percentage of the waste is sent for recycling. There exists, in both cases, a social problem with people living at the open landfill, working without any kind of protection or social welfare initiative. Environmental problems are also present with contaminants that enter the atmosphere and groundwater.

The description of the situation can be clearly seen in Figure 1 and Figure 2. Figure 1 shows an open and uncontrolled landfill in the Province of Jujuy and Figure 2 shows the controlled landfill in the Province of Salta with biogas extraction. It is clearly notable that, in both cases, a system improvement is necessary with the aim to achieve environmental targets. Moreover, it is also necessary to consider the application of a broader system approach where not only the physical or technical aspects on a waste management system are considered but also broader and deeply oriented aspects that describe the cause of the system problem, as it is described in the fifteen factors provided by the WHAT methodology. All these aspects are relevant during the implementation or improvement of a waste management strategy, as well as being important as part of a broader oriented system perspective on resource management, were waste issues are discussed together with production and consumption. (Singh, 2014).

The problem in Jujuy and Salta is clear on a municipal level, in terms of lack of sorting and treatment of waste, but it is also equally clear that there are problems on a more general level in terms of greenhouse gas emissions that contribute to enhance the natural greenhouse effect, which is assumed to lead to a warmer climate in the area. Argentina ratified in September 2016 the Paris Agreement and needs to actively work to reduce greenhouse gas emissions levels by 2030. Argentina recently adopted the “Biofuel law” and a new “Renewable Energy law”. The government and municipalities are aware of the necessity of a solution regarding the evaluation of an integrated waste management system, taking the advantage of the local raw materials and the generation of energy that is highly demanded in Argentina according to the legislation of energy efficiency. (Ministerio de Planificación Federal, 2007).
Figure 1 Open landfill "Finca el Pongo" San Salvador de Jujuy, Argentina, April 2016.

Figure 2 Controlled landfill "Finca San Javier", Salta, March 2016.
1. AIM AND OBJECTIVES

The aim of the thesis is to make an assessment, about the current waste management situation and its challenges in the Municipality of San Salvador de Jujuy in the Provinces of Jujuy and in the Municipality of Salta Capital in the Province of Salta in Argentina to assess the waste management situation in both provinces. The research question assumes that a broader perspective and a more complete approach considering the concept of integrated waste management is needed in combination with new models and practices to implement a sustainable waste management system in developing countries.

The objectives are

a) To assess the waste management situation in the Municipality of San Salvador de Jujuy in the Province of Jujuy and in the Municipality of Salta Capital in the Province of Salta.

b) To identify the most critical factors in each waste management system to establish an integrated waste management system.

c) To contribute to further development for stakeholders in the area with a new practical approach for the analysis of the factors that a municipality needs to consider in order to implement or improve an integrated sustainable waste management system.

d) To recommend further actions to implement a sustainable waste management system.

To address the objectives of the thesis, it is necessary to answer the following questions:

1) How is the basic situation regarding waste source, waste composition, waste production and existing waste handling systems in the Municipality of San Salvador de Jujuy in the Province of Jujuy and in the Municipality of Salta in Salta Province?

2) What are the technical, economic, political and social challenges on waste management in each province?

3) What is the potential in terms of technical solutions and raw materials available in this region for biogas or energy production?

4) What are the main challenges that need to be addressed and actions that should be taken to get an integrated waste system in place?

2. SYSTEM BOUNDARIES

The system boundaries are set on the municipal solid waste management system with focus in organic waste, taking into account waste source, collection, transport, disposal, separation and treatment in the two cities, San Salvador de Jujuy with 265 249 inhabitants (DIPEC Drection of Census and Statics -Jujuy, 2010) and Salta Capital, with 536 113 inhabitants (DGE Direction of Census and Statistics-Salta, 2016), as it show in the Figure 3.
Figure 3 Province of Salta and Province of Jujuy located in the north of Argentina. Source: National Geographic Institute.
3. METHODOLOGY

The method in this master thesis is based on an integration of several qualitative research methods. The method is focused on the analysis and description of the current waste situation in the two municipalities in the Provinces of Salta and Jujuy. Moreover, to provide the identification of the possibilities and crucial factors in order to implement an integrated waste management system. The research methodology is developed and based on:
Data collection. Data collection from scientific information, existing databases regarding waste management, primary and secondary source of information is used. As well as information, reports, articles and interviews from the public and private sector at the National level as well as Regional level in the Provinces of Jujuy and Salta. The qualitative data provides a better understanding of the situation. The information was collected through more than 40 interviews during the period of February 2016 to April 2016 in three locations: Buenos Aires, Province of Jujuy and Province of Salta. The most relevant part of the information was provided by the Ministry of Environment in the Provinces of Buenos Aires, Salta and Jujuy. As well as the Governments and Municipalities and the private sector in Salta, Jujuy and Buenos Aires.

The interviews in Buenos Aires, provides a picture about the waste management strategy at the National level. The interviews, in the Provinces of Salta and Jujuy, provides a picture about the local challenges in the waste management area. The data was complemented with the study visits and interviews with the stakeholders and some other studies provided by the government of Salta and Jujuy. The objective of the study visits in Salta and in Jujuy was aimed to obtain information about the source of waste, waste composition, waste quantity, waste collection and transportation and technical information about the landfill area, maintenance, monitoring and leachate. The methodology of observation was used to understand the waste practices at the landfill and to analyze the predominant waste category and the amount of waste.

Integrated Waste Management approach and a new methodology based on waste management practices. In this thesis, the Integrated Waste Management (IWM) approach from UN-HABITAT and UNEP, Global Waste Management Outlook was applied, as well as the chronological practical methodology WHAT (Waste Holistic Assessment Tool) from the Municipal Association “Gästrike Återvinnare” (Gästrike Återvinnare, 2017) based on fifteen (15) aspects that are considered relevant to assess the waste management system in those two locations, considering the Swedish waste management model. Several questions of each factor described in the WHAT model were applied in Salta and Jujuy during the investigation. The answers of each factor provided a validation of the status of each factor on a scale from 1-5 from bad/low level, medium good and excellent. Moreover, suggestions and recommendation to further development of these methodologies are included.

The thesis is processed with different categories of tools and methods, the research stages are described in Figure 5:
The methodology is developed by considering a range of different parameters:

**Environmental:** by the description of the waste situation and the environmental impacts as atmospheric effect and hydrological effects as well as contamination and other types of environmental problems.

**Economical:** by the description of the economic situation regarding funding and costs for investments as well as the possibilities to access public funding.

**Technical:** by the description of the suggestion of the waste treatment technology that can be recommended considering local raw materials.

**Political:** by the analysis of the local legislation on environment and the description of the political goals regarding waste management.

**Social:** by the description of the social problem of people living in open landfills.

**Methodological:** by the description of different methods considering Integrated Waste Management and other methods with broader perspective than has been applied in different waste scenarios in Sweden and abroad.
4. INTEGRATED WASTE MANAGEMENT CONCEPT

During the last decades, solid waste management has been going through a lot of changes regarding, regulation and applications of models and systems. New practices to solve environmental problems have been approached in different scenarios, situations and in different countries. The UNEP in 1996 recognized the importance of Integrated Waste Management and defined the approach as a frame of reference for designing and implementation of new waste management systems. The objective of an integrated system is to be both economical and sustainable.

Today the problem of waste management requires a broader approach which should include new methodologies, systems, practices and models to continue the development of sustainable waste management. Especially, in developing countries with the lack of waste management knowledge or infrastructure. According to the concept of Sustainable Waste Management, the system needs to ensure health and safety but in addition it must also be must be environmental, effective, economically affordable and socially acceptable (McDougall, 2001).

Definition and the development of Integrated Waste Management concept

The definition of Integrated Waste Management (IWM) according with McDougall “combine waste streams, waste collection, treatment and disposal methods, with the objective of achieving environmental benefits, economic optimization and societal acceptability. This leads to a practical waste management system for any specific region” (McDougall, 2001).

Historically, the system approach “Integrated waste management” (IWM) (Wilson, 2015) was proposed by W.R Lynn in 1962 and this approach “viewing the problem as an interconnected systems of component operation and functions” (Mc Dougall, 2001.p 21). The concept was further developed by R.M Clark in 1978, when he included the hierarchical approach to waste management in the United States. The hierarchical approach establishes preferred program priorities based on sustainability and not only end of the pipe approach but mostly on an integrated approach. However, the most important development of the definition was in 1991 when the Economic Commission for Europe published a Draft Regional Strategy for Integrated Waste management defined as a process with necessary control of gaseous, liquid and solid material flow in the human environment. (McDougall, 2001).

In 1996, the UNEP recognized the importance of the approach of Integrated Waste Management and defined the concept as a framework of reference to the design and implementation of waste systems. The “Integrated waste management” approach has also been mentioned in the UNEP’s Governing Council (UNEP GC 24/5 Governing Council Decision, 2007) and in (UNEP GC 25/8 Governing Council Decision, 2009) and it is also classified in (Wilson, 2015) as an integration of the system taking into account the physical elements. In 2010, the United Nations presented the UN-HABITAT approach of Integrated Waste Management as a Global Report developed in 20 cities around the world. The report is based on solid waste and recycling systems providing benchmark indicators and practical information on how solid waste management works in practice in large and small cities around the world. The UN-HABITAT (Figure 6) approach is based on six components:

Three governance components: 1) Inclusivity: user and provider 2) Sound-institutions: proactive policies 3) Financial Sustainability.

Figure 6 The integrated Sustainable Waste Management (ISWM) framework used by the Waste ware indicator set. This is a simplified version of the original ISWM concept drawn by Darragh Marteson (Wilson, 2015).

Later, in 2015 the UNEP developed The Global Waste Management Outlook, a scientific assessment to provide an assessment of the state of waste management situation and practices around the world. The report collects the scientific knowledge from the leading experts in the areas and provides an analysis on governance and finance mechanisms in the implementation of waste management systems. The aim is to also provide tools to stakeholders in the decision-making process taking the holistic approach from UN-HABITAT into account and recognizing resource management toward sustainable development and climate change mitigation.

The analysis model created by Thomas Nylund at Gästrike Återvinnare WHAT (Waste Holistic Analysis Tool) is a practical methodology created in Sweden in 2017 based on waste handling practices, considering the Swedish successful model for establishing a sustainable Waste Management System. The aim of the tool is to take the Integrated waste management UN-HABITAT approach as well as the Global Waste Management Outlook practices and turn them into a practical tool for self-assessment to get a picture of the knowledge, current waste situation and challenges in a municipality. The analysis model is based on fifteen (15) points as described in Figure 7 with a scale from 1-5, where 1 is basic knowledge in the area an low level of actions and 5 is good knowledge in the area and good action level. This methodology is applied to develop this work regarding the assessment of the waste management situation in the Province of Jujuy and Province of Salta.
The WHAT- Waste Holistic Assessment Tool

The objective of the practical analysis model tool is to provide a self-assessment to get an overview of the current waste situation in a municipality. The model can be applied both to the whole system of handling of waste and on a single type of waste to determine the circumstances and possibilities regarding improvements either on the system scale or regarding a type of waste that the user wishes to focus on. Moreover, the analysis model tool also provides support to stakeholders in formulating actions to implement or improve a waste management system. The starting point is to determine the scope of the analysis. It might range from an ambition to cover the whole waste management sector including all kinds of waste in a general matter or to focus on a certain category of waste. It is possible and preferable to target one category of waste at a time and then gather a number of analyses to form the overall general picture.

In the now present version the data-collector and/or the receiver of the answers might do her own validation of the status of knowledge of each factor and the level of action of the stakeholder in relation to each factor. For example, on a scale from 1-5 or from bad/low and not action level, to medium, good and excellent knowledge and good action level.
Scale 1-5
The scale is based on the level of knowledge and level of action related to the different factors:
0: Non-existent knowledge- The essential parts of the knowledge of each factor in the system are missing completely in the system perspective. No action level.
1: Extremely flawed knowledge- Several essential parts of the factor are missing significantly. Low level of actions missing the essential part in the system.
2: Weak knowledge- Several essential elements in each factor exist but need further development. Several actions that need further development.
3: Basic level knowledge- The essential elements of the basic level are fulfilled at the basic level. Basic level of actions.
4: Good level knowledge- Most essential parts of the factor are satisfied at acceptable levels of knowledge. Good level of actions at acceptable level.
5: Very good knowledge- Very good knowledge and complete knowledge in all the essential parts of the factor. Complete actions at good level.

The information about the questions in each factor are developed in the Annex I.

The core platform for the analysis defines the type of waste you aim to target, what amounts there are, what the environmental impact of this waste is and what kind of ambitions do you want to set for improvements regarding decrease of waste and environmental impact, increase of recycling, establishing better treatment etc. The next step is to gather facts on the actual status of a number of key factors that are crucial for a well-functioning waste management system and for the chosen category of waste and improvement ambition, what goal to achieve. This phase can be performed as a self-assessment based on a number of questions regarding the level of development considering these factors. The assessment of the factors is aimed to give a picture of which factors should be targeted in order to achieve the goals that have been set up. After the definition of the most important factors or areas to target a plan of action can be made.

5. THE PROVINCE OF JUJUY IN GENERAL

The Province of Jujuy is located in the north of Argentina. The Province is limited on the north and west with the Republic of Bolivia and Chile respectively and in the south and east with the province of Salta. The Province of Jujuy has an area of 53 2139 km² and its crossed by the Tropic of Capricorn, with a population of 718 971 inhabitants (July 2014). The most important commercial activities are agriculture, livestock, mining and forestry. The Province is also internationally recognized for its ecological and climatic characteristics and for its prized biodiversity with sixteen (16) internationally protected areas.

The most well know areas are:
1. The biosphere reserve, Yungas and Laguna de Pozuelo protected area by the UNESCO
2. World heritage protected by UNESCO, Quebrada de Humahuaca
3. Ramsar site, Laguna de Pozuelo

From the point of view of its ecosystem, the province it is represented in different ecoregions, High Andes Mountains, Central Area Dry and Central Areas Yungas and it is internationally recognized for the biodiversity and its ecosystems (Proyungas, 2010). At the present, the protected and not protected areas are threatened by the waste management problem throughout the province. This thesis is focus in the capital of the Province of Jujuy in San Salvador de Jujuy where the waste management problem is significant in terms of production of waste and in terms of the general environmental problems. The
assessment of the waste management in the Province of Jujuy is developed by WHAT (Waste Holistic Assessment Tool) questionnaire methodology to provide a general knowledge of the local waste situation.

5.1 WASTE MANAGEMENT PROBLEMS AND GOALS IN THE CAPITAL OF JUJUY

The municipal solid waste situation in San Salvador of Jujuy with 265 249 inhabitants, (DIPEC Direction of Census and Statics -Jujuy, 2010) is going through a difficult time. The increase of untreated waste, leads to environmental, health and social problems of people living at the open dumps. The production of unsorted waste in San Salvador de Jujuy has increased to approximately 400 tonnes per day including industrial and hazardous waste according with the information provided in 2016 by the Ministry of Environment. The general estimation of the quantity of household waste is usually based on the population statistics from INDEC ( (DIPEC Direction of Census and Statics -Jujuy, 2010) and is estimated to be 1- 1.5 kg of waste produced per household per day. Therefore, the most prevalent method of disposal is open and uncontrolled dumping. (Ministry of Environment, 2009).

The problems are clear in terms of the increase of clandestine dumps with contamination of soil, air, water, and there also a presence of disease vectors, landscape degradation and risk of fires. The situation requires special attention, especially under the circumstance that the Jujuy is a very important tourism destination and it is dependent of the incomes from tourism that contribute to its economic growth. In other hand, from the waste sector point of view, the waste management problem in the Province of Jujuy is basically a “political problem” due to the lack of sustainable waste management planning and priority measures regarding environmental issues. Furthermore, another important problem is manure waste that they need to address, not only on the final disposal of the waste, but rather to improve control and good practices of the slaughterhouses to implement better cleaning and disinfection procedures.

The Province of Jujuy changed government in December 2015 after several years of political instability. The new government assumed in 2016 bringing priority to the environmental issues, specially, in the area of waste management. Other areas are also included such as water, mineral extraction, oil extraction and protection of indigenous population in Jujuy. The government of the Province of Jujuy implemented a new green strategy called Carbon Neutral 2030. This initiative aims to implement adaptations and mitigations to reduce greenhouse gas emissions as well as to improve the economic, environmental and cultural identity of the Province of Jujuy. (Government of Jujuy, 2016)

Evaluation regarding the general waste management situation and goals in waste management is 1 on a scale 1-5.

5.2 SOURCE AND TYPE OF WASTE

The type of waste is unsorted household waste without prior treatment. There is not any official information or study regarding the exact quantity and type of waste coming to the landfill. However, through the field visit and with information provided by a report made by the university UNJU (University of Jujuy), it is possible to make a general estimation of the quantity of waste, with the reference to the quantity that is collected at the landfill. The estimation is based on the
information of what the informal pickers collect per week at the landfill “Finca el Pongo” to get an estimation of the quality and quantity of the waste.

The informal sector collects per week the following quantities described in the Figure 8:

![Collected waste per kg and week at Finca el Pongo](attachment:collected-waste.jpg)

*Figure 8 Collected waste per week by informal pickers at “Finca el Pongo” Source, UNJU,2015 p.18, Social Inclusion Plan (UNJU University of Jujuy, 2015).*

The Figure 8 shows that the highest quantity of waste collected per week at the landfills is plastic with 24 070 kg per week, in second place paperboard with 13 560 kg, in third place paper with 8 042 kg, in fourth place metal with 1 481 kg, in fifth place glass and textile with 68 kg per week. If we consider that 400 tonnes per day is coming to the landfill, that is an equivalent of 2 000 tonnes per week (5 days a week). Consequently, the quantity that the municipality recycle per week gives an average recovery rate of 2.5% per week.
It was noticed (also through field observation) that regarding the different kinds of waste, one of the most predominant quantities of waste are the plastic bags and pet bottles as well as the organic waste from plants and animals, as is shown in Figure 9. According to the information provided during interviews, the percentage of the organic waste is estimated to 50% and plastic waste around 30% based on the field studies made by the municipality.

Figure 9 Field observation at “Finca el Pongo”, household waste at “Finca el Pongo”, March 2016.

In resume:

<table>
<thead>
<tr>
<th>Tabell 1 Summary of type of waste in Jujuy, Source interview with the Municipality of San Salvador de Jujuy, March 2016.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic waste</td>
</tr>
<tr>
<td>Plastic waste</td>
</tr>
<tr>
<td>Other kind</td>
</tr>
<tr>
<td>Recycle rate</td>
</tr>
</tbody>
</table>

A good example from Versalles, Colombia
A small town, Versalles in Colombia, implemented an integrated waste management plan, with the help of a non-profit organization to avoid contamination of its water and to avoid health impacts of bad practices. The objective was to achieve an adequate collection, transport and disposal. Also, to engage active participation of the stakeholders, administrators and recyclers. The result in 2015 shows a separation rate of 80% with recoverable material and organic matter transformed in compost for sale. Of 42 tonnes of waste generated per month, 27 tonnes are organic matter and 7 tonnes are material for recycling. (UNEP, GWMO, 2015).

Conclusions
A major problem is the uncertainty regarding the quantity and quality of waste. In the Province of Jujuy there is a lack of official information. The production of waste in San Salvador de Jujuy has risen to approximately 400 tonnes per day and the amount of waste generated per household per day is estimated to 1-1.5 kg. All the 400 tonnes of waste goes to open landfill. Sorting is practically made by hand by the informal pickers at the landfill with a rate of 2.5% per week of the total amount of waste.
The fraction of organic waste is estimated to be 50% of the total amount of waste generated. Plastics 30% and other kinds of waste to 20%.

**Evaluation** regarding the general situation in terms of having control over the waste generation and handling situation is 1 on a scale 1-5.

**Recommendations**
Improvements are important to have a picture of the situation based on facts.

**Actions**
It is relevant the improvement of data collection regarding the amounts, quality and different sorts of waste should be taken.

### 5.3 COLLECTION AND TRANSPORT

In the town of San Salvador de Jujuy -the capital of the Province of Jujuy- the collection of 60% of household waste is carried out by the municipality and 40% by a private company. The collection and transport is done on daily basis in the capital city without any kind of separation system. According to the information provided by the Municipality of San Salvador de Jujuy, the waste is transported every day to the open Landfill “Finca el Pongo”, located 23 km from the city San Salvador de Jujuy, where the waste is separated by hand by the informal pickers living there. They collect plastics, paper, metals and paperboard.

During the observation of the collection, it has been identified that there are practical problems that makes the collection of the household waste more difficult. In first place, the lack of trash cans, make the collection of the unsorted waste difficult. The diverse quantity of pick up points for every household means that waste is left in different places as well as that they leave other kinds of waste beside the household waste. In second place, animals as dogs, cats and birds have easy access to the plastic bags and spread the waste, which make the collection even more difficult. Consequently, the collection takes more time. Because of these circumstances, the people working with collection, must pick up the garbage from the floor and other places, which can delay the collection and also cause spinal pain and other kinds of health problems for the people working daily with the collection. That brings not only health risks but also hazardous risks during the collection. The response of the Municipality regarding the lack of cans or bins to improve the waste sorting is that this is because of risk of theft of the material. Regarding the health and hazard risk they provide only gloves to the workers.

In *resume*:

*Tabell 2 Summary of waste management system in Jujuy, source, Municipality of San Salvador de Jujuy, March 2016.*

<table>
<thead>
<tr>
<th>Days of collection</th>
<th>6 days a week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport to landfill every day</td>
<td>23 km</td>
</tr>
<tr>
<td>Quantity</td>
<td>1- 1.5 kg waste per household per day</td>
</tr>
<tr>
<td>Collection problem</td>
<td>Lack of bins and places to deposit the waste</td>
</tr>
<tr>
<td>Health problems</td>
<td>Picking up the waste from different points/contamination</td>
</tr>
</tbody>
</table>
During the study visit the standards of the vehicles used for transport were observed. The transportation is mainly carried out by trucks without compactors. There were only a few units with compactors, just only 10%. During the collection is was observed that, the amount of waste, exceeds the capacity of the trucks and the waste falls during the travel on the highway, with high possibility to cause traffic accidents. To solve this problem -in some cases- the workers put a plastic textile over the waste, which, in most of the cases it is deficient. The Figure 10 shows a truck from the Municipality of San Salvador de Jujuy with the plastic textile.

Figure 10 Field observation, truck from the Municipality of Jujuy at “Finca el Pongo”, March 2016.

**Good example of Municipal collection systems and transfer systems UN-HABITAT**

The UN-HABITAT report provides good examples of implementation of secondary collection systems to improve the collection. This type of collection system avoids the long transport distance to the landfill through the construction of small transfer stations in the city. This trend, putting smaller transfer stations close to the buildings that generate waste, was started in China, Vietnam, Egypt and Nicaragua. This kind of solution, avoids the cost for the municipality, creating small enterprises that provide the services. In this case, the collection is paid by fees which they collect directly from the households to avoid the cost for the municipality. The company also receives an extra income collecting the material and selling the recyclable material. With this solution, the capital required of investment for a municipality will be greatly reduced. (UN-HABITAT, 2010).

According to the UN-HABITAT there are three principles of success in the collection of waste:

- Use the appropriate collection system depending of the waste characteristics, streets, traffic conditions, distance between the collection and disposition.
- Keep costs down by avoiding multiple manual handling of the waste. From Household waste to bigger container and then to the disposal, avoiding the separation by hand.
- Ensure the coordination of primary and secondary collection by the municipality. (UN-HABITAT, 2010).

**Conclusions**

There is an organized regular collection system working six days a week covering the major settlements, which is good. However, the trucks and equipment used for the collection and transport of the waste are poorly suited for the purpose. The use of open trucks results in waste spread in the roads creating risks for the environment, problems with traffic and health issues. There is no sorting of waste prior to collection or transport and consequently, household waste is mixed with hospital waste which increase the risk for diseases and it relates to the working conditions as well.

**Evaluation** of the collection and transportation system gives a 2 on a 1-5 scale.
Recommendations
Improvements regarding the vehicles for collection and transport as well as route planning of collection of waste are necessary. The same applies for the working infrastructure and working conditions. A fixed collection system with fixed bins where people can drop the waste is recommended. It also is important adapt the collection in different points considering different categories as houses, apartments, industrial facilities. (Chandrappa, 2012).

The different system has different levels of services and different costs. The design of the system depends not only of the physical factors, such as type of waste or source, but it is a political issue depending of the willingness of the people to pay for the service. Other factors, that are important are the role of the public authorities to promote public awareness, waste prevention, promote minimization and provide a collection system to separate at origin or in the recycling stations. It is also important to consider the optimization of frequency of the collection as well as the route planning for the collection. (Nilson, 2010).

Actions should be taken for investments in waste bins, collection and transport vehicles.

5.4 WASTE SORTING

There is a lack of sorting system or sorting stations implemented by the Municipality or the private company in charge of the waste collection. The waste sorting is made by informal workers living at “Finca El Pongo”. 121 people live in the landfill including children. They work every day from 5am to 7pm without any kind of protection, salary or any access to social or health services. In addition, some unknown companies send the trucks every day to the landfill where they pick up and buy the material per kilo. After the collection, the material is transported by trucks to the south of Argentina, to Mendoza, Córdoba Rosario, Santa Fe or Buenos Aires. The transport routes of this material are estimated between 1500 km to 2000 km, depending of the city of final transport. Consequently, there is a high grade of the emissions attributed to the transport of the material for recycling. The scenario is very clear, and it is clear the dominant position of the private sector using these workers without taking any social responsibility. (UNJU University of Jujuy, 2015).

The collection of material for recycling is made once a week at “Finca el Pongo” and the material is bought by private companies. They payment varies depending on the type of material:

<table>
<thead>
<tr>
<th>Material per Kg</th>
<th>Argentine Peso AR/ per kg</th>
<th>Equivalent SEK /per kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>White paper</td>
<td>1.8 AR</td>
<td>1.05 SEK</td>
</tr>
<tr>
<td>Plastic</td>
<td>1.00 AR</td>
<td>0.59 SEK</td>
</tr>
<tr>
<td>Paperboard</td>
<td>1.5 AR</td>
<td>0.88 SEK</td>
</tr>
<tr>
<td>Aluminum/Iron</td>
<td>5.00 AR</td>
<td>2.91 SEK</td>
</tr>
</tbody>
</table>

Tabell 3 Material per kg at “Finca el Pongo”. Source field observation at “Finca el Pongo”. The information about the exchange rate was taking FROM SEB bank exchange rates from 2017-10-07 1ARS=0.46 SEK.
In addition, this income is the only source of income of the informal workers without any social or provisional benefits. During the interview, it was observed that workers interviewed, in Figure 11 and 12, showed obvious signs of the consequences of poor nutrition, as well as there are noticed characteristics of lung disease from pollution and other kind of diseases as consequences of their work at the landfill. Due to the low level of education, these workers are forced to work at the landfill without any protection or salary or social insurance.

*Figure 11* Informal workers at “Finca el Pongo”, March 2016.
Regarding the future for 2017-2020, the Ministry of Environment of the Province of Jujuy started with the construction of a recycling station called Environmental Centre Chanchillos. The environmental Centre is in Palpala, very close to the open landfill, about 5 kilometers from “Finca El Pongo” and it is founded by the Inter - American Development Bank. This project includes the construction of a sorting plant and the construction of a controlled landfill and a compost plant for the municipal solid waste. It also considers the social inclusion with the aim to provide better working conditions to the people working at the landfill. The project consists in the construction of a sorting plant. (Figure 13,14) The project includes engineering work, infrastructure, equipment, social inclusion plans and environmental communication. The operative cost of the Centre will be guaranteed by the municipalities of Yala, San Salvador de Jujuy, Palpala, Monterrico, Perico, El Carmen and San Antonio. (Government of Jujuy, 2016).
Figure 13 Environmental Center, Chanchillos, October 2016. Source Ministry of Environment of Buenos Aires.
Consequences of poor planning in India an example from the GWMO, 2015
In Lucknow India, the municipality had a problem of disposal space and they decided to implement a solution to treat 300 tonnes of waste per day that would bring the double-dividend of also generating energy. The biogas plant was built in 2003, but they had to close it in 2004 because of the mixed waste was piling up around the premises. They gave a lot of attention to the technology but they did not have a good waste sorting technique to separate the organic waste. Consequently, the mistake in their planning was more than evident. In this case, the system approach regarding collection and sorting of waste was not considered, leading to problems to get the raw material (organic waste) to the system. (UNEP, GWMO, 2015). This type of problem could also happen in the capital of San Salvador de Jujuy if the municipality does not actively work in the implementation of a proper separation system.

Good example; Building the private sector and reducing poverty through recycling, UN Habitat
The international Finance Corporation (IF) initiated a recycling program with the private sector in the Western Balkans (Albania, FYR Macedonia, Serbia, Bosnia and Herzegovina, Montenegro and Kosovo). The objective of the program is to improve the recycling rate by creating economic, and social inclusion of informal pickers and improve the environment through waste prevention (UN-HABITAT, 2010).

Good example of Inclusion of informal pickers, GWMO
Informal workers at the landfill exist when there is economic crisis and it is difficult for people to find a job. In addition, the import of raw materials is expensive as we can see in the Provinces of Salta and Jujuy. The informal sector is a very complex issue and it is organized differently in each city. The informal sector recover, reuse and recycle material and can contribute to sustainable resource management. Besides, they work independent from the governmental authorities and their work and health conditions are unsafe. In this aspect, it is important and relevant to work actively with the integration and inclusion of the informal workers as important stakeholders in the waste system.

This with the aim to avoid competition with the private sector or organizations in charge of collection and recycling. The education and training of the informal workers is also relevant to understand the value of a clean city. In some cities, the informal sector work with the separation of waste but they leave plastics bags around the city and the rest of the waste. But, as can be seen in cases as in Brazil, the solution for this kind of problem is solved leaving the pickers with the additional responsibility to clean the city and understand the value of having a clean city. Another good example is the City of Bogota that created a register of Recyclers to identify the areas of work, to improve working conditions as well as the creation of network to organize the work. This case was a long process where recyclers has been recognized as a legal organization and as a part in the waste management system (UNEP, GWMO, 2015).

Conclusions
There is no official system implemented for sorting of household waste. No sorting facilities after collection. Sorting of waste and recycling is based on the activity of informal workers living at the landfill picking out materials that can be sold to a private company. Living and working conditions for these informal workers are very poor and hazardous. The material is also transported long distances producing more emissions instead to focus on circular economy and focus on the production of new products locally. The construction of a sorting plant is positive but the lack of separation systems is going to limit the usefulness of the equipment. It will probably make it difficult to do the proper separation, of the waste coming in to the plant, for recycling or for future treatment. The other problems of this system are the direct contact of the workers with the contaminated waste and the lack of the capacity of the
system for 400 tonnes a day. The separation is important, as well it is important to achieve a good quality of the raw material to secure its potential to become material to manufacturing or to implement a waste to energy solution in the future.

**Evaluation** of sorting gives (due to the lack of a proper sorting system) a 1 on a scale 1-5.

**Recommendations**
Improvements of the implementation of a sorting system is a key to higher degree of recycling and lower impact on the environment. A solution could be to start with an association to include the people living at the landfill to allow them access to the social and medical welfare system. This association, could reduce, recycle and recovery the material coming to the landfill. As well as opening the possibility to produce new products locally. Reducing waste is the most important component in waste management. Waste reduction has two important aspects, it is environmentally and economically beneficial to the society, bringing business to the community. The cost saving in reducing waste is usually achieved by less waste being processed and consequently saving energy cost, waste storage space, transport cost, administrative cost and even lower greenhouse emissions. (Williams, 2005).

**Actions**
Actions should be based on a study regarding possibilities of establishing ways of improved sorting of waste in different parts of the handling processes of the waste. It is important that the municipality can educate around separation at origin and provide bins and improvement of collections points. The construction of a separation waste pant it is necessary and the planning of investments and maintenance cost for different solutions. Work with the integration of the informal workers to the social and medical welfare system and the promotion of the concept of circular economy.

**5.5 WASTE TREATMENT - TECHNICAL ASPECTS**

Regarding the disposition of waste is dumped in an open landfill “Finca El Pongo”. The surface area of the landfill is 30 hectares. The landfill “Finca el Pongo” was constructed originally as a sanitary landfill with the trench method. The trench method for the solid waste is when the waste is placed in cells excavated in the soil. The cells are lined with a lining system to restrict the movement of landfill gases and leachate. The cells vary from 50 to 300 m in length, 1-3m in depth and 5-15 m in width. The trucks unload the waste in the trench, and then the waste is compacted naturally due to the semi aerobic biodegradation under a cover of clay. Moreover, the ground is formed with an impermeable clay without any protective membrane. Consequently, there is a high risk of the contamination of groundwater. The soil excavated from the cells is used to cover the waste. According to the information provided by the municipality the cells have a leachate and a gas collection system. However, during the study visit it was verified that there was an absence of the extraction of gas and leachate system. It was also noticed that there is a lack of control of the quantity of trucks coming in and the lack of information of signs or signals regarding worker’s security and it was observed a high risk for accidents.
In the Province of Jujuy, there are 28 slaughterhouses in operation, some of them run by public owners, some by private owners. One of the principal slaughterhouses is located very close to “Finca el Pongo”, around 3 km. The private company running the slaughterhouse, is responsible, for having built a drain to transport completely untreated slaughterhouse waste to a lagoon in the same area, that is severely contaminated with rest of slaughterhouse waste without any kind of treatment. (Figure 16) Moreover, the cattle waste is dumped around the lagoon and covered with tobacco waste. (Figure 17) According to the information provided by the municipality the objective of the tobacco is to remove the smell and the birds.
Figure 16 Lagoon with slaughterhouses waste. Source: Source study visit, April 2016.

Figure 17 Slaughterhouses waste cover with tobacco. Source: Study visit, April 2016.
The cattle waste shown in Figure 18 has still the registration number and is dumped illegally which confirms the lack of administrative control and penalties from the authorities. With this identification, it is possible to identify of the company that dumped the waste in these areas that could be subject to a penalty fee for illegal dumping.

**Moving from open dumpsites to sanitary landfill in Mauritius, GWMO**

In Mauritius until 1980 the waste was deposited in open dumpsites. In 1990, the Government of Mauritius started action to improve the situation by adopting sanitary landfill as a disposal method. Moreover, they built five transfer stations around the island and provided cost-effective transportation.

![Figure 18 Cattle waste with registration number. Source Study visit April 2016.](image)

The services became better by developing institutional capacity and the participation of the private sector as part of the waste management system providing services. In 2011, the private sector invested in a composting plant, where 35 000 tonnes are processed of 450 000 tonnes of waste generated annually during 2014. During 2015, the government had a plan to implement a separation of the waste in organic and recyclables. Here the cooperation with the private sector in business-to business was an important factor for the development of the waste management system. (UNEP, GWMO, 2015).

**Conclusions**

The landfill “Finca el Pongo” is constructed originally as a sanitary landfill with the trench method. The landfill is not constructed or working properly. There is problem of lack of control of the quantity coming in to the landfill and illegal dumping with high risk of negative environmental and health impacts. Regarding the slaughter waste, which is dumped illegally, there is a high risk for water and soil contamination.

**Evaluation** of treatment gives a 1 on a scale 1-5.

**Recommendations**

Improvements and control over the existing landfill and proper planning and construction of new landfills is necessary. The first step is the development of a sanitary landfill practice to address, in first place, the human health concerns. This involves several operational practices that focus on minimizing the spread of disease vectors, to achieve waste compaction, to organize cells and improve the cover soil application at the landfill. This is important to avoid odors, fires and to help stop the storm water and leachate. Is possible to use the extraction of the landfill gas and the utilization of this resource to produce biogas and energy. This practice, includes the conversion of LFG (landfill gas) to electricity using engines turbines. The experience, has demonstrated, that it is important to consider the operational aspects of the landfill to avoid the increase of liquid levels that can affect the extraction of the gas from the landfill. A proper construction of a sustainable landfill can promote efficient gas recovery and
accelerated waste stabilization. (Townsend, 2015). There is a potential to use the slaughter waste and liquid waste generated in the lagoon (Figure 16) as a raw material for biogas or fertilizer production.

**Actions**

Should be taken to close and cover the existing landfill in a way that minimizes the risks of impact on the environment. New landfills must be planned and constructed according to modern environmental standards. The landfill components such as liners, leachate treatment, biogas extraction and management and landfill operation must be considered according to engineered principles. There is a potential to extract the biogas from landfill. It is also necessary to implement a system of control, monitoring and maintenance of landfill. There is also a high potential to improve the collection and dumping of the slaughter house waste to be used as a raw material for biogas production.

### 5.6 LAW AND REGULATIONS

The Province of Jujuy has a general law and three levels of legislation regarding environmental protection. The General Law 5063 establishes the general rules aimed to ensure the protection and preservation and conservation of the environment and promoting sustainable development. The three levels of legislation are described below:

a) **The National Constitution**: establishes the rights and guarantees regarding environment and its protection and the autonomy of the Municipalities to conserve public hygiene. The municipalities are responsible for the compliance of the rules and regulation and for the collection of taxes.

b) **The Province Constitution**: establish also the protection and guarantees regarding the conservation of the environment

c) **National law, decrees and regulations**: there are rules regarding urban solid waste management at National Level and Provincial level. The objectives of the National Law 25 916 (Law 25916, 2004) are the achievement of a management of household waste including collection, transport and deposition of waste. Another law is the National Law 25612 of industrial waste. The same objectives are established in the Province of Jujuy with Law 5063. (Law 5063, 1998) Moreover, exist other complementary and more specific legislation as hazardous waste Law 5011 (Law 5011, 2012) protection of fauna Decree 2187/08, (Decree 2187, 2008) and Industrial waste 5980/06 modified by Decree 9067/07.
In resume

<table>
<thead>
<tr>
<th>National Level Legislation</th>
<th>Province Level Legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pathological waste Decree 6003/06 (Decree 6003/06 , 2006)</td>
</tr>
</tbody>
</table>

The legislation and the environmental protection is assured and the allocation of responsibility and sanctions in cases of non-compliance are clear. However, the problem is usually the non-enforcement of the legislation or lack of penalty for bad practices in waste management. Moreover, there are no labour rules of work protection for the people living and working at the landfills. Also, it is necessary to reorganize the municipalities with clear roles to assure the control of the waste practices, the implementation of waste management plan as well as the legislation on extended producer responsibility.

In September of 2016, a new legislation was approved GIRSU 5954 (Law 5954, 2016) with the aim to improve the waste management system by creating a public company that will oversee the provincial waste management plan, training, infrastructure and new technology to the municipalities to solve the waste management problems.

Conclusions
A legislative framework is in place concerning the issues of waste and environmental protection, as well as specific legislation on hazardous and industrial waste. A new legislation is in process, aiming to improve the waste management in the Province. Resources for training, infrastructure an implementation of new technology will be allocated. However, there is a lack of enforcements of rules and legislation regarding waste management and lack of processes and controls to follow and apply the legislation.

Evaluation of the law and legislation is a 3 on a scale 1-5.

Recommendations
Improvements are needed regarding the implementation of the legislation through sanctions in cases of non-compliance. Framework legislation is necessary to provide legal status to the strategic goals and create a frame of reference for other more specific regulations and to enforce the compliance of the legislation. More specific legislation in zero waste, waste prevention and waste reduction as well as
waste sanctions and extended producer responsibility (EPR) are necessary to implement. According to
the GWMO report, the experiences suggests that an effective waste management requires the
combination of three important instruments: 1) The direct regulation that includes the legislation and its
enforcement 2) The economic instruments, providing the economic incentives and disincentives for
specific waste practices and 3) The social instruments based in communication and cooperation between
stakeholders. (UNEP, GWMO, 2015).

**Effective Legislation, GWMO**
According to the GWMO, in the area of waste management, direct regulation is the base of an effective
waste management system and to assure the compliance of the regulation. The direct legislation relies
on the legitimacy and provides to the authorities with the power of the state to enforce those rules.
Moreover, the application of civil and criminal law plays an important role in order to achieve
environmental protection as well is also important to achieve resource recovery (UNEP, GWMO, 2015).

**Example of good legislation, Milano Italy, GWMO**
In Milano one of the most important pieces of legislation was a Decree 152/2006 that not only improved
the national waste management system but at the same time introduced a separate collection and the
improvement of recycling targets up to 65% by 2012. Consequently, they achieved an important
separation of food so that it is collected separately. (UNEP, GWMO, 2015).

**Actions**
Actions that should be considered are putting in resources for inspections and follow-up on waste
management operations regarding compliance to legislation and environmental impact. Work towards
more specific legislation regarding prevention and waste reduction as well as waste sanctions system
and extended producer responsibility (EPR) is necessary to implement.

**5.7 PUBLIC AWARENESS**
The municipality of San Salvador de Jujuy has an important role in increasing public awareness in waste
management, but the municipality does not have a waste plan or any planning or public campaign in
prevention or recycling waste at the municipal level.

In San Salvador de Jujuy, there is only one independent organization, called the Tinku Foundation, that is
carrying out this type of campaign regarding prevention of waste or recycling at the municipal level. The
Tinku Foundation is a cooperative that works independently with the collection and transport of
the household waste at origin. They collect materials such as plastic and cardboard to recycling and organic
material to compost. The foundation provides educational services to schools and companies with focus
on prevention, separation and recycling. The foundation is working besides the public system and it is a
self-supporting foundation. They are supported financially by the income of sales of the material to the
private sector. In addition, a lot of material is recycled. The quantity collected in 2015 rose to 30 tonnes
of plastic and 10 tonnes of cardboard per month. The foundation consisted in April 2016 of 30
employees, some of them are originally workers from the landfill “Finca el Pongo”. There is a very
important initiative that started with the separation of the collection at origin but the lack of economic
resources made it difficult to cover a larger part of the city. For this reason, they only operate in a few
neighborhoods.
Example of increased public awareness with social documents, GWMO

Social documents are used when a government or private stakeholder aim to raise people’s knowledge, awareness and to influence them. There is a useful framework to change people’s behavior that combines four elements: encourage providing the right signals, enable making it easy to understand, engaged making the people involved and exemplify, leading by example. To design this kind of activities it is necessary to adopt the information to the local situation to get a better result. In Africa, the government often works with NGOs to carry out campaigns meeting the community through, music, radio, etc. (UNEP, GWMO, 2015).

In addition, regarding the stakeholder’s roles in the waste management system it is important to implement a strategic planning to avoid conflict of interest between stakeholders with a lot of power and those with a low influence. The objective is to increase public awareness with cooperation and, at the same time, to have a common objective regarding the waste strategy actions. In the Capital of Jujuy, the public awareness strategy is quite confusing because the municipality promotes the separation at the landfill and the association promotes the separation at origin which are two different waste strategies that can confuse the population about how to handle the waste.

According to the UN-HABITAT report, inclusivity in planning the waste management strategy is another important aspect, where the stakeholders individually propose specific aspects to plan the new strategy or system. (UN-HABITAT, 2010) Another good example is the urban waste planning in Vietnam in 1998, where many of the stakeholders were invited to join the process and workshop to prepare a provincial waste management strategy. The initiative resulted in a creation of new and modern waste management planning. (UN-HABITAT, 2010).

Conclusion

There is no broad acceptance or well spread public awareness or concern about the environmental impact of waste. There is though one cooperative self-supporting foundation that works with collection and transport of waste. This can be a good example for others to follow. However, the municipalities have an important role to implement and increase public awareness and to communicate to the public in general regarding the importance of prevention and recycling for the benefit for environment and sustainability.

Evaluation of the state of Public Awareness is 2 on a 1-5 scale.

Recommendations

Start cooperation between the municipalities in a larger geographical area to educate people and to increase the level of recycling rate. Separation of waste is critical to ensure that the waste is separated in dry recyclable and organic fractions. The separation is important to minimize the waste going to landfill, to avoid contamination and maintain the quality of the material, which leads to more effective recycling. (UNEP, GWMO, 2015).

It is also important to consider the waste management hierarchy, that is developed by the European Union and that has been adopted by different countries, which indicates an order of preference to actions with the aim to reduce and manage waste. The first action is preventing the generation of waste, in second place the actions to reduce waste, preparing for re-use in third place recycling, in fourth place energy recovery and the last action is disposal. The directive includes the principle of
‘polluter pays’ and the extended producer responsibility. This directive provides information to the member states to adopt waste management plans and waste prevention programs. (2008/98/EC, 2008)

**Actions**

Continue and increase cooperation with different stakeholders as government, universities, municipalities and private sector, to discuss and complement each other to establish a common and mutually agreed waste strategy.

**5.8 COOPERATION**

The cooperation with other municipalities only limits to coordination of the waste deposition at the landfill. The Province of Jujuy does not have a local, or provincial waste management plan to follow and that makes it difficult for the stakeholders to take decisions in the different aspects of the waste management system. Some municipalities, without authorization, transport the waste to “Finca el Pongo” over a distance of 100 km taking advantage of the lack of controls at the landfill. Consequently, the illegal dumping makes the situation more difficult and increases the possibility that the estimated amount of waste entering every day to “Finca el Pongo” exceeds 400 tonnes per day. That brings also difficulties of political differences regarding the waste management issues. The other aspect is the absence of cooperation at national level.

According to the UNEP guidelines for National Waste Management, the national government can make contributions to influence the local waste management plan by making waste management a national priority. It can also ensure the resources that are necessary to be applied, ensure the availability of knowledge and capacity and furthermore establish national recycling schemes. Consequently, the waste management policy is usually implemented and applied at local level but can be influenced by the national level. (UNEP, 2013).

Waste management is one of the most important public services in a municipality, where in many cases the lack of political cooperation is notable, especially in low- and middle income countries, that is reflected in a deficient waste management system. (UN-HABITAT, 2010). Good governance is reflected in a transparent system considering the principle of subsidiarity, where the state is put in the function of upholding the interests of the inhabitants.

**Good example of Inter Communal cooperation in Palestine, UN Habitat**

In this case, the principle of subsidiarity is applied to provide a better waste management service to the municipality by creating an inter-communal cooperation between municipalities. Palestine created an efficient system and a transparent financing system to support recyclers, contractors and operators by uses of synergies. (UN-HABITAT, 2010).

**Conclusion**

Inter Municipal and national cooperation is limited. The political differences in different municipalities damage the possibilities of joint actions in waste management by the deposition at the common landfill. There are even municipalities undertaking illegal actions of waste dumping at the common landfill.

**Evaluation** of the cooperation is 1 on a scale 1-5.
Recommendations
Cooperation is important at local and national level as a part of an integrated waste management. The importance of cooperation between the different authorities on several levels from government, down to a range of different stakeholders is necessary to have a common waste management plan. This plan is important for co-operation or establishing strategies for example in collection, transport and disposal issues as well as regarding infrastructure and to share the economic burdens in waste management.

Actions
Improve the cooperation at the provincial and national level in a common waste management plan and increase the cooperation, participation and responsibility in the different municipalities at the Provincial level, national level as well as with the private sector. According to the GWMO report it is crucial to overcome political differences between municipalities. This can be achieved by working in a transparent process to build trust and facilitate cooperation. Good cooperation also requires a consistency in decision making that is applied to all levels and dimensions of the system. This means, that a common same strategic goal not only can be related to policy and institutions but also to the chosen technology and the financing model.

5.9 PLANNING
The Province of Jujuy has been going through a difficult time regarding the political aspect and for more than twenty (20) years with a government that did not address the environmental problems and never implemented a strategy regarding environment. In December 2016, a new government in the Province of Jujuy and a new phase in the political economic area is assumed. One of the most important pillars of the new government is the environment strategy with the aim to convert the city into a green and sustainable province to 2030. A new ministry of Environment is formed to develop a provincial and national environmental program where waste management is one of the main objectives.

The main project of the government to 2016-2020 is the construction of the “Environmental Centre Chanchillos” which consists of a separation plant for recovery of the recyclable materials as well as the separation of the organic material to composting. The capacity of the plant is 100 tonnes per day. The main equipment is: receiving hopper, lifting tape, trammel, tape to collect fines parts, high ranking tape, tape rejection, vertical press for packaging material recovered, chipper and mobile equipment. (UNJU University of Jujuy, 2015). This is the first step of the government to establish the waste management strategy for Jujuy.

Implementation of a waste management plan, UNEP
According to the UNEP guidelines, to implement a waste management system at national level, it is important to consider three fundamental principles 1) the waste management hierarchy 2) the concept of the life cycle approach and 3) Resource management. Moreover, a good planning provides economic benefits, social benefits and environmental benefits. (UNEP, 2013).

Conclusion
There is neither any local, provincial or national waste management plan to follow.
During the last 20 years, the Provincial Government has not addressed the environmental problems. There is now a new Government in place since 2016 that has announced higher ambitions, aiming to create a green and sustainable province to 2030. A project to establish an Environmental Centre with sorting of waste, separation for recovery and improved landfill has started. The focus seems to be in establishing these technological facilities. Unfortunately, there is no confirmation regarding the existence of planning-instruments to establish long term Waste Management Plans that covers all the Municipalities in the Province, to establish a holistic sustainable waste management system. To have a sustainable waste management system in place it is necessary to have a long-term planning in place at both national and local level.

**Evaluation** of Planning gives 1 on a 1-5 scale.

**Recommendations**
Implement long term waste management planning at national and local level.

**Actions**
Start to work with planning-instruments to establish long term Waste Management Plans that cover all the Municipalities in the Province to establish a holistic sustainable waste management system.

### 5.10 FINANCING

The collection system involves operational cost, that mostly are covered by charging a municipal tariff. In the Province of Jujuy, there is a problem of an inequality in the distribution and payment of the tariffs that finance the municipality waste system, since the private sector takes much of the most relevant financing coming in to the system. The difference is that the public sector provides the service in the poorest area of the city and the private sector in the middle and upper class area and that makes a difference of 800% on the price of the fee paid for the service. Consequently, there is an imbalance of the economic system that makes difficult to cover the needs of future investments and future planning to improve the system. There is also an issue concerning the lack of capacity building and the lack of knowhow regarding waste management, technology, operations and financial system. (Ministry of Environment, 2009).

The Municipality does not have a separation system and for this reason it is difficult to get revenue from the sales of the recycling materials. In this case, the implementation of a separation and sorting system is relevant and a priority for the municipality. The Capital of Jujuy has also a problem to access public funding to the investments in technology and capacity building in waste management.

**Good example from Colombia “Proposed Nama financing for the waste sector in Colombia”**
The aim of the government is to create interest for investments in waste management with more productive objectives and promoting sustainable economic growth and improving the living conditions of informal recyclers. The government therefore, created “Nama”, an equity fund that contributes with equity capital on a concessional basis to help build waste management facilities. The project also attracts equity and debt investors to finance the facilities. The repayment of the equity will remain in the fund to invest in future projects. (UNEP, GWMO, 2015).
Conclusion
There is a system in place for charging the customers for services provided regarding collection of waste. Due to low incomes, people in certain areas have problems paying for the services. So, there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities etc. According to the GWMO, 60 to 70% of the cost in a waste management system are operational costs and that includes collection, separation, transport and disposal. Resource recovery activities can generate revenue from the recyclable materials. (GWMO, 2015).

Evaluation of Financing gives a 1 on a scale 1-5

Recommendations
It is important to work in the selection of a financial model adapted to the local and economic circumstances. The GWMO propose the GiZ model with 5 steps to choose a financial model:
- Step one, establish the framework conditions
- Step two, define the objectives for improvements in the waste management
- Step three, assess conditions and capacity
- Step four, select the model, asses the advantages and drawbacks. (UNEP, GWMO, 2015).

Actions
It is important to review the economic circumstances and the system to set and change the tariffs so that the operational system can be maintained and still have a margin for future investments in infrastructure, training and technology.

5.11 KNOWLEDGE

According to the information provided by the Municipality of Jujuy and the people living at the landfill, there is a lack of knowledge about a proper waste management system. Moreover, the companies in charge of the service do not provide capacitation regarding waste collection, waste transport, waste sorting and they do not have proper future planning or strategies in this area. There is also the lack of capacitation of the risk measures that are needed to prevent accidents. The level of education of people working and living at the landfill is low according to a report made by the University of Jujuy in 2015 for the American Development Bank. (UNJU University of Jujuy, 2015). The level of education of the people working at landfill in the Province of Jujuy are the following:

Tabell 5 Distribution of level of education in Jujuy. Source UNJU, 2015, p.18, Social Inclusion Plan

<table>
<thead>
<tr>
<th>DISTRIBUTION OF LEVEL OF EDUCATION</th>
<th>PERCENT%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without education</td>
<td>6.4%</td>
</tr>
<tr>
<td>Incomplete primary school</td>
<td>23.65%</td>
</tr>
<tr>
<td>Complete primary school</td>
<td>37.44%</td>
</tr>
<tr>
<td>Incomplete high school</td>
<td>22.17%</td>
</tr>
</tbody>
</table>
According to the GWMO, and experience collected from different countries, there are three essential levels of capacity: 1) enabling environment, 2) the institutional level and 3) the individual level. With enabling environment, the institution can proceed with direct environmental on their own. At the institutional level, it can proceed with the internal organization, including responsibility and how an institution can achieve the goals. At the personal level finally, it can proceed by improving capacity building. (UNEP, GWMO, 2015).

**Conclusion**

The level of education among people involved in the Waste management sector is low. Less than 2.5 % has studied at University level, of which only 0.49 % has a complete University degree. However, the informal workers at the landfill have of course gained practical skills and experience about the possibilities of sorting and recycling materials, and that gives a potential to future improvements of education and the possibility to get an employment in the area. In conclusion, there are notable gaps regarding the different aspects of an integrated waste management system and gaps in the knowledge of separation and treatment of different kind of fractions of waste, such as industrial, hazardous- and hospital waste.

**Evaluation** of knowledge and skills is 1 on a 1-5 scale.

**Recommendations**

Start the cooperation with stakeholders in the public and private sector to improve the knowledge in waste management.

**Actions**

It is necessary to implement a long-term training plan in the different areas of waste management that is implemented by the municipality and controlled by the Ministry of Environment. There is a potential to implement capacity building and a competence and skills grade scale to encourage the workers and to provide certification in different areas. The university has an important role in this kind of initiative.

### 5.12 BUSINESS OPPORTUNITIES

There is potential for business opportunities in waste management after the implementation of a proper waste management system. As it is described in point 5.8 there is a foundation called “Tinku” that is undertaking their own collection of different fractions of the waste that is transported long distances and sold to the industry. These materials are plastic, glass and paperboard. There are several private companies that buys the material from the informal workers living at the landfill. They just pay for the material, without paying any salary or health insurance and the workers are out of the social welfare service. There is a potential and interest from the chamber of young professionals (Union de Empresarios) to start-up companies in waste management. There is only one private company and only one public company in waste management in the capital of Jujuy. The private company is responsible for
40 % of the collection and transport of waste and additionally providing other services such as lighting, sweeping and cleaning of the city. The other 60% oversees the Municipality. There is a big potential to start waste management companies that could provide better and more complete services to the municipalities in the Capital and specially in other areas of the Province of Jujuy where the service is insufficient. (Union de Empresarios/ Entrepreneurs union, 1933).

**Raw material potential, UNEP**

Waste is an economic concept with potential in the meaning that the resources are not used efficiently today. The waste is a raw material that can be used in the production chain to produce energy or to make new products. The recovery of raw material from waste can reduce the need to use new extracted material, as well as provide employment for many people. In conclusion, waste management opens the possibility to better environment and health, economic opportunities and social opportunities. (UNEP, 2013)

**Conclusion**

There are significant opportunities and interest from the establishment for development of business activities in Waste Management. There are already many companies established that are dealing with recyclable raw materials. Regarding other activities such as collection, transport and treatment of waste there can be an interest for upcoming entrepreneurs.

**Evaluation** of Business is 2 on a 1-5 scale.

**Recommendations**

Improvements can be made through a more systematic and holistic approach to the waste management operations on a provincial and inter-municipal level. An approach in the waste management planning includes an analysis of the opportunities for different actors to participate and contribute on commercial grounds.

**Actions**

Actions that should be taken are establishing a long-term waste management plan that also covers the Business Opportunities through dialogue with the different stakeholders and actors. Possibilities of Start-up support to entrepreneurs in waste management should be considered.

**5.13 SOCIO ECONOMIC ASPECTS**

The Province of Jujuy has a total population of 673 307 inhabitants and an estimated population growth rate of 1.69% for the period 1995-2000, which represents an increase of 9300 inhabitants per year where 50.5 % of the population are women. The population structure shows that 47.1% are up to 19 years old and 7.6% are over 60 years old. 33% of the households have unsatisfied basic need conditions.

Considering the total population the work ratio is constantly very low, 31.8% if we compare with the rest of the country where it was 41% during 2010. The principal activities are divided into three areas, tobacco, mining and sugar. This gap implies a high population potential to contribute to economic growth if the economic conditions should permit the incorporation of more population in the labour market. Regarding the level of education, the province is below the national average. The illiteracy rate is 6.7% while 8.2% of the population over 20 years old has never attended an educational establishment.
25.8% did not complete the primary school level, 11.2% completed secondary level and only 5% have reached university level. The rate of net coverage of the primary level (6-12 years old) is 96.9% but at the secondary school the ratio falls to 60.5%. The employment rate is 53% and the province is below the national average level regarding minimum wage. The wages in the public sector are lower in a general scale of -26%. (DIPEC Drection of Census and Statics -Jujuy, 2010).

**Example of integration and education of women**
In India, the SEWA (Self Employed Women’s Association) started a vision of full employment for the women workers. Of around 1.8 million, 74 000 works in recycling and cleaning. The association gives them the possibility to access education and work. (UNEP, GWMO, 2015).

**Conclusion**
The Province of Jujuy is below national average when it comes to level of education and below the national level of income. Only 5% of the population of nearly 675 000 inhabitants has an education on a University level. One third of the households are considered to have unsatisfied basic need conditions. There is a significant number of inhabitants living on landfill and dump sites, gaining their income in the informal sector picking waste.

**Evaluation** of socio-economic factors gives a 1 on a 1-5 scale.

**Improvements** are necessary in terms of education, income and employment.

**Actions**
Actions in the Waste management sector improves, it could also create new jobs and give people a chance to further education needed to be able to work in the Waste Management sector.

6. **THE PROVINCE OF SALTA IN GENERAL**

The status of the waste management, in the Province of Salta, is also mapped by the **WHAT** questionnaire methodology, to provide a general knowledge of the waste situation in the Province of Jujuy. The Province of Salta is also located in the north of Argentina 120 km from the Province of Jujuy. The Province has several protected areas of environmental and cultural value, the most important areas are conformed by two national parks and two natural monuments:

a) National Park Baritú  
b) National Park El Rey  
c) National Park Los Cardones  
d) Natural Monument Tarauaca  
e) Natural Monument Los Cardones

**6.1 WASTE MANAGEMENT PROBLEMS AND GOALS IN THE CAPITAL OF SALTA**

The waste management situation in the capital of Salta is better organized than in the Province of Jujuy in terms of planning and implementation of a waste management system. The city has its own controlled landfill called “Finca San Javier” managed by a private company. In 2010 Salta implemented a waste
management plan by the Decree 1365/10 (Decree 1365/10 Waste Management in Salta, 2010). The primary objectives of the plan were the implementation of a provincial waste management plan to promote and implement preventive actions in the area and to solve waste management problems. In terms of infrastructure, organizations and the economic situation. The city of Salta shows a better potential to improve waste management strategies, however, the capital need to improve the waste management regarding production of waste and treatment of waste. Each inhabitant produces at least one kilo of garbage per day and only a small part of the waste is recycled. Also, the collection and public awareness needs to be improved. All the waste goes to a controlled landfill that need technical improvements to reduce the environmental problems of groundwater and air contamination.

**Evaluation** regarding the general waste management situation and goals in waste management is 3 on a scale 1-5.

### 6.2 SOURCE AND TYPE OF WASTE

The facts about the type a quality of waste is taken from a national study that was carried out in 2010 by the government of Salta to upgrade quality, data and generation of municipal waste management according to the Standard Test of Composition of Unprocessed Municipal solid waste ASTM 5231-92 and IRAM 29523 (first edition 2003-03-10).

The study provides information about the characteristics, composition and the technical, economic and social aspects of waste in Salta Capital. According to the information of the samples of the study made in Salta the composition of the waste is shown in Figure 19 considering the quantity of different materials. The figure shows that 46.89% are organic waste, in second place diapers with 11.74%, in third place garden waste with 11%, paper with 9.58%, plastic with 7.79% and glass with 3.87%.

**Figure 19** Waste composition in Salta Capital. Source Ministry of Environment, Salta (2010).

**Conclusions**

Data about the quality and quantity of waste, in the capital of Salta, are from 2003 which provides one idea of the different kinds of waste and fractions. It is however necessary the updating of the data because of the changes in the consumption of the inhabitants and related to the increase of the population during the last years. The production of waste in Salta was, according to the report from 2003, 1kg per household a day and the organic waste was 46.89% of the total waste followed by diapers 11.74%, garden 11%, paper 9.58% and plastic 7.79%. The total amount of the waste produced by Salta
Capital was 600 tonnes a day that went to the open landfill. Sorting is, as today, practically made by the informal pickers at the landfill and estimated to 140 tonnes of dry material per month.

**Evaluation** regarding the general situation in terms of having control over the waste generation and handling situation is 1 on a scale 1-5.

**Recommendations**

Improvements of statistics are important to have a picture of the situation based on facts.

**Actions**

Improvement of data collection regarding the amounts, quality and different sorts of waste should be taken.

### 6.3 WASTE COLLECTION AND TRANSPORT

According to the information provided by the public sector and by the last report provided by the Ministry of Environment, the amount of waste collected in Salta Capital is still 600 tonnes per day. The collection is made once a day and 6 days a week from Monday to Saturday. In some places, as in the bank district and places with tourist attractions, the collection is made twice a day. There are around 140 000 collection points, or household points, served by 30 trucks for the collection. The waste is deposited in the open and the controlled landfill is located 7 Kilometers from the city of Salta, in a location called “San Javier”, which is managed by a private company. (Ministry of Environment Salta, 2010).

According the waste collection company, there are similarities with the problems described in the Province of Jujuy as earlier shown. During the waste collection process, there are some practical problems. In first place, the lack of trash cans makes the collection of the unsorted waste difficult. This happens because of the different points where people leave the plastics bags and other kinds of waste. In second place, the dogs, birds and other kind of animals have access to the plastic bags and spread the waste which makes the collection difficult and consequently the collection takes more time.

The unsorted waste, of all kind, makes the collection difficult as we see in figure 20 where there is household waste, mixed with car tires and hospital waste in the central part of the city.
In resume:

<table>
<thead>
<tr>
<th>Days of collection</th>
<th>6 days a week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of collection points</td>
<td>140,000 every day</td>
</tr>
<tr>
<td>Tourist places</td>
<td>Twice a day</td>
</tr>
<tr>
<td>Type and number of trucks</td>
<td>30 trucks</td>
</tr>
</tbody>
</table>

The waste transport responsibility is divided between the Municipality and a private company. The Municipality has 5 units and the private company 30 units with compactors. These units cover a geographical area of 34,000 blocks and the frequency of the collection is daily from Monday to Saturday with two persons per turn. The unsorted household waste is transported to “Finca San Javier”, located 7 kilometers from Salta City. The waste is discharged in different sectors of the landfill to permit the informal workers to sort the waste as soon as it is coming to the landfill. (Picture 21) The trucks have waste compactors which allows the compaction of the garbage during the collection and the possibility to transport more waste per turn.

![Image](image_url)

**Figure 21 Open landfill San Javier. Source Patagonica Fueguina company, Salta, April 2016.**

**An example of improvement of the collection, Bulgaria, UN Habitat**

In 2002 in Byala, Bulgaria five rural villages with a winter population of less than 2500. They had a problem with the rising price and high consumption of fuel for waste collection. During the first four months, of the year, they consumed the fuel that they usually consume during a whole year. In the process of updating the waste plan, Byala invited an international consultant to help them with cost reductions. The consultant made an audit about the relationship between the waste generated and
frequency of the collection. They discovered that, when the 40 liter dustbins where collected, three times a week, they were less than 20% full. They decided to change the collection from three times a week to once a week. This allowed save money and to cover its fuel needs with the existing budget the entire year. (UN-HABITAT, 2010).

Conclusions
The collection of waste in Salta covers the whole city of Salta within 6 days which is positive. The trucks also have compactors that enables transport of a larger quantity of waste per truck. However, the collection of the unsorted waste and the infrastructure need improvements. The waste collection is better organized than in the capital of Jujuy but have the same problems regarding infrastructure as the lack of trash cans and storage of waste. The Provinces of Salta has a most primitive system by hand picking and sweeping. For this reason, the implementation of a new collection system is important with onsite or offsite storage of waste and proper containers to facilitate the collection. (Chandrappa, 2012).

Evaluation of the collection and transportation system gives a 3 on a 1-5 scale.

Recommendations
A fixed collection system with fixed bins where people can drop the waste is recommended to facilitate the collection and transport of the waste in a better way.

Actions should be taken for investments in waste bins, collection and more transport vehicles.

6.4 WASTE SORTING

There is an informal wasting sorting program implemented by a cooperative called “Sorting together” that helps poor people to collect and sell the material from the landfill. This program only covers 2000, out of 34000, blocks of the city of Salta. (point.6.8) The cooperative works every day at the landfill in the separation of metal, plastic, paperboard and tetra bricks. The material at the landfill is pre-sorted in origin and transported to the landfill. The amount of dry material collected by the association is less than 140 tonnes a month as the separation system is only applied in 14 000 households which benefits 60 000 inhabitants. Only just 10% of the population of the capital. Thus, it is necessary to increase the separation program to cover the whole Capital.

God example considering waste as a resource, UN-HABITAT

The UN-HABITAT promotes the concept of waste as a resource and provide an example about the value of organic waste in Dhaka, Bangladesh where there where implemented a house to house waste collection system from vegetable markets. In this case, the organic waste from household and market is taken to a community based composting plant where it is turned into organic fertilizer. (UN-HABITAT, 2010).

Conclusions
A cooperative in cooperation with a private company oversees the waste sorting. It provides waste management services and implements the sorting program. This program is a good initiative but it only covers 2000 blocks of the city and 14 000 households representing only the 10% of the total area.
Consequently, it is necessary to invest and implement a program for the whole city of Salta with the aim to promote the separation at the origin to get a better raw material for recycling.

**Evaluation** of the separation 2 on a 1-5 scale.

**Recommendations**
A fixed collection system with fixed bins, where people can drop the waste, is recommended to facilitate the collection and transport of the waste. The separation is also important to enable recycling of the material and the quality of the material would be better when a proper system is implemented. The GWMO, mention this in a report (GTZ/CWG, 2007) on the informal sector, made during 2006 to 2007, in six low and middle income countries. The ISWM research provide a closer look at the recycling and organic waste management and suggests that the understanding from the informal recyclers of the activities is the key ingredient for successful recycling. (UNEP, GWMO, 2015).

**Actions** should be taken for investments in an enlarged program for waste sorting that covers the whole city.

### 6.5 WASTE TREATMENT-TECHNICAL ASPECTS

The controlled landfill with biogas extraction in the Province of Salta is located in “Finca San Javier”, situated 7 km from the city of Salta. The ground surface of the area covers 66 hectares but the area belonging to the landfill is only 23.5, hectares. The landfill is divided in three subareas, San Javier I (SJ I) with a surface of 12 hectares where the landfill was on operation until 1999. San Javier II (SJ II) with a surface of 9 hectares which was on operation until 2011 and San Javier III (SJ III) with a surface of 2.5 hectares that is in operation (Figure 22). To the landfill of San Javier arrives, from the city of Salta with 600 000 inhabitants, 600 tonnes of unsorted waste per day which includes household waste, hazardous waste, electronic waste as well as pathogen waste from hospitals, industrial waste, etc.

![Figure 22 “Finca San Javier” I, II, III. Source Patagonica Fueguina, Salta, April 2016.](image-url)
The waste, at “Finca San Javier”, is covered with impermeable clay, which is 36 cm thick, but without any proper membrane between the waste and the ground. According to the geo-electric measurement made at the landfill, by “Patagonica Fueguina”, the ground consists of clay that is 25 meters deep, in all the area, which protects the groundwater. Moreover, the trucks unload the waste, and the waste compacts due to the semi aerobic biodegradation, which is also covered with clay. In the landfill, there are also two leachate evaporation ponds that are situated to the left side of the landfill (Figure 23). The neutralization ponds are used to treat the wastewater. The first pond is 50 m x 40 m and 2.8 m deep and the capacity of reception is 5600 m³ and the capacity of operations is 6000 m³. The pond has 600 m³ of safety capacity because of the periods of rain. The second pond is 20 m x 20 m and 2.3 m deep. Capacity of reception is 920 m³ and the capacity of operation is 900 m³. That means that the second pond has a security capacity of 120 m³. The ground of the ponds has double geomembrane HDP 2000 microns. The treatment of the wastewater is made by physical-chemical treatment to control and stabilize the presence of hydrocarbons and the organic molecules and to separate the heavy metals from the wastewater. The control of the leachate is made every 3 months where the physical, chemical and bacteriological analyses are carried out.

In September 2007, the World Bank approved a project of the capture of landfill gas with the aim to mitigate climate change by the reduction of 79 664 tons of CO2 caused by methane (GHG) gas generated in the landfill. The project aimed to improve solid waste disposal practices to reduce uncontrolled fires and to improve waste management practices and benefit the informal workers at the landfill (World Bank -Salta Landfill Gas Capture Project, 2007).

Figure 23 Evaporation pond to the left side of the landfill. Source study visit March 2016.
The gas capture consists of an extraction from 110 extraction wells and a flaring facility to capture and flaring of the landfill gas generated through the anaerobic decomposition. Flaring the gas in a controlled process produce for the destruction of the methane gas and the result is CO2 that is another gas without methane. In conclusion, the project contributes to reduce GHG emission by flaring methane from landfill gas without any technical solution to use the heat to generate electricity. (Figure 25). The quality of the biogas is from 38° to 60° depending on the humidity.
The technical problems verified, during the study visit, is that during the gas extraction process it is noticed that the tubes are filled with leachates and oxygen that ingress into the holes where methane gas is extracted. (Figure 26, 27). To solve this problem, the company changed the tubes from PVC to CPVC and changed the positions of the tubes to be able to separate the leachate and the biogas. The quality of biogas is from 38\(^\circ\) to 60 \(^\circ\) depending on the humidity. If oxygen enters the system, the burning process is stopped. The company in charge of the landfill did not invest in technology to upgrade the biogas to bio-fuel or to generate energy that is highly demanded in the Province. One of the main problems is the financial necessity to develop and improve the landfill and hence the company is interested in investors to implement new technology.

Figure 26 Capture of the landfill gas Source study visit March 2016.
Conclusions
The landfill, which is using the cell method is well constructed, considering important aspects as the size of the cells, quantity and variation of rainfall, the absorptive capacity of the waste as well as the control of the capacity of the cells for high degree compaction. Another important aspect is the leachate treatment and monitoring of the landfill. One of the disadvantages of the cell method is that the landfill walls take a lot of space that could be used to house waste, but in this case, they are removing the walls to use as cover, which is a good solution. The technical problem at the landfill is the necessity to work on the fugitive emission of gas during the extraction of gas that is described in figures 26 and 27, producing stops in the incineration system and consequently an increase of the emissions during the stop of the system. Another important aspect to be considered is when the air is mixed with the landfill gas, the mixture can become explosive. The problem of the inclination of tubes to avoid the humidity of the biogas need to be improved. For this reason, because of the danger of the landfill gas and to avoid the humidity of the biogas it is probably necessary to change out the equipment and use high standards equipment to avoid the fugitive emissions of gas. Because of the danger and nature of landfill gas it is essential that the equipment used is designed and built to the highest standards. Gas leakage or excessive air must be avoided. There is also a potential to upgrade the system to use the burned gas to an energy recovery solution. (Burnley, 2014).

Evaluation of the landfill construction and waste treatment is a 3 on a scale 1-5.
**Actions** It is necessary to overlook the landfill gas extraction system, change equipment to avoid the fugitive emissions and to carry out a feasibility study on how to upgrade the system for more efficient energy recovery.

**6.6 LAWS AND REGULATIONS**

The relevant aspects of the legislation regarding the environment protection is divided in three levels of legislation and on similar levels as in the Province of Jujuy. The legislation levels are:

1. **The National Constitution**: establishes the rights and guarantees regarding environment and its protection and the autonomy of the Municipalities to conserve public hygiene. The municipalities, by its administrative organ called “urban hygiene”, are responsible for the compliance of the rules, regulation and for the collection of taxes.

2. **The Province Constitution**: establishes also the protection and guarantees regarding the conservation of the environment.

3. **National law, decrees and regulations**: regarding urban solid waste management at National Level and Province level. The objectives of the National Law 25 916 (Law 25916, 2004) are the achievements of a management of household waste including collection, transport and deposition of waste. The same objectives are established in the Provincial Constitution and the Law 7070.

There is also other complementary legislation as the protection of fauna, legislation on hazardous waste, and industrial waste as well as the Decree 1365/10 (Decree 1365/10 Waste Management in Salta, 2010) regarding an integrated waste management plan for the Province of Salta. However, there is an absence of labour law that include the rights for the informal workers at the landfill regarding working hours and minimum wage as well as protection and sanity and health protection measures, as well as legislation about extended producer responsibility. (Ministry of Environment Salta, 2010)


<table>
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<tr>
<th>National Level Legislation</th>
<th>Province Level Legislation</th>
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<td>National Constitution of environment protection</td>
<td>Provincial Constitution of environment protection</td>
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**Legislation GWMO**

According to the GWMO, in the area of waste management, direct regulation is the base of an effective waste management system and to assure the compliance of the regulation. Moreover, the application of
civil and criminal law plays an important role to achieve environmental protection and to achieve resource recovery (UNEP, GWMO, 2015)

**Conclusions**
A legislative framework is in place concerning the issues of waste and environmental at national and provincial level. A new provincial legislation is in process, aiming to improve the waste management in the Province. However, it is necessary to adopt specific legislation, regarding waste management practices considering, waste hierarchy as well as EPR (Extended Producer Responsibility)
There is a lack of enforcements of rules and legislation regarding waste management and a lack of processes and controls to follow and to apply the legislation. A legislative framework is necessary to provide legal status to the strategic goals and to create a frame of reference for other more specific regulation and to enforce the compliance of the legislation.

**Evaluation** of the law and legislation is a 3 on a scale 1-5.

**Recommendations**
Improvements are needed regarding the implementation of the legislation through sanctions in cases of non-compliance. A legislative framework is necessary to provide legal status to the strategic goals and create a frame of reference for other more specific regulation and to enforce the compliance of the legislation. More specific legislation in zero waste, waste prevention and waste reduction as well as waste sanctions and EPR is necessary to implement.

**Actions**
Actions that should be considered is putting in resources for inspections and follow-up on waste management operations regarding compliance to legislation and environmental impact. Work towards more specific legislation regarding waste prevention / zero waste and waste reduction as well as waste sanctions and extend producer responsibility (EPR) extended producer responsibility is necessary to implement.

**6.7 PUBLIC AWARENESS-INFORMAL WORKERS**

The Municipality in Salta implemented a pilot project “Separamos juntos” (Sorting Together Program) in 2011 to introduce the separation of the waste with three objectives. In first place, to minimize the waste going to the landfill, in second place to encourage recycling and in third place increase the public awareness. This started as a pilot program in 4 zones of the city of Salta with around 2000 blocks. The program was developed in cooperation with students of the local university. The program is driven by the Municipality but executed by the private company responsible for the collection of the household waste. The program encouraged the separation of paper, metal, cardboard and tetra brick. (Figure 28).
Example of a waste management agency, Belo Horizonte, UN Habitat
In Belo Horizonte, the development of waste management was improved by forming a new waste management agency representing the municipality that provide environmental and educational services, technical services and advice to waste pickers. (UN-HABITAT, 2010).

Conclusions
An initiative has been taken from the Municipality to enhance awareness concerning the matters of waste going to landfill and the need of recycling to lower the impact on environment. The initiative is good but covers only a small part of the city. However, this is a good start and a baseline for further activities in this direction has been set.

Evaluation of Public Awareness reaches a 3 on a 1-5 scale considering the serious actions taken.

Recommendations
To start a cooperation between the municipalities within a bigger geographical area to educate people, raise public awareness and increase the level and amount of the recycling material. Separation of waste is critical to ensure that the waste is separated in dry recyclable and organic fractions. The separation is important to minimize the waste going to the landfill, to avoid contamination and maintain the quality of the material, which leads to more effective recycling. (UNEP, GWMO, 2015) . In the case of Salta, it is important that stakeholders have the same strategy of separation of the material at origin.

In addition, regarding the stakeholder’s roles in the waste management system it is important to implement a strategic plan to avoid conflict of interest with and between stakeholders with a lot of power and those with low influence. The objective is to increase public awareness through cooperation and at the same time to have the same common objective regarding the waste strategy actions. According to the UN-HABITAT report, inclusivity in planning the waste management strategy is another important aspect, where the stakeholders individually propose specific aspects to plan the new strategy or system. (UNEP, GWMO, 2015).

Actions
It is important to continue spread the initiatives and experiences for further development in a broader scale at the municipal and provincial level. Continue and increase cooperation with different stakeholders as government, universities, municipalities and private sector, to discuss and complement each other to establish a common and clear mutually agreed long term waste strategy.

6.8 COOPERATION

The cooperation with other municipalities is not clearly and practically established regarding the waste management plan or for the development of strategies in the area. This makes it difficult for both private and public companies to implement and follow the provincial or the national waste management plan.

Good example of Cooperation in Brazil, UN habitat
In the south of Brazil an inter-municipal cooperation between four municipalities led to the formation of a consortium in 1997 called Quiriri that benefits 125 000 inhabitants. This includes shared final disposal and institutional infrastructure for regional planning. As a result, open dumps are being upgraded,
hospital waste are being properly treated and a waste separation system has been implemented in most of the cities.

**Conclusion**

Inter Municipal cooperation is very poor and limited and exercised with only one private company in Salta Capital. The political differences in different municipalities damage the joint action in waste management.

**Evaluation** of the cooperation is 1 on a scale 1-5.

**Recommendations**

It is relevant to establish an inter-municipal platform for strategic and long term joint planning for waste management. Waste management is one of the most important public services in a municipality. In many cases the lack of political cooperation is notable, especially in low- and middle-income countries which is reflected in a deficient waste management system. (UN HABITAT, 2010 p 187) Good governance is reflected in a transparent system considering the principle of subsidiarity, where the state makes decisions, considering the interest of the inhabitants. The cooperation is an important part in integrated waste management. The cooperation between the different authorities at the government level as well as with local stakeholders is necessary to have a common waste management plan. It is important to work together and implement strategies for example in collection, transport and disposal issues as well as infrastructure to share the economic burdens from the implementation of a waste management system.

**Actions**

Improve the cooperation at the local and Provincial level in a common waste management plan and increase the cooperation, participation and responsibility in the different municipalities at the Provincial level. The cooperation between the public and private sector has huge relevance.

**6.9 PLANNING**

In Salta, there is a Provincial plan for development of strategies in the area of waste management, with the aim to develop the technical, educational and economic aspects in the area of waste management. (Ministry of Environment Salta, 2010). One of the principal objectives of the long-term plan, is to close the controlled landfills in the province. The challenges to develop the strategy is the lack of planning and investments at the Provincial and National level. It is also connected to the lack of technical and economic knowledge in the area.

**Good example for a long-term planning, UNEP**

To have a sustainable waste management system in place it is necessary to have a long-term planning at national and local level. According to the UNEP-guidelines it is important to consider three fundamental principles to implement a waste management system at national level: 1) waste management hierarchy 2) the concept of the life cycle approach and 3) resource management. Moreover, a good planning provides economic benefits, social benefits and environmental benefits. (UNEP, 2013).

**Conclusion**

Lack of long term regional Waste Management Planning.
**Evaluation** of the cooperation is 1 on a scale 1-5.

**Actions**
It is important to establish an inter-municipal platform for strategic and long term joint planning for waste management and to increase the public and private cooperation in the area. Working together with other municipalities on strategies for collection, transport and disposal issues as well as infrastructure to share the economic burdens in waste management. Start to create instruments to establish long term Waste Management Plans that covers all the Municipalities in the Province to establish a holistic sustainable waste management system.

**6.10 FINANCING**

Regarding the waste management at the city of Salta, the percentage of population that pays the fee is 80% (Ministry of Environment Salta, 2010) The fee, however does not cover the operative cost of the collection and the landfill process. For this reason, it is difficult for the company responsible for the operations to affront the operative cost and at the same time develop the services and reinvest in new technology. Consequently, there is no sustainable economic system in place that can cover the cost and make investments on a long term. According to the GWMO, 60 to 70% of the cost in a waste management system are operational costs and that includes, collection, separation, transport and disposal. Resource recovery activities can generate revenue from the recyclable materials. (UNEP, GWMO, 2015).

**Increasing the Fee in Bengaluru and Bemako, UN Habitat**

In Bengaluru, the payment rates are 40% and the fees are minimal, but the reason for non-payment is attributed to a passive political choice, because of the lack of controls and penalties for non-payment. In this case, there is a willingness to pay but the government doesn’t want to charge a fee because the politicians need the votes. On the other hand, the city of Bemako reduces the same problem by creating a municipal platform to this. (UN-HABITAT, 2010).

**Conclusion**

There is an inequality in the system in place for charging the customers for services provided, regarding collection of waste. 20% of the households still does not pay for the services provided. Consequently, there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities and for improvement of the system.

**Evaluation of Financing** gives a 1 on a scale 1-5

**Actions**

It is important to review the economic and structural system to implement new regulations and new fees and to make rate changes so that the system can be maintained and likewise have a margin for future investments in infrastructure, education and technology.
6.11 KNOWLEDGE

The knowledge to develop new technology at the landfill is one of the principal objectives of the company in charge of the waste management. The municipality has conducted training workshops in waste management. However, there are financial problems to afford new projects. The aim of the private company is to acquire knowledge and find investors to build a treatment plant to minimize the waste and on a long term to be able to close the landfill. There is knowledge of biogas extraction from landfills but there is a demand for future development in waste to energy. However, there are notable gaps about separation techniques of waste as well as regarding financing of the system.

**Good examples of public and private collaboration in waste management, UN-Habitat**

According to the UN-habitat rapport the participation of the private sector in waste management takes place for two reasons. In first place, the public institutions need private investment and in second place the provision of technical expertise and equipment to the municipalities. For this reason, it is more and more common that the private sector is engaged in waste management collection and in infrastructure projects. To support this type of collaboration it is important that the public sector generates revenue, through taxation or fee charges to afford the waste management costs. (UN-HABITAT, 2010).

**Conclusions**

There is knowledge of biogas extraction from landfills but there is a demand for future development in waste to energy. However, there are notable gaps about separation techniques of waste as well as regarding financing of the system.

*Evaluation of knowledge give* 3 in scale of 5

**Recommendations**

To start a joint public and private company to invest in knowledge and new technology

**Actions**

It is important to make an investment plan to acquire training and technology for future development.

6.12 BUSINESS OPPORTUNITIES

There is a potential for business opportunities in waste management at the private level. In the Capital of the Province of Salta the waste management services are managed by a private company which is responsible for the collection for deposition as well as sweeping and cleaning the city. According to the information during the study visit, the company has economic problems regarding future investments because of the low fee that the government pays to the company for the services provided in accordance with contract. There is an interest to start partnerships with other private companies to invest in technology. In first place to convert waste to energy and to invest in technology to upgrade biogas from landfill to CNG for public transportation. There are potential in all the areas of waste management with the aim, in the long term, to close the controlled landfill San Javier in Salta.

**Example of private partnership, UN HABITAT**

Bulgaria gradually worked during 1999 to 2009 on the privatization of the waste collection and landfill that today is operated privately with good results. (UN-HABITAT, 2010).
Conclusion
There are significant opportunities and interest of the establishment and development of business activities in Waste Management. There is only one private company in charge of the waste management. There is a potential to increase the number of stakeholders in activities such as collection, transport and treatment of waste.

Evaluation of Business is 1 on a 1-5 scale.

Recommendations
Improvements can be made through increase the interest from other actors in waste management. Different actors can participate and contribute on commercial grounds.

Actions
Actions that should be taken is establishing a long-term Waste Management Plan that also covers the Business Opportunities through dialogue and inclusion of different stakeholders and actors. Possibilities of Start-up support to entrepreneurs in waste management should be considered.

6.13  SOCIO ECONOMIC ASPECTS

The Province of Salta has a population of 536 113 inhabitants (DIPEC Drection of Census and Statics - Jujuy, 2010). According to the statistic indicator from the INDEC 2001, considering the socio-economic aspects, the distribution of the population is divided in three levels and the amount of waste depend of the socio-economic level. In the following table, we can see that the high-class citizens produce more waste than the low class. (Ministry of Environment Salta, 2010).

Tabell 8 Socio Economic Aspects in Salta. Source Ministry of Environment, 201.

<table>
<thead>
<tr>
<th>Socio-Economic Level</th>
<th>Waste Generation per Person per Day</th>
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<tbody>
<tr>
<td>High socio economical level</td>
<td>1.227 kg per person per day</td>
</tr>
<tr>
<td>Middle socio economical level</td>
<td>1.088 kg per person per day</td>
</tr>
<tr>
<td>Low economical level</td>
<td>0.613 kg per person per day</td>
</tr>
</tbody>
</table>

Conclusion
The Province of Salta has only 14 % of the citizens on high socio economical level, 50% with middle socio economical and 36% on low economical level. In conclusion only 14% has high economic level and consequently university degree. The increase of the population, waste generation and the economic development provides possibilities to create new jobs in waste management but it is necessary with more investments in education.

Evaluation of socio-economic factors gives a 1 on a 1-5 scale.

Improvements are necessary in terms of education, income and employment.
Actions
Improvements in the Waste management sector could also create new jobs and give people a chance to further education needed to be able to work in the Waste Management sector.

7. ENVIRONMENTAL ASPECTS IN JUJUY AN SALTA

In resume, the general environmental problems that the Provinces of Jujuy and Salta is facing are the following:

a) **Contamination of the soil and groundwater:** big part of the population of Jujuy and Salta depends of groundwater for drinking water and need water for irrigation. The problem with the increasing amount of waste at the landfills and the contamination of the soil occurs when man-made products, such as chemicals, oil, gasoline and other pollutants get into the groundwater and the water becomes unsafe for human use. The consequence of this is that drinking contaminated water can have serious health effects causing diseases such as hepatitis and dysentery as well as poisoning caused by toxins in the water. Another long-term effect such as certain types of cancer can also be the result from exposure to polluted water.

b) **Environmental pollution:** the open landfills and the organic matter produce greenhouse gas emissions (methane and carbon dioxide) also odors and air contamination as well as risk for fires and explosions.

c) **Social problem of people living at the landfill:** the problem of the integration of the social workers in the social system need a long-term planning to provide work and better working conditions.

d) **Health problems:** the proliferation of disease vectors that directly or indirectly affect the public health.

e) **Global climate change issue:** the IPCC estimates that 3% of the global greenhouse gas emission (GHG) are attributable to waste management. (2015, IPCC). According to Manfredi direct emissions from landfill systems are up to 1000 m³ CO₂ per tonnes of waste. (Manfredi, 2009)
8. RESULTS OF THE WASTE MANAGEMENT ASSESSMENT

Figure 29 Results of the thesis in Salta and Jujuy.
The assessment of waste management in the Provinces of Jujuy and Salta shows and determines what challenges exist in each Province that need to be addressed to implement or improve a sustainable and integrated waste management system. The results show that the Province of Salta has a better system and has already started to implement an integrated waste management system with a separation system in small scale and biogas extraction, but need some technical and social improvements of the system. On the other hand, the Province of Jujuy needs to start the implementation of a sorting system, taking in consideration the informal workers, and improve the technical aspects of the transport and deposition of waste as well as to increase the knowledge and public awareness and to improve the technical aspects of the landfill.

### 8.2 RESULTS IN THE PROVINCE OF JUJUY

In the Capital of Jujuy, the general waste management situation is deficient in general. However, the results of the assessment identified the most important aspects that need high priority to start with the implementation of an integrated waste management system.

#### Aspects with 1 result point

The result shows 10 aspects with 1 result point with low degree of system knowledge. The 10 points shows necessary aspects that need priority to implement an integrated waste management system. These are: system goals, waste source and type, waste sorting, waste treatment, cooperation, planning, financing, knowledge, socio economic aspects and environmental aspects where the result show the lowest level, (5.1, 5.2, 5.4, 5.5, 5.8, 5.9, 5.10, 5.11, 5.13, 7)
Aspects with 2 and 3 result points

Regarding the aspects with 2 result point, indicates that there are already some actions implemented but a need for improvement: These are: transport, public awareness and business. (5.3,5.7,5.12) The legislative framework (5.6) with 3 result points shows that the legislation is in place concerning the issues of waste and environmental protection as well the legislative framework at national and provincial level. However, it is necessary to develop specific legislation, regarding waste management practices considering, waste hierarchy as well as EPR. Moreover, the control and enforcement of rules and legislation is necessary.

A major problem is that there is an uncertainty regarding the quantity and quality of waste and the lack of a separation system. In the Province of Jujuy there is a lack of official information. The production of waste in San Salvador de Jujuy has risen to approximately 400 tonnes per day and the amount of waste generated per household and day is estimated to 1-1.5 kg. All the 400 tonnes of waste go to open landfill. Sorting is practically made by hand by the informal pickers at the landfill with a rate of 2.5%. The fraction of organic waste is estimated to be about 50% of the total amount of waste generated. Plastics are about 30% of the total amount and consequently 20% is other kinds of waste. In addition, after the collection, the material is transported long distances. Consequently, there is a high grade of the emissions attributed to the transport of the material for recycling.

Regarding the technical aspects of the open landfill, the disposition of waste is dumped in an open landfill “Finca El Pongo” which is an uncontrolled dump where the waste is compacted and mixed with sanitary hospital waste. This arises concerns due to the presence of pigs that eat mixed household waste and hospital waste which can cause outbreak of trichinosis. The landfill “Finca el Pongo” is constructed originally as a sanitary landfill with trench method, but today it is an example of an open and uncontrolled dump with social, economic and environmental problems. There is also an issue with the lack of capacity building and the lack of knowhow regarding waste management, technology, operations and financial system.

8.3 CONCLUSIONS IN JUJUY

In the province of Jujuy, the situation of the waste management needs to be prioritized. The level of knowledge of the system perspective is very low and they need the creation of goals, objectives and policies for the implementation of a sustainable system. The municipality do not have a long-term waste management plan to work with all the important factors together to achieve a result. There is an also uncertainty regarding the quantity and quality of waste and the lack of a separation system

From the result of the thesis it can been seen that is necessary to assess the type and quality of the waste, to have a picture of the situation based on facts. The collection and transport need improvements on infrastructure and regarding the workers working conditions during the collection. There is a lack of sorting system or sorting stations implemented by the municipality. Sorting of waste and recycling is only based on the activity of the informal workers living at the landfill. The construction of a sorting plant is positive but the lack of separation system is going to limit the usefulness of the equipment. The other problems of this new system are the direct contact of the workers with the contaminated waste and the lack of the capacity of the system for 400 tonnes a day.

Regarding the public awareness, there is only one cooperative self-supporting foundation that works with prevention, collection and transport of waste in small scale. The Inter Municipal and national
cooperation is limited. The political differences in different municipalities damage the possibilities of joint actions in waste management by the deposition at the common landfill. There are even municipalities undertaking illegal actions of waste dumping at the common landfill.

Concerning the disposition of waste, it is dumped in an open landfill “Finca El Pongo”, located 23 km from the City of Jujuy. The surface area of the landfill is 30 hectares. The technical aspects of the landfill, the level of technical knowledge is low regarding the proper construction of a sanitary landfill with trench method, because it is not constructed or working properly. The ground is formed with an impermeable clay without any protective membrane. Consequently, there is a high risk of groundwater contamination. There is also a problem of lack of control of the quantity or weighting of the waste coming into the landfill and there is hospital waste. At the landfill, there are pigs eating mixed household waste and hospital waste. This leads to outbreak of trichinosis.

In relation to legislation, a legislative framework is in place concerning the issues of waste and environmental protection, as well as a specific legislation on hazardous and industrial waste. A new legislation is in process, aiming to improve the waste management in the Province. Resources for training, infrastructure an implementation of new technology will be allocated. However, there is a lack of enforcements of rules and legislation regarding waste management and lack of processes and controls to follow and apply the legislation. There is neither any local, provincial or national waste management plan to follow. Unfortunately, there is no confirmation regarding the existence of planning-instruments to establish long term Waste Management Plans that covers all the Municipalities in the Province, to establish a holistic sustainable waste management system.

Regarding the financing aspects, there is a system in place for charging the customers for services provided regarding collection of waste. But, there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities etc. In relation to the socioeconomic aspects, the level of education among people involved in the Waste management sector is low. Less than 2.5 % has studied at University level, of which only 0.49 % has a complete University degree. However, the informal workers at the landfill have of course gained practical skills and experience about the possibilities of sorting and recycling materials, and that gives a potential to future improvements of education and the possibility to get an employment in the area.

There are significant opportunities and interest from the establishment for development of business activities in Waste Management. There are already many companies established that are dealing with recyclable raw materials. Regarding other activities such as collection, transport and treatment of waste there can be an interest for upcoming entrepreneurs. The environmental consequences at the Province of Jujuy are summarized in the contamination of the soil and groundwater, environmental pollution because of the landfill Finca el Pongo and the social problem, regarding the people living at the landfill.

In conclusions, the optimization of the system is relevant to obtain the raw material in optimum conditions to proceed to the treatment of the waste collected. However, regarding the technical aspects it is important to point out the potential of implementing sustainable landfllling technologies and waste to energy solution as:

a) Possibility to reduce the gas emission from the landfill and capturing the additional gas for conversion into energy. Is necessary to improve the technical aspects of the landfill “Finca el Pongo”. There are multiple techniques that can be used for the collection of the landfill gas (LFG). With the
capture of the landfill gas it is possible to generate biogas and electricity. (see Annex II)

b) Possibility to build up a biogas plant at Chanchillos to generate biogas with electricity generation or biofuel with possibilities to use, manure, slaughter waste and agricultural waste to avoid the landfill deposition. (see Annex II)

8.4 RESULTS IN THE PROVINCE OF SALTA

In the Capital of Salta, the implementation of an integrated system is in place but it is necessary with an improvement of the system. The results of the assessment identify the most important aspects that need to be targeted and focused to continue the development of an integrated waste management system.

Aspects with 1 result point
The 6 aspects with 1 result point shows necessary priority to continue develop and improvement towards an integrated waste management system. These are: source and type of waste, cooperation, planning and financing, business opportunities and socio-economic aspects. (6.2, 6.8, 6.9,6.10,6.12, 6.13)

Aspects with 2 and 3 result points
Regarding the only aspect with 2 result points, indicates that there are already some actions implemented but a need of improvements. These is: waste sorting. (6.4). The 6 aspects with 3 result points that shows better results are: system goals, collection and transport, waste treatment, the legislative framework, public awareness and knowledge. (6.1,6.3,6.5,6.6,6.7,6.11) However improvements are necessary also regarding these aspects. It shows nevertheless that the government strategy is working positively regarding instruments and legislation. Anyway, the control and financial system need improvement to afford the necessary investments and improvements in the waste management system.

8.5 CONCLUSIONS IN THE PROVINCE OF SALTA

The waste management situation in the capital of Salta is better organized than in the Province of Jujuy in terms of planning and implementation of a waste management system. The city has its own controlled landfill called “Finca San Javier” with biogas extraction. The amount of waste produced in Salta is 600 tonnes a day. Regarding the waste collection and separation there are similarities with the problems of infrastructure described in the Province of Jujuy, such as the lack of trash cans, that makes the collection difficult and the lack of a separation system is a common deficit. The municipality does not have an update data of the quality and quantity of waste since 2003. The collection covers the whole city of Salta within 6 days which is positive. The trucks also have compactors that enables transport of a larger quantity of waste per truck.

In relation to public awareness there is a cooperative in cooperation with a private company oversees the waste sorting. It provides waste management services and implements the sorting program. This program is a good initiative but it only covers 2000 blocks of the city and 14 000 households representing only the 10% of the total area.

The waste is transported to the landfill, which is using the cell method and is well constructed, considering important aspects as the size of the cells, quantity and variation of rainfall, the absorptive
capacity of the waste as well as the control of the capacity of the cells for high degree compaction. The controlled landfill has technical problems during the extraction of biogas with leachates and oxygen that ingress into the holes where methane gas is extracted.

In relation to the legislation, a legislative framework is in place concerning the issues of waste and environmental at national and provincial level. A new provincial legislation is in process, aiming to improve the waste management in the Province. However, it is necessary to adopt specific legislation, regarding waste management practices considering, waste hierarchy as well as EPR.(Extended Producer Responsibility). There is a lack of enforcements of rules and legislation regarding waste management and a lack of processes and controls to follow and to apply the legislation. Regarding the Inter Municipal cooperation, is very poor and limited and exercised with only one private company in Salta Capital. The political differences in different municipalities damage the joint action in waste management. There is any long term regional Waste Management Plan.

In relation to financing, there is an inequality in the system in place for charging the customers for services provided, regarding collection of waste. 20 % of the households still does not pay for the services provided. Consequently, there is a problem with financing, to cover not only the costs for the daily services but to secure financing for needed investments in infrastructure, treatment facilities and for improvement of the system. Related to knowledge, there is knowledge of biogas extraction from landfills but there is a demand for future development in waste to energy. However, there are notable gaps about separation techniques of waste as well as regarding financing of the system. There are also significant opportunities and interest of the establishment and development of business activities in Waste Management. There is only one private company in charge of the waste management. There is a potential to increase the number of stakeholders in activities such as collection, transport and treatment of waste.

In relation to the Socio-Economic aspects, the Province of Salta has only 14 % of the citizens on high socio economical level, 50% with middle socio economical and 36% on low economical level. In conclusion only 14% has high economic level and consequently university degree. The increase of the population, waste generation and the economic development provides possibilities to create new jobs in waste management but it is necessary with more investments in education. The environmental consequences at the Province of Salta are summarized in the contamination of the soil and groundwater, environmental pollution because of the landfill and the social problem, regarding the people living at the landfill.

However, regarding the technical aspects it is important to point out the potential to upgrade the biogas from the landfill with two possibilities:

a) Upgrading for electricity generation. Electricity can be produced from biogas by combustion in a gas engine or a gas turbine. While electricity is produced also heat can be produced. In addition, it is possible to sell the generated electricity to the distribution system to get an extra income. (See Annex II)

b) Upgrading for biofuel. The biogas can be used as vehicle fuel after the cleaning and upgrading process. There are several different techniques to upgrade the biogas. (See Annex II)
9. DISCUSSION

The implementation or development of a sustainable waste management system in a municipality is very complex. The primary purpose of solid waste management (SWM) is to address health issues, environmental issues, land use and economic concerns. (Henry, 2006); (Marshall, 2013). Engineering system analysis models have been tools for decision makers to improve the solid waste management system (SWM) mostly based on isolated problems within the larger system bases in technical solutions. (Marshall, 2013) System engineering models and system assessment tools are designed to handle a problem but there is still a gap in the knowledge of waste management that need to be improved considering holistic and integrating methodologies that can address socio-cultural, environmental, economic and technical aspects (Marshall, 2013).

During the last decades, the term integrated waste management has been used to integrate the physical element from collection to treatment without considering the stakeholder’s perspectives or governance aspects. All the three factors: physical, stakeholders and strategy are important to implement a well-functioning system that works in a long term (UNEP, 2013) However, there are other practical factors in the context that need to converge to have a sustainable waste management system and learn the governance aspect with an adaptive approach to formulate strategies and long-term policies. This thesis aims to identify from a management perspective what are the priorities and which conditions are necessary to create, run and maintain to have an effective, long term integrated waste management system.

The result of the thesis shows that a practical and general assessment in two municipalities provide not only physical aspects of integrated waste management but the governance aspects as well as the practice in waste management in two municipalities. The factors describe clearly what are aspect that need to be considering and need to be improved in the whole system and provide important information to understand the stage of development of waste management in Salta and Jujuy. The stakeholders usually participate in the decision-making process and for this reason the practical knowledge of the whole waste system provides valuable information to establish a long-term waste management plan. As a result, the municipality has the possibility, to save money and time, focusing on the most important aspects that need priority. In the Province of Jujuy 50% of the waste is organic waste and there is access locally to raw material as slaughterhouse waste with a lot of potential to implement biogas and electricity generation which is highly demanded. Salta has already a controlled landfill with a lot of potential to upgrade the biogas system and generate electricity during a short time period.

The international experience provided by the UN-HABITAT and the Integrated Waste Management Outlook (IWMO) provide valuable information and good and bad examples in the implementation of waste management from the past years. It shows that the Integrated Waste Management (IWM) approach can be applied in countries with developing economies as well as in countries with developed economies. However, the differences in infrastructure and limited resources in developing countries change the applicability of the approach (McDougall, 2001). Therefore, a practical approach of an assessment as WHAT methodology in this two cases show that it is relevant to adapt the waste management strategy considering the local circumstances and the identification of the success factors for the implementation a sustainable waste management system. The WHAT methodology is a practical tool based in the Integrated Waste Management approach that can be used by the stakeholders at the municipalities to make a general assessment about the whole waste management system. One of the disadvantages or difficulties to use this methodology are the uncertainty regarding the quantity and
quality of the data at the municipalities for the quantifications of the results. The difficulties to acquire relevant information can be complemented by studies visits and interview with the stakeholders. The positive aspects in using the WHAT methodology is the possibility to provide a practical tool that just only by answer the questionnaire of the methodology (Annex I) a municipality quickly understand which factors and actions need priority and start to address the bad practices. Because, the consequences, of not addressing the bad practices in waste management can be costly to the municipalities and society of the future.

10. RECOMMENDATIONS

The recommendations are suggestions to future development of Integrated Waste Management in both provinces.

Recommendation to the Province of Jujuy to implement a IWMS:

- **Waste management plan**: work in a long-term waste management plan.

- **Data collection and Infrastructure**: It is relevant to improve the data collection regarding the amount, quality and different sorts of waste. It is also important to improve the infrastructure of the collection with places constructed to leave the waste and to increase number of garbage bins.

- **Landfill**: Actions should be taken to close and cover the existing landfill in a way that minimizes the risks and impact on the environment. New landfills must be planned and constructed according to modern environmental standards. The landfill components as liners, leachate treatment, biogas extraction and management and landfill operation must be considered according to engineered principles. There is a potential to extract the biogas from landfill. A system of control, monitoring and maintenance of landfill is also necessary to implement.

- **Legislation**: Actions that should be considered is to allocate resources for inspections and follow-up on waste management operations regarding compliance to legislation and environmental impact. As well as implement more specific legislation in zero waste, waste prevention and waste reduction as well as waste sanctions and extended producer responsibility (EPR).

- **Public awareness**: Continue and increase cooperation with different stakeholders as government, universities municipalities and private sector, to discuss only one waste strategy and complement each other. Implement strategies and information campaigns considering waste hierarchy with the aim to increase public awareness in relation to waste management and recycling by sorting of the different fractions of waste. The separation of organic waste can be done at households and can represent an opportunity to reduce the quantity of waste up to 50% and can also contribute to reduce the pollution and health problems as well as the major source of leachate.

- **Cooperation**: Improve the cooperation at the provincial and national level in development of a common waste management plan and increase the cooperation, participation and responsibility
in the different municipalities at the Provincial level, national level as well as with the private sector.

- **Planning:** Introduce planning instruments to establish long term Provincial Waste Management Plans that covers all the Municipalities in the Province to establish a holistic sustainable waste management system.

- **Financing:** It is important to review the economic circumstances and instrument and the tariff system economically to make rate changes so that the system can be maintained and likewise has a marginal for future investments in infrastructure, capacitation and technology. It is relevant to increase the fees of the waste system to implement a sustainable system. (5.10)

- **Knowledge:** It is necessary to implement a long-term training plan in the different areas of waste management that is implemented by the municipality and controlled by the Ministry of Environment. There is a potential to implement a competence and skill scale grade to encourage the workers and to provide certificate in different areas. The university should cooperate in this initiative.

- **Business:** Conduct a business plan in waste management. A good waste management system can bring positive effects to the society and the economy. It can also bring job creation and the potential to produce energy or biofuel.

- Conduct studies about the quantity and quality of waste as well as the quality and quantity of the local raw material. It is necessary to make the studies of the waste management to get the TS (Total Solids) and VS (Volatile Solids)

- Conduct a feasibility study for biogas production as well as CBA Cost Benefit Analysis for biogas extraction at “Finca el Pongo” and biogas plant at “Chanchillos”.

- Improve the collection of data on waste management.

- Using the life cycle approach to waste management according the IPCC, “using a lifecycle approach. It has been estimated that a 10% to 15% reduction in global greenhouse gas emissions could be achieved through landfill mitigation and diversion, energy from waste, recycling and other types of improved solid waste management. Including waste prevention could potentially increase this contribution to 15 to 20%.” (UNEP, GWMO, 2015)

**Recommendations to the Province of Salta**

- **Infrastructure:** Investments should be taken in waste bins, collection and more transport vehicles

- **Waste sorting:** actions should continue with the implemented program “Sorting together” and continue the investments in a bigger program that covers the whole city.
- **Landfill improvements**: it is necessary to check the landfill gas extraction system, change equipment to avoid the fugitive emissions and suggest a feasibility study to upgrade the system to energy recovery. Improve the pipelines of the biogas system to avoid losses and decrease in the quality of biogas.

- **Legislation**: Necessity of resources for inspections and follow-up on waste management operations regarding compliance to legislation and environmental impact. More specific legislation in zero waste, waste prevention and waste reduction as well as waste sanctions and EPR extended producer responsibility is necessary to implement.

- **Public awareness**: It is important to continue spread the initiatives and experiences of the program “Separemos juntos” (Sorting together) and develop a broader scale at the municipal and provincial level.

- **Cooperation**: Improve the cooperation at the local and Provincial level in a common waste management plan and increase the cooperation, participation and responsibility in the different municipalities at the Provincial level. The cooperation with the public and private sector has huge relevance.

- **Planning**: It is relevant to establish an inter-municipal platform for strategic and long term joint planning for waste management and to increase the public- and private cooperation in the area. Working together with other municipalities on strategies for collection, transport and disposal issues as well as infrastructure to share the economic burden in the area of waste management.

- **Financing**: It is important to review the economic and structural system to implement new regulations and new fees to be able to make rate changes so that the system can be maintained and likewise has a margin to cover future investments in infrastructure, education and technology.

- **Business**: What should be considered is establishing a long-term Waste Management Plan that also covers the Business Opportunities through the inclusion and dialogue with different stakeholders and actors.

- **Knowledge**: To start a public or private company to invest in knowledge and new technology

- Conduct a feasibility study for upgrading of biogas systems to generate electricity or biofuel.

Recommendation to future development of the WHAT model

- There is potential to developed the **WHAT** tool and to include the experience from the Swedish waste management model and the international experience in developed and developing countries.

- There is a potential of development of a software tools that can provide a quick assessment diagnosis of the waste management situation at the Municipal level that can be used by stakeholders and give decision makers support to avoid high costs to start up a waste strategy or to focus on wrong aspects.

- Potential to include a database and scientific information about the results of implementation of waste management.

- Potential to include a financial tool with cost and benefits of the investments
References


Naturvårdsverket. (2012). Biogas from manure, waste and residues, Good Swedish Examples.


The total biogas production in Sweden
Sweden produced in 2015 more than 1. 9TWh of biogas from 282 plants. Of the total amount, 63% was upgraded, 20% was used for heat production, 3% went to production of electricity and 2% were used for industrial use. The main substrates for biogas production are manure, sewage sludge, food waste and food industry waste. In addition of the production of biogas, the plants produced in 2015 more than 2 025 million tonnes (wet weight) of digestate which 99% was used as bio-fertilizer. The main application area of biogas in Sweden is upgraded biogas as biofuel that represents 63% of the total use and shows an increase of 20% compared with the previous year. The second largest application area is the production of biogas for heating with 20% and the remaining gas is used for electricity generation. (Biogasportal, 2015)

Landfill gas in Sweden
In Sweden, most of the landfills are closed as a result of a restrict legislation for disposal of 2008. Today only 1% of the waste is deposited in landfills. During 2015, Sweden produced a total of 190 GWh of landfill gas coming from the 58 waste sites of which 137 GWh was recovered energy. The energy recovery from landfill gas consist of 18 GWh to produce electricity, 1 GWh of vehicle gas and 118 GWh of heat. (Avfallsverige, 2016)

The biogas process
The production of biogas is conducted by a digestion process of the organic waste that is divided in four different biological processes: hydrolysis, acidogenesis, acetogenesis and methanogenesis. The hydrolysis, monomers are produced from complex polymers which in the future transforms into volatile acids (acetic, propionic and butyric acid) and hydrogen (H₂) during acidogenesis. During the acetogenesis, the acetate, carbon dioxide and H₂ are converted in methane gas under the methanogenesis. (Carauna, 2012)

Biogas (CH₄ + CO₂)

Mechanism of methane formation

a. splitting of acetic acid \[\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2\]

b. reduction of carbon dioxide \[\text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}\]

The process is conducted in a digester, where raw material is introduced and where microorganism interact with each other in a complex interaction at 37 degrees. The dry matter content must be on maximal 15%. In the cases of thermophilic digestion, the temperature increases to 50 degrees. During the process, carbohydrates, proteins and fats break down and form methane and carbon dioxide. The process is developed as a natural process, in an environment, with limited quantity of oxygen. To have a correct balance, it is necessary to keep a value of pH between 6.5-7.5. In the digester, methane and carbon dioxide are produced but it is possible to find small quantities of ammonia and nitrogen and hydrogen sulphide. The gas is later saturated with water vapor and the material left in the digester can be used as fertilizer. (Biogas Syd, 2010)
**Substrate and co-digestion**

Many organic materials are suitable to produce biogas as substrates for anaerobic digestion, waste from households, sludge, manure, food waste, crops residues and food processing industry. The mixture and co-digestion of various materials provides a high methane yield. Some of the substrates as manure waste need a pre-treatment to eliminate contamination. It is important to determine the substrate characteristics and nutritional composition with the aim to evaluate the possibility to get high methane yield. The TS (Total Solids) value indicates the materials content of residual compounds when water content is evaporated at 105 °C. The materials with high TS content (10-15%) often need to be diluted to function in reception. The material with low dry content can be used to dilute the thicker subtract.

The VS (Volatile Solids) specifies the material content of combustible substance at 550°C and it is useful for calculation of a substrate of an organic content. In consequence, high VS (Volatile Solids) contents produce high gas yield since the organic part of the waste can be digested in the digester and contribute to the production of biogas. The analyses of the TS and VS are used to characterize the organic waste before and after the treatment. During the co-digestion the microorganism need carbon, nitrogen, phosphorus and vitamins for its growth. In the waste mixture, all these parts must be available in sufficient quantity. It is also desirable that after the process, the remaining part of the digestate contains available nutrients. Consequently, the ratio between carbon and nitrogen in the substrate is important. A ratio of up to 30 is favorable for microbial cell metabolism. A lower ratio of 10-15 causes accumulation of ammonia and high pH (measurement of acidity) and can consequently accumulate toxic microorganisms. (Biogasportal, 2015) After the biogas process the rest of the organic waste contains all the nutrients that can be used as bio fertilizers (Svensk Gasteknic Center, 2011)

**Pre-treatment**

Some substrates as manure products, require pre-treatment with the aim to get rid of the element that should not be in the process. The biogas plants that treats material of animal origin normally heats up the material to 70°C to avoid contamination before it is fed into the digester. In the case of dry material, it need to be soaked up and highly liquid substrate as waste water and sewage must be dewatered to decrease the volume before entering to the digester. In the case of household waste, the organic material must be separated from both the packaging and wrongly sorted waste. It exists different kinds of techniques that can be used in the pre-treatment as grinding, decomposition, chemical or thermal pre-treatment for making the material available to the microorganisms.

**Potential of landfill biogas and electricity generation**

The biogas is produced when the organic material in the landfill breaks down in an anaerobic process in the absence of oxygen. Landfill gas becomes explosive when it escapes from the landfill and mixes with oxygen and can cause fires at the landfill. The gas in the Province of Jujuy can be extracted from the landfill “Finca El Pongo” as it is extracted in the Province of Salta. The gas extracted from landfill has smaller methane content because the methane production is not controlled in the same way when it is produced in a digester. This process is a slow process and the methane can be extracted during 30-50 years. Electricity can be produced from biogas by combustion in a gas engine or a gas turbine. While electricity is produced also heat can be produced. In addition, it is possible to sell the generated electricity to a distribution system to get an extra income. To generate electricity, in general the gas must have a concentration of at least 40 % and gas quality is needed to improve. However, in Sweden today there is a new technology that converts biogas with a low methane concentration (18 %) into electricity and heat. This kind of technology,
CHP System opens a new opportunity beyond traditional system because today can produce power for 20 years longer and the raw biogas from both farms, waste water plants can be use directly from source without processing. (Cleanenergy, 2017)

**Biogas as biofuel**
The biogas can be used as vehicle fuel after the cleaning and upgrading process. There are several different techniques to upgrade the biogas. This process requires the separation of methane gas and carbon dioxide to obtain significantly lower content of carbon dioxide. The techniques are, pressure swing absorption (PSA), water wash, chemical absorption, separation by membrane, cryogenic separation. The most common is the water wash, technique when the biogas is bubbled through water. The water absorbs carbon dioxide and other kind of impurities. After this the gas is dried and compressed. During the anaerobic digestion, fugitive emissions of CH₄ are produced during the process. This emission is variable depending of the plant facilities and technology used (Eggleston, 2006)

Today many of the municipalities in Sweden can control the choice of the biofuel by including the requirements in the public procurement process. The most common use is the biogas to the public transport but they also use other alternative fuels. The alternative fuels are RME made from rapeseed oil and HVO which is a synthetic diesel made from slaughterhouse or grain waste. (Avfallsverige, 2016)

**Investments and profitability**
The profitability and efficiency of a biogas plant is related to high biogas production and it is determined by supply and type of substrate and how to control the process to get a better result. One study made in Sweden in 2013 shows that the substrate gave higher revenue than production cost per tonne waste were slaughterhouse waste and food industrial waste where used. If the process provides a higher methane yield the revenue can increase and give a 50% decrease in cost for personal and maintenance. An increase of biogas production can be obtained by utilizing a mixed biomass that today Is not used to improve the potential up to 10 TWh per year. (Murto, 2013)

**Good example of biogas in Sweden**
Sweden has come a long way in the use of biogas and is an example for the purification of biogas to vehicle quality. The investments in Sweden was made by the government and investments from local environmental programs. There is a big potential of export of knowledge to developing countries in the area of renewable energy where the waste and environmental problems need an urgent solution. During 2003-2010 Sweden made 200 biogas projects that contribute to an overall reduction of greenhouse gas emissions by about 170 000 tonnes of carbon dioxide per year during 2003-2010. This carbon dioxide reduction corresponds to 56 000 cars annual emissions.
This biogas plant in Kristianstad has a complete biogas system with two productions units. It was decided to upgrade the facilities in order to get an own biogas network and their own gas station. The biogas plant consists of two reactors with a volume of 6000 m³ and 4 000 m³. The plant also uses landfill gas. The process is mesophilic at 38° C in a single stage process during 40 days. The slurry is from sorted household waste collected in paper bags, liquid manure, slaughterhouse waste and various organic waste from food. The capacity of the plant is 150 000 tonnes per year. Prior the digestion, the material is pasteurized in three parallel tanks at 70° C.

Facts about the plant in Kristianstad

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<table>
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<tr>
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<tbody>
<tr>
<td><strong>Start biogas plant</strong></td>
<td>1996</td>
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<tr>
<td><strong>Reactors volume</strong></td>
<td>6000 m³ and 4000 m³</td>
</tr>
<tr>
<td><strong>Process temperature</strong></td>
<td>38° C</td>
</tr>
<tr>
<td><strong>Upgrading</strong></td>
<td>1996 and 2007</td>
</tr>
<tr>
<td><strong>Upgrading method</strong></td>
<td>Water wash</td>
</tr>
<tr>
<td><strong>Substrate per year (2011):</strong></td>
<td></td>
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<tr>
<td><strong>Sorting household waste</strong></td>
<td>25 000 tonnes</td>
</tr>
<tr>
<td><strong>Slaughterhouse waste</strong></td>
<td>30 000 tonnes</td>
</tr>
<tr>
<td><strong>Slurry</strong></td>
<td>20 000 tonnes</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>10 000 tonnes</td>
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<tr>
<td><strong>Biogas production:</strong></td>
<td></td>
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<tr>
<td><strong>From the biogas plant</strong></td>
<td>41 000 MWh</td>
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<tr>
<td><strong>From the treatment plant</strong></td>
<td>8 000 MWh</td>
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<tr>
<td><strong>From landfill</strong></td>
<td>18 000 MWh</td>
</tr>
<tr>
<td><strong>Upgraded biogas</strong></td>
<td>34 000 MWh (40 000 MWh 2012)</td>
</tr>
<tr>
<td><strong>Liquid digestate</strong></td>
<td>80 000 tonnes</td>
</tr>
<tr>
<td><strong>TOTAL INVEST 107 million SEK</strong></td>
<td>USD 11 886 000</td>
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</table>

The information about the exchange rate was taking SEB bank exchange rates from 2017-03-07 1ARS = 0,59 SEK

*Tabell 9 Facts about the biogas plant in Kristianstad (Naturvårdsverket, 2012)*)