Tackling the Waste Issues on Isla Navarino

A Research into the possibilities of Waste Materials

Version: Final version April 2007
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Issued: April 16, 2007
Studies: Business Administration, International Management
Type: Master of Sc.
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Management summary

Enviu is a Dutch non governmental organization (NGO) which focuses on an entrepreneurial attitude towards sustainable development. Enviu has several projects in the Netherlands but is also active in the most southern parts of Chile, South America. It is active on the island Isla Navarino. Puerto Williams with 2200 inhabitants is the biggest village on the island, which is the southernmost village on earth.

Enviu and other people on Isla Navarino are concerned about the waste situation on the island. The quantity of waste has grown over the years because the population has grown. Moreover more tourists visit the island and they also produce waste.
Another issue is that the waste dump on which household waste is dumped, is reaching its maximum capacity. A third challenge is that waste is not separated; a consequence is that useful materials are lost. Plans for a new waste site are in progress but it is not clear when it will be implemented. A new waste dump however only provides new capacity and does not reduce the waste dump in general, nor prevents the dumping of useful materials. That is why this research focuses on reducing the total quantity of valuable materials dumped and uses waste materials in a better way. The research objective is formulated based on this problem definition: *Improving waste management on Isla Navarino by decreasing the volume of valuable materials dumped on the domestic waste dump through sustainable waste solutions.*

The analysis of the current situation leads to the identification of valuable materials present on the island. Case studies and literature research lead to the identification of possible methods that can be used to process these materials. This research identifies 7 possible waste projects for the island. Three of the projects are based on transporting materials (metals, glass and paper) to Punta Arenas, the nearest Chilean city some 300 kilometres from Puerto Williams. The other 4 projects are recycling glass, paper, plastic and metals on the island.

In consolidation with the local community, six criteria (time until results, breakdown time, quantity of material, start-up costs, processing costs and revenues) are established. These six criteria were the basis for ranking the 7 waste projects from “best” to “worst”. Transporting metal to Punta Arenas is identified as being the best project of the 7 projects. This project should be implemented first to improve the waste situation in a sustainable way.

To facilitate implementation, increase acceptance of the implementation and ensure the long-term success of the project several steps are recommended to execute when implementing a waste project. These steps are:

- Role of the stakeholders

The success of the project depends on the how well each party involved carries out its own role. The municipality for example has the responsibility for the waste infrastructure. The municipality also may have a role as initiator of a waste project. Executing the project is not the responsibility of the municipality. It can however help entrepreneurs to set up a waste project and make sure more projects are executed after that. It is essential to get all roles and responsibilities clear before starting the project.

- Financial funds

It is evident that investments need to be made, for example for collection containers. Stakeholder must apply for funds if the money cannot be raised on the island.

- Education

Not all people are ready and willing to separate waste. To change this mindset, residents need to be educated on why it is important to separate. An education and communication campaign needs to be initiated to educate on what kind of waste is dangerous, what can be done with certain materials, what people can do themselves, which revenue opportunities waste management offers and where the collection containers are located.

- Waste infrastructure

Before a waste project even can be implemented the current waste infrastructure needs to be adjusted. At this point there is no infrastructure to separate valuable materials from the rest of the waste. Collection-containers need to be placed in strategic places so that materials can be disposed of by people living in the community.

- Make a new waste dump

The last step that should not be forgotten is that the municipality should finish the new waste dump. At this point there are plans to build it, it is however not clear when it going to be finalized. This is however very important because non recyclable/reusable waste should be disposed of in a save way, on a save waste dump.

These steps are put into a timeframe so it is clear which actions need to be carried out first when implementing the “best” waste project. Overall it is recommended to start with the “transporting metals to Punta Arenas” project. This project scores the best because this is the only project with can gain revenues immediately. The project should be implemented first to obtain experience with a waste project with the aim to further improve in the future.

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Resumen ejecutivo

Enviu es una organización no gubernamental (NGO) de origen Holandes, cuyo enfoque es el desarrollo sustentable. Enviu tiene varios proyectos en los Países Bajos pero también lleva a cabo actividades en la zona más austral de Chile, en América del Sur. Enviu realiza actividades en Isla Navarino cuya capital y principal ciudad es Puerto Williams la cual es, a su vez, la más austral en la tierra.
Enviu y otras personas en Isla Navarino están preocupadas sobre la situación de los residuos en la isla. La cantidad de desechos ha crecido durante los años porque más personas están llegando a la isla. Por otro lado, más turistas visitan la isla y ellos producen residuos extras. Otro problema es que el vertedero domiciliario, está alcanzando su máxima capacidad. Un tercer problema es que no existe separación de los residuos lo cual tiene como consecuencia la pérdida de materiales que podrían ser útiles. Los planes para un nuevo sitio para el vertedero están en marcha, pero no está claro cuando se terminará.
El nuevo vertedero sólo proporciona un nuevo espacio físico y no reduce el material desechado en general, ni previene la descarga de materiales útiles. Por esto, esta investigación se enfocó en reducir la cantidad total de materiales valiosos. El objetivo de la investigación se formula basándose en la siguiente definición del problema: Mejorar el manejo de residuos en Isla Navarino disminuyendo el volumen de materiales valiosos descargados en el vertedero domiciliario, identificando posibles proyectos para el manejo sustentable de los residuos.
Esta investigación ha identificado 7 posibles proyectos de residuos para la isla. Tres de éstos son basados en el transporte de los materiales (metales, vidrio y papel) a Punta Arenas, la ciudad chilena más cercana, unos 300 kilómetros de Puerto Williams. Los otros 4 proyectos son el reciclaje de vidrio, papel, plástico y metales.
A partir del diálogo con la comunidad local, se establecieron seis criterios (tiempo hasta obtener resultados concretos, tiempo en disolverse, costos en procesar un metro cúbico, cantidad de material, costos de comenzar el proyecto y ganancias). Estos seis criterios fueron usados para generar una clasificación jerárquica de los 7 proyectos de residuos en orden de "mejor" a "peor". El transporte de metal a Punta Arenas se identificó como el mejor de los 7 proyectos. Por ello, éste es el proyecto que debe llevarse a cabo primero para mejorar la situación de los residuos en Isla Navarino.

Por facilitar la fase de implementación y asegurar el éxito, se hicieron algunas recomendaciones:

- Infraestructura para la basura

Antes de que un proyecto de residuos pueda llevarse a cabo, la infraestructura necesita ser ajustada. Actualmente no existe ninguna infraestructura para separar los materiales de valor del resto de los residuos. Los contenedores necesitan ser puestos en los lugares estratégicos para que los materiales puedan ser entregados por las personas de la comunidad.

- El rol de los stakeholders (grupo de influencia)

El éxito de los proyectos depende en gran medida de cómo los actores involucrados llevan a cabo su rol. Por ejemplo la municipalidad es responsable de la infraestructura para los residuos. Ellos también tienen un rol importante en iniciar proyectos de residuos. La ejecución de los proyectos no es necesariamente responsabilidad de la municipalidad. Sin embargo, ellos pueden ayudar a empresarios a realizar proyectos de residuos y a su vez, pueden asegurarse de que más proyectos se ejecuten después del término de alguno. La responsabilidad de los residentes de la isla es separar los materiales de valor en sus casas y llevarlos al contenedor para que pueda ser procesado.

- Educación

No toda la gente esta preparada ni dispuesta a separar la basura. Para cambiar esta mentalidad los residentes deben tomar conciencia del porqué la separación de la basura es importante. Por lo anterior, es necesario iniciar y preparar de la mejor forma posible una campaña de educación y comunicación. Educar por ejemplo, sobre qué materiales son peligrosos, que es posible hacer con éstos, qué pueden hacer las personas por si mismas y a donde se encuentran los contenedores.

- Evaluación

El proyecto de residuos debe evaluarse después de que se ha llevado a cabo. Esta evaluación puede conducirnos a realizar mejoras del proyecto actual, y también puede proporcionar valiosa información para los futuros proyectos.

Preface

This is my graduation thesis for the study Business Administration at the university of Twente . Within this study, I followed the track International Management. For my graduation project I was looking for an opportunity to return to Latin America. A few years ago I have been to Latin America and had good experiences. Enviu gave me the chance and the opportunity to dive in the world of sustainable development in a rural setting.

The past seven months I have written a research proposal in the Netherlands, took Spanish classes in Barcelona and carried out research in Puerto Williams, Chile. The main topic in my research is sustainable waste management, more specifically this research focuses on prolonging the life cycle of waste materials instead of dumping waste. Due to the fact that Isla Navarino is very secluded my research has not always been easy. The language barrier and a very slow internet conncetion(if existing at all) have made this experience even a bigger adventure. Doing my research project on an island in a totally different environment than in the Netherlands and experiencing these difficulties has altogether been a very interesting experience from which I have learned a lot.

I would like to thank the other Enviu-ers (Marieke, Sjoerd, Rudolfo, Murielle, Andres and Ignacio) who were in Puerto Williams at the time of my stay for their company. Their presence made my stay a lot more fun. They were always there when I needed a break from my research in the office. I would also like to thank all the people who I have interviewed for providing me with the required information to complete this research.

I would especially like to thank all the members of my graduation committee. W. Kersten of Enviu for his very valuable feedback and always quick response to my e-mails, sometimes within ten minutes. I would like to thank Ir. S. J. Maathuis for his feedback on my research. I would also like to thank the co-reader Dr. Ir. S.J. De Boer for taking the time to read my research and providing feedback.

Finally I would like to thank my family and friends, they gave me distraction when I needed it.

Marije Bellinga

April 19th 2007, Enschede

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1. Introduction

This research aims to tackle waste management issues on Isla Navarino. In section 1.1 the research area, Isla Navarino is introduced. The research is carried out for a Dutch non governmental organization Enviu, section 1.2 will elaborate on Enviu. To understand what the waste situation is on the island, section 1.3 gives an analysis of the current situation. Based on issues encountered, a problem definition and research objective are given in section 1.4. In section1.5 research questions are formulated to reach the objective of the research and section 1.6 specifies the way the research was carried out.

1.1 Isla Navarino

Chile stretches over 4000 Km and therefore has a variety of natural habitats. The climate in the north is very dry and the Atacama Desert is the driest area in the world. The central climate is moderate and the south is generally cold and humid with strong prevailing winds and even more towards the extreme south (Enviu, 2006). The country is divided in thirteen regions, a map of Chile can be found in appendix A. Isla Navarino is a sub-Antarctic (approximately 50 x 100Km) island and is located in the most southern part of Chile, the Region of Magallanes and Antarctica Chilena (Region XII). The island has about 2200 inhabitants. The nearest Chilean city is Punta Arenas at 300 kilometres, see figure 1. The other 12 regions can also be found in appendix A. Region XII is divided into four provinces: Última Esperanza, Magallanes, Tierra del Fuego and Chilean Antarctic. Isla Navarino belongs to the Chilean Antarctic Province and is part of the municipality of Cape Horn. It is situated on the southern side of the Beagle Channel across from Argentinean Tierra del Fuego (Enviu, 2006), see figure 1. It is relatively isolated from the rest of Chile due to its geographical remoteness and the limited transport infrastructure.

Figure 1: Map of Tierra del Fuego (Source: www.worldatlas.com)

The majority of the population of the province Antartica Chilena lives on Isla Navarino, in the town of Puerto Williams, which is the administrative capital of both Cape Horn County and Chilean Antarctic Province. A map of Puerto Williams can be found in figure 2 (page 13). Puerto Williams and the Northern part of the island concentrate the main economic activities: fishery, agriculture and forestry, as well as public administration and to a certain extent tourism (Paumen 2004; Mark 2004). The town, which was first named Puerto Luisa, is a Chilean Naval Base since 1950. It slowly evolved towards a civilian society with the establishment of the Municipality of Navarino, now called the Cape Horn Municipality. The Cape Horn region, with its unique ecosystems is considered as one of the few 'pristine' areas of the world which means that 70% of the original environment is still intact and free from human impact (Rozzi et al., 2004). In the last few years, tourism to the island has been increasing due to original environment, the proximity of Cape Horn, Antarctica, Tierra del Fuego and an overall trend for tourism to natural sites. However, tourism infrastructure and tourist services remain limited on Isla Navarino.

1.2 Enviu

The initiative of this research lies with Enviu. Enviu (The Environment and You) is an international non-profit organisation for and by young people. Enviu facilitates young entrepreneurial people in starting up and scaling up their activities focused on profitable solutions for environmental and social issues. It operates in the Netherlands and low to medium income countries.

Target group:
For: starters within large organisations or non-profit organisations, established small business entrepreneurs and intrapreneurs (young entrepreneurial professionals within a large company). By: students and young professionals, between the age of 21 and 35, primarily with a business or economic background. They apply themselves as volunteers in Enviu projects.

Core activities:

- Start-up and scale-up facilitation: from generating ideas, concept and business plan development to the first implementation. Activities are for example brainstorming sessions, workshops, market research, expertise exchanging sessions, training, facilitation of a stakeholder dialog and change management.
- Management of the Enviu international community: offering an attractive, inspiring work- and study environment to young entrepreneurial people. Personal and professional development are the main points in this. For example: brainstorming sessions, workshops, participation in projects, training, internships, theses and voluntary work in the Netherlands and abroad.

1.3 Problem identification

Since 2004, Enviu has carried out several projects to raise general awareness about the contribution of sustainable development in the south of Chile (sustainable development is explained further in 1.4). These projects vary from cultural activities to helping small and medium enterprises with a marketing plan (Enviu, 2005). Local people on Isla Navarino and Enviu have noticed the increasing waste issues on the island and want information on how to improve the situation in the future. This research will contribute by increasing the awareness of the waste

problem and give suggestions on what can be done to improve the waste situation on the island. By interviewing local residents, waste management issues have been identified.

Waste Management in this research is defined as: Products, systems and services for the collection, handling, treatment (including recycling) and disposal of municipality, commercial and industrial wastes (Ecodirectory, 2006).

The first issue identified is that the waste produced on Isla Navarino is growing. The growth is caused by two factors. On the one hand the town of Puerto Williams is growing. Puerto Williams is an old naval settlement. In the past the navy, called Armada in Chile, provided everything for Armada residents. For example, they provided residents with wood for heating, but also took care of the solid waste. The Armada prevented Puerto Williams from growing. These restrictions however were removed 20 years ago (Municipality, 2006). The municipality took over responsibility of the island and since then the town is growing, which leads to more waste.

The second issue is that more tourists visit the island, which produce extra waste on the island. Blanco (2006) has identified a growth of 8% of tourists that visit the island on a yearly base since 2005. The extra waste is caused by the depositing of trash on the island. Cruise ships, for example the Mare Australis, have approval from the local authorities to deposit trash on Isla Navarino when passing through. No tax or fees are paid for this. Tourists represent an opportunity for regional development. However the tourists also form a threat to the unique ecosystem.

The municipality sees the necessity to tackle the waste situation. Many projects have been started over the last two years to raise general awareness. This will be explained further down in this research (Interview, 15th of January 2006). To this point however no concrete action has been taken to actively address the increasing waste.

At this moment, Isla Navarino has two open air waste dumps (Interview, 14th of November 2006). An open air waste dump is an “unsecured” disposal site where solid wastes are disposed of in a manner that does not protect the environment (Kurian, 2002). The waste dumps are open fields and therefore not protected against weather conditions. Furthermore, the strong winds which are common on Isla Navarino spread the solid waste from the open air dump all over the island. An open air waste dump is a relative cheap solution to dispose of waste, but does not include the costs on the environment and future cleaning costs.

One waste dump on the island is for industrial waste, which mainly contains of fish products. This dumpsite is located 15km outside Puerto Williams. Domestic waste (definition see page 13) is disposed of on the second waste dump, located above Villa Ukika, see figure 2 (red arrow).Villa Ukika, is a village which is inhabited by Yaghan, the original inhabitants of the island (Lonely planet, 2006). This waste dump has almost reached its maximum capacity, so a new site needs to be found (Interview, 15th of November 2006). The last issue is that there is no separation of valuable waste materials, so more waste is dumped than necessary.

Figure 2: Map of Puerto Williams (Source: Flyer Puerto Williams made by Enviu 2006)

From the problem background above the following three problems can be identified on Isla Navarino:

- The increasing waste produced on the island.
- The capacity of the domestic waste dump is reaching its limits.
- Valuable materials are lost on the waste dump.

1.4 Problem definition and research objective

The previous section sketches three problems on the island. Because this research is bounded by a timeframe, this research will contribute to the solution of one of the identified problems.

The decision of the specific focus for the problem was based on the following factors:

- The wishes of Enviu Chile (who know the wishes of the local community because they consulted them)
- Initiatives taken to solve problems by other parties
- The area in which the research would have the most benefit

Using the mentioned criteria, it was decided to choose the problem of valuable materials lost on the waste dump. This research only focuses on domestic waste and specifically solid waste dumped on the domestic waste dump.

Domestic waste in this research isdefined as: Solid waste from houses, streets, and public places, shops, offices and hospitals, which are very often the responsibility of the municipality or other government authority. Domestic waste can therefore also be referred to also municipality solid waste (Zurburgg, 2003).

Solid waste in this research is defined as: a material which is not in liquid form, and has no value to the person who is responsible for it. Synonyms to solid waste are terms such as garbage, trash, refuse and rubbish (Zurburgg, 2003).

Based on the above identified problem the objective of the research is:

Improving waste management on Isla Navarino by decreasing the volume of valuable materials dumped on the domestic waste dump through sustainable waste solutions.

Improving waste management on Isla Navarino by decreasing valuable materials dumped on the domestic waste dump...
The basis of this research is to improve waste management on Isla Navarino. Because waste management is a very general concept, the objective is specified by focusing only on decreasing valuable materials dumped and finding methods to reuse and recycle them. Several methods can be used to establish this improvement of waste management.

.....by identifying possible sustainable waste projects
Enviu played an important role in the choice of possible sustainable waste projects. Enviu aims to get the local community involved to improve their own waste situation. This can be done by showing the local community the opportunities of domestic waste. On the other hand the mission of Enviu states that it wants to contribute to a sustainable world. This together explains the choice of a sustainable waste project, which is based on the concept of sustainable development.

Sustainable development is in this research defined as: *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (WCED, 1987:43).

Perhaps one of the fundamental conclusions about sustainability was drawn by Tibbs (1999), namely the conclusion that the current pattern of production of goods in many countries is unsustainable. Key strategies to create sustainability include improvement of production efficiently, shift from a product to a service focused economy, closing of the material cycle and elimination of waste (Gertsakis & Lewis, 2003). Therefore sustainable waste management is important. Sustainability of waste management is necessary to protect the social and ecological environment and all the benefits it has to offer.

Sustainable waste management covers the following concept. For Waste Management to be sustainable is must be efficient in terms of economic feasibility and in terms of environmental protection and social acceptance (Van der Klundert, 2001).

1.5 Research questions

In the previous sections the problem definition and research objective have been identified. In this section the knowledge necessary to reach the research objective will be identified using research questions. By answering these questions the research objective will be accomplished.

The main research question follows from the research objective:

Which sustainable waste projects can be recommended to reduce the volume of domestic waste dumped on Isla Navarino?

To be able to address the main research question, other elements need to be investigated. First, the current situation needs to be investigated to understand the local situation. Next, alternative solutions need to be specified to resolve the established waste problem. After identifying waste projects, the projects need to be ranked based on established criteria. This will result in a best project. Based on information found on the current situation, recommendations can be given on how the project can be implemented. All these other elements that need to be investigated are provided in the form of sub research questions. The answers of the sub research questions will lead to the answer of the main research questions. The following sub research questions are identified:

1.) What causes problems in the current waste situation on Isla Navarino?

2.) What are possible waste solutions for the identified waste problem on Isla Navarino?

3.) What is the ”best” waste project for Isla Navarino, based on established criteria?

3.1) What criteria must be used to rank a waste project?

3.2) What are the weights of the established criteria?

4.) What plan can be made to implement the “best” sustainable waste project?

1.6 Research approach

This research is a practical oriented research project, which means that a real life problem will be investigated (Verschuren en Doorewaard, 2000). The research will take place on Isla Navarino. An approach to do a research is called a research strategy according to Verschuren and Doorewaard (2000). The research approach will be discussed using the four parts of a research method (type of research, research design, data collection methods, data analysis) identified by Geurts (1999).

Type of research

The main strategy used during this research is a design strategy. A design is made to change the current waste situation into a more desired situation. This is also known as the Management Problem Solving Method (Heerkens, 1998). This type of research contains of the following research steps:

1. The problem identification
2. Formulation of problem approach
3. Problem analysis

4. Identifying alternative solutions
5. Choosing an alternative
6. Implementation of the alternative
7. Evaluation of the alternative

The first step of these research steps is described in 1.3. This section focuses on the second step, the formulation of the problem approach. In the next part, the research specific steps for this research are specified. Step 7 is not part of this research.

Research design, data collection methods, data analysis
Information needs to be collected to answer the research questions. The main data collection & data analysis methods used during the research are:

- Literature Study

A literature study entails the study on literature that can be used to find data, to explore what has been researched in the past and to learn more on a topic. The books and papers that were consulted are included in the literature list in this report.

- Interviews

Information from people was collected by open face-to-face interviews. These interviews were held informally to ensure that people are at ease and will provide all information which is needed.

- Observation

The last data collection method used is observation. The researcher observes aspects that where or where not present in the research field.

Different methods are used during the research steps depending on the information needed. The following explains how research steps contribute to the research and how information is obtained. The research consists of the following steps:

1. <u>Current situation</u>

   The present waste situation is not fully functioning because waste problems are identified. By studying the elements of the current waste system and its context the problems which are the result of the current waste system are identified. In this step the first research question is answered.

Methods used to obtain information on the current situation: Observation, interviews municipality, research of legal documents & previous research done on the island

2. <u>Identification of sustainable waste projects</u>

   The current situation analysis identifies valuable materials present on the island. Real life waste case studies provided ideas for waste projects on the island. When no case studies were found a literature study was done on what was possible with the material. In this step the second research questions is answered.

Methods used to identify waste projects: Research of real life projects, literature and interviews

3. Selection of the best waste project

   Now that waste projects are identified, the "best" project needs to be identified. This choice is made by formulating criteria. By interviewing stakeholders, the most important criteria are established. After that, stakeholders are consulted whether particular criteria are more important than others. Waste projects are ranked based on agreed and weighted criteria.

Method used to obtain selection criteria: Literature research on sustainable criteria, interviews with local stakeholders

4. Implementation plan

   Recommendations are made based on failure and success factors of the case studies and the island specific factors identified during the context analysis.

Method used to obtain determine the weight of selection criteria: Interviews with local stakeholders

1.7 Report structure

In this report structure, the content of each chapter will be explained shortly.

Chapter 1

The first chapter explains the research design. The background of the problems, problem definition and research objective are given. From this the research questions will follow, which will be answered in the rest of the research.

Chapter 2

The second chapter focuses on explaining the theoretical framework used during this research. First all the theories and models will be explained separately and in the final section of the chapter, the total research model is given. The model gives an overview of which models and theories are used in all parts of the research.

Chapter 3

This chapter is divided in two parts. First it explains the current waste situation on the island. An analysis is given from how waste flows from the point of generation to the final disposal. This is followed by an overview of current methods used to reduce waste. The second part of the chapter focuses on the context of the island. What are special factors that improve or make the the waste situation worse.

Chapter 4

Chapter four identifies possible waste projects. These projects can be executed on the island and may contribute to improve the current situation on the island.

Chapter 5

In this chapter the waste projects identified in chapter 4 are ranked. To rank the projects, first criteria are established with local stakeholders. An assessment is made based on the opinion of local stakeholders whether it was necessary to weigh the criteria. Based on established criteria and weights a ranking is made and the best waste project is identified.

Chapter 6
The best project that should be implemented first is identified in the previous chapter. This chapter provides an implementation plan, how the waste project can be implemented and which steps need to be taken.

Chapter 7
In the final chapter the main research question is answered using the sub-research questions. After this, some recommendations on how to implement waste projects and for further research are given.

Figure 3 visualizes the research structure.

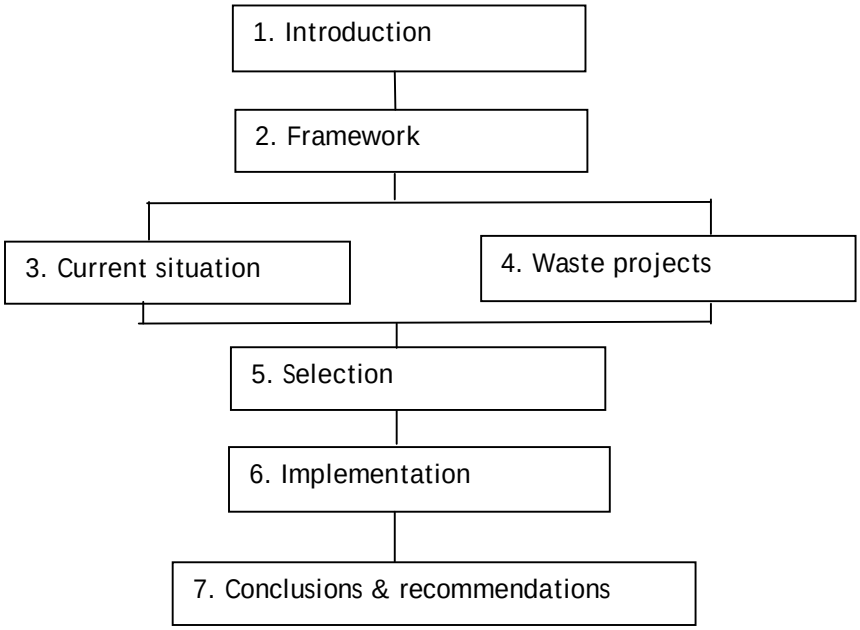

Figure 3: Research structure

2. Models and theories

In the previous chapter several research questions were formulated. This chapter will give an overview of the theories and the model used to answer these research questions, which will lead to the answer of the main research question. The rest of the chapter explains models and theories used per research question and explains how information will be obtained.

2.1 Parts of the research model

The research model is built-up using several models and theories. Models and theories are introduced per research question in the rest of this section. These will eventually be combined to one greater model with will be presented in section 2.3.

2.1.1 Current situation

To analyse the current waste situation on Isla Navarino the Integrated Sustainable Waste Management model is used. The Integrated Sustainable Waste Management (ISWM) model is developed by a Dutch organization, Foundation Waste. It is based on the idea that a waste system is a process, a process in which waste flows from the place where it is produced to final its disposal. This model gives an in depth understanding in the elements of a waste system. This model provides a framework that will result in a clear overview of the current waste situation on the island and therefore will function as a guideline to answer the first research question.

Basic principles and use of the ISWM framework

The Integrated Sustainable Waste Management (ISWM) framework is based on five basic principles (Van der Klundert, 2001). These principles are:

1. Equity: All citizens are entitled to an appropriate waste management system for environmental health reasons.
2. Effectiveness: The waste management model applied will lead to the safe removal of all waste.
3. Efficiency: The management of all waste is done by maximizing the benefits, minimizing the costs and optimizing the use of resources, taking into account equity, effectiveness and sustainability.
4. Sustainability: The waste management system is appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends.
5. Fairness: This means that the costs of the system are distributed, based on the ability of the stakeholders to bear those costs. Fairness as a principle will often result in cross subsidies in practice, where payments from rich households are used to cover the cost of serving slum areas.

The ISWM framework fulfils two main purposes: First, to assess and monitor existing waste management systems Secondly, to plan a new waste management system, including the selection of appropriate technologies, making sustainable investment decisions.

There are other waste models that have the same purpose. For example, the solid waste management model of MacDonald (1996). The model is based on improving the solid waste management model by improving the flow of materials. The model solely looks at the technical

elements of waste management. A technical element is the step taken to decrease waste, for example recycling. Also the engineering-based waste model mentioned by Nakanura (2002) discusses only the technical elements of waste management.

The ISWM research approach differs from used engineering-based models like the two mentioned above. It acknowledges the significance of the technical elements, but the model goes a step further. It stresses the importance of the context of a waste system. The environment in which a waste system functions has great impact on the performance of it. This is very important for this research because the possible solutions must fit within its context. Another addition to engineering based models is that it emphasises the importance of stakeholders. The definition of the word stakeholder is given is the section 3.1 of this report. Local stakeholders can “make or break” a project, it is therefore essential to know the stakeholders outlook on the situation.

These two extra viewpoints, the contextual view and the stakeholder view make the ISWM model a multi-disciplinary approach of waste management (Anschütz et al., 2003). The stakeholder participatory and research approach enriches the ISWM model. Therefore this model will be part of the research model and assist in the execution of the first part of the research, the analysis of the current situation.

The dimensions of ISWM
ISWM strives for an integrated approach of three major dimensions:
- The stakeholders involved in waste management.
- The practical and technical elements of the waste system.
- The aspects of the local context that should be taken into account when assessing and planning a waste management system.

1. Stakeholder involvement
A stakeholder is a person or an organization that has a stake and/or an interest in the welfare of Isla Navarino. For example local tourist agencies have an interest in the waste situation on the island. If waste is cluttered all over the island, it looks very messy. Tourists can tell other tourists and they may be discouraged to visit Isla Navarino. This can lead to less income for the tourist agencies.

Stakeholders in waste management differ in each location, so they need to be identified in the local context. The influence of a stakeholder, the extent to which stakeholders are able to persuade others, varies. But also their importance varies. The extent to which their problems, needs and interests are a priority in a project or plan varies (Anschütz et al., 2003). This results in stakeholders having various interests and roles in a particular waste management project, but they can nevertheless cooperate for a common interest.

The ISWM model concretely states the flowing kind of stakeholders.
- Local authorities
- Non Government Organizations
- Service users
- Private informal sector
- Private formal sector
- Donor agencies

This part of the research will determine which of the mentioned stakeholders are present and if so establish what their roles and interests are.

2. Practical & technical waste system elements

The practical waste elements are based on the real process, starting from waste generation to final waste disposal. All waste system elements should be looked upon as being flows of materials from the ground material via processing it to a product, through the consumption stage to the final disposal stage. The practical waste elements according to the ISWM are:

- Generation & separation
- Collection
- Transfer & transportation
- Treatment & disposal

This will give a complete picture of the current waste flows for generation to final disposure on the island. A waste system is a combination of several stages of the flow of materials within a region. Decisions should be made about how the materials should flow (Klundert, 2001) and how the flows can be reduced.

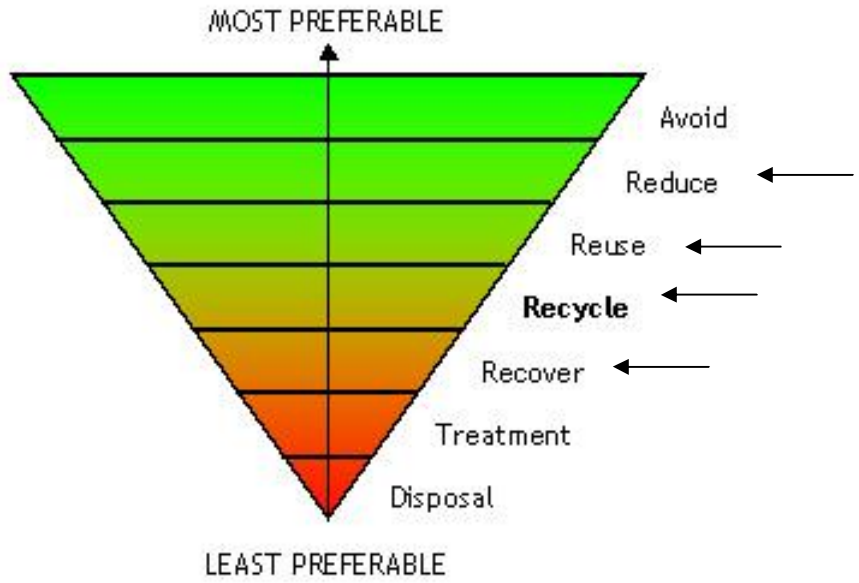

Figure 4: The Waste Hierarchy (Source: Zerowaste 2006)

Rather than seeing “waste” as a homogeneous mass that should be buried, the waste hierarchy theory sees waste as being made up out off different materials. Certain materials must not flow to the waste dump but to another process. This idea is also based on the waste hierarchy, some materials need to be avoided, some reduced some reused etc (Schall, 1992), see figure 4. The higher up in the hierarchy how bigger the impact is on reducing the produced waste.

The technical elements are the steps taken to decrease waste. These technical elements are based on the 4 R’s of the waste hierarchy (figure 4, above):

- Reduction
- Reuse

- Recycling
- Recovery

This will give an overview of what is presently done to decrease waste on Isla Navarino.

3. Context aspects

In the ISWM model the context analysis is subdivided in 6 aspects. There are other models that present another approach to do context analysis. Zurbrugg (2003) for example, argues that factors influencing solid waste management in developing countries can be divided into four categories:

1. Waste amount and composition
2. Access to waste for collection
3. Awareness and attitudes
4. Institutions and legislation

Ogawa (1995) identifies 5 constraints that are caused by the environment of a waste system:

1. Technical constraints
2. Financial constraints
3. Institutional constraints
4. Economic constraints
5. Social constraints

ISWM	Technical	Environmental	Financial-economical	Socio-cultural	Institutional	Policies/legal/political
Zurbrugg	1&2	2		3	4	4
Ogawa	1		2&4	5	3	
3 P Model	Planet	Planet	Profit	People	People	People/Profit

Table 1: Comparison of Waste context analyses factors (Source: composed based on the numbers given to the factors above this table)

All above mentioned methods of context analysis can be fitted into the ISWM model. As can be seen in table 1, none of the other context analysis methods cover all the aspects of the ISWM model. This model is therefore the most complete and 6 aspects of the ISWM model will be used to construct the context analysis. These aspects are important to map the whole context of a waste system. The link between the 3P model and the ISWM model (explained in 2.1.3) is also visualised in table 1.The six aspects of ISWM are described below (Van der Klundert, 2001):

1. Technical and performance aspects concern the observable practical implementation and maintenance of the waste elements: what equipment and facilities are in use or planned; how they are designed; what they are designed to do; whether they work in practice; and how clean the city is on a consistent basis.

2. Environmental aspects focus on the effects of waste management on land, water and air; on the need for conservation of non-renewable resources; pollution control and public health concerns.

3. Financial-economic aspects pertain to budgeting and cost accounting within the waste management system and in relation to the local, regional, national and international economy. Some specific issues are: privatization; cost recovery and cost reduction; the impact of environmental services on economic activities; the commodities marketplace and how the recycling infrastructures connect to it; efficiency of municipality solid waste management systems; macroeconomic dimensions of resource use and conservation; and income generation.

4. Socio-cultural aspects include the influence of culture on waste generation and management in the household and in businesses and institutions; the community and its involvement in waste management; the relations between groups and communities, between people of various ages, sex, ethnicity and the social conditions of waste workers.

5. Institutional aspects relate to the political and social structures, which control and implement waste management: the distribution.

6. Political/legal aspects address the boundary conditions in which the waste management system exists: setting goals and priorities; determination of roles and jurisdiction; the existing or planned legal and regulatory framework; and the basic decision making processes.

The 6 context aspects together give insight in the context of Isla Navarino's waste system. The current situation on Isla Navarino can not be analysed based on the ISWM model as explained above. This is because the parts of the model are still not well defined. For example, generation & separation is an element of the practical waste system. It does not implicate what concrete factors should be examined to describe the generation of waste. To overcome this problem Foundation Waste (Van der Klundert, 2001) has made a checklist of questions that concretely need to be asked to execute the analysis. In Appendix B these questions can be found. It states all the questions that were asked during stakeholder, waste element and context analysis. Appendix B additionally shows which methods and techniques were used to answer the individual questions. In appendix C the interview list can be found of people consulted during this research.

Sustainability
The goal of the ISWM model is to create a more sustainable waste management system, the complete model can be found in figure 5 on the next page. Over time the components of the ISWM model will lead to sustainability, as can be seen in figure 5. The waste system will develop in a way that meets the present needs of the community, without undermining the ability of future generations to meet their own (WCED 1987: 43).

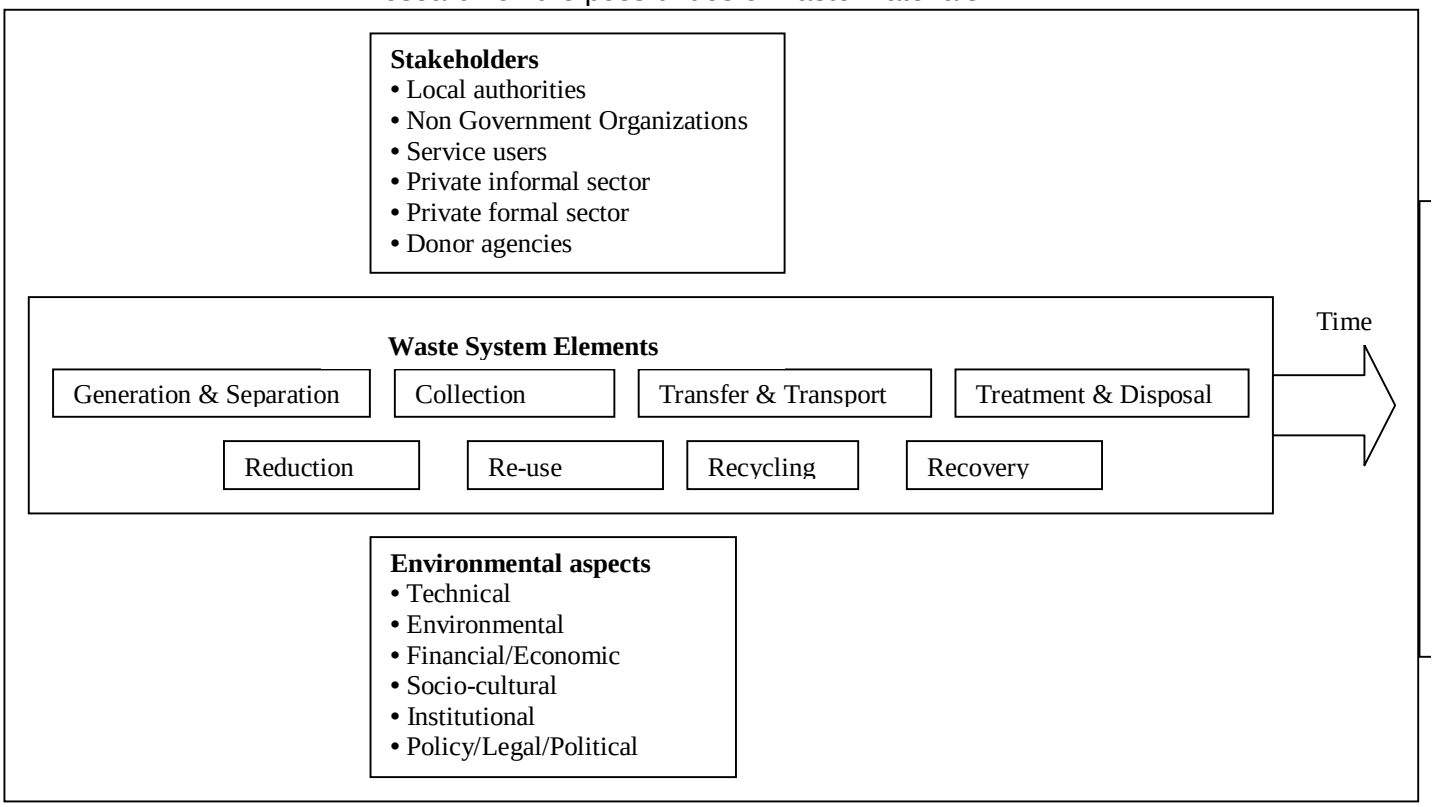

Figure 5: The Integrated Sustainable Waste Management model (Van der Klundert, 2001).

2.1.2 Identification of waste projects

During the analysis of the current situation, waste materials present on the island are identified. The waste materials present will form the basis for the waste projects. The identification of projects is based on three factors, namely the context of Isla Navarino, the ideas of the local community and the best practise of real life waste projects.

- Context factors: The ISWM model analysis of the current situation has given insight in strengths and weaknesses of the waste system on the island. It is possible that certain characteristics of the island make projects more or less attractive. These insights are taken into account when selecting a project.
- Ideas of the local community: The local community may have good ideas of what can be done. The local outlook will contribute to the success of a project because the local community knows best what is possible on the island.
- Best practices: Case studies are also consulted to identify possible projects. The combination of context factors and real life waste projects will contribute to the success of the project.

2.1.3 Selection of the "best" waste project

Enviu strives to improve sustainability on the island of Isla Navarino. Waste projects are ranked, based on how "sustainable" they are. The definition Enviu uses is based on the 3 P's model or the triple bottom line sustainability of Elkington (1998) see figure 6 (page 25).

The three P's: people, planet and profit relate to the social aspect, economical viability and environmental protection of sustainable waste management (Van der Klundert, 2001). A good sustainable solution must contribute to all the P's, no P is more important then another P. This is why the model is often visualized as a triangle, which symbolizes that all P's are equally important, see figure 6.This model is used as an umbrella under which the criteria extracted from the ISWM model are placed. The ISWM model gives practical criteria whereas the 3 P model is more abstract. Using the ISWM model practical criteria were established.

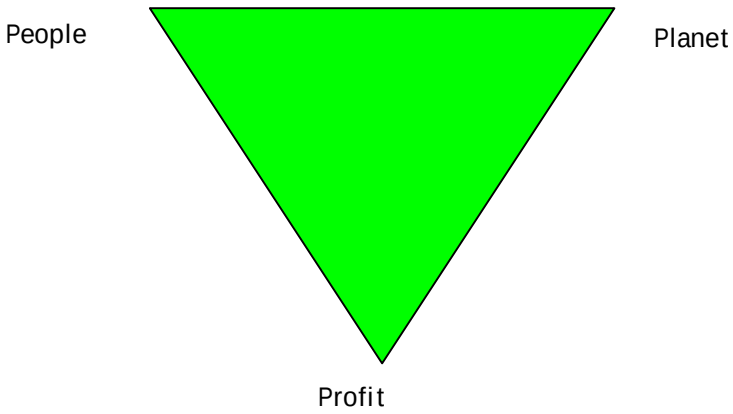

Figure 6: Three P's model (Source: Elkington, 1998)

This research aims to deliver possible sustainable waste projects. However, it is difficult to determine whether a waste project is "good" according to the 3 P's. When is a waste opportunity good for the people? To overcome this problem, the three P's will be split up into a few "good" criteria.
A "good" criterion must contain the following elements (Belton & Stewart, 2002):

- Value relevance: A direct link between the criteria and the concept that is being investigated.
- Understandable: It is important that all decision makers have the same understanding of the concept.
- Measurability: The criteria must be measurable

These criteria function as a tool to establish how a waste project contributes to the 3 P's and how sustainable a waste project is. Stakeholders are consulted to establish selection criteria and to make the selection criteria measurable. The ascertainment of selection criteria is only the first part of the third research question. An additional method is needed to rank the selection criteria. After identifying selection criteria for possible waste solutions, the possible solutions need to be ranked to find the "best" waste project. To rank the criteria a Multi Criteria Decision Analysis (MCDA) is used. A MCDA is in general "An umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter" according to Belton and Stewart (2002). Alternatively, a tool to help decision makers choose between the best alternative from a range of alternatives (Pietersen, 2006).

There are some typical misconceptions about MCDA. First, MCDA does not provide the 'right answer', but merely gives the tools to make an objective decision. It does not mean that an objective analysis relieves decision makers from their responsibility. Finally, it is does not make decision making easy because the decision maker still has to consider multiple criteria. MCDA however does provide structure, complement and challenge intuition and assist in justification and communication (Belton & Stewart, 2002). Three broad categories are recognized within MCDA:

- Value measurement models: Numerical scores are constructed in order to represent the degree to which on alternative may be preferred to another.
- Goals, aspiration or reference level models: Desirable levels of achievement are established for all criteria.
- Outranking models: Alternatives are compared pair wise.

A desired level of criteria is not set in this research, the "best" alternative is chosen based on all selection criteria found. Model 2 is therefore not suitable for this research. Secondly, all identified alternatives will be compared to each other. Therefore, model 3 does not apply to this research either. A Value measurement model will be used in this research. Value measurement models analyze the performance of alternatives based on individual criteria. All the criteria are scored. The sum of the scores of the criteria is the total performance of the alternative. This is called the SMART method, simple multi attribute rating technique. Criteria however are often not weighted equally. In that case, the Analytical Hierarchy Process (AHP) model is used. In this model the individual criteria are weighted based on significant impact. Before staring this phase, it will be clear whether criteria need to be weighted or not. That will determine if the SMART method or the AHP model will be used.

Local stakeholders have been interviewed to determine if they consider certain criteria more important them others. If this is the case, criteria will be weighted in consultation with important stakeholders. This will be done through informal interviews. The selection criteria based on the 3 P's model and the MCDA will collectively answer the third research question.
A ranking of waste projects is identified in this stage of the research.

2.1.4 Implementation plan

The theories and models mentioned above have provided sufficient information to answer the last sub question (*What plan can be made to implement the "best" sustainable waste project?*). Foundation waste (Foundation Waste, 2007) provides the following aspects that need to be discussed when making an implementation plan for changing the waste infrastructure:

- Institutional framework (specific actions to establish clear roles, responsibilities and accountability between stakeholders)
- Waste collection & recycling (Conducting trials of new waste management system)
- Waste treatment & disposal (improving the waste disposal site)
- Financial sustainability (making a specific plan how to finance waste projects)
- Public awareness & participation (Implementing awareness campaigns)

In chapter 3 an analysis of the current situation is given. The stakeholders, waste system elements and the environmental aspects of the ISWM model together, give insight on how the above mentioned aspects are currently functioning. When aspects perform insufficiently specific actions are mentioned to improve the situation. The action steps are placed in a time frame so that the action plan shows what steps need to be taken and in what order of time.

2.2 Research model

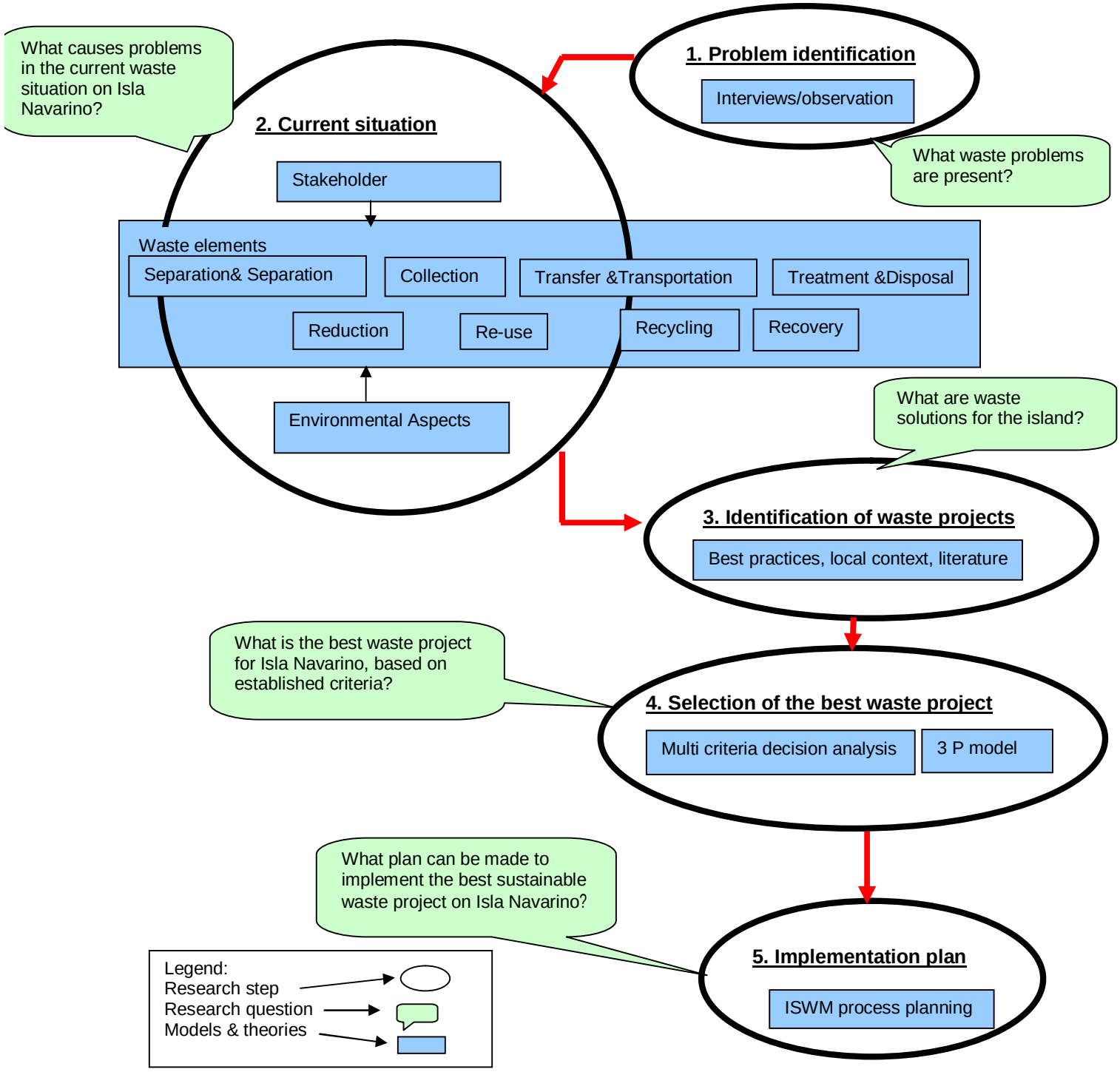

Figure 7 Research model

3. Current situation

The division of this chapter is based on the three dimensions of the ISWM model. Section 3.1 clarifies who the local stakeholders are. Section 3.2 discusses the waste elements present on Isla Navarino. These elements are identified by observation of the research environment, for example observations at the waste dump. Secondly, information was gathered by interviewing people that work directly with waste, for instance people that are responsible for waste collection. Section 3.3 is devoted to giving insight in the external aspects that influence the waste situation on the island. Information was contained by observations, interviews of local people and information from other research carried out for Enviu.

3.1 Stakeholder analysis

There are different stakeholders present on Isla Navarino. All the different types of stakeholders mentioned in the ISWM model are discussed. This section will briefly explain what they do and what their relation is to the waste situation. This information is based on data from websites and interviews with stakeholders.

The term stakeholder here is used in a form that was previously recognized by ENVIU (Pauwen, 2005). A stakeholder is any group or individual who can affect or is affected by certain actions, decisions, practices or goals.

Before introducing the local stakeholders it is important to understand that Chile is divided into 13 regions. These 13 regions are divided into 51 provinces, which are divided in 364 communities. The region, province and community of this research are visualized in appendix D. This research is taken out in community of Cape Horn. This community is part of the province Antartica Chilena and also part of Region XII Magallanes y Antarctica Chilena

• Authorities

Authorities can affect the waste situation by laws, policies and regulation. There are several Chilean institutions involved in the control of domestic waste. This structure of responsibilities is founded by Gobierno de Chile, the Chilean government (SESMA, 2006). The roles of the institutions are explained shortly below; their interrelations are visualized in appendix E.

Municipality: Are responsible for the cleanness and tidiness in the community. The exact contribution of a municipality is stated in the laws and codes, to be precise “Ley Organica de Municipalidades” and “Codigo Sanitario”. These determine which methods the municipality should adapt for recollecting, transporting and eliminating waste that is disposed or produced in the city.
Ministerio de Salud: The ministry of health defines rules for the management and handling of final waste products (MISAL, 2006)
Gobierno Regional: The regional government generates policies about solid waste management in the region (Goremagallanes, 2006).
Secretaria Regional Ministerial de Vivienda y Urbanismo: This institution is responsible for the housing and urbanisation. It defines and suggests policies agreements of waste waters.
SEREMI: Secretaria Regional Ministerial: This institution coordinates and checks treatment, disposal and elimination of solid waste projects at a local level.
Conama: Commision National de Medio Ambiento: Coordinates the approval of projects related to management, treatment and elimination of final waste products at national level.

Within the municipality a certain hierarchy of waste management was established to address waste management. Waste management is situated within the department “Public works”. Within this department there is one person, who is the waste manager and responsible for waste management (Interview, 27th of November 2006). The hierarchy is visualized in figure 8.

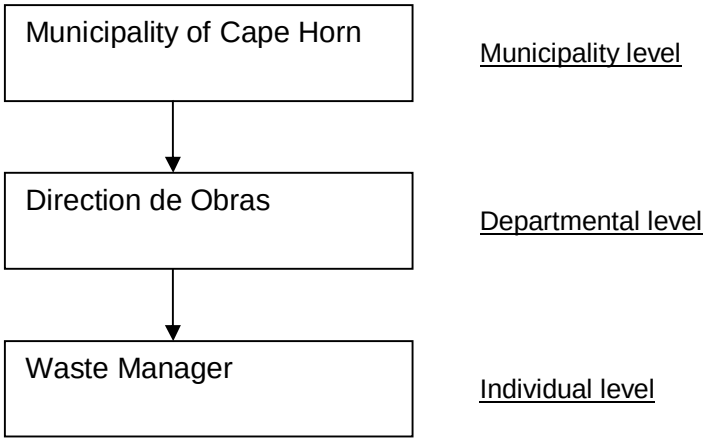

Figure 8: Hierarchy of waste management Municipality of Cape Horn (Source: Interview 27th of November 2006)

The municipality sees its role in waste management mainly as the facilitator of waste infrastructure (Interview, 29th of January 2007). Besides this the municipality sees it as their role to educate the community. The municipality undertakes many projects to raise awareness of the waste problem and its consequences. They are interested in keeping the island clean, so it looks nice for the residents but also for tourists. Tourists are a source of revenues for the island people. For example, the municipality has a project that simulates residents to keep their gardens clean. Another project of the municipality has been to sponsor waste bins for public areas in Puerto Williams (Interview, 15th of November 2006).

• Non Government Organizations & Community Based Organizations

The responsibility of Enviu is the role of facilitator. A basic definition of facilitator is given by R. Bacal (2003). “A facilitator is an individual whose job is to help to manage a process of information exchange. While an expert’s" role is to offer advice, particularly about the content of a discussion, the facilitator's role is to help with HOW the discussion is proceeding.” The facilitator is not the one who will implement a project. That is the role of local stakeholder who will initiate projects basic on information facilitated by Enviu.

In this case Enviu is interested in improving the waste situation on the island. This is because it wants to encourage sustainability on the island. Enviu will facilitate the people and other stakeholders of Isla Navarino to gain access to information about the waste situation on the island. The expert will write the report for Enviu and local stakeholders, which will give information on the current waste situation and make recommendations of how to improve the waste situation on Isla Navarino. This research will provide Enviu, in their role as facilitator, with tools on how to proceed with the waste situation on the island and provides concrete information to other stakeholders at the same time.

Besides projects carried out by one single stakeholder, there are also projects that are carried out by a group of stakeholders. Enviu and the local school work in cooperation. Enviu has organized cultural activities for the school. These activities are not all aimed at waste but some are, for example, a recycling workshop and a cleaning campaign to clean the streets off Puerto Williams (Enviu, 2006).

There is a community based organization (CBO) that has shown interest in improving the waste situation. This CBO is called Comite de Gestion Medio Ambiental. Several stakeholders take part in this committee: The Municipality, Omora[1] (which is another NGO on Isla Navarino), Enviu, the school and the museum. In November of 2006 this CBO has organized a clearing campaign of the streets of Puerto Williams, "Fiesta de Calles Limpia". During this campaign, the schoolchildren picked up rubbish from public areas in Puerto Williams (Enviu, 2006)

• Service users
All the residents of Puerto Williams, the hospital, the local entrepreneurs and the municipality are the service users. They are the ones responsible for generating domestic waste and therefore service users of the waste system. They are affected by the waste management system that is in place on Isla Navarino and dependent on how "good" it functions. Most people are interested in improving the waste situation on the island. Clean streets are a point mentioned by many people on the island. This however does not always correspond with their actions. For example people throw trash on the streets when there is no trashcan is nearby. There are two groups on the island, one group that does not see it as there task to improve the waste situation. The other group thinks it is vital that residents participate in improving the situation.

• Private informal sector
The informal sector of waste management, also called the scavenger system, is a very common system in the world and especially in developing countries. Medina (1997) has compiled an overview of common characteristics that apply to scavengers in general. The most important ones will be mentioned below.

- Scavengers are relatively poor
- Scavengers have a low social status
- Scavengers are often (rural) immigrants
- Scavenging can provide economic and environmental benefits
- Scavengers supply middlemen or industry with raw material

During interviews people have been asked if there is an informal waste management system present on Isla Navarino. This is not the case. During visits to the open air waste dump, it was confirmed that there were no scavengers present on the site. No informal nor formal waste collection companies exits, nor any waste-to product initiatives.

• Donor agencies
Isla Navarino does not have donor agencies, next to the local authorities mentioned, that offer the expertise or money to tackle the waste situation on the island. There are however strategic partners that may be helpful improving the waste situation.

[1] The Omora Foundation is a Chilean non-governmental organization (NGO) dedicated to bio-cultural conservation in the extreme southern tip of South America (Omora, 2007).

• Strategic partners
Besides the institutions mentioned above, there are a couple of other institutions or businesses that are not directly implicated with waste management. This group is not mentioned in the ISWM model, but can play an important roll when implementing waste projects. This is because these institutions have a big influence in the community. This group can therefore affect the waste situation but is also affected by it. These stakeholders should or could be the drivers when implementing a waste project.

Supermarkets
There are three supermarkets present on Isla Navarino. Two are accessible for all residents of the island and one is only for the Armada people. The supermarkets are the biggest source of domestic waste, because a great deal of food and non foods bought by the community passes through here. For example, the supermarkets can buy "smarter packages" which are better for the environment or produce less waste. The supermarkets are supplied once a week by a ferry from Punta Arenas.

The school Donald Mc-Intyre Griffiths
A large part of the population is under age. The population of Puerto Williams exists of 2200 people of which 22% are children (Municipality, 2006). These children all attend Donald Mc-Intyre Griffiths, because this is the only school on the island. It houses pupils for primary and secondary school until college. Because there are so many children, everybody has children, children in the family or friends with children. The school is a good source to start informing people because a lot of people can easily be reached (Interview, 16th of November). The school has already shown its interest in waste management. They have been involved in several projects facilitated by Enviu. There was a recycling workshop in which children learned to recycle and made aware of waste produced at their homes (Enviu, 2006). The school also participated in a cleaning campaign mentioned earlier.

Museum Martin Gusinde
The Martin Gusinde Museum plays an important cultural and educative role in the community. Its main functions are to preserve historical and cultural heritage as well as to provide space for education. Special projects are organised with the school to educate children about the cultural background of the island. The Chilean government approved a project to renovate the existing museum; the renovation started in December of 2006 and is still going on.
This strategic partner can provide an educational role for waste possibilities on the island.

Armada & Broom Austral (the ferry company)
The armada of Chile has several boats. They go to Punta Arenas several times a week, see figure 1(page 9). There is also the ferry that goes between Punta Arenas and Puerto Williams once a week. This is the same ferry that stocks the supermarkets. These boats could play a role in transporting things to or from the island.

It can be concluded that all stakeholders are interested to a certain extent in improving the waste situation. However, this is not always represented in their actions. The roles of the different stakeholders clash. There is a discrepancy between how the municipality sees community contribution and the willingness of a part of the local community to actually actively participate in improving the situation. Roles and responsibilities of all stakeholders should be made clear so that they can be held accountable for their actions in the future.

3.2 Waste system analysis

This section first discusses the practical waste elements. It elaborates on how materials flow from the waste generation to the final point of disposal on the open air dump. Secondly, it portrays the technical waste elements present. It explains what is physically done with waste on the island.

3.2.1 Practical waste elements:

The practical waste elements are based on the real process of waste generation to final disposal. This section will specify the four elements the ISWM model uses, generation & separation, collection, transfer & transportation and treatment & disposal of waste on Isla Navarino.

Generation & separation

Generation:

As mentioned earlier, this research focuses only on domestic solid waste. Domestic waste is generated in the houses of the local community of Puerto Williams, public places, the government and municipality offices and the hospital. Generated waste is collected in waste bins. These waste bins come in different forms, shapes and sizes; see photos 1 to 4.

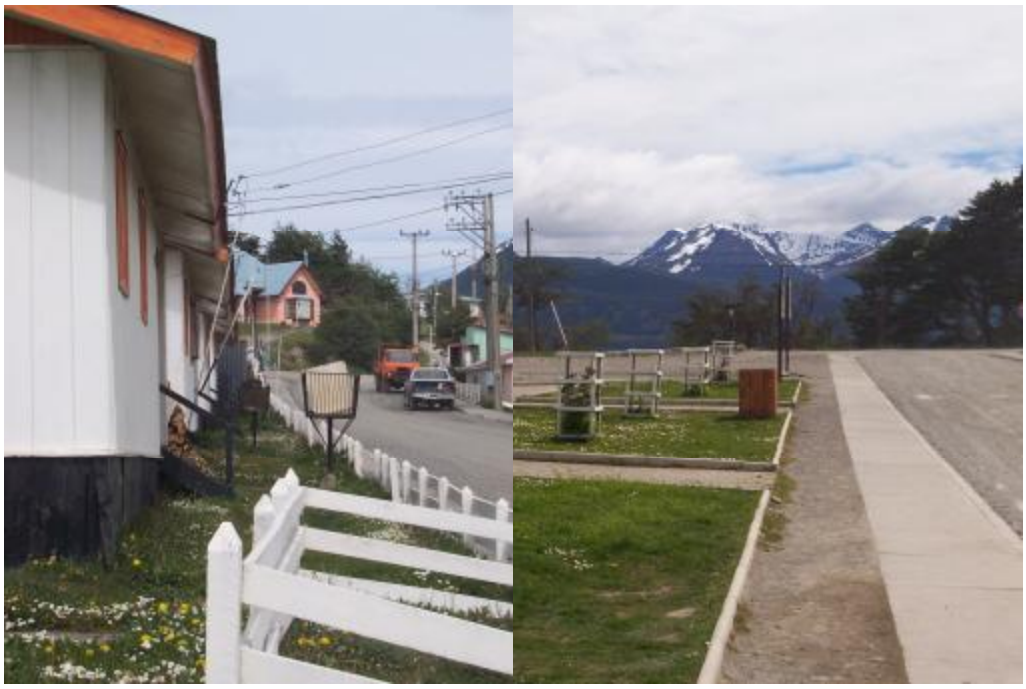

Photo 1: On the left a garbage cage on a post to prevent dogs from opening trash bags
Photo 2: On the right a public waste bin

Photo 3: On the left a garbage container
Photo 4: On the right an old oil drum used as garbage container

There are also people that live outside of Puerto Williams. There are 11 places between Puerto Williams and Puerto Navarino where people live (Zwebe, 2006). Puerto Navarino is a 52 kilometre drive from Puerto Williams, on the opposite of Ushuaia the nearest city in Argentina, see figure 1(page 9). There are only a couple of houses and an emigration office. These people generate waste, but this waste is not collected. The people dump it near their homes.

There is one other village on Isla Navarino, Puerto Toro. This village contains about 30 inhabitants all year round but can grow to 150 in the fishing season which is from July to December (Zwebe, 2006). These people are not serviced, but bring their own waste to Puerto Williams or dump it near their homes. There also is a hotel located 4 kilometres outside of Puerto Williams, Hotel Lakutaia. This hotel does lie on the route of the garbage truck. Waste is picked up here once a week.

Research has been carried out about domestic waste produced in the capital Santiago de Chile, Region Metropolitana. This research indicates that about 1 kilo of domestic waste is produced by one person a day (SESMA & CONAMA, 2006). Other research on domestic waste however point out that there is an essential difference between the amounts of domestic waste produced in urban or rural areas. Domestic waste produced in rural areas is lower than in urban regions (Ojeda-Benitez, 2000). It is to be expected that waste on Isla Navarino is less than 1 kilo, because it is a rural area and due to the fact that it is not possible to buy a lot of things on the island.

According to the person responsible for the waste truck at the municipality of Cape Horn approximately 3400 litres of domestic waste is collected in a collection round (Interview, 12th of

December 2006). This is equivalently to 3400 kilos of domestic waste. This equals 10200 kilos a week. Inhabitants of Isla Navarino produce 0,66 kilo per person per day (p.p.p.d.). This corresponds with the findings of Ojeda-Benitez that less domestic waste is produced in rural areas. Table 2 shows domestic waste produced on Isla Navarino.

Generation p.p.p.d.	Total generation a week	Total generation a year
0,66 kilo	10.200 kilos	530.400 kilos

Table 2: Total domestic waste collected on Isla Navarino (Source: Calculations based on Interview 12th of December 2006)

Separation:
Two decades ago Chile started recycling domestic waste in the capital region Metropolitana (CONAMA, 2006), figure 9 shows that more and more domestic waste is being recycled. In 2001 Chile recycled about 7% of their domestic waste in the capital region. This is a start but not as good as some other countries, the Netherlands and Switzerland for example recycle about 50% of their domestic waste (SESMA, 2006).

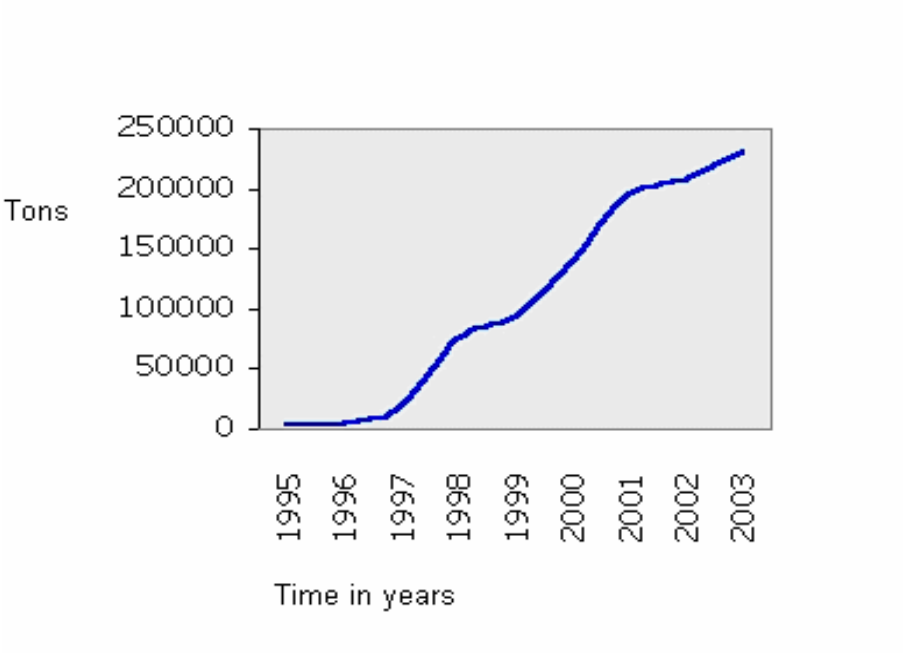

Figure 9: Evolution of recycling in the Metropolitana region (Source: CONAMA)

On Isla Navarino no domestic waste is separated yet and and no materials are recycled. When the waste is collected, everything goes into the same truck and ends on the open air dump. Some people of the local community separate certain materials, like glass. This is a personal initiative; in the hope the municipality will start a recycle program. In most houses carton and papers are kept out of the waste bin, because people use it to start the stove. Paper separation is however not done by the municipality, which uses a large volume of paper throughout the year.

Collection
Domestic waste is picked up three times a week, on Monday, Wednesday and Friday. Areas outside Puerto Williams are serviced once a week on Friday (Interview, 12th of December 2006). Waste is collected by three garbage men, one drives the truck and the other two throw in the trash in the back of the truck. These garbage men are hired and paid by the municipality. Their salary is about $500.000 Chilean Peso's (CP) monthly (Interview, 12th of December 2006). This salary is sufficient to support a family with children on the island. The garbage men however were not always directly employed by the municipality. Until May of 2006, this service was done by a contractor paid by the municipality (Interview, 9th of January 2007). The monthly salary equals about $926 or € 714, these calculations are based on the exchange rate presented in table 3. The exchange rate on the 25 of January is rounded to a round number to make calculations easier.

Foreign currency	Value Chilean Peso	Exchange rate used for calculations
1 Dollar ($)	539,40 CP	540 CP
1 Euro (€)	699,08 CP	700 CP

Table 3: Exchange rate Chilean Peso to the American Dollar & Euro (Source: www.wisselkoers.nl 2007-01-25)

Different materials are collected by the garbage men. COMAMA (2001) uses the following classification to classify domestic waste that is collected in the Metropolitana region, see table 4. The Metropolitana region is where the capital Santiago de Chile is located and the largest part of Chileans live in Chile. This decomposition is based on domestic waste that is dumped at waste dumps in the metropolitan region.

Materials	**Percentage**
Organic Materials	49,3
Paper & cartons	18,8
Ashes, remains of sanitary materials, pottery	6
Plastics	10,2
Textiles	4,3
Metals	2,3
Glass	1,6
Carcasses	0,5
Others	6,9

Table 4: Decomposition domestic waste Region Metropolitana (Source: CONAMA 2001)

Fehr at al (2000) used another classification that divides domestic waste into seven categories. These categories are biodegradable materials (these materials will decay without doing anything special with it), plastic, paper & cardboard, glass, metal, textiles and others, which are materials that do not belong to the other seven categories. Table 5 shows the adjusted classification of domestic waste for the Metropolitana region according to the classification of Fehr.

Material	Percentage
Biodegradable materials	50,2
Papers & cardboard	18,8
Plastics	10,2
Textiles	4,3
Metal	2,3
Glass	1,6
Others	12,9

Table 5: Adjusted decomposition domestic waste Region Metropolitana

The category “Ashes, remains of sanitary materials, pottery” of the CONAMA classification is added to others. This is done because these materials are not likely to be reused in any sort. The category: Carcasses is added to biodegradable materials because this material will decompose without special treatment. This classification is also used for the decomposition of the domestic waste of the island, because it gives a clear overview of the different material categories.

An estimation is made on the decomposition of domestic waste on Isla Navarino because no information is present about this. Domestic trash will be quite similar to Santiago. There are however some differences due to certain habits on the island. The decomposition of domestic waste on Isla Navarino is based on a couple assumptions. These are based on observations on the island. Observations include analysis of two of the three local supermarkets to observe what is sold. Secondly, people of the local community have also been asked about the waste generated and disposal.

Assumptions:

- People throw away less paper and cardboard than in Santiago because most people burn it in the stove.
- Domestic waste on Isla Navarino contains more plastic, because plastic is not separated yet contrary to Santiago where for example plastic bottles are separated and reused.
- Domestic waste on Isla Navarino contains more glass, because no glass is collected yet in contrary to Santiago where glass is separated and recycled.
- Less biodegradable materials are thrown away on Isla Navarino. Because all food has to be exported per boat from the mainland, it is more expensive than in the rest of Chile. People are more careful with how much they buy to save money.
- Relatively more canned food is eaten, because this is cheaper and has a longer shelf life. This leads to more metals being thrown away.

These assumptions have resulted in an estimation of a local decomposition. Biodegradable materials are decreased with 7,2 points, because when preparing food it always gives some waste. For example, the skin of a banana is not eaten. The paper category is decreased by 8,8 because a lot of paper is burned in the stove. Plastic is increased with 9,8 because people drink a lot of soft drinks, but also wine is bought in a tetra pack, which includes plastic. Both plastic bottles and tetra packs are recycled in the capitol region. The category textile is rounded off to 4.

People on Isla Navarino wear cloths down to the end because barely any cloths are sold on the island. Metals are increased with 4,7 because a lot of canned food is consumed, due to the fact that it lasts longer. Glass is increased with 2,4 because no glass is separated from the waste before dumping it. The amounts are chosen so that the new decomposition only contains whole figures. Figure 10 shows the decomposition of domestic waste on Isla Navarino.

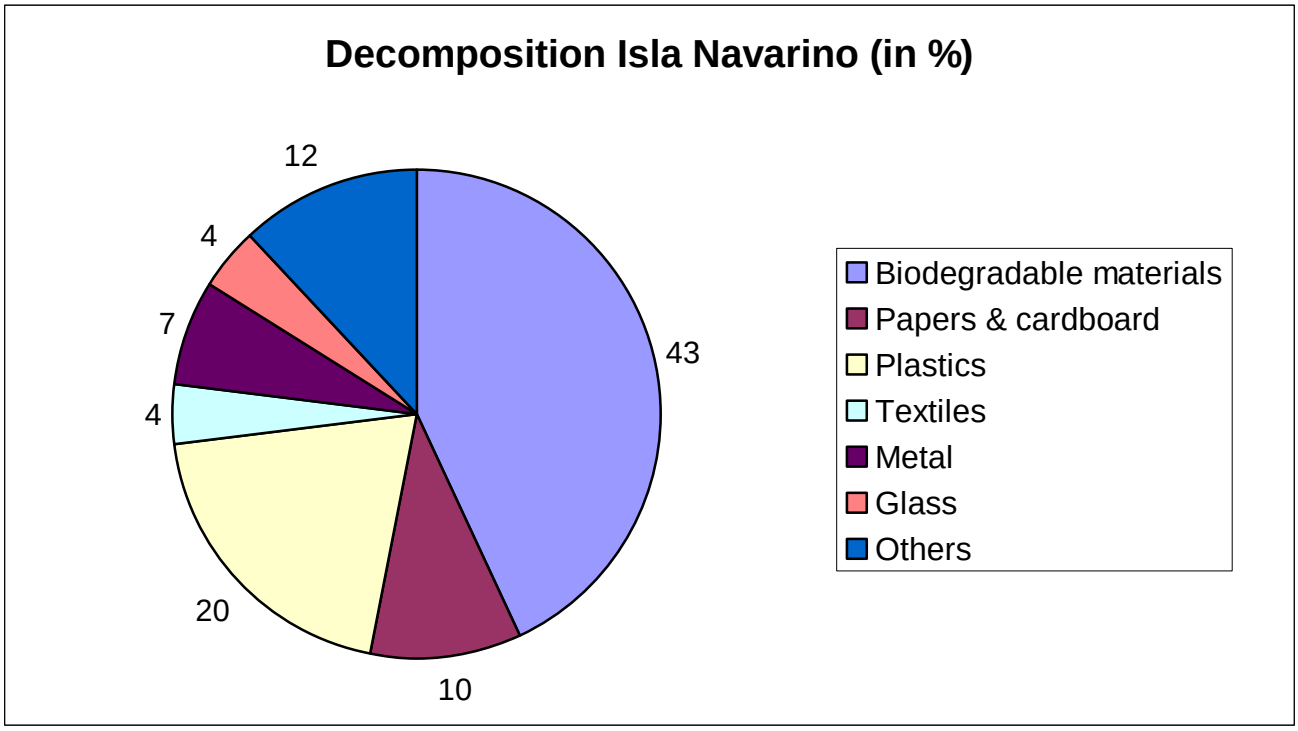

Figure 10: Decomposition domestic waste Isla Navarino

The decomposition given is merely an indication of the volume of the categories and is therefore subjective. A random sample of waste is not taken because this would be a one time observation and domestic waste differs per day/week/season etc. The decomposition is made to get a general idea of how much material is lost per waste category. Based on this, calculations can be made to predict an annual amount of available material on Isla Navarino.

Transfer & transport

The municipality owns two trucks; one is a normal lorry truck and one waste truck with a hydraulic press (see photo 3). The hydraulic truck is used to collect domestic waste and transport waste to the dump location (technical information to the waste truck can be found in appendix F). The waste dump is located about 5 kilometres outside of Puerto Williams (Figure 2, page 12). It is a ten minute drive from the centre of town. The truck makes 2 stops at the waste dump during its round (Interview, 12th of January 2006).

Photo 5: The two waste trucks

Treatment & disposal
The garbage is brought to the central collection point, an open-air dump. This dump is not covered by a roof or surrounded by walls. The often strong winds on Isla Navarino have resulted in collected waste being blown all over the island.

Recently an external waste expert was hired to assess the waste dump. Usually, a waste dump is divided in different sectors and waste is dumped orderly. However, this is not the case at the domestic waste dump on Isla Navarino. Waste has been dumped randomly on the open air dump.

The municipality is now rearranging the dump with bulldozers. They are dividing the waste in sectors. The waste in stacked in layers of 4 meter and covered with a 25 centimetres layer of dirt. Wooden pools are added at places where chimneys will be placed in the future. The intention is to totally close the site in the future. The chimneys are placed to let the gas out of the dump; otherwise the closed landfill will explode in the future (Interview 27th of November 2006).

Photo 6: The waste dump

3.2.2 Technical waste elements:

The technical waste elements according to the ISWM model are the steps taken to decrease the waste dumped. These steps are based on the 4 R's (recovery, recycling, reuse and reduce) of the waste hierarchy. This hierarchy ranks methods from least preferable to more preferable. This section will focus on these four R's and what is currently done on the island.

Recovery

At the moment, no materials are recovered before dumping the trash on the waste dump. Everything is dumped together and therefore a lot of possible reusable or recyclable materials are lost. Based on the estimation of the domestic waste decomposition of Isla Navarino, a calculation is made to establish how much of which materials are lost. The different types of materials that have been identified in domestic trash and the amounts generated in kilos are given in table 6 on the next page.

At the moment, there is no place where materials can be recovered. There were plans to add a recycling centre to the new waste dump, but no concrete plans exist at the moment. In the future, it is important to plan what the best way is to recover materials. Should this be done central by means of a recycling centre? Should all materials be recovered at once or is it smarter to start with one material?

Material	Percentage	Kg per week	KG per year
Biodegradable materials	43	3.486	228.072
Plastics	10	1.020	53.040
Papers & cardboard	20	2.040	106.080
Textiles	4	408	21.216
Metal	7	714	37.128
Glass	4	408	21.216
Others	12	1.224	63.648
Total	100	10.200	530.400

Table 6: Material quantities Isla Navarino (Calculated based on Figure 9)

Recycling
As mentioned earlier there is no recycling on the island. Not all of the material can be recycled or reused. Which materials can be recycled or reused strongly depends on the exact material and production method. Not all glass for example can be recycled. For example, a mirror contains metals and therefore this glass is not fully recyclable. Appendix G gives the recyclable-overview of Bruijnzeel (2005).

Each type of waste material has its own breakdown time as. For example, a plastic bag will take 10 to 20 years to decompose. The breakdown time depends heavily on the weather conditions. In sunny moist place a bag will decompose faster than a shadow rich dry place. This causes the big gap between the breakdown times (ZEMST, 2006). Table 7 gives the breakdown times of common domestic waste products.

Kind of waste products	breakdown times
Paper & carton	1 day - 0,5 year
Cigarettes	1- 5 years
Banana peel	up to 3 years
metal cans	1,5 - 50 years
Aluminium	80 - 1 million years
Plastic soda bottle (PET)	5-10 years
Plastic bags	10-20 years
Biodegradable plastic bag	90-400 days
Paper bag	90 - 400 days
Chewing gum	20-25 years
Glass bottle	1 million years
PVC	5-10 years

Table 7: Breakdown times Source: (Source: Adjusted milieucentraal & zemst, 2006)

Biodegradable materials are not mentioned in this overview because the material will decay on its own on the waste dump. Textiles are also not mentioned, an example of reuse of clothes is a second-hand clothes stores. In the future it is recommendable to start the recycling process in

the most general form possible. This research will contribute to specifying possible solutions that can be implemented in the future and how this process can best be started.

Re-use

This element is classed higher in the waste hierarchy because no processing is needed to reuse the material. This saves national resources, like energy, necessary for a process. Some materials or used products are being reused by the local community. For example, polystyrene boxes are used to transport fish and meat from Punta Arenas to Puerto Williams. These boxes are reused as a cool box or storage box by people. These boxes are also used for other purposes like as flower box. Also oil barrels are reused as garbage bins (see photo 2 of on page 32). This reuse is been done by individuals. No reuse is organized by a formal structure, for example the municipality or a private company. It is recommendable to investigate what is possible on the island.

Photo 7: (A plastic container used to transport meat reused as a flower pot)

Reduction

The best thing to do with waste is not producing it at all. When that is not possible, produce as little as possible. There are no official programs to reduce waste on the Isla Navarino. With reducing is meant, reducing the domestic waste that people produce in contrast with recycling and reuse, which decrease domestic waste dumped up the open air dump. The projects from the municipality are presently focused on raising awareness among residents. In the future these need to be changed to programs on how people can reduce waste produced.

3.3 Context analysis

This part of the research focuses on the context of Isla Navarino. All cities, areas, countries are situated in a specific local context. This context needs to be taken into account when planning a waste project, because the local context can make or break a project. It is therefore important to identify these factors.

3.3.1 Technical

This section will be divided into two parts. The first part is the technical context aspect of the ISWM model, which gives tools to measures the current performance of the waste system. The first two points measure the effectiveness of the waste system. The last point measures the efficiency. The second part gives technical aspects of the local context.

Collection coverage ratio

Of the total population of Isla Navarino, about 2200 people (Municipality), approximately a 100 people live outside of Puerto Williams, these people are not serviced. This is 100/2200 = 4,5% of the total population. The collection coverage rate is the amount of people that are served as a percentage of the total population (Anschütz et al., 2003). This rate is consequently set on 95,5%.

Collection rate ratio

The collection rate is, is the amount of domestic waste is collected as a percentage of total amount generated (Anschütz et al., 2003). This rate will be lower than the collection coverage because not all waste generated in serviced areas is actually picked up. One reason why waste is not picked up is that it is blown away by the wind when a rubbish bag or waste bin is not closed properly. A second reason is that trash is taken out of waste bins by local animals, for example dogs. Both causes mentioned largely depend on the kind of waste bins used, see photo 1 to 4. Based on observation on the streets it is estimated that 2% of domestic waste is lost this way. Both assumptions lead to a collection rate of 93,5%.

Performance of waste processing plants ratio

The performance of a processing plant can be measured by the amount processed as a % of the total capacity of the plant. There is however no processing plant present yet on the island, so this rate is 0%. Waste is not processed (for example recycled) because it is not separated and waste is not separated because there is no processing method. The separation ratio in general is the amount of waste separated as a percentage of the total waste produced and is here also 0 %.

The mentioned measure instruments can in the future be used as an evaluation tool to measure the results of the waste system. The following part gives technical aspects of the island. These technical aspects need to be taken into account because they can influence the outcome of a waste project.

3.3.2 Environmental

The following section will first give two measuring tools from environmental issues and explain what is done to raise environmental awareness on Isla Navarino. After that environmental aspects that can influence a waste project are discussed.

Disposal rate
The disposal rate is the percentage of waste collected which is disposed of in a sanitary or controlled landfill (Anschütz et al., 2003). A waste expert of the Porvenir municipality has confirmed that the present waste dump is not controlled or environmental secure. The disposal rate is set at 0 % on Isla Navarino. This will change in the future when the new secure waste dump is taken into use.

Recovery rate
Recovery rate is the amount of waste that is recycled and/or reused by the governmental and private sector. On Isla Navarino the recovery rate is 0 % of the total amount generated waste because nothing is recovered. (Anschütz et al., 2003). Small individual initiatives are not recorded in this ratio. Only initiatives that are conducted by an authority or as a private business are covered in this ratio. At present times nothing is being recycled and or reused by the government or private sector.

Environmental awareness
The municipality is in charge of many awareness projects as mentioned before. The budget and initiatives of these projects lie within the department of community health in Spanish Comuno Saludable. This department has a budget to organize projects for the community, but does not have the money to invest in big projects, such as starting a recycling factory (Municipality, Interview 29th of January). ONAMA however has money, CONAMA, as mentioned during the stakeholder analysis, is an organization at government level that provides grants for waste projects.

Many “creating awareness” initiatives are carried out in cooperation with other organizations. A specific project to promote prevention and recycling is conducted at the school. The school organized a workshop with Enviu in 2006. The workshop showed children how they can recycle paper (Enviu, 2006). Another project , “Fiesta Calle Limpa” as mentionede before, was organized by Comite de Gestion Medio Ambiental.

Isla Navarino has some special geographical, physical and climate features. Puerto Williams the capital of Isla Navarino is the most southern village in the world. It is located about 800 kilometres of Antarctica and 150 kilometres from Cape Horn (Rozzi, 2004). As a consequence of its location, it has an extreme climate. Climate changes rapidly, a local saying is that Isla Navarino can have four seasons in one day. This has been confirmed during the stay on the island.

3.3.3 Financial/Economic

This section elaborates on the financial aspects of waste management. In short will be explained how waste management is financed. Secondly the economic market potential of the island is briefly made explicit.

Financing waste
The municipality is able to raise its own taxes for waste. Nevertheless residents do not pay waste tax. Residents pay one tax to the municipality, no specification is given. What part of the municipality tax is allocated to waste management is not clear. Costs are not equally divided

over all service users because only the fish industry pays waste tax. The industry does pay separate waste tax; this is about € 600 a month, 420.000 CP (Interview, 27th November of 2006).

The waste management development receives a fixed amount to maintain the waste trucks and pay the garbage men. The municipality has a separate budget to create general awareness on waste issues.

A budget has been calculated for the new waste dump; however the municipality did not want to supply this information. How these costs are going be allocated over the residents and industries is not clear. The investment of the new waste dump was approved by CONAMA, at the moment however it is not clear when the dump is going to be finished.

Market potential

Isla Navarino has about 2200 residents. These people form the local market of the island. Next to the residents, tourists visit the island. As mentioned in the section 1.3 these tourists cause extra waste. Tourists can however also be seen as potential buyers. These tourists come whith the boat from Ushuaia (Ushuaia boating), with cruise ships or with sailing boots. Table 8 shows the prognoses of the amount of tourists that visited Isla Navarino in 2005-2006.

Means of transportation	2005-2006
Yachts	1600
Ushuaia boating (Boot from Argentina)	1481
Cruise ship	5657
Total visitors	8738

Table 8: Tourists numbers Isla Navarino (Source: Jampen & Katewijk, 2006 unpublished)

The exact number is higher because these numbers do not include arrivals by plane Aerovias DAP and ferry Austral Broom. The tourists may be an interesting market to sell recycled products to. This market is nearly four times the size of the local market and growing. The tourism sector on Isla Navarino is growing at approximately 8% per year (Blanco, 2006).

3.3.4 Socio-cultural

In section 3.1 “waste” stakeholders have been identified. These are stakeholders that can possibly assist during a waste project. There are also other social organizations present on the island that have influence on the local community in general. This section focuses on how the community can influence each other through communication. The community communicates with each other in different ways. Mainly they communicate in an informal setting with friends and family. There are also formal means of communications.

According to Rozzi (2004), the following forms of social organisations can be found on Isla Navarino: Neighbourhood Associations, Corporations and Foundations for the Public Good (e.g. the Red Cross etc.), Unions (e.g. the fishermen's union), Indigenous communities (e.g. The Yagan Community), Professional Associations, Commercial and Civil Societies and Sports Clubs. People can express opinions through these organizations, for example the neighbourhood association which is described below.

The civil part of Puerto Williams is divided into two neighbourhoods. Both have their own neighbourhood association "Junto de Vecinos". Each has an elected president, who is a resident in the neighbourhood. The committee represents the interests of the neighbourhood and forms the link between the neighbourhood and the local authorities.
Local organisations in general have a relatively weak management capacity, according to the diagnosis in the county development plan (Pladeco, 2004). The report mentions the high percentage of non-permanent residents who stay less than four years in the county as one of the reasons for this. Another reason mentioned is the absence of social leaders capable of consolidating the process of self management, required to strengthen and better activate the organisations. The Pladeco in general identifies the following challenges for projects on the island:

- The capacity of the organisations to formulating, implement and support projects is not fully developed.
- Lack of strong relationships between the permanent residents of the county.
- Organisations presently see their role as practical actor and not as a factor in the development of the community.

These challenges can also apply to waste projects and are therefore mentioned in this research. Pladeco however does not only identify challenges, he identifies the following opportunities present on Isla Navarino. These factors need to be taken into account when planning a waste project, because they may have a positive influence on the outcome of the project.

- Most of the population is concentrated in an urban sector, Puerto Williams, which should enhance the means of communication between the inhabitants and the activities that make the community come together.
- The local population is predominantly young from a demographic point of view, which can favour a better spirit of enterprise and a higher capacity to identify themselves with the commune in the long term

Misrachi (2005) has identified other factors that may influence community participation. She has categorised these factors in three categories, namely operational, structural and cultural. The limitations on cultural level are mentioned here, the operational and structural limitations will be explained in section 3.3.5.
The following limitations on cultural level to community participation can be identified:

- Lack of a "culture of (political) participation"
- Short term approach; direct, concrete, practical results

A social organisation not mentioned by Rozzi, because it did not exist yet, is the in July 2006 formed platform for micro enterprises, Asociacion Comunitaria pro Turismo (A.C.T.) This is a platform for local tourist micro enterprises (De Nijs, 2006). The association was formed out of local initiatives and help of Enviu. They have meetings once a month. Members attending the meetings vary highly and attendance is low in general. The low attendance rates at platform meeting confirm "*lacks of motivation to participate in the development of the country through organisations" (*Pladeco, 2004).

This "lack of motivation" also stands out when talking to people and can be a possible threat to future waste projects. The local community sees waste building up, however does not undertake action. A primary reason for this is that people feel they cannot make a difference themselves. When giving specific examples of what can be done, people reaction is that people are to rigid

and the solution lies in hands of the youth. Secondly, a lot of people see improving the waste situation as a task of the municipality. The people of Puerto Williams have some influence in the municipality. Once every four years there is an election for mayor. Besides that there is a municipality council, which is composed of local citizens and constitutes a form of local participation through local representation (Municipality, 2006).
People can stress their worries about the waste situations via the municipality council. This is not done often. The centralisation of power within the municipality and government is a barrier for people to contact authorities, as mentioned by Misrachi (2005). She also mentions the fragmented community in different social classes, origins, sectors of economic activity, level of identification with the island and length of stay as a barrier to undertake action.

Another medium residents can use to improve their own waste situation is a telephone number. This is a direct number to improve their waste situation. People can call the municipality if they have waste, for example after a house renovation. The municipality will send a truck to pick up the waste. This is to prevent people from dumping or leaving it in their gardens. Next to other waste wandering the streets, this does not give a Puerto Williams a nice look. During a street cleaning campaign, also organised amongst others by Enviu in November of 2006, children for the school picked up 6 truckloads of waste from public areas but also from people's gardens. Whole heaters, toilet bowls and other things where retrieved from these areas. This could have been picked up by the municipality; the telephone number is nevertheless never used. Why this is the case can be twofold, one people are not aware of the municipality service or they don't call for other reasons. These other reasons can be related to the causes mentioned by Rozzi and Misrachi for a lack of community involvement.

3.3.5 Institutional

This section focuses on the links between the political and social structure. As mentioned in 3.2 there are a lot of stakeholders on Isla Navarino. Section 3.3.4 discussed the social-cultural impacts of the island and more specifically limitations to community participation.

As mentioned earlier the responsibility of domestic waste lies within the municipality. It is responsible for the process, from collection to disposal. The four R's of the waste hierarchy however are not necessary the task of the municipality. Waste projects can also be undertaken by the private sector, for example as a micro enterprise or as a community based organization (Interview, 29th of January 2007). Figure 11 shows the different roles local stakeholders can play in the future to improve the waste situation.

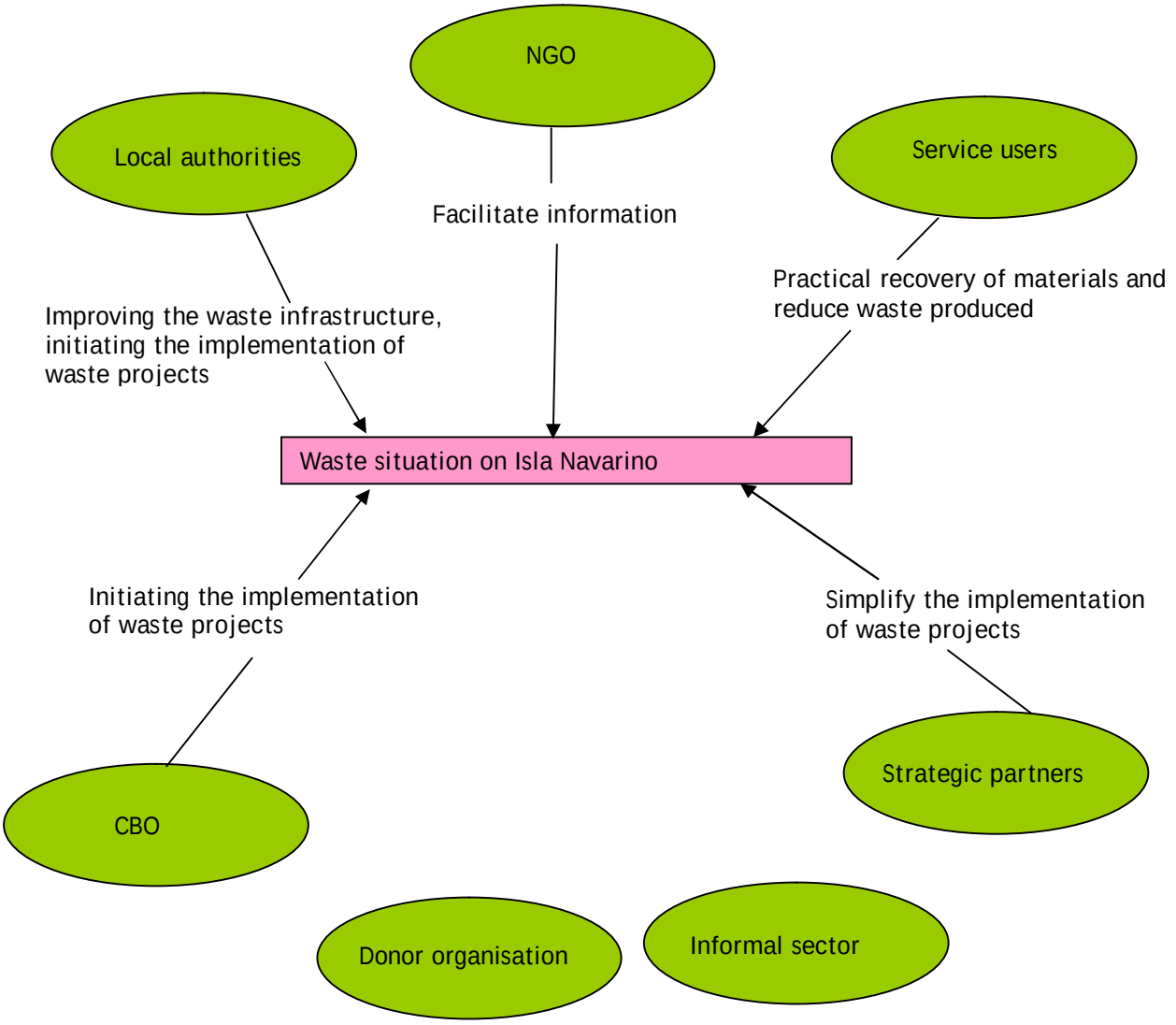

Figure 11: Roles of stakeholders in changing the waste situation

It is apparent that to improve the waste situation all stakeholders should combine there different roles and power and work together. This is because all stakeholders play different roles and a combination would improve the change of success of a project. There are other local institutional conditions that may influence the outcome of a waste project next to cooperation of the stakeholders. These limitations are divided in two categories. Misrachi (2005) in general mentioned the following limitations on operational and structural level. These limitations may also influence waste project. At operational Level (action):

- Centralization of power to government
- Division of power within social structure

- Short Term and top-down approach
- Emphasis on conservation

At structural Level (context):

- Highly fragmented community
- Dependence on social welfare
- Expertise, education, awareness
- Lack of Information
- Limited access to capital and land ownership

3.3.6 Policy/Legal/Political

As mentioned in section 3.1 there are two laws “Ley Organica de Municipalidades” and “Codigo Sanitario” that state that the municipality is responsible for domestic waste. Next to the environmental laws there is another law that can influence waste projects. Isla Navarino is qualified as a ‘Zonas Extremas (ZE)’. Isla Navarino is one of the four areas that does not have to pay income tax, these areas are called “libre comercio extremo”. The area is also a tax free zone, so residents and businesses do not have to pay VAT. This law is installed because of the distance to the capital, cost of living and the remoteness of the region (World Bank, 2005). But mainly to stimulate development in the region a special law applies to Isla Navarino, the law of Navarino (N°1 8.392). Not paying VAT should be taken into account when calculating costs of for example machines that need to be imported. On the other hand, businesses do not pay VAT on the invoice out off business processes.

3.4 Conclusions

In this section the first research question (*What causes problems in the current waste situation on Isla Navarino?*) will be answered. Further several important context aspects that contribute to the current situation are discussed.

Technical aspects have shown that the waste collection rate is very high, above the 90%. This rate does not have a big improvement potential. The separation rate of materials is 0% this has a very big improvement potential rate. In the current situation no materials are separated because nothing can be done with the materials recovered, there are no processing methods present on the island. On the other hand no materials can be processed because they are not being separated of the rest of the waste, see figure 12.

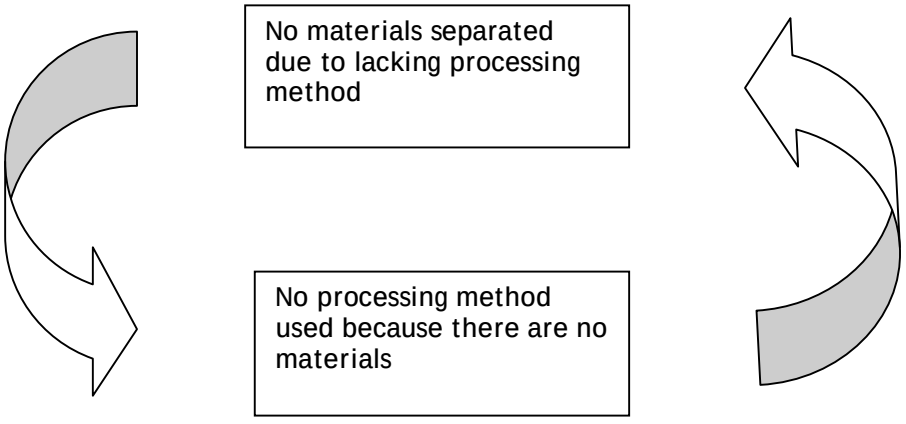

Figure 12: Current vicious cycle

In the current situation all domestic waste is dumped on the waste dump as is visualized in figure 13.

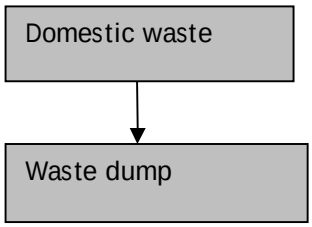

Figure 13: Current waste flow

Domestic waste flows are generation, collection, transportation and disposal. The practical waste element is missing an important aspect “separation”. This fact results in the fact that recovery, recycling, reusing and reduction cannot be carried out. Separation needs to be started to make a waste project to a success, eliminating the first part of the vicious cycle mentioned in figure 12(page 48).

Environmental aspects improve when breaking the vicious cycle shown in figure 13. It can also improve social aspects by providing people with new means of gaining financial independence. It is therefore important to find a way to reduce the dumped quantities. The impact on the environment also depends on the kind of material. The quantity and kind of material are important factors that need to be taken into account when improving the environment and are possibly criteria for waste projects.

Financial/ economic aspects show that the municipality can raise own waste taxes. This is positive because it is independent of others. The small market potential on the island is however a weakness. If waste projects should improve the financial independence, costs and revenues are possibly important criteria on which waste projects should be selected.

Implementation time is also viewed as important. The faster the waste can be reduced, the faster it will have influence on the environment and the social environment of the people of Isla Navarino. Also the continuity of projects is important. Waste projects should not be a one time event. Implementation time and continuity of a project are therefore possible criteria. In chapter 5 all possible criteria are discussed with local stakeholders.

Social-cultural threats are mentioned that can complicate implementation of changes needed. The social context of Isla Navarino is mentioned as being “complicated”. This is among other thing caused by the fact that the island has a big floating population. Many people only live there for a few years and do not feel connected with the environment. The initiative of change may have to lie at the municipality. Other stakeholders however also have important roles in making the new waste system work. It is essential for results to get institutional and people working together. Chapter 6 elaborates on how waste projects can best be implemented to overcome this.

In the next chapter waste projects are identified that will change the current situation by providing the island with a processing method and thereby eliminating the second factor of the vicious cycle, explained in this chapter.

4. Identification of waste projects

The previous chapter has explained the current situation on Isla Navarino. This chapter will focus on identifying possible waste projects to improve the current situation and reach a more desirable situation on the island. Together these possible waste projects will change the current situation that has no separation of waste and no processing possibilities. To a new more desirable situation in which materials are recycled and unusable materials are dumped, see figure 14.

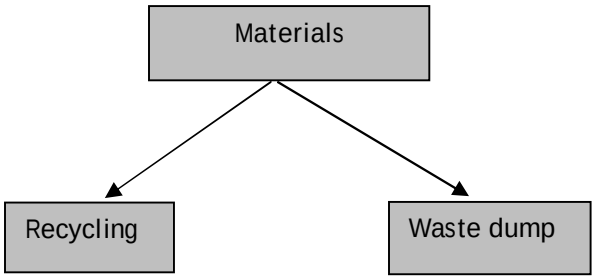

Figure 14: Desirable material flow

4.1 Possible solutions

In chapter 3, 7 waste material categories (biodegradable materials, plastics, paper, glass, metal, textiles and other) were identified. Depending on the kind of material different methods can be used to recycle. The possibilities of textiles are not investigated because since the category is small and cloths are handed down when possible. The possibilities of the category 'other' will also not be identified because it contains all different kinds of materials and it is not possible to find one method to recycle it.

Because many projects are possible this research will only focus on recycling projects. Local stakeholders feel that two kinds of projects are possible. The two scenarios are:

- Recycling on the island
- Recycling on the Chilean main land.

4.1.1 Biodegradable materials

About 43% of the domestic waste on Isla Navarino is biodegradable, this equals to about 230.000 kg a year. Biodegradable materials are the biggest material category present on the island. The biodegradable materials can be used in three ways (Klundert van der, 1993).

- To feed animals (fodder),
- To improve the soil (compost),
- To produce energy (biogas or briquettes).

There is nearly no livestock present on Isla Navarino. This way of reusing biodegradable waste is therefore not an option for Isla Navarino. According to the waste expert from Porvenir producing energy with biogas will costs more than the energy it would supply (Interview 27th of November 2006). In depth research is needed to investigate what possible method can be feasible on the island. Due to time limitations, energy options have not been investigated further.

Biodegradable materials can however be used to improve the soil. It changes over time to materials that are absorbed by the earth. This is a natural process that takes place naturally.
Food wastes, fruits and vegetable, garden wastes and carcasses can be composted. These become organic fertilizer through a controlled process of biological decomposition in about 35 to 45 days. Composting technology is basic and simple, requiring minimum skill and capital (Composting in the Philippines, 1996). Because minimum techniques are required it is logical to compost biodegradable materials on the island. This process can be undertaken in two ways on Isla Navarino, a central composting site or individual composting units. Both options have their own advantages.

Success & failure factors of a compost plant in the Philippines

One of the main obstacles in the Philippines is space, the factory has maxed out its capacity and if it wants to grow. More space and tools are needed. Space is not a binding factor on Isla Navarino. When a composing site is implemented it should not max out its capacity. So if biodegradable materials grow on the future the site can handle this.

Other obstacles that can be cited are product quality and raw material source competition. This is however not a problem for Isla Navarino because there are not other companies that offer the same product.
Another obstacle is that not enough technical knowledge present. The organization AWARE (Assorted Waste Administration and Recycling Enterprise) initiate's improvements for equipment and other technical matters. This can also be an obstacle for Isla Navarino because no qualified personal is present. Is can be overcome by education the people how are going to work at the composing site.

The most important success factor has been the social factor. There was a big need to improve the SWM (Solid Waste Management). This threatens national and local governments to tackle the problem. Without is input of the community the project would have been more difficult. The temperature is very important for composting; a temperature of 50 degrees is preferable. The moistness of the environment also has a positive effect on the composting process.

A central composting site

This idea is taken from a case study of a compost site Sta. Maria in the Philippines, explained in the textbox above. The initiative was started after a neighbouring town stopped accepting waste outside the jurisdiction. Steps needed to be taken to drastically decrease domestic waste dumped in their own jurisdiction.

The composting process contains of three stages, which are briefly explained here:

- Sorting: The waste is collected by a waste truck. Biodegradable and non-biodegradable are sorted out at the source.
- Composing process: a shredder machine was fabricated to cut the waste. Some other tools are needed, like a shovel to handle the biodegradable. And plastic cover is needed to cover the process. A compost fungus activator can be used, what helps to accelerate the decomposition process.
- Refining process: A shifter was made locally to separate the fine components from the larger ones, by a vibratory motion. A grinder was also fabricated locally to cut the compost into desired pieces. After that it is put into bags so it can be transported.

Individual composting
Individual composting is for example done in the Netherlands. A small plastic compost bin can be bought. The only thing that people have to do is to throw in food rests and wait. After a while the compost can be taken out at the bottom of the bin and used for example to fertilize a garden. Its option is cheaper than the central composting site. Residents on Isla Navarino can make a composting bin themselves. Costs exist of the material costs used to make the compost bin. No other costs have to be made like transport or separation costs, because the waste is composted at the source. Revenues are for the maker, because the compost can be directly used for the garden.

The end product in both composting methods can be used to fertile gardens in Puerto Williams or be used in the community green house. It is not clear if there is a market for fertiliser on Isla Navarino or if the people are willing to pay for fertilizer.
The composting option is not further investigated because this option is being investigated by another person on the island (Interview 16th of November 2006).

4.1.2 Plastics

On a yearly basis the residents of Isla Navarino produce little more than 53.000 kilos of plastic. Plastic is a man made material that is produced from oil or natural gas. It can be recycled using different machines. The four commonly used machines are mentioned in table 9. All machines work differently, the technical process of these machines are explained in appendix H. Because different methods are used, the process is fit for a specific kind of product.

Machines	Types of products
Extruder:	Pipes and hoses
Injection moulding:	Various items (like household items)
Blow moulding:	Bottles
Film moulding:	Bags or sheets

Table 9: Plastic moulding machines

A plastic recycling factory on Isla Navarino
There are many different kinds of plastics; there are four types that can be recycled. These four types are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Three basic tests can establish the type of plastic you're dealing with. These tests can be found in appendix I. PE and PET (Polyethylene Terephthalate, which is non recyclable) are mainly used for bottles, plastic bags and food packaging. These are the most common found plastics in domestic waste on Isla Navarino (Lardinois, 1995). A common problem however is that products are often made out of more then one type of plastic (recycling plastic), what makes it hard to recycle. PET bottles cannot be recycled whereas PE can be recycled. The process of recycling plastic contains of three steps (Rajaram, 1997):

1. The plastic must be cleaned and sorted. This can be a very basic process and done by hand.
2. The plastic must be cut into a manageable size to make the parts fit into a small machine and easier to store.

3. The plastic must be moulded into its new form. There are different processes for forming plastic; the method used depends on the kind of plastic handled and the desired end product.

Success & failure factors of plastic recycling companies in India
Rajaram (1997) did an investigation on small scale industries (SSI) in Bangalore India. The research is based on 8 small scale companies that reprocess plastic. The following shortly introduced the case studies and the processes they use.

1. Universal Industrial Engineers started in 1987. This small scale plastic recycling unit uses mainly road waste as raw material (PP).
Process: scrap → sort → grind → wash in necessary → high speed mixer (add colour) → feed extruder → pelletizing
2. Vinayraj Plastics started in 1974. This small scale plastic recycling unit uses waste generated from factories and manufacturers of PP woven sacks which are used extensively in the cement and fertilizer industries.
Process: scrap → grind → high speed mixer → feed extruder → pelletizing → baling straps
3. Munnot Plastics Industries started in 1991. This unit uses HDPE scrap such as buckets and other household articles.
Process: scrap → colour sorting → size reduction → feed extruder → pelletizing
4. Neha Pladtics started in 1978. This unit recycles milk pouches (PE).
Process: scrap → remove dirt → grind → wash → rinse → heating → feed extruder → pelletizing
5. Mr. Nayandahalli started this unit in 1994. White PP carry bags are purchased from a wholesaler and processed.
Process: scrap → sort → grind feed extruder → pelletizing
6. Hindustan Plastics started in 1981.This unit processes only "Raffia" which is waste PP woven sack material.
Process: scrap → extrude lumps → grind → heat → feed extruder → pelletizing
7. Allied Containers started in 1984. This unit processes only machine waste.
Process: scrap → size reduction → high speed mixing→ grind → feed extruder → pelletizing
8. Apex Polymer Extrusions was started in 1984. PVC electric cable wires are recycled.
Process: scrap → sorted → size reduction → grind → high speed mixing →feed extruder → pelletizing

There are some key success factors mentioned by Rajaram. The main growth of SSI was caused by government encouraging instruments. The government has a key role in stimulating waste projects by for example financial and tax incentives. Community based project have a higher change of success because everybody is involved. Finally, a last a network improves innovative ideas, but also stimulates market competition.

Transport plastics
There are many companies in Chile that collect plastic materials. Most of which are located in Santiago. These companies, for example Eco plastic and Reciclajes Del Sur Itda, have a minimum delivery of a 1000kgs. Some companies pay for delivered products, this can be paid in kilos or tons some goods are priced per units, like tires (Scheinberg, 2000). There three kinds of plastic products collected in Chile are: Tetra packs, plastic bags and PET bottles.

- Tetra packs

Last year in 2006 there was a national campaign held in Chile called "Tetra for Chile". Tetra packs where collected and recycled (Tetrapak website). The department Comuna Saludable of

the municipality organized this campaign on the island. A lot of tetra packs where collected. The collected material was however never transported, because the costs of transport where to high (Interview, 29th of January 2007). The collected tetra packs were dumped on the waste sump outside Puerto Williams. The lesson learned is that transporting material to Santiago is not economical feasible for tetra packs. This option will not be looked at further.

- Plastic bags

There is another company that collects plastic bags. These bags need to be delivered in bundles of 500 kilos. This company is located in the northern part of Chile. This is about 4500km north of Isla Navarino. This option will not be calculated. If transport to Santiago is not feasible, transport to Antofagasta will not be feasible either.

- PET bottles

A company called Recipet collects PET bottles and reuses them. This company has several locations in Chile. The bottles must be delivered in a compact state; this makes transportation costs cheaper. This is caused by the fact that a compacted bottle takes less space (Recipet, 2007). Recipet pays for the delivered PET bottles. The PET bottles are the only plastic material that is paid for by the receiving company. The of transporting plastic will focus on transporting PET bottles, because if transporting a material that has value is not feasible the non-value plastics will also not be feasible.

4.1.3 Paper

Domestic waste contains more then 100.000 kilograms of paper. There are two possibilities for paper. One is to recycle it on the island. The second possibility is to transport it to the main land. The big advantage of recycling paper is that fewer trees need to be cut and less energy is needed then when new paper is made. To produce 1 ton of new paper 7.600 kilowatts is needed and when recycling paper this is only 2.850 kilowatts (chilepotenciaalimentaria.cl, 2007)

A paper recycling centre on Isla Navarino

Paper recycling can be a simple or a difficult process. This depends on the end product you want. The more advantaged the process the better the quality of the paper. Recycled paper can however also be used for other products then paper. The simplest way to recycle paper is executed in a workshop at the local school. This process can however also be set-up in a bigger way to recycle more material.

The process: First the paper is cut into small peaces. Leave it to soak in a mixture of water and glue. After the paper has soaked it is let to dry in a mould. After it is dry you can get it out of the mould and it is ready for use.

Transporting paper

There are several paper-recycling centres in the capital region. For example Sorepa is situated in Santiago and has a minimum delivery quantity of 500 kilograms. This means that if paper is going to be transported a container is needed to ship it to Santiago. It has however already been established, that transporting material to Region Metropolitana is not economically feasible.

In the most southern part however these companies are more scares. There is a person in Punta Arenas who wants to collect paper to recycle it. This is however not operational yet.

Because transporting materials that do not gain revenues is not economically feasible this project is not identified as a possible waste project.

4.1.4 Metal

About 37.000 kilos of metal is produced in a year. Metals have a high value per kilo. This makes it a good candidate for recycling because the costs of raw material or used material are lower. Furthermore, no high-tech machinery is needed to recycle metals. It cost less energy to transform used metals then to make new metal. For example, it costs 17.6000 kilowatts to produce one ton of new aluminium, whereas it only takes 750 kilowatts to recycle a ton of aluminium (Chilepotentaalomentaria, 2007).

Community involvement as critical success factor

Because no case studies of all sort of waste projects identified could be found, this section focuses on factors that influence projects with sustainable goals in general. Projects with sustainability goals are projects that secure development objectives with a sustainable use of natural resources both for productive inputs and waste generation (Hardoy *et al.*, 1992). In practice however most projects that are judged as sustainable do not damage natural researches (Moningka, 2000). Community involvement is found as a red line throughout literature on sustainable projects and in the case studies found. It can therefore be concluded that community involvement is a critical success factor. However no specific information was given on how to establish this involvement. This section will give insight on what is important to establish efficient community involvement and why the community is important.

- **Improving impact & sustainability of projects**

Involving the community in the project possibly will increase local ownership of projects and enhance a sense of responsibility for maintaining services provided by projects. These aspects are both essential for the durability and continuity of projects (Imperato & Ruster, 1999).

- **Improvement of effectiveness**

If the community is involved in the design of the project, it is possible to integrate its needs and constraints in the objectives of the project and in this way come to a more effective implementation (Paul, 1987).

- **Improvement of efficiency**

Community participation may be used to enhance the understanding and agreement of cost sharing (both financial and physical contribution). Furthermore, community participation can be used to prevent conflicts and to stimulate cooperation and agreement between different actors. In this way delays in project execution can be reduced and overall costs minimised (Paul, 1987).

- **Empowerment.**

Community participation may give people the opportunity to discover and start strategies to improve their situation (Mitlin & Thompson, 1995; Imperato & Ruster, 1999).

Focusing more on waste, Scheinberg (2000) said the following: that involving small & medium enterprises in ISWM) is good for cost, quality and link with the community, focus. The chances of success can be increased by starting in a small way with a pilot project.

Recycle metals on Isla Navarino

Metals can very easily be recycled, there are two processes possible. One process is melting the metal in total. An oven to melt the metal is needed. Secondly a mould is needed to pour the melted metal in. The second process is only melting a small piece and in this way changing the shape of the material. For this process only an oven is needed and tools to shape the product. At this moment, barbeques are build from old iron.

Transporting metals

Metal can be sold after it is used. There is a company called Copasur, which buys metal materials. The company pays $650CP for a kilo of metal. This company is however located in the Metropolitana region. There is another company located in Punta Arenas. This is the nearest Chilean town (figure 1, page 9). The company Metales Douglas buys and sells metal materials. The option of transporting metals to Punta Arenas is identified as a possible waste project. Punta Arenas is located much closer to Puerto Williams than to Santiago, so it will make a big difference in transport costs.

4.1.5 Glass

On Isla Navarino approximately 21.216 kilos of glass are yearly dumped on the waste dump. It is cheaper to recycle glass then to make glass for scratch.

Recycling glass on Isla Navarino

Recycling glass is a relatively easy process. Glass bottles for example are first broken into small pieces. The small pieces go into a bucket, which goes into an oven where the glass is melted and something can be blown out of it.

Case studies: Success & failure factors of glass recycling in Syria (Damascus)

Out of my own experience I have seen the success of glass recycling. In the capital of Syria, Damascus there are a lot of people working in the informal waste sector. Some of these people collect glass. This glass is among other things is used to supply a small glass factory. This factory is located in the suburb of Damascus. Glass is delivered to the factory, where it is sorted on colour. There two women break the glass with a rock as a tool.

The glass pieces are melted in a self made oven, where after it is moulded into different artefacts, for example tea glasses and candleholders.

Transporting glass

CONAMA identified four glass recycling companies in Chile. One of these companies has a department in Punta Arenas. Punta Arenas is a city in the 12th region and the nearest Chilean city to Puerto Williams. The organization is called Coaniquem. This organization does not specialize in recycling, but is an organization that helps children who are burned. The organization in Punta Arenas collections glass and the full container is shipped to Santiago. The organization gets paid for the delivered glass and the container. Revenues go to the burned victims fund (Coaniquem, 2007). The company does not have a minimum delivery quantity. The company does not pay for the supplied glass. The glass can be delivered in complete or grinded form as long as the transport package is in a manual handle size.

4.2 conclusions

In this section the second research question (What are possible waste solutions for the identified waste problem on Isla Navarino) was answered.

Seven waste projects were identified. The methods used depend on the waste material. Waste projects are identified for four kinds of materials: plastics, paper, metals and glass. For each of these materials a project is identified on the island as well as a transporting option, in total the following 7 projects were identified as possible waste projects:

- Plastic recycling factory on the island
- Paper recycling factory on the island
- Transporting paper to Punta Arenas
- Metal recycling factory on the island
- Transporting metal to Punta Arenas
- Glass recycling factory on the island
- Transporting glass to Punta Arenas

The next chapter focuses on establishing ranking criteria for the waste projects identified in this chapter. After formulating these criteria a ranking of waste projects is made.

5 Selection of the best waste project

The previous chapter has given a couple of solutions to minimize the dumped waste. In this chapter the identified waste projects will be ranked so hat the best project is identified, Section 5.1 focuses on finding criteria based on which the found solutions are ranked. In section 5.2 the importance of the criteria is investigated and if necessary the weight of the criteria is established. In section 5.3 the solutions are ranked based on the criteria. After the projects are ranked, the "best" project is clear. In section 5.4 recommendations are given on how to implement the waste project. Section 5.5 gives the conclusion of the ranking of the possible solutions for Isla Navarino.

5.1 Identifying success criteria

In order to compare the identified projects, selection criteria are formulated. The criteria are based on the 3 P's model of Elkington (1998). For a project to be sustainable and what is also the goal of the ISWM model, it has to contribute to the people, the planet and be profitable. This is because benefits of implementing possible solutions are not only expressed in money (profit), but also less pollution (planet), improving the living environment (people) (Scheinberg, 2000).

The elements that are important depend on the stakeholder. The price of a waste project is likely to be more important for the person who is carrying out the project, in contrast to the people who live in Puerto Williams. They will be more interested in the improvement of their living environment. Therefore all the stakeholders present on the island are involved in the process of establishing criteria. The different groups of stakeholder present on the island as mentioned in the ISWM model are:

- Local authorities
- Non Government Organizations & Community Based Organizations
- Service users

The group "Strategic partner" that was identified in 3.2 was not added as a special group. This is because this group is mainly important in the implementation phase of a waste project as visualized in figure 11 (page 47). Their possible role depends on the selected waste project, for example the role of the Austral Broom when exporting material. At this point no project is chosen so the role of is not clear and this group will be seen as a normal service user. Four people out of every group were asked there opinion about waste projects and what they think is important.

A multi criteria decision analysis model will be used in this chapter. To use this model multiple criteria will be selected to rank the identified waste projects. As mentioned in section 2.1.3 good criteria must have a direct link with the concept that is being investigated. In this cause there are three concepts that lead to sustainability:

- People -> social aspect
- Profit -> economical viably
- Planet -> environmental protection

Secondly all stakeholders must have the same understanding of what the criteria implies. It must be unambiguous to all stakeholders. Finally, a good criterion must be measurable so the criteria can be ranked (Belton, 2002).

A value measurement model is used, which means that waste projects are given a value that represents the degree to which one alternative may be preferred to another (Belton, 2002). The value of a waste project is made up out off the sum of the value of established criteria. All criteria are measured on a three point scale, ranking from 3 the best to 1 worst. The projects with the "highest" scores are the best projects for the island.

People

This concept measures the impact on the people of Isla Navarino. This impact can be in different ways. Stakeholders have been asked what they think is important when executing a waste project and how they view the role of the people in this.

Visible result

The time until results are accomplished is viewed as important by most service users. This aspect however is of less importance to the local authorities. The municipality for example states that it is not the time that is important but the end result (Interview, 29th of January 2007). Also the NGO's and CBO questioned emphasized on the importance of the outcome of the project rather than on time. A visible result in general is however hard to establish because not many people visit the waste dump and will not notice whether less waste is dumped there. It is however possible to estimate the start of a waste project until the first material is processed. To make it visible to the people an announcement in the local media is suggested. This criterion is defined as following:

- Time to results, the time between the moment the project is started until the moment the first material is processed (measured in months).

Continuity

A factor that was important to all stakeholders was the fact that a waste project must be continued over time. A one time effort is not what they want. This was also a condition that Enviu considered necessary for all waste projects identified in chapter 4, so this criterion will not be used, because this fact applies to all waste projects.

Community influence

Community influence is another factor that comes to the surface. The municipality see their role as a facilitator of the waste infrastructure (Interview, 26th of January 2007). The community needs to actively contribute to reducing waste dumped, for example separation at the house so material can be recycled. This opinion is shared by an independent waste consultant, who also works for a CBO (Interview, 26th of January 2007).

Striking was however the opinion of the service users. One group sees no possibilities for the residents of Isla Navarino. This is mainly because they feel that the ways of the island people are very rigid and they are hard to change. If the municipality decides that they have to separate the people will not do this. The second group commented that it was essential to involve the local community and that people should start separating materials in the house. This opinion is shared by local authorities and NGO's. One service user thinks that the community should have a say in the decision on which waste material should be tackled first. Because no univocal translation of the concept "community involvement" can be found, this is not used as a criteria the concept of people. However community involvement was already identified as a critical success factor of a waste project (chapter 4). Therefore community involvement will be discussed further in chapter 6.

Planet

The concept planet measures the impact on the environment. This impact depends on the amount and type of waste present on the island.

Quantity of waste material

The amount of waste produced has a direct relation with the environmental impact. This criterion is defined as follows:.

- Quantity of waste that can be reduced, which is based on the total amount of waste material present on the island (in kg)

Breakdown times of material

Stakeholder interviews indicated that not only the amount of material reduced is important, but also the kind of material. Biodegradable material will dissolve quickly whereas the breakdown time of plastic is much longer. This criterion is defined as followed:

- Time that the material takes to dissolve (in years).

Profit

Literature on waste management gives costs as a critical success factor (Scheinberg, 2000). To keep things orderly only two costs are used as a criterion. One is the initial investment of a project. When the start-up costs of a project are very high, the project will never be initiated. However when the costs of processing a cubic metre of material are very high, the initial investment should not be made.

Start-up costs

This criterion is defined as follows:

- The one-time investment needed (for example tools and machines) to get a process started.

Processing costs

The second cost used as a criterion are the process cost. These are variable costs for processing one cubic metre of material. Processing costs are always given in cubic metres because this makes it easier to compare. This is included because if the costs of processing material are too high, the start-up investment should not be made.
This criterion is defined as follows:

- Costs of processing a cubic metre of waste material, from separation to the final user.

Revenues

Besides costs a project will hopefully also gain revenues. A project is sustainable when it can earn revenues. A project that makes money is more likely to continue and it can operate as an autonomous unit. Because it is an important factor for the continuity of a project this criterion is added.
The criterion is defined as followed:

- The potential revenues a project may gain by selling the “end product” to the final user.

The start-up costs, processing costs and revenues of all projects can be found in Appendix J. Appendix K explains how these 6 criteria are made measurable. It also explains the scale per criteria and how the 7 identified projects score for each criterion.

5.2 Weighting the criteria

In the previous section criteria were identified and given a value. As discussed in 2.2.4, now a choice should be made between the SMART (Simple multi attribute rating technique) and the AHP (Analytical Hierarchy Process). The SMART method assumes that all criteria are equally important whereas the AHP are weighted based on significant impact. To establish if criteria need to be weighted, stakeholders have been interviewed to assess the importance of the selected criteria, see appendix M for example of the inquiry held. The same groups as during the selection of criteria are used. All stakeholders are presumed to be equally important, that is why the same amount of people is interviewed. It was not possible to conduct all 4 interviews within NGO and CBO in the category only three interviews were carried out.

- Local authorities (4) (4)
- NGO /CBO (4) (3)
- Service users (4) (4)

To establish how important criteria are to stakeholders, they were asked to rank the factors mentioned in 5.1 from 1 to 7, because there are 7 factors most important factors. The two factors that are not selected as criteria are also ranked, but not shown in the graph that shows the importance of the criteria. Revenues are also shown in the graph. This criterion was however not ranked during stakeholder interviews. The importance of revenues is presumed to be the same as processing costs. This is because revenues are linked to the total of material processed; more processed material means that more materials/products can be sold. The results of the stakeholders' opinion are shown in appendix N. Based on these opinions a figure is made to visualize the opinions of the different stakeholder groups. Figure 15 is based on the mean of the stakeholder groups.

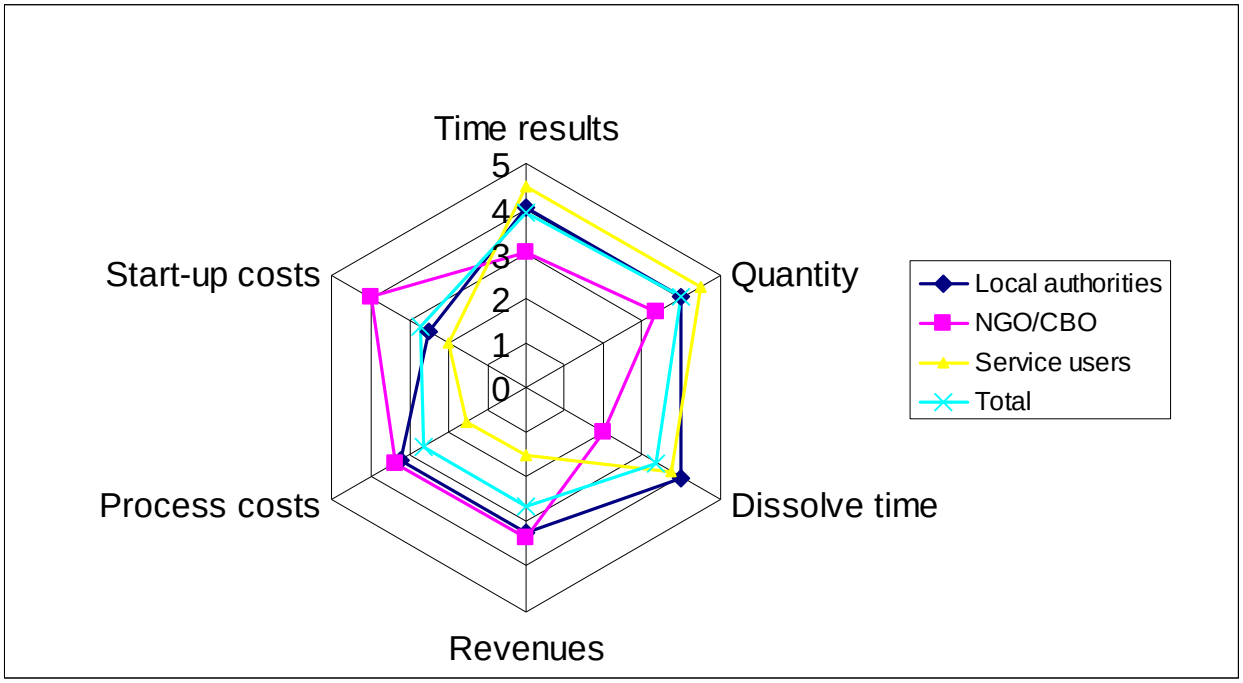

Figure 15: Stakeholders opinion

The most important aspects were ranked decreasingly with number 7 as most important to number 1 which is the least important aspect. The most important criteria are pictured more to the outside of the grid. The quantity of waste that can be reduced is more important to all stakeholders then the start-up costs, because all the points of quality lay further from the centre then the start-up ones. When only looking at the time to results criteria, it can be concluded that the service users find this the most important, followed by the local authorities and the NGO group think it is the least important.

As can be seen in figure 15(page 61), the service users don't think that costs and revenues are important. This is because they feel it is the responsibility of the municipality to handle the waste and are that the municipality is responsible for the costs. Service users find time until results and quantity much more important then the other stakeholder groups. The local authorities and NGO stakeholders share the same opinion of how important costs are. Figure 15 also displays how the different criteria are important to different stakeholders. Should criteria be weighted based on these stakeholder opinions? In table 10 the overall stakeholder mean value is given per criteria.

Criteria	Revenues	Process costs	Start-up costs	Dissolve time	Time results	Quantity
Mean value	2,6	2,6	2,7	3,4	3,9	4
Index	1,0	1,0	1,0	1,3	1,5	1,5

Table 10: Index weights of criteria

An index is used to compare values amongst each other. The revenues criterion is set at index one and the rest of the indexes are based on that criterion. The criterion Quantify has the higher mean, which means that that it is 1,5 more important to all stakeholders than revenues of processing costs.

The index shows that Time results criterion is perceived as important as Quantity. Dissolve time is 1,3 times more important than revenues. Costs are the least important factor. Costs and revenues are the least important of the criteria, according to the mean of stakeholder opinions.

This implies that criteria should be weighted and that costs are less important. However the initiative of starting or providing infrastructure for this lies within the municipality. During interviews they indicate that costs are not the most important thing. However when the cost of a waste project are extremely high it will not be executed. Cost is the first factor that the municipality will look at when choosing a waste project. A project with low costs is more likely to be executed by the municipality. It is apparent that some projects are more costly than others. The comparison is based on the 3 point scale used to measure the cost criteria. The project with the lowest score symbolizes the project with the lowest total costs and vice versa.

Based on this knowledge, the profit criteria are assumed to be more important then the other two concepts. Therefore these criteria will be weighted twice as heavy as the other criteria.

5.3 Ranking the solutions

The multi decision making model

Brigdman (1963) A multi-attribute decision making problem in general has *m* criteria (C) and *n* alternatives (A), $C_1,...,C_m$ and $A_1,..,A_n$. In this research a C1….C6 and A1…A7 problem needs to

be solved. A standard method to solve such a problem is making a decision table. In the table each row belongs to the criteria and the column to the alternative. The score a*ij*, represents the performance of alternative *j* against criteria *i*. The decision table is visualized in figure 16.

The ranking value of X_j of alternative $A_j = \Sigma C_m A_j$ j= 1,…,7

Formula:

$$A_j = \sum_{M=1}^{5} C_m A_j \quad j= 1,\ldots,7$$

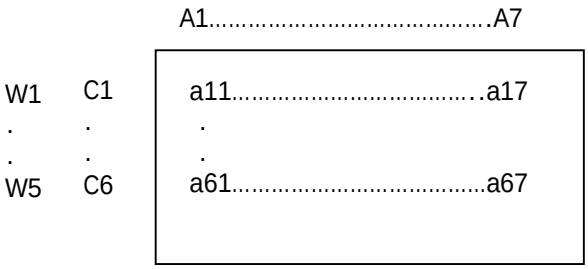

Figure 16: Decision table multi criteria decision problem

Now that the criteria and weights of the criteria are clear the waste projects identified in chapter 4 can be ranked. Table 11 shows the projects ranked based on the criteria from the established criteria. Projects are ranked from best to least sustainable. The same is visualized in figure 17 on the next page.

	1	2	3	4	5	6	Total
1. Transporting metal	3	2	3	6	2	6	22
2. Paper recycling factory	2	2	1	6	6	4	21
3. Metal recycling factory	1	2	3	4	4	4	18
3. Glass recycling factory	2	1	3	4	4	4	18
3. Plastic recycling factory	1	3	2	2	6	4	18
4. Transporting paper	3	2	1	6	2	2	16
5. Transporting glass	1	1	3	6	2	2	15

Table 11: Scores of waste projects

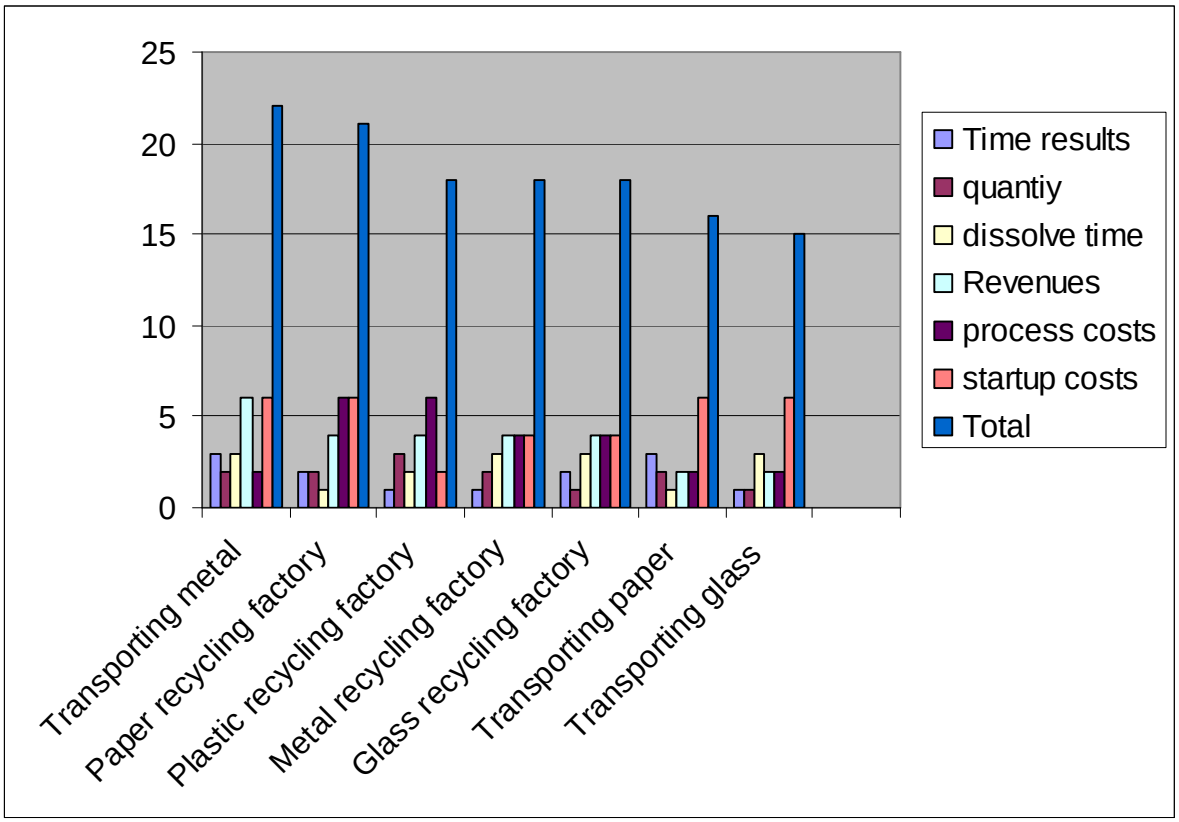

Figure 17: Comparison scores criteria of ranked waste projects

This is obvious that the Transporting metals project is the best option for Isla Navarino; it has the highest total score. The second best project is Paper recycling. Table 11 gives the scores of the waste project based on the SMART method used explained in 5.1 and 5.2. It is clear what the "best" and the worst project is. The parts in between are less clear, three projects finish on the same place. Plastic recycling is ranking last because this project has the highest start-up costs.

Sensitivity analysis

The used MCDA method was used to select the "best" alternative out off a range of alternatives. The concept "best" and "better" are based on values given to criteria (Meszaros, 1996). Values of these criteria can be very subjective and so also the SMART used in this research. The scores and weights of the criteria used to rank the alternatives always contain some uncertainties. It is therefore important to see how the outcome of the model changes when parameters change. A sensitivity analysis is conducted; by the sensitivity analysis of a multi criteria decision problem is meant the analysis of the results, when small alternations to weights and/or values of alternatives with respect to criteria are made (Ekart, 2003).

A lot of literature is written on sensitivity analysis. The simplest case is when the value of the weight of a single criterion is allowed to vary (Forman & Selly, 2001). For a wide group of multi attribute decision models Mareschal (1988) showed how to determine the stability intervals for the weights of different criteria. It shows the values that the weights of one or more criteria can take without altering the results, based on a starting situation.

Triantaphyllou and Sanchez (1997) presented an approach of a more complex sensitivity analysis with the change of the scores of the alternatives against the criteria, as well. Mészáros and Rapcsák (1996) present a method for a wide class of MAUT models where the sum is based on generalized means. In this approach the weights and the scores of the alternatives against the criteria can change simultaneously in given intervals.

The wide scale of literature available makes it clear that are is not one “best” way to do a sensitivity analysis. The methods mentioned above however do imply that there are different kind of sensitivity analysis (Ekart, 2003) a model that assumes that alternative values are fixed, a model that assume that weights are fixed and models that assume that both can change at the same time. The three point scale to value criteria was chosen so that project attributes could change without changing the value category they are in. Therefore it is assumed that the criteria values are fixed.

This leaves the sensitivity analysis of the weights. Three different circumstances have been calculated. The weighted (used to make the ranking). the not weighted and the stakeholder outcome rankings are given in table 12.

Project	Weighted	Not weighted	Stakeholders
Transporting metal	1	1	1
Paper recycling factory	2	2	2
Glass recycling factory	3	3	3
Metal recycling factory	3	3	3
Plastic recycling factory	3	3	4
Transporting paper	4	4	5
Transporting glass	5	5	6

Table 12: Sensitivity analysis weights (Source: ranking based on appendix O)

A simple sensitive analysis is used; this method looks at how much the value of criteria can change without changing the outcome of the ranking (Forman & Selly, 2001). Appendix P gives the exact scores of the projects for the three given circumstances. In table 12 can be seen that all three cases lead to the same “best” and “worst” project. The upper and lower bound is calculated for all projects in all three situations (see appendix P). With upper and lower bound is meant the amount one criterion value must change to change the outcome of the ranking, when all other parameters remain unchanged. Upper bound is the amount a criterion needs to increase to move one place up in the ranking vs. for the lower bound. These bounds are used to assess how stable a solution is (Ekart, 2003)

In the same appendix P, the upper and lower bounds are given. It can be concluded that in the weighted situation the “best” project has a 1 point interval. This is the same as in the not weighted situation, the stakeholder situation has a 1,8 interval. This is a bigger and therefore more stable interval. The mean interval of the weighted situation is however 2,2 and 1,8 respectively lower bound and upper bound. The other two situations have lower and upper bound intervals round 1. The weighted situation is therefore more stable then the other two presented circumstances.

5.4 Conclusion

In this chapter two sub research questions (*What criteria must be used to rank a waste project?* and *what are the weights of the established criteria?*) have been answered. Based on that information the third research question (*What is the "best" waste project for Isla Navarino, based on established criteria?*) was answered.

During interviews with stakeholders six criteria were identified namely: time until result, quantity, breakdown time, start-up costs, processing costs and revenues. These criteria were made measurable using a 3 point scale. After this, the weight of the criteria was assessed. The service user and NGO stakeholder opinion displayed that the cost criteria were less important. Interviews at the municipality however pointed out that this will be the first thing a choice of a project is based upon. This lead to the decision to weight the costs criteria double, although other stakeholders opinion view costs as less important.

Using the established criteria and the weights, Transporting metal to Punta Arenas was identified as the best project to carry out on Isla Navarino. With the identification of the "best" project the next chapter will focus on making an implementation plan for this project.

6. Implementation plan

In the previous section the best project was identified. In this section the last sub research question is answered (What plan can be made to implement the "best" sustainable waste project on Isla Navarino?) Section 6.1 introduced the main implementation steps and in 6.2 these steps are put into a timeframe.

6.1 Main implementation steps

The 5 aspects of the ISWM process planning as explained in section 2.1.4 are taken into account when making the implementation plan. These aspects are explained in this section.

6.1.1 Institutional framework

As stakeholder interviews revealed, it is not clear what role each group should play. Before starting implementing a project it is essential to get the roles of the stakeholders clear. This must be evident to make the project work. People in general are a key success factor on the island. They can make or break the project. This was also mentioned in the case studies as a crucial success factor.

The interviews at the municipality show that they see their role as the facilitator of the waste infrastructure. This is acceptable in the future but at this point in time its role should be broader. A strategic stakeholder said that a long-term projects need to be in consolidation with an "institute" to give the project more weight and importance (Interview, 14th of December 2006). This would enhance the change off success. Because the municipality is responsible for the waste infrastructure, they are the obvious institution that should initiate the waste project.

During an interview at the municipality it was also made clear that the municipality already have plans in this direction. They want to work together with one or two families. These families are the ones that are responsible for the processing of the waste material. In this case the compacting of the metal and transporting it to Punta Arenas. The revenues out off the projects are for the families, to make them self-sufficient. The municipality would help in the start-up phase, but after that it should function as a stand alone company (Interview, 29th of January 2007).

Concrete action: The first step that needs to be taken during implementation, are face-to-face meetings with stakeholders to discus all roles and responsibilities. The output of this should be a document that shows the roles, responsibilities and accountabilities of all stakeholders, so that stakeholders can be held accountable. Without consensus on responsibility and accountability waste projects will fail.

6.1.2 Financial sustainability

The costs and revenues of the identified waste projects are given in appendix J. This gives a general idea of what a project is going to cost. At this point, funding is missing to implement the best waste project. Investments are needed to change the waste infrastructure, for example investing in containers but also to educate people about separation. The limited access to capital is often a problem on the island. Funding can be applied for at the Chilean government. At this point only 3% of funds granted by the government go to the 12th region of Chile (Interview, 5th of February 2007)

Concrete action: Calculate how much funds are needed to execute the waste project. If funding is short it is essential to investigate which institutes can provide help. The stakeholders involved need to apply for these funds.

6.1.3 Public awareness & participation

At this point people are not ready to start the separation of waste. Without the participation of the community the project can not work. For people to participate in the waste projects, the mindset of the people of Navarino must change. A big group of people depends on financial support of the municipality (Misrachi, 2005). The people who are practically responsible for transporting metal should see this as their own job. Something they can do to gain financial independence and not as a one time project or just something to do in their spare time. Waste materials must get a new status on the island, that of an own job opportunity. Another mindset that needs to be changed is that of the service users. As mentioned the interviews show two groups of people. The ones that see the possibilities of separation at the home and the group that does not. It is crucial for the success of the project to have the residents separate trash. Without this separation there is no material to process.

How can residents be motivated to separate waste? The key factor mentioned by local authorities and NGO's during interviews is education. At this point residents do not have the knowledge to make better decisions. People should be educated in three different stages. The education should evolve over time, starting with the first point and extend this to all three points. The three suggested stages of education:

1. What waste is "bad" for the environment
   Talking to people lead to the conclusion that people do not know exactly what materials are bad for the environment. If people do not know what materials are bad, materials that have a longer breakdown time, they can not make an informed decision. The school already started with these kinds of workshops. It is however essential to also get this information to adults of Navarino. This is because they are the ones that buy products and cook. When better informed they can make better decisions.
2. What can be done with different waste materials
   After people understand which materials are bad and which are better, it is essential to give information on what can be done with the materials, what kind of recycling methods exist. There are lots of people that come from other regions of Chile and know about recycling. The possibilities on the island however are unknown to most. It is crucial to educate people that processing waste is also possible on the island.
3. What can and must they do themselves
   After informing people about materials and what can be done with it, this stage makes the step to what residents can do themselves. A big campaign must be held to tell the whole of Puerto Williams of the new project. Also the locations of the collection containers must be communicated very clearly. A once off effort is not enough, the location and importance of the projects must be stresses several times throughout the year. An evaluation must be held after one year to see how many people are actually separating their waste and bringing it to the collection-containers.

An advantage is that the majority of the population is concentrated in an urban sector, Puerto Williams. This would enhance the means of communications. It is possible to reach and educate all people personally. Other means that can be used are the local television and radio. Education and communication does not solely have to come from the municipality. Other

organisation like CBO's like Comite de Gestion Medio Ambiental and Enviu can play a key role in this. Education leads to awareness of what people can do. On the long run this may even lead to reduction of waste produced because people can make better choices.

Concrete action: An education campaign should be set up, containing the three stages mentioned above. Public awareness on what can be done by the local community will lead to participation of the local community, if they have the idea that they really can make a difference.

6.1.4 Waste collection & recycling

The municipality is responsible for the waste infrastructure. They should make it practically possible to separate valuable materials and provide a sufficient waste infrastructure for that. This can be done by placing separation container so that residents can separate materials as mentioned in chapter 4. Without the proper infrastructure to separate waste, the project has no chance of succeeding. This is because there will be no material to process without a proper waste infrastructure. Containers should be bought or made and placed in strategic places so that materials can be recovered from waste dumped.

Concrete action: Buy or make collection-containers and place these on strategic places in Puerto Williams.

6.1.5 Waste treatment & disposal

This aspect does not have a direct link with implementing identified waste projects. It is however important to dump waste in a responsible way. So the municipality must make sure that the planned secure waste dump is built.

Concrete action: Implement the plans for a new waste dump.

6.2 Time schedule

The concrete steps explained in 6.1 are put into a time frame in figure 18.

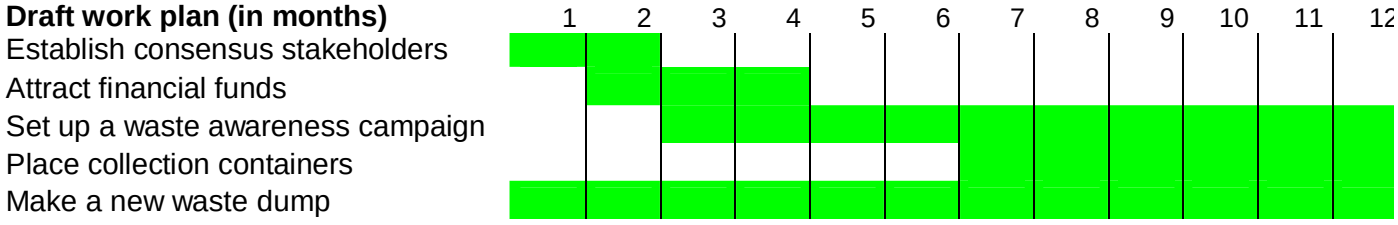

Figure 18: Time frame implementation (in months)

6.3 Conclusion

The most important step that needs to be taken is to get consensus between the roles and responsibilities of the stakeholders. Secondly, stakeholders should apply for financial resources. Public awareness is also very important. It is not a once off initiative even after placing the collection containers. The education campaigns should continue to keep the community participation high. The municipality should finish the new save waste dump, thus that non separated waste can be disposed of in a save way.

7. Conclusions & recommendations

In this chapter the main research questions (*Which sustainable waste projects can be recommended to reduce the volume of domestic waste dumped on Isla Navarino?*) will be answered (7.1). Section 7.2 gives the reflection on the process and the product produced. Finally, section 7.3 will give some general recommendations.

7.1 Conclusions

Before answering the main research question a short summary is given of the sub research questions. These answers lead to the answer of the main research question.

1.) *What causes problems in the current waste situation on Isla Navarino?*

Domestic waste produced on the island of Isla Navarino is growing. This leads to more waste being dumped on the local waste dump, which is getting full. A new waste dump is going to be built but at this point it is not clear when it is going to be finished.
Analysis of the current situation has lead to the conclusion that a separation element is missing in the waste infrastructure. No materials are separated from the waste that is being dumped on the waste dump. On the other hand, there are no processing methods present on the island to process the waste. This vicious cycle needs to be broken by on one hand finding a suitable waste infrastructure. On the other hand this research has identified waste projects, which provide the people of the island with processing methods for specific waste materials.

2.) *What are possible waste solutions for the identified waste problem on Isla Navarino?*

Several projects were identified as waste projects. All projects are based on a common separation approach. Separation should be done by placing collection-container at strategic places in the town. In total 7 waste projects were identified:

- Plastic recycling factory on the island
- Paper recycling factory on the island
- Transporting paper to Punta Arenas
- Metal recycling factory on the island
- Transporting metal to Punta Arenas
- Glass recycling factory on the island
- Transporting glass to Punta Arenas

3.) *What is the "best" waste project for Isla Navarino, based on established criteria?*

3.1) *Which criteria must be used to rank a waste project?*
During interviews with stakeholders 6 criteria were identified: Time until results, Breakdown time, Quantify of material, Start-up costs, Processing costs and Revenues. The criteria were made measurable by using a three point scale.
3.2) *What are the weights of established criteria?*
Stakeholders were consulted to determine the importance of the established criteria. The municipality is most likely the initiator of the waste project. It will first look at the costs of the waste project. That is why the criteria of Start-up costs, Processing costs and Revenues are weighted twice as heavy as the other criteria.

Using the criteria and weights established in 3.1 and 3.2, the “Transporting metal” project is ranked as the “best” project to pursue on the island at this point. The paper recycling project ranked second. The other recycling projects (glass, metal and plastic) finish on the third place. Transporting paper ends on the fourth and transporting glass on the last place.

4.) *What plan can be made to implement the “best” sustainable waste project?*

At this moment the island is not ready to implement the waste project. Several changed need to be made. For example adjust the current waste infrastructure. Five concrete steps were identified to implement the waste project and increase the chance of success.

- Establish consensus between stakeholders: The municipality is responsible for the waste infrastructure. The initiative of waste projects should also come from within the municipality however more stakeholders may be involved in this process. All stakeholders must reach consensus on responsibilities and accountability of the project.
- Attract financial funds: Stakeholders must calculate how many funds are needed. Stakeholders must apply for funds if the money cannot be raised on the island.
- Set up a waste awareness campaign: People of Puerto Williams need to be educated more on waste. An education campaign should lead to waste separation by the local community.
- Place collection containers: Separated waste should be collected of in a central point.
- Make a new waste dump: Waste that is not reused or recycled should be disposed of in a save way, on a save waste dump.

The above answered research questions lead to the answer of the main research question: *Which sustainable waste projects can be recommended to reduce the volume of domestic waste dumped on Isla Navarino?*

Overall it is recommended to start with the “transporting metals to Punta Arenas” project to obtain experience with a waste project with aim to further improve in the future. Starting the waste project is however not enough to guarantee a successful outcome.

Many success factors are intertwined, which together will lead to the successful outcome of the waste project. The vicious cycle visualized of not separation materials and not having a process method on the other hand, needed to be broken by placing an adequate waste infrastructure and simultaneously identifying processing methods. This is however also not enough to guaranty the successful outcome. The residents of the island must all decide to work on a project together and all separate waste in the home. The people of Puerto Williams therefore are the most important critical success factor and have the power to make or break the project.

7.2 Reflection

This section reflects on the process of the research carried out and the final product it produced.

I was glad that I collected a lot of literature before I came to the island. I was warned that the internet connection is very bad and at times non existent. Without the literature found upfront it would have been impossible to carry out the research.

During this research several methods and theories were used. The most important model used is the ISWM model. The model provides a broad overview of a waste situation. The model also

makes a link with the context of the waste system. But it also involves the stakeholders into the change process. This was useful because it gave a clear idea of what the stakeholder think is important and how decisions are made by potential waste project initiators.

Isla Navarino is a small island and very secluded. The municipality is still young and this can be noticed in waste management. Information is not always present. This is caused on the one hand because not much is documented. This would not be a problem if people would stay on the island longer. Because not much is documented and people do not stay on the island long, people leave the island without transferring knowledge. The knowledge is lost when a project is not evaluated and possible leaning points are missed. The checklist is provided by Foundation waste to investigate a waste system. This checklist however is too extensive for the island. Many questions on the checklist do not apply to the island. It confirms the fact that waste management is not fully implemented and many changes can be made to professionalize the process.

The current situation analysis provided several criteria. The importance of criteria is based on stakeholder's opinions. On this survey stakeholders needed to rank the criteria from 1 to 7, only using every number one time. People were however were cautions when asked to fill it in. After assuring that I was only interested in their own opinion, most people participated. It was a new challenge to get people to fill in the form correctly. The ideas of the survey were written on the form and explained verbally to all participants. After executing some surveys it became apparent that people still did not understand what they needed to do. After taking this into consideration I decided to do my survey in the form of a game. I made separate cards for all criteria. I asked people to pick the most important criteria from the group and repeated the process until I had the ranking. The lesson learned is that a survey is not the best way to get information from the local community. A game simplified the process of getting information needed.

This research has reached its objective as formulated in chapter 1: *Improving waste management on Isla Navarino by decreasing the volume of valuable materials dumped on the domestic waste dump through sustainable waste solutions.* The all over aim is to improve the waste situation. In the last week in Puerto Williams this research was presented to the governor on Isla Navarino. He saw great potential in the projects and wants to get involved to making it to a success. The governor suggested a meeting with the mayor and Enviu to establish the roles of each institution and how the local community can be involved. Hence real action can be taken soon.

7.3 Recommendations

On the basis of information gathered during this research the following recommendations can be made for further research possibilities.

- Market research

At this point it is not clear what potential market is the best to enter for the recycled products and how big the possible market is. Should products only be sold on the island or are there possibilities of exporting products to Punta Arenas or even Ushuaia (Argentina)? The market research should also contain an investigation of possible products that the potential buyers may like. It must also be investigated what potential buyers are willing to pay for a certain product.

- Payback time

A market research will shed more light on how large the buyer market is and what they are willing to pay for a product. This results in more insight in possible revenues of a waste project. Based on this information calculations can be made on how much material can be processed and what the payback time is for the initial investment and whether an initiative can become financially self-sustainable after a while.

- Containers

This research is based on the placement of one collection-container per material. In the future a research should be carried out to investigate if one collection is sufficient to collect a material. If not, a research is necessary to identify how many containers should be placed and on what locations.

- Community awareness

A study needs to be executed on the waste awareness of the people of the island. What do they know about waste and more important that do they not know? This can be the basis for the education and communication campaign mentioned in 5.4.
After the waste infrastructure has been altered and a separation structure is in place an investigation should be carried out to measure how many people actually separate. But also important is to find out why people do not separate their waste.

- Regional level (economy of scale)

This research focuses only on Isla Navarino, however other cities in the 12th region of Chile face similar waste problems. It may be interesting to consider the possibilities of setting up recycling factories in the region at which waste materials from the whole region can be processed. A study can show whether this is economically possible and if so what the best location for such a factory should be located.

- Evaluation

After the project has started, an evaluation should be held after one year to see how many people are actually separating their waste and bringing it to the collection-containers. The evaluation may give new insights on why people do or do not separate. This can lead to new ways to communicate to the people. It will also give information on whether sufficient containers are placed on the island. An evaluation must investigate what went well and wrong, after implementing the first waste project. These failure and success factors are key leaning points for future projects. At this point critical success factors are based on other case studies and studies done on the island. But a real project would provide information on what the real relevant critical success factors on the island are.

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Tackling the Waste Issues on Isla Navarino

A Research into the possibilities of Waste Materials

Appendices

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Table of content:

Appendix A: **Map of Chile** (Source: www.gochile.cl visited on 14 November 2006)

Appendix B: Research stages with methods & techniques.

Stage 1: Problem analysis

Topics	Information needed	Methods & techniques
Problem analysis	•What waste problems are present on Isla Navarino?	-Interviews with local people -Observation of the research environment

Stage 2: Analysis of the current waste situation on the island

Topics	Information needed	Method / Technique
Stakeholder analysis	•Who are the stakeholders? •What is their roles and interests? •What is the relationship with other stakeholder?	-Interviews Local community -Interviews Municipality -Context analysis of websites of authorities
Practical waste elements	•How does waste flow from generation to final disposal? • What Areas not served by regular collection • Duration and volume of one collection round trip •How much domestic waste is generated? •What kind of materials are collected? •What kind of waste materials are separated?	-Observation of the waste dump - Interviews with Municipality -Literature on the waste situation in Chile
Technical waste elements	•What is done to recover, recycle, reuse and reduce domestic waste on the island of Isla Navarino?	-Observation of the waste dump - Interviews with Municipality
Technical • Capacity of collection or treatment technology	• What is the collection rate? • What is the collection coverage rate? • Performance of waste processing plants?	-Interviews Municipality Waste department -Observation of public areas
Environmental • Effects of technology on the environment • Effects of technology on opportunities for reuse and recycling • Working conditions and environmental health of waste workers	• Disposal rate • Recovery rate • Presence and enforcement of local regulations supporting recycling and reuse • Existence of policies to promote waste prevention, (safe) reuse and recycling • Policy, budget and activities for environmental awareness-raising	-Interview waste expert -Interviews municipality -Observation of the research environment
Financial-economical • Capital and labour cost • Operation & maintenance	• Does the municipality have the authority to raise its own funds for waste management? • Does waste management have its own	-Interviews municipality -Interviews local community -Interview waste expert

costs compared with waste management budget	budget lines? • Are costs analysed before fees are set? • Level of cost sharing by other stakeholders • Are fees the same for commercial and residential clients? •What is the potential market on the island?	
Socio-cultural • Average level of awareness among population • Willingness & ability to pay • Cultural attitudes towards waste and implications for waste handling, separation at source, recycling	• Who has an interest in waste management or is affected by it? • What type of activities do these stakeholders carry out? • Does the municipality co-operate with these stakeholders? • How do they communicate with each other? • Is there any complaint mechanism in the municipality for the general? • Is this complaint mechanism functioning well?	-Stakeholder analysis - Interviews local community - Interview municipality - Literature study of previous studies of Enviu
Institutional • Skill level waste management staff	• Is solid waste management the responsibility of one department or are tasks divided over several departments? • Are all waste management, recycling and composting functions under a single municipality jurisdiction? • Does the municipality have the authority to contract private enterprises? • Is there sufficient skilled staff for waste management?	-Interviews municipality -Interview garbage collectors
Polities/legal/political • Political priorities • Policy and regulations regarding technologies and equipment • Contracting rules; biases in contracting procedures	• Is there a national framework waste management law? • Does the municipality have jurisdiction and authority to plan, finance and operate waste management systems and/or to contract them out? • Are laws and regulations for waste management sufficient? • How well does enforcement of these regulations function? • Is there a strategy or plan for waste management at the city level? Is there a planning requirement or mandate? • Who is the disposer of last resort for waste? Who is the payer of last resort? • If there is, what are the main obstacles for attaining the objectives in the strategy/plan?	-Waste structure from stakeholder analysis -Interview municipality

Stage 3: Identifying possible sustainable waste projects

Topics	Information needed	Methods & techniques
Possible solutions	• What kind of waste projects is done in the	- Case studies analysis

	world? • What material is present? • In what quantity is the material present? • What can be done with the material? • What does a material sell for a kg? • What are transportation costs? • What are the start-up costs of a project • What are the variable costs?	- Information found in previous parts of this research

Stage 4: Identifying and weighting criteria for waste projects & Ranking the waste projects

Topics	Information needed	Methods & techniques
Criteria (3 P's)	•What criteria are important to stakeholders •What are criteria set by the research environment?	-Interviews stakeholders - Literature of sustainability
Weight of criteria (AhP)	•What is the hierarchy of the established criteria?	-Interviews stakeholders

Stage 5: Making recommendations on the waste project

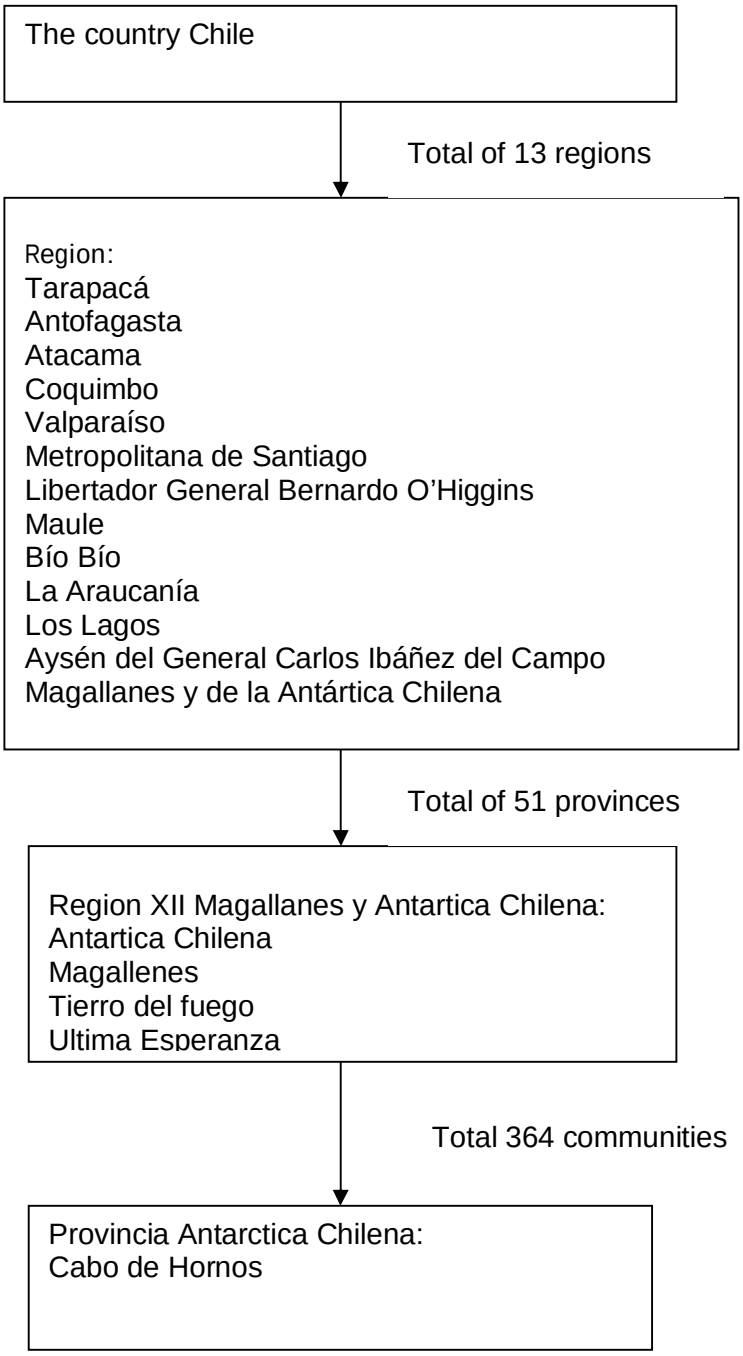
Topics	Information needed	Methods & techniques
Recommendations	What recommendations can be made based on context information gained during the rest of the research? How can the implementation steps be put into a timeframe?	- Information found during previous parts of the research

Appendix C: Interview list

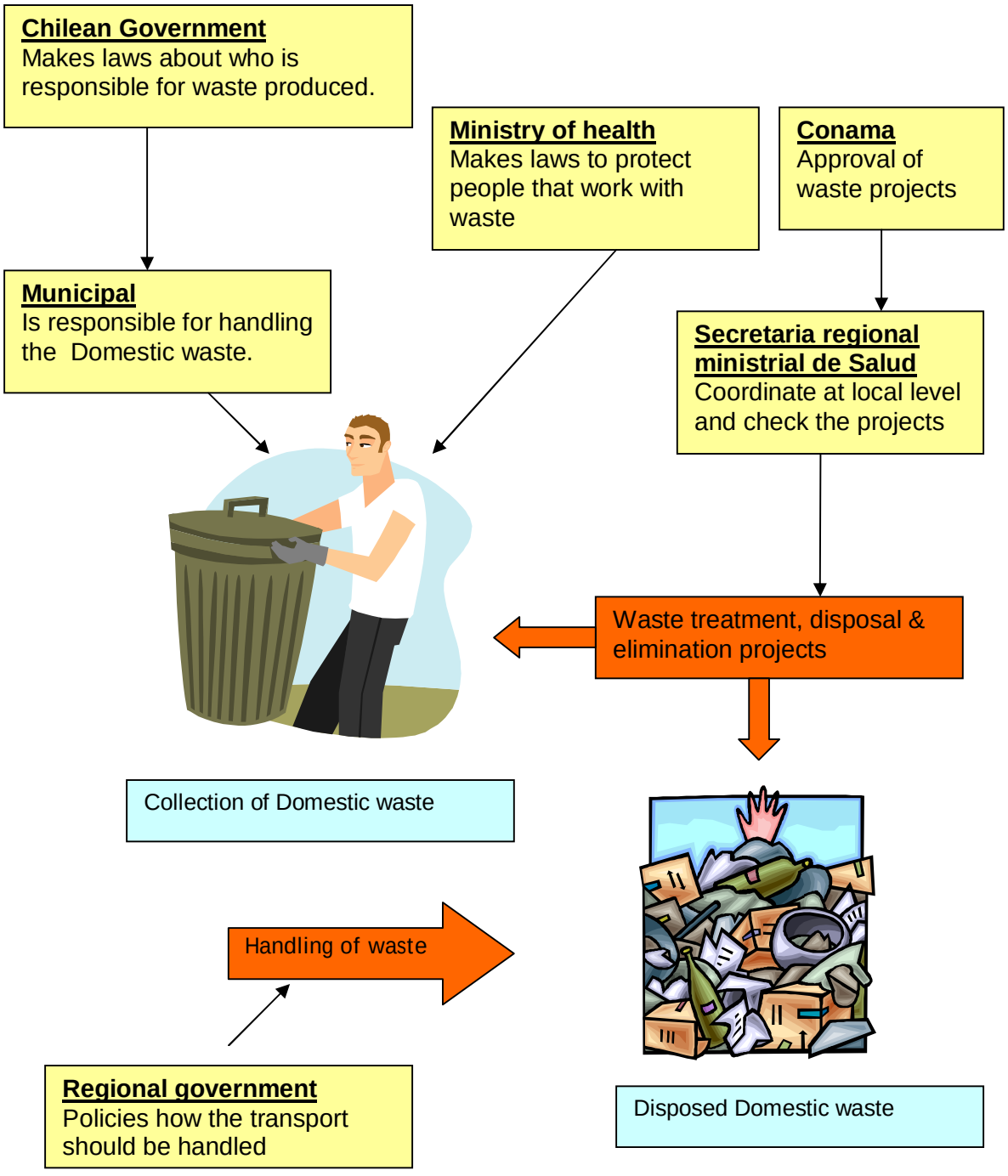
Name	Function	Date
Belgica Ariz Mendy	Governor	14th of November 2006
Joso Soto Passek	Mayor	15th of November 2006
Pedro Roco	Ex Garbage men	15th of November 2006
Javiera Gaona	Independent waste consultant	16th of November 2006
Felipe Smith	Director de Obras	27th of November 2006
Hernandez Hetcherarvy	Waste expert (Porvenir)	27th of November 2006
Luis Barria	General administrator Obras	12th of December 2006
Paola Grendi Llharreborde	Director of Museum Martin Gusinde	14th of December 2006
Enrique Camblor	Municipality inspector	9th of January 2007
Mrs. Cuevas	Ex- Contractor	10th of January 2007
Hugo Henriquez	Community development officer	29th of January 2007
Javiera Gaona	Independent waste consultant	26th of January 2007
Benjamin Rovez Viera	Director de Obras	30th of January 2007
Claudio Flores Flores	Governor	4th of February 2007

Appendix D: Structure of Chile

(Source: sesma 2006)



Appendix E: Roles of stakeholders



Appendix F: Features Waste truck:

(source: Usimeca Chile Pan-Americana Norta 3525 (Conchall) Santiago, Chile).

Feature	Specification
Brand:	Transpak
Model:	Galata
Type of load:	Trunk loader
Volume of load:	15m³
Capacity of the loading container:	1700 litres
Shape of the container:	Elliptical sections
Main press	Hydraulic driven shutoff valve
Main truck system	Electric regulation system

Appendix G: Recyclable-overview

(Source: Bruijnzeel, 2005 adjusted)

Recyclable Materials	Non Recyclable Materials	Reuse
PAPER		
Envelopes Newsprint Office Paper Phone Books Paper Grocery Bags	Envelopes with plastic windows Soiled paper Wax or plastics coated paper Magazines and Catalogues Used towel, tissues and napkins Pizza Boxes Milk cartons	Books Egg Cartons Magazines
GLASS		
Jars Bottles of clear glass Bottles of brown, green glass **METAL**	Light Bulbs Mirrors Ceramics	
Aluminium Cans, like Soda Cans Scrap Metal Tin Cans	Bottle & jar lids with plastic liners Cans used for chemicals of paint Aerosol spray cans	
PLASTICS		
Plastic soda and juice bottles Milk Jugs Acrylic plastics [Plexiglas]	Styrofoam packaging materials &cups and plates	Plastic Bags Plastic Bottles
OTHER		
Timber Cork Batteries [Regular, Mobile Phone, Car]	Aerosol Cans Non functioning Equipment	Functioning Equipment Cartridges, Refill Hangers, dry cleaner

Appendix H: Plastic manufacturing techniques

(Source: recycling plastics)

Manufacturing techniques

• ***Extrusion*.** The extrusion process used for manufacturing new products, the product is usually in the form of a continuous 'tube' of plastic such as piping or hose. The reclaimed plastic is forced along the heated tube by an archimedes screw and the plastic polymer is shaped around a die. The die is designed to give the required dimensions to the product and can be interchanged.

• ***Injection moulding***. The first stage of this manufacturing process is identical to that of extrusion, but then the plastic polymer emerges through a nozzle into a split mould. The quantity of polymer being forced out is carefully controlled, usually by moving the screw forward in the heated barrel. A series of moulds would be used to allow continual production while cooling takes place. This type of production technique is used to produce moulded products such as plates, bowls, buckets, etc.

• ***Blow moulding*.** Again the spiral screw forces the plasticized polymer through a die. A short piece of tube, or 'parison' is then enclosed between a split die -which is the final shape of the product - and compressed air is used to expand the parison until it fills the mould and achieves its required shape. This manufacturing technique is used for manufacturing closed vessels such as bottles and other containers.

• ***Film blowing***. Film blowing is a process used to manufacture such items as garbage bags. It is a technically more complex process than the others described in this brief and requires high quality raw material input. The process involves blowing compressed air into a thin tube of polymer to expand it to the point where it becomes a thin film tube. One end can then be sealed and the bag or sack is formed. Sheet plastic can also be manufactured using a variation of the process described.

Appendix I: Identifying plastics:

Source: (recycling plastic) polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC).

Identification of different types of plastics

There are several simple tests that can be used to distinguish between the common types of polymers so that they may be separated for processing.

- ***The water test.*** After adding a few drops of liquid detergent to some water put in a small piece of plastic and see if it floats.
- ***Burning test.*** Hold a piece of the plastic in a tweezers or on the back of a knife and apply a flame. Dose the plastic burn? If so, what colour?
- ***Fingernail test.*** Can a sample of the plastic be scratched with a fingernail?

Test	PE	PP	PS	PVC
The water test	Floats	Floats	Sinks	Sinks
The burning test	Blue flame with yellow tip, melts and drips. Smell like candle wax after burning	Yellow flame with blue base. Smells like candle wax bur less strong then PE	Yellow, sooty flame drips. Smells sweet	Does not continue to burn if flame is removed Smells like hydrochloric acid.
The fingernail test	Yes	No	No	No

Appendix J: Costs of waste projects

This appendix elaborates on the costs of the 7 identified projects. The plastic recycling on the island project is used to explain the different cost. For all projects the costs are calculated in this appendix. Costs are calculated for the following projects:

1. Plastic recycling on the island
2. Transporting plastic
3. Recycling paper on the island
4. Recycling metals on the island
5. Transporting metal
6. Recycling glass on the island
7. Transporting glass

1. Costs of plastic recycling on the island

According to Lardinois (1995) the costs of plastic recycling can be divided into three sorts of costs, a fourth costs sort is added by Scheinberg (2000):

1. Raw material costs (collection of raw materials): With are the costs of separating material from the rest of the domestic waste so it can be used.
2. Production costs (all costs that are made to produce the end product): This includes the initial investment needed to start a factory. Secondly two other costs are estimated, these are the labour costs and location costs.
3. Transportation costs (costs made to get the product to the client): This is the cost of getting the "product to the final user". This can be a buyer of a product made from waste material or a buyer of material used as input for a new process.
4. Hidden costs There are always unexpected costs when starting a new process, to anticipate on this a 10 % margin is inflicted for unexpected costs (Scheinberg, 2000).

Costs of tools and machines will be an estimation based on market prices at the time of the research, these can change with time. It is impossible to give an exact price of how many labour hours are needed to execute a process. An approximation will be made based on common sense of how much time a process will take. This estimation will be based on processing one cubic metre of material.

The cost distribution given above will be used for calculating the costs of plastic recycling and other methods used to reduce waste on the island. This distribution also is useful for calculating the costs of transportation material. In this case however the raw material will be the end product. The cost of raw material will be the same for both recycling on the island and transporting. The other to cost categories will differ.

Raw material costs

The cost of raw material mainly depends on the way plastic is collected and at which point in the waste chain it is collected. As mentioned in chapter 3 it is very important to think about the "Separation" element, because at this point it is not present and therefore a weakness in the waste system. The method of material collection can vary. The following gives some ideas (Lardinois, 1995):

- House to house collection of plastics and other materials (e.g. paper).
- House to house collection of plastics only (but all types of polymer).
- House to house collection of certain objects only.
- Collection at a central point e.g. market or church.

- Collection from street boys in return for payment.
- Regular collection from shops, hotels, factories, etc (is already picked up during normal round)
- Purchase from scavengers on the municipal dump.
- Scavenging or collecting oneself.

The first four methods may be used in Puerto Williams. The last four methods are not applicable to the island. Because there is no informal waste system present. These methods of material collection can be applicable to other materials too.

The costs of collecting domestic waste are not totally clear at the municipality. This is a new service that the municipality provides. Since May of 2006 the municipality has taken over this service from a private contractor. It will take a year before the municipal has a clear picture of the actual costs of domestic waste collection. When waste collection was still contracted out by the municipality, a fee of 1.800.000 CP was paid monthly (Interview 10th of January 2007). This is for 4 weeks and 3 collection rounds a week, a total of twelve rounds a month. The municipality was paying 150.000 CP per collection trip. Because no exact data is present at the municipality, the 150.000 CP will be set as the cost of one collection round. These costs may decrease when separating materials, this because less waste needs to be picked up.

The garbage truck that currently picks up domestic waste has one container. House to house collection of materials in general therefore means a separate collection round will cost 150.000 CP per collection round.

According to the municipality the cheapest method of collecting specific materials a central collection point (Municipality, Interview 12th of December). A central point can be at a public building or a container in a central point. The good location to place this container is near the two public supermarkets because a lot of people visit this place daily. These supermarkets are located opposite each other.

Costs of a container are a one time investment. There are several types of containers that are designed for different materials and come in different sizes. The prices and features of the containers are given in table J1. The container with a special collection lid is the best option to collection materials, because it has a special opening in which product can be put, but no products can be taken out. The 1000lts container is chosen because process costs are going to be measured in cubic metres and that is the same volume. Costs of a plastic collection container are set at 214.670 CP.

Model	Features	Price
Container + normal lid	240lts. 2 wheels	31.323 CP
	340lts. 2 wheels	48.015CP
	770lts. 4 wheels	135.715 CP
	1000lts.4 wheels	188.108 CP
Container + special collection lid	240lts. 2 wheels	47.624 CP
	340lts. 2 wheels	64.316 CP
	770lts. 4 wheels	162.277 CP
	1000lts.4 wheels	214.670 CP

Table J1: Prices collection-container (Source: Offer Plastic Omnium S.A, 23 jan 2007)

Production costs

In contrast with the final stages of reprocessing plastic, the initial stages are labour intensive, requiring little capital investment and relatively few specific technical skills (Ladinois, 1995). Plastic can be sorted and cut by one person who does not need any specific skills. A monthly salary is about 500.000 CP (Municipality, Interview 12th of December 2006). The work-week is officially 40 hours. Labour costs are calculated at 3.125 CP an hour (500.000 CP / (4 x 40). It will take 8 hours to sort and cut a cubic metre of plastic, labour costs are 25.000 CP.
The price of machines depends on the machine you need and the capacity it has. A second-hand extruder can be found for approximately $2.500, which is 1.350.000 CP (Ebay, 10Jan 2007).

The most common recyclable plastic that is present is PE. The injection moulding and blow moulding machines are frequently used to recycle PE. The injection moulding machines has a wider variety of outcome then the blow moulding machine. The injection moulding machine can fill-up mould, the end product depends on the mould used. The blow moulding machine is mainly used to produce bottles. There is no market for this on Isla Navarino, because there is no industry present that uses plastic bottles. Because the injection moulding machine can produce a diversity of products, this machine seems more practical to invest in a machine like this when staring a plastic recycling project on Isla Navarino.

A second-hand injection moulding machine could be found for approximately $3.500, which is 1.890.000 CP (Ebay, 10 Jan 2007). It will take approximate 2 hours to process a cubic meter of plastic with the machine, labour costs for this are 6250CP. Next to the machine some tools are needed during the process, like scissors to cut the plastic and moulds to make a product in or it is possible to make pellets out of it. These are small plastic balls which can be sold to the plastic processing industry. This is another investment of about $200 or 108.000 CP (Ebay, 10th of January 2007).

Location costs depend on the size of the building. Most businesses in Puerto Williams are run from home. This is on one hand caused by high prices of renting space. On the other hand it is hard to find an office, because simply there are not a lot of houses available in Puerto Williams (Blanco, 2007). The cheapest solution and the most likely solution is to set-up the recycling process in an empty room. This location costs are therefore set at zero, because the space was going to be rented anyway and no extra costs are made.

Transportation costs

Transportation costs are also zero to nothing. Everything within Puerto Williams is within walking distance. End products can be sold out of the home or from the souvenir shops located in the “Centro Commercial” the economic heart of Puerto Williams. Transportation costs in Puerto Williams will in all cases be also set al zero.

Total costs recycling

The costs given previous in this section are divided in two kinds of costs, initial and variable costs. Together they add up to the total costs in the first year of a project as shown in the formula. Initial costs are the investments made to start-up the project, like investment in machinery. Variable costs depend on the volume processed.

Formula: Total costs (TK) = Initial costs (IC) + variable costs (VC)

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	1.458.000
Variable costs	Labour costs (31.300 a cubic meter)	1.314.600
	Hidden costs 10%	298.727
Total costs		3.285.997

Table J2: Costs of recycling plastic

Table J2 gives the costs of the recycling plastic project. The initial costs are the costs of the container and the start-up investment. The second kind of costs is variable costs. These costs depend on the volume that is processed. The variable costs cannot be calculated exactly. The amount that can be progressed depends mainly on the collection rate of material and the processing speed. About 53.000 kilos of plastic is produced in a year but not all plastic can be recycled, as mentioned previously PE is the most common plastic in domestic waste. Some studies claim that 80 % of plastic recovered is PE (Stanford Dairy, 2006). Assuming that this number also applies for Isla Navarino about 42.400 kilos can be processed (815 kilos a week). A cubic meter of plastic weights approximately 1000 kilos, a cubic metre of processed plastic would cost approximately 1.314.600 (42 x 31.300) a year.

The revenues of this product are still unclear. This depends on what products are made for the plastic and for what price it can be sold. It is however possible to gain revenues from this project. Because revenues are unclear it is impossible to calculate the payback time of the investment at this point. Further research is needed to calculate how much material must be processed (variable costs) and at what price products need to be sold (revenues) to reach the break-even point or even make profit

2. Transporting plastics

Raw materials costs
The same collection method as explained in 4.2.1 can also be used to gather plastic that is used when plastic is collected for recycling on the island. This method will be used to collection all materials. The costs of the collection-container are 214.670 CP per container.

Production costs
The collected plastic needs to be compacted before Recipet will accept this. This will cost money. Compacted plastic will nevertheless take less space so the transport costs will be lower. There fit about a 600 2 litre bottles of soda (100grams) in a cubic metre. A compacted bottle will take about a 4 times less space so in compacted form, so about 2400 bottles will fit in a cubic metre. A cubic metre of Plastic weights approximately 240 kilos. This is different from the kilos in a cubic metre than in 4.2.1 because compacted bottles take more space than cut plastic.

The costs of collecting PET bottles are 214.670 CP. After this a person must compact the PET bottles and put in a container to be transported to Santiago. This work can be done by one person. The process will approximately take a day (8 hours) to compact 600 bottles. Labour costs are therefore state at $25.000 CP. Some initial costs are needed to buy tools to compact the plastic; these costs are estimated on 50.000 CP

Transport costs
Pushing is a company that sells and rents out container, the company is located in Punta Arenas. An offer was requested to find out prices of containers. They have two kinds of containers, a small one and a big on. Prices and sizes of these containers can be found in table J3.

Model	Volume	Price of buying	Rent price a day
Small	33 m3	1.200.000	5.500
Big	67 m3	1.700.000	6.500

Table J3: Prices container (Source: offer Pushing prices in CP excl. VAT)

Calculation shows that the small container needs to be rented more then 128 days and a big one more then 262 days, to be cheaper then renting a container. Collected material is kept in Puerto Williams and is not stored in the container. The container is only needed to transport the material. It is therefore cheaper to rent a container. Transport costs will be based on a small rented container.

It takes the Austral Broom ferry two days to get to Puerto Williams, it stays overnight and then two days back, a container needs to be rented for 5 days to get the material to Punta Arenas. The container costs are 27.500 CP (5 X 5.500). At the Austral Broom ferry prices transport costs were asked, it costs 23.000 CP to transport a cubic metre of material from Puerto Williams to Punta Arenas. Transport costs of a small container to Punta Arenas are 759.000CP (23.000X33) (Austral Broom). The total transport costs to Punta Arenas are 786.500 CP.

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	50.000
Variable costs	Labour costs (25.000 a cubic metre)	825.000
	Transportation costs (23.000 a cubic metre)	786.500
	Hidden costs 10%	187.617
Total costs		2.063.787

Table J4: Costs of transporting plastic (to Punta Arenas)

The costs given in table J4, are transport costs of one 33 cubic metre container to Punta Arenas, the nearest Recipet location is however located in Puerto Montt. Prices were asked but no clear answer was given, except that it would costs a lot. The price that Recipet pays for a kilo PET is given in table J5.

Sort of PET	Price
PET bottles uncoloured material	$230/kg
PET bottles coloured material	$160/kg

Table J5: Prices of plastic

At the moment of writing this research a person in Punta Arenas has plans to start a plastic recycling factory. He has the knowledge he needs to process it; however funding is missing (Enviu, Puerto Natales). If the company can pay the same amount as Recipet, the revenues of a container would be as followed:

Revenues for PET plastic:
White -> 230 *120 =27.600 CP for a cubic metre and 910.800 CP for a container
Colour -> 160 *120=19.300 CP for a cubic metre and 636.900 CP for a container

These revenues are only sufficient to cover the transportation costs to Punta Arenas. Transporting it further for example to Puerto Montt would not be economically feasible. A nearer location most be found or started. That is why it can be interesting for Isla Navarino to help execute the plan of starting a plastic recycling factory in Punta Arenas, so they can set up a flow of materials to Punta Arenas in stead of Puerto Montt. This will significantly reduce transportation costs. This is confirmed by Scheinberg (2000), who said that the economy of scale for recycling depends on the distance to the buyer market and transportation costs. In the case of Isla Navarino, the transport costs are the bottleneck (to Puerto Montt) because the island is so secluded. This is the reason why this method is not a possible waste project for Isla Navarino at this point because no recycling is possible in Punta Arenas. This project is therefore not a possible waste project for the island and will not be identified as a possible waste project.

3. Recycling paper

Raw materials
The same collection method as explained in 4.2.1 can also be used to gather paper. The costs of a paper container are therefore 241.670 CP.

Production costs
There are some tools needed during the paper recycling process. Scissors are needed to cut the paper into small pieces. Plastic containers or moulds to dry the paper/glue pulp in. Initiation costs contain the materials that are needed to start-up the process like cutting tools, the plastic containers and moulds. Costs of these materials are estimation on 100.000 CP. These costs are based on an estimation made to start a recycling workshop at the school. Labour costs of processing a cubic metre of paper are estimated on 8 hours, 25.000 CP. Another 50.000 CP is calculated because certain materials are necessary for the recycling process. These materials are variable costs because they depend on the quantity processed.

Location costs
As already explained at the location costs of a plastic recycling factory, businesses are usually run out off the house. No extra space is rented so location costs are assumed to be zero.

Transport costs
As also already explained under the part of transporting costs of a plastic recycle factory, transport costs in Puerto Williams are zero to nothing because Puerto Williams is not big. Transport costs in general are therefore presumed to be zero for all recycle projects located in Puerto Williams. This cost will from this point on not be mentioned anymore at a local project.

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	100.000
Variable costs	Labour costs (25.000 a cubic metre)	1.650.000
	Materials (50.000 a cubic meter)	3.300.000
	Hidden costs 10%	526.467
Total costs		5.791.137

Table J6: Costs of recycling paper

Calculations have lead to the estimation that cubic meter of paper weights about 1500 kilos.
To recycling all material 100.000 kilos of paper, 66 cubic meter of paper must be processed. The costs of processing these 66 cubic meters of paper are given in table J6. As mentioned at plastic recycling it is unclear what the revenues of paper products are going to be. An optimal processing quantity at break-even point or that makes profit needs to be found. But at this point information on the demand side of the market is missing.

4. Recycling metals

Raw materials
This material can also be collected with a container. There is also a lot of non domestic waste that is metal. This can many also be collected to get more of the material.

Production costs
It depends on the metal that is melted what kind of oven is needed, or at least the temperature that needs to be reached to melt the material. For example the melting point of bronze is about 950°C whereas the melting point of copper is 1083°C (http://www.metaalwinkel.nl/index.php?item=1029 26 Jan). There are small size ovens that can reach the temperatures needed to melt different kinds of metals. A small model, so not for industrial use can be found in the Netherlands for €369, or 258.300 CP (Hobbyglas, 2007). This oven is accentually a glass oven but temperatures to 1200C can be reached so it can also function as a metal melting oven. Some extra tools are necessary to handle the melted metals are estimated on 50.000 CP. It will take about 40 hours to process a cubic metre of metal in the oven mentioned (125.000 CP). Costs are given in table J7.

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	308.300
Variable costs	Labour costs (125.000 a cubic meter)	125.000
	Hidden costs 10%	64.797
Total costs		712.767

Table J7: Costs of recycling metal

There are different kinds of metals that have different weights. This makes it harder to assess how many kilos of a material go into a cubic metal. It is also not possible to calculate the exact amount of a specific kind of metal present in the domestic waste. Therefore no further costs specifications are made. It is assumed that the variable costs of processing a cubic meter of metal are 125.000 CP. Also for this project it is unclear what the revenues of metal products are going to be. An optimal processing quantity at break-even point or that makes profit needs to be found. But at this point information on the demand side of the market is missing.

5. Transporting metal

Raw materials
This material can also be collected with a container; however the container must be emptied more often to ensure that the maximum weight capacity is not reached. There is also a lot of non domestic waste that is metal, like building materials. This can many also be collected to get more of the material. Because these other materials may come in odd shapes, it may be wisher to collect the metal at the place of production. This research however only focuses on domestic waste and for domestic waste only a container is sufficient. However odd shapes and heavy materials be delivered to the place.

Before transporting metal it is best to reduce its size. This to minimise transportation costs, a flat soda can takes less space then a whole one. This can be done with a big hammer or a similar tool; costs are estimated on 50.000 CP. The labour costs of processing a cubic metre of metal are estimated on 25.000 CP (8 hours).

Transport costs
It costs about 23.000 Chilean Pesos to transport a cubic meter to Punta Arenas. A container costs 786.500 CP. See table J8 for an overview of all costs.

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	50.000
Variable costs	Labour costs (25.000 a cubic meter)	825.000
	Transportation costs	786.500
	Hidden costs 10%	187.617
Total costs		2.063.787

Table J8: Costs of transporting metal

The prices paid for metal are given in table J9 . Because a lot of products contain metals and they have are made out of different materials and have different sizes it is not possible to make and estimation of how much product goes into a cubic meter.

Sort of metal	Prices
Copper	$ 1000/kg
Bronze	$ 600/kg
Aluminium	$ 450/kg

Table J9: Metal prices (Source: Company Metales Douglas 8 Jan)

Therefore this train of thought is turned around. How much kilo of a material must be put into a cubic metre to be break-even, so that the costs of transport equal variable costs? The variable

are labour costs and transporting costs (25.000 + 23.833= 48.833 CP). The breakeven point is as can be seen depends on the sort of metal transported.

Revenues of a cubic metre of metal	Copper	49 kilo	(48.888/1000)
	Bronze	81 kilo	(48.833/ 600)
	Aluminium	108 kilo	(48.833/ 450)

6. Recycling glass

Raw materials
Prices of a special glass container were also asked, these containers costs about 600.000 CP. This type of container however needs a special truck to empty it. This would mean an extra big investment, therefore this option is written of. The same container is used as to collect the other material, which costs 214.670 CP.

Production costs
There is a machine availed in the Netherlands that grinders glass. This machine is called the bottlenecker, see appendix L for additional technical information. This machine can grind bottles to about a fifth of the size. This machine costs E2.400, so 1.680.000 CP and that is without shipping costs. This process can however also be done manually to save costs.

The melting point of glass depends on the kind of glass, 727C is normal (http://www.scheikundig.nl/stoffen/s4.htm, 25 Jan 2007) there are many small ovens that can reach temperatures high enough. An example of such an oven is the Volvano Glassmeltoven. This oven costs about €369, what equals 258.300 CP. Next to the oven a couple of tools are needed for example to handle the melted glass, this tools total the start-up costs to 450.000 CP. labour costs are estimated on approximately 8 hours, 25.000 CP.

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	450.000
Variable costs	Labour costs (25.000 a cubic meter)	2.000.000
	Hidden costs 10%	266.467
Total costs		2.931.137

Table J10: Costs of recycling glass

A standard wine bottle has a diameter of 7 centimetres and is 28 centimetres high, weighs 0, 46 kilo(measure) and has a capacity of 0,000343m3 is one bottle. A cubic meter of glass can contain about 2915 bottles in a cubic meter what will weigh about 1345 kg. This means that it will take about 16 processing rounds to process the material. Table J10 gives the total costs of this processing capacity in one year.

The revenues of this project are also not exactly clear. It is clear however that, revenues can be gained from this process by for example selling glass souvenirs. More research is needed to explore possible markets and investigate the optimal processing size to produce break-even or make a profit.

7. Transporting glass

Raw materials

The collection of material is the same as all other materials.

Transport costs

If glass is going to be transported to Punta Arenas this has to be in a grinder form. This is because grinder bottle takes up a fifth of the space of a complete one. There are several ways to minimise glass. Breaking glass manually is as mentioned in 4.5.1 the cheapest option. A small start-up investment is needed to buy tools to break the glass. It costs about 23.000 Chilean Pesos to transport a cubic meter to Punta Arenas

Total costs

Cost sorts	Costs	In CP
Initial costs	Raw material costs	214.670
	Start-up investment	50.000
Variable costs	Labour costs (25.000 a cubic meter)	825.000
	Transportation costs	786.500
	Hidden costs 10%	187.617
Total costs		2.063.787

Table J11: Costs of transporting glass

The costs in table J11 give the costs of transporting a container of glass to Punta Arenas. Calculations are based on a full container. That much glass is however not produced in one year. If decision to transport glass, it is more costs efficient to sent a full container in stead of one that is halve full.

No revenues are gained from this project. It can however be a project of a local authority to help the community. Secondly, the returns what the company gain go to a fund for burn victim, so the projects kills to birds with one stone.

Conclusion of costs

The initial costs of transporting are lower then recycling on the island it self. This has to do with the start-up investment of machinery. The start-up investment differs per process. It is for example cheaper to recycle paper then plastic, this because a big investment in machinery is needed to recycle plastic. Labour costs are estimated based on the process done. The estimation is based on time and on the knowledge needed.

The transportation costs on Isla Navarino are assumed to be zero. Because the island is so small, the recycling location will most likely be in Puerto Williams. The product of the process will also be sold in Puerto Williams for example at a shop in the Centro Commercial, the local commercial centre. The distances within Puerto Williams are very small and therefore assumes negligible. Transport costs within Puerto Williams are set at zero. Transportation costs from the island are high. There is one ferry that goes to Punta Arenas and that makes it expensive. No other shipping companies normally pass the island so the ferry is the only option.

Transporting material has one big disadvantage to recycling on the island. The transportation costs are very high. There are companies however that pay for delivered materials. This can considerably cut the processing costs of some materials, which can make it interesting to transport. The only project that at this moment has a certain payoff is transporting metal, for other materials nothing is paid presuming that materials are only transported to Punta Arenas. The revenues of a product for a recycling process on the island are uncertain. That is because at this point it is unclear that products are going to be made and for that price it is going to be sold. It is an option to consider marketing a product for visiting tourists because that is the biggest local market.

Appendix K: Selection criteria

This appendix explains how the selected criteria are made measurable and how the identified waste projects score on all 6 criteria.

1. Time to results, the time between when the project is started and the first material is processed (measured in months).

Stakeholders were asked what they think is an acceptable time to result. Of the people who indicated time until results as being important thee persons answered 3 months, two persons answered 6 months and 1 person answered 12 months. The faster result is the best for the people so this category gets 3 point, the longer the time to results the more points.

Time to results is measured as followed:
1: Longer than 6 months
2: Between 3 and 6 months
3: Within 3 months

- For the recycling metal, plastic and glass special machines and tools need to be ordered, that is why these projects get 1 point.
- Recycling paper is a relatively simple process and no high-tech machines need to be ordered. That is why this project gets 2 points.
- Transporting metal, glass and paper is anticipated to have the shortest result time because the material only needs to be collected reduced in size and after that it can be transported. This group of waste projects therefore gets 3 points.

2. Quantity of waste that can be reduced, what is based on the total amount of waste material present on the island (in kg)

This criterion is made measurable based on the estimated waste decomposition given in figure 10 (page 37) . The biggest material category has the biggest reducing potential that is why that material gets 3 points.

Based on the material present the following scale is used to score the waste projects:

1: Less than 5 % of the domestic waste
2: Between the 5 and 10 % of the domestic waste
3: More than 10% of domestic waste

- Glass get 1 point because it 4% of domestic waste produced.
- Metal and Paper get 2 point, they are respectively good for 7 and 10% of domestic waste.
- Plastics are the biggest group, causing 20% of domestic waste and therefore get 3 points because the biggest reduction is possible in this category.

3. Time that the material takes to dissolve (in years).

To make this criterion measurable the breakdown times in table 7 (page 40) is used. These times are based on the longest breakdown time. For some materials different breakdown times

are gives, for example metal can be a metal tin which has a shorter breakdown time then aluminium tin which also falls in the category metal. In this case the longest breakdown time functions as the breakdown time of the whole material category. The projects which the longest breakdown times get 3 points, because this reducing this material will have the biggest “positive” impact on the environment.

Based on breakdown times of materials the following scale is used to score waste projects:
1: Shorter than 1 year
2: Between 1 year and 20 years
3: Longer than 20 years

- Paper has a breakdown time of 0,5 years, this is relatively short, and so this material gets 1 point.
- Plastic as a breakdown time of 20years and therefore gets 2 point.
- Glass and metals have a very long breakdown time, about a million years. This material gets 3 points because the environment will benefit the most if this material is handled.

4. Start-up investment is a one-time investment needed for example tools and machines to get a process started.

The categories will be made based on calculated costs in chapter 4. The distribution does not pass judgement on if it is economically feasible, merely shows which waste project is more expensive than another waste project. Waste projects which low costs are obviously preferred to those with higher costs. That is why the smallest cost category gets 3 points.

Based on start-up costs calculated in chapter 4 the following scale is used to score waste projects:
1 Bigger than 500.000 CP
2 Between the 200.000 CP and 500.000 CP
3 Smaller than 200.000 CP

- Recycling plastic has the highest initial costs and therefore gets 1 point.
- The start-up investment of Recycling metal, recycling glass is way smaller the one of plastic recycling. That is why metal and glass recycling get 2 points.
- Transporting paper, metal and glass; recycling paper get 3 points, the one start-up investment needed is a collection container and in some cases some basic tools.

5. Process costs, costs of processing a cubic metre of waste material, from separation to the final user.

In the cost tables given in appendix J, processing costs are labour, location and transport costs. The distribution also does not pass judgement on if it is economically feasible, merely shows which waste project has higher processing costs compared to another waste project.

Based on processing costs calculated in chapter 4 the following scale is used to score waste projects:
1 Bigger the CP 500.000 CP
2 Between the 100.000 CP and CP 500.000
3 Smaller the 100.000 CP

- Transporting paper, plastic and glass have the highest processing costs so they get 1 point.
- Recycling metal and recycling glass have higher processing costs so get 2 point.
- Recycling plastic and recycling paper have the lowest processing costs and therefore get 3 points. Transporting metal also gets 3 point. The costs of transport are high, however this is the only material for which is paid is Punta Arenas at the moment.

6. Revenues, the potential revenues a project may gain by selling the "end product" to the final user.

As mentioned in 4.6, it is hard to estimate the exact revenues of a project. The scale used is based on the possible revenues a project may gain. Projects that have a high likeliness of revenues are rewarded with 3 points.

1 Projects with a certain revenue
2 Projects with a likely revenue
3 Projects with no revenues

- Transporting glass, plastic and paper have no revenues when transported to Punta Arenas, so these projects get 1 point.
- All local recycling projects on the island have a likely revenue, at this point it is however unclear how big these revenues can be. These projects get 2 points.
- Transporting metal is the only project that gets one point, this because it is the only project which a certain payoff. That is the prices that Metales Douglas pays for metals see table J9 in appendix J. This project gets 3 points.

Appendix L: The bottlenecker

(Source: www.bottlenecker.nl)

Technical details

- 1600 Watt/220V motor;
- Seamlessly glued laminated MDF;
- Filling orifice with double stainless steel non-return safety flaps;
- Display with emergency-stop switch, standby indication, overfill indication and thermic safeguard;
- Automatic starting/stopping device;
- Sound Isolating Housing(± 72 dB);
- Capacity: 80 bottles per minute;
- Removable front panel for exchanging purposes;
- 60 liter reservoir (Maximum 60 kg granulate)

Capacity:

- 80 bottles per minute
- ca. 20.000 kg lifespan glass chisel
- ca. 250 30-cl bottles, ca. 130 liqueur bottles or ca. 130 wine bottles in just one reservoir

Appendix M: Inquiry Stakeholder (English/Spanish)??

This concept inquiry was translated into Spanish.

It is possible to reduce the waste dumped on the waste dump of Isla Navarino. Waste products (glass, metal, paper and plastics) can be reused or recycled.

What do you think is important when somebody in Puerto Williams wants to do something with present waste products, for example transport glass to Punta Arenas for recycling. What factors would do you find important for such a project in Puerto Williams

- Time until results are visible on the island (months)
- That the project is continued over time (yes/no)
- Involvement of the community
- Quantity of waste that can be reduced (in kg's)
- Time that the material takes to dissolve of the material handled is high (in years)
- Process costs of a cubic meter (small, medium large)
- Start-up investment (Small, medium, high)

What do you thing is important for a waste project but was not mentioned?

Scale the following aspects for lest important to most important how would that be, numbering the criteria from 1 until 7 (using every number only one time)?

- Time until results are visible on the island
- That the project is continued over time
- Involvement of the community
- Quantity of waste that can be reduced
- Start with material that takes the longest to dissolve on this own
- Process costs of a cubic meter
- Start-up investment

Appendix N: Results importance of criteria

Response	Time results	continues	community	quantity	dissolve time	process costs	startup costs
Local authorities							
1	1	2	4	3	5	6	7
6	3	7	5	4	6	2	1
5	5	6	7	4	2	3	1
4	7	6	4	5	3	2	1
Total	16	21	20	16	16	13	10
NGO							
1	2	6	7	5	4	3	1
2	2	7	6	3	1	4	5
3	5	4	7	2	1	3	6
4							
Total	9	17	20	10	6	10	12
Service users							
1	3	6	7	5	4	1	2
2	5	7	4	6	3	1	2
3	5	7	6	1	4	2	3
4	5	3	7	6	4	2	1
Total	18	23	24	18	15	6	8
All over result	43	61	64	44	37	29	30

Appendix O: Ranking results weighted, not weighted & stakeholder situation

Not weighted	Time results	Quantity	Dissolve time	Revenues	Process costs	Start-up costs	Total
Plastic recycling factory	1	3	2	2	3	1	12
Paper recycling factory	2	2	1	2	3	3	13
Transporting paper	3	2	1	1	1	3	11
Metal recycling factory	1	2	3	2	2	2	12
Transporting metal	3	2	3	3	1	2	14
Glass recycling factory	2	1	3	2	2	2	12
Transporting glass	1	1	3	1	1	3	10

Weighted	Time results	Quantity	Dissolve time	Revenues	Process costs	Start-up costs	Total
Plastic recycling factory	1	3	2	4	6	2	18
Paper recycling factory	2	2	1	4	6	6	21
Transporting paper	3	2	1	2	2	6	16
Metal recycling factory	1	2	3	4	4	4	18
Transporting metal	3	2	3	6	2	6	22
Glass recycling factory	2	1	3	4	4	4	18
Transporting glass	1	1	3	2	2	6	15

Stakeholders	Time results	Quantity	Dissolve time	Revenues	Process costs	Start-up costs	Total
Plastic recycling factory	1	3	2,4	2	3,9	1,3	13,6
Paper recycling factory	2	2	1,2	2	3,9	3,9	15
Transporting paper	3	2	1,2	1	1,3	3,9	12,4
Metal recycling factory	1	2	3,6	2	2,6	2,6	13,8
Transporting metal	3	2	3,6	3	1,3	3,9	16,8
Glass recycling factory	2	1	3,6	2	2,6	2,6	13,8
Transporting glass	1	1	3,6	1	1,3	3,9	11,8

Appendix P: Sensitivity analysis

Project	Weighted	Not weighted	Stakeholders
Plastic recycling factory	18	12	13,6
Paper recycling factory	21	13	15
Transporting paper	16	11	12,4
Metal recycling factory	18	12	13,8
Transporting metal	22	14	16,8
Glass recycling factory	18	12	13,8
Transporting glass	15	10	11,8

Scores of project with the different weighting methods

	Weighed		Not weighed		Stakeholders	
Project	UB	LB	UB	LB	UB	LB
Plastic recycling factory	3	2	1	1	0,2	1,2
Paper recycling factory	1	3	1	1	1,8	1,2
Transporting paper	2	1	1	1	1,2	0,6
Metal recycling factory	3	2	1	1	1,2	0,2
Transporting metal		1		1		1,8
Glass recycling factory	3	2	1	1	1,2	0,2
Transporting glass	1		1		0,6	
	13	11	6	6	6,2	5,2
Mean interval	2,2	1,8	1,0	1,0	1,0	0,9

Stability of ranking places (UB= upper bound, LB= lower bound)