# Technologies for municipal solid waste management in Masaya Nicaragua : a study on compost systems

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# Municipal Solid Waste Management
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**Errata for the paper "Technologies for municipal solid waste management in Masaya, Nicaragua; a study on compost systems"**
**Page 3 of the paper must be replaced entirely by the page presented here.**

What actually is said, is that the main indicators that have an effect on the composting production process are the technology climate and the technological capabilities of the country and community concerned. These concepts largely embrace the elements indicated in the basic theoretic framework: the social system features, the social means and the geographical features. So in a simpler manner the theoretical framework can be presented as in figure 1.2. The technology climate, which influences the technological capabilities as well, and the technological capabilities determine the appropriateness of the composting production process and thus the choice of the appropriate composting technology. In appendix I.4 the indicators for the technology climate and the technological capabilities are presented.

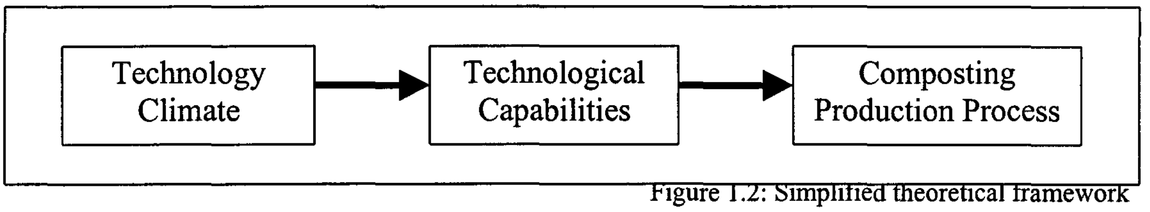



Figure 1.2: Simplified theoretical framework

Technology climate refers to the national setting within which science and technology programmes are being executed. Thus the national social system features influence the effects and impacts of technological transformation facilities and may produce different results in different technological climates.

Technological capabilities refer to the storage of knowledge in a country (technology stock) both in quantitative as well in qualitative sense, at macro-, meso- and micro-level of the economy. This stock should supply the country with the skills, the know-how and the knowledge to select, master and adapt the technologies needed and most appropriate to the social system of the country concerned. Moreover this stock should enable the country to develop and generate its own new technologies (autonomous technology generation) (van Egmond-de Wilde de Ligny, 1996).

## § 1.3 Research question

Considering the preceding paragraphs the research question is as follows:

*What composting production process and thus composting technology is the most appropriate to be applied in Masaya, Nicaragua, taking into account the technology climate and the technological capabilities as well as the input and output characteristics of the composting production process?*

The aim of this research is to present the most appropriate composting production process and the conditions that have to be satisfied and can be satisfied to successfully implement this process in Masaya, Nicaragua. The research findings on the indicators of the features presented in appendix I allow us to make certain statements on the major factors surrounding the composting production process as given by the UNEP-IETC: scale, siting, input stream, selection of an appropriate technology and market development.

## Summary

This report presents the results of an investigation on the possibilities of implementing and maintaining a compost system for the city of Masaya, Nicaragua. This compost system is viewed as a production process, where the input is the domestically produced solid wastes, the production technology is the composting technology and the output is compost. This production process is placed in its geographical, social and technological environment. These environments provide us with the characteristics and conditions in which the compost system can best be set up, and the appropriate composting technology for this system can be selected.

The environments described in the appendices to this report let us conclude and recommend the following regarding the major factors to consider for a compost system:

- Scale. Decentralised composting on the community scale is the scale on which the compost system should be set up.
- Site. When site preparation is executed according guidelines, few locations throughout the city of Masaya pose constraints for site location.
- Input stream. The input stream should and can be based on the households separating the solid wastes in an organic and non-organic part (source separation) to ensure compost quality.
- Selection of an appropriate technology. Manual pre-processing and the technology of the active pile system with manual turning are considered to be the best technological options for the compost system to be set up for the city of Masaya.
- Market development. One of the most critical factors to guarantee the functioning of the compost system is the development of the compost market. Especially the municipal authorities have to make considerable efforts to create and develop this market.

Making the compost system work requires serious commitment of and co-operation between Masaya's municipal authorities, its community organisations, its community and some private entrepreneurs. Where it is very difficult for a compost system to actually make a profit, the improvements in the health situation and the environmental benefits (especially the enormous reduction of waste to be landfilled) are very important contributions to consider when committing oneself to the composting of the domestically produced solid wastes.

Finally, the first phase of the implementation of the compost system, the execution of a pilot composting project, is touched upon and accompanied by an opportunity study to give an idea of the costs of the project.

All in all deciding on composting as one of the Municipal Solid Waste Management treatments is a feasible option, especially considering the potential waste reduction.

# Preface

This report is the final thesis of my Master of Science course International Technological Development Studies at Eindhoven University of Technology in the Netherlands. This thesis is based on the investigation performed in the city of Masaya during the period from October 1998 until March 1999. The investigation was made possible through the generosity of the Municipality of Masaya, who were willing to receive me through the twin city link Masaya has with the Dutch city, Nijmegen. I would hereby like to thank the Municipality of Masaya and Nijmegen to have made this opportunity available to me and for their support during my stay in Masaya.

Many persons have supported and assisted me during the investigation and the time completing the report. I want to thank my supervisors of the Eindhoven University of Technology, My first supervisor: Mrs. Ir. E.L.C. van Egmond-de Wilde de Ligny, my second supervisor: Dr. Ir. P.C. Beekman and my third supervisor: Drs. H. Gaillard, for their supervision and assistance.

Furthermore I want to thank Carlos Ramirez my supervisor of the Municipality of Masaya. He has been very helpful in providing data, information and at times even transport. Finally, I want to thank my Nicaraguan family and Arina Cremers for looking after me during my stay in Masaya, Nicaragua, and my parents, other family and friends for their understanding, support and enthousiasm.

Dennis A. van Hunen.

## List of abbreviations

**CDS** Comité de Defensa de la Revolución
(Revolution Defence Committee)

**ENITEL** Empresa Nicaragüense deTelecomunicaciones
(Nicaraguan Telecommunication Company)

**FSLN** Frente Sandinista Liberación Nacional
(National Sandinistic Liberation Front)

**GDP** Gross Domestic Product

**GNP** Gross National Product

**INAA** Instituto Nicaragüense de Acueductos y Alcantarillados
(Nicaraguan Institute of Aqueducts and Sewerage)

**INEC** Instituto Nicaragüense de Estadísticas y Censos
(Nicaraguan Institute of Statistics and Censuses)

**INETER** Instituto Nicaragüense de Estudios Territoriales
(Nicaraguan Institute of Territorial Studies)

**INIFOM** Instituto Nicaragüense de Fomento Municipal
(Nicaraguan Institute of Municipal Promotion)

**MAGFOR** Ministerio de Agricultura y Forestería
(Ministry of Agriculture and Forestry)

**MCN** Movimiento Comunal Nicaragüense
(Nicaraguan Communal Movement)

**MSW** Municipal Solid Waste

**MSWM** Municipal Solid Waste Management

**UNEP-IETC** United Nations Environment Program –
International Environmental Technology Centre

**UNI** Universidad Nacional de Ingeniería
(National University of Engineering)

# Contents



## Appendices

# Chapter 1 Introduction

## § 1.1 Research objective

The objective of this report is to determine the appropriate composting technology to be applied in a compost system for the city of Masaya through technological transfer and technology development. When choosing the appropriate technology for a certain situation, we have to take into account the factors that influence this choice.

The concept of technology comes down at the skills and knowledge embodied in man, machines, information and organisation, applied for the production of goods and services required by a society in which and by which it is being used. Analogously to this definition the composting technology will be regarded as part of a production process, namely the compost system. The compost system, therefore, will be seen as a production process where the input is municipal solid waste, the output or end product is compost and eventually some by-products and the production technology is the composting technology.

The concept of appropriate technology refers to the technology mix contributing most to economic, social and environmental objectives in relation to resource endowments and conditions of application. So not only the characteristics of input and output have to be taken into consideration, but the economic, social, geographical and environmental conditions as well. Thus, a compost system has to be placed in its proper environment (van Egmond-de Wilde de Ligny, 1996).

## § 1.2 Theoretical framework

The interaction of these factors is presented in figure 1.1. This figure is based on the model productive activities in their environment by Ir. E.L.C. van Egmond-de Wilde de Ligny. The relation between social needs and means provides us with the technology prerequisites for choosing an appropriate composting technology. The composting technology chosen is also dependent of the characteristics of the Municipal Solid Waste, which forms the input that the composting technology has to process and the characteristics to which the output of the process should comply. The characteristics of the input and the output, as well as the technology prerequisites and the social needs and means are in their turn influenced by the geographical features and social system features in which the compost system will be developed.

The geographical features are:

- City characteristics
- Climate
- Physical conditions

The social system features are:

- Economic environment
- Political environment
- Community environment
- Educational environment
- Health environment

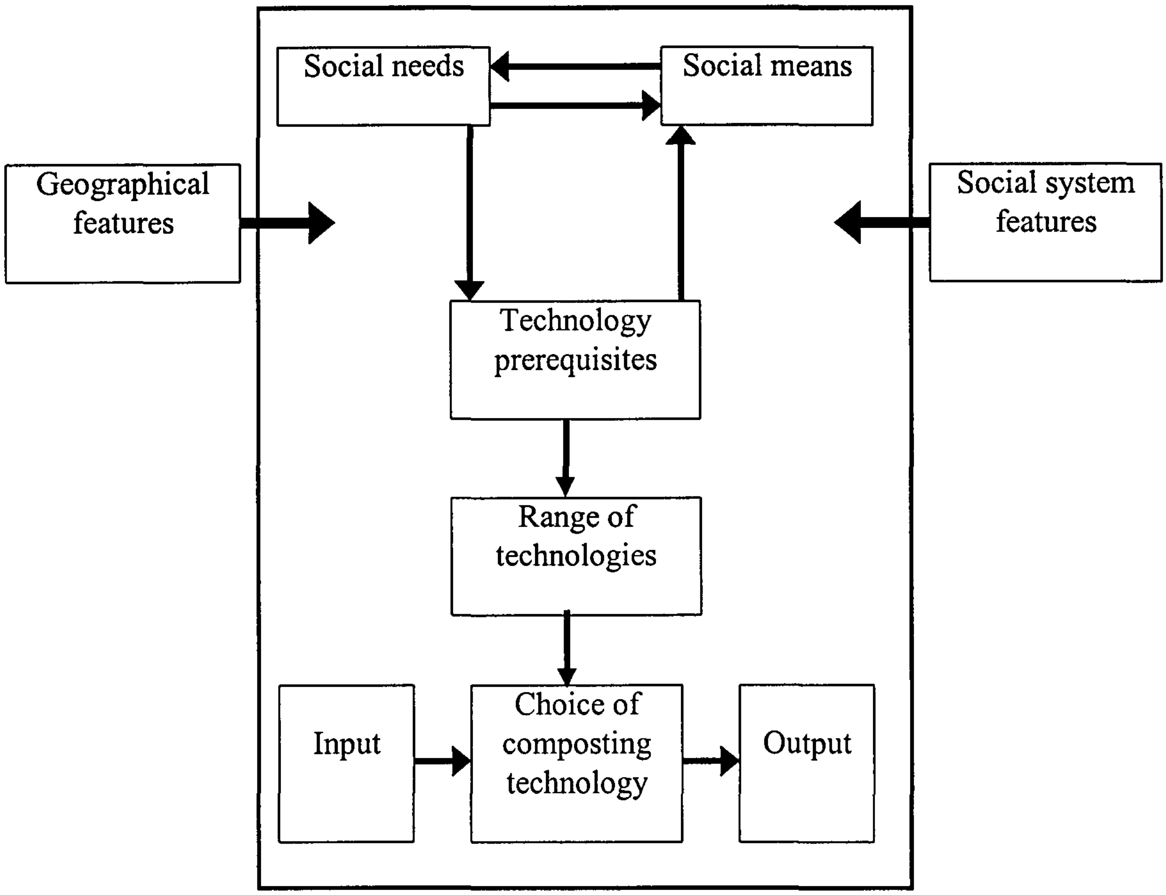



Figure 1.1: Influencing factors on the choice of a composting technology.

Input-, MSW-characteristics are:

- Size
- Composition

Output characteristics are:

- Function
- Marketability

All these features pose constraints and within these constraints the appropriate composting technology needs to be determined. The indicators used to measure these characteristics are listed in table I.1, I.2 and I.3 in appendix I.

There is another important feature that needs to be taken into account, which is the technological environment. The technology climate and the technological capabilities of the country or community will be used here to indicate the technological environment.

Technology climate refers to the national setting within which science and technology programmes are being executed. Thus the national social system features influence the effects and impacts of technological transformation facilities and may produce different results in different technological climates.

Technological capability refers to the storage of knowledge in a country (technology stock) both in quantitative as well in qualitative sense, at macro-, meso- and micro-level of the economy. This stock should supply the country with the skills, the know-how and the knowledge to select, master and adapt the technologies needed and most appropriate to the social system of the country concerned. Moreover this stock should enable the country to develop and generate its own new technologies (autonomous technology generation) (van Egmond-de Wilde de Ligny, 1996).

Although, through a lack of data, this technological environment can not be described as extensively as preferred, the indicators put forward in table I.4 in appendix I for the technology climate and the technological capability give us a good indication of the technological environment.

## § 1.3 Research question

Considering the preceding paragraphs the research question is as follows:

*What composting technology is the most appropriate to be applied in Masaya, Nicaragua, taking into account the geographical and social system features, the technological environment as well as the input and output characteristics of the composting technology?*

The aim of this research is to present the most appropriate technology and the conditions that have to be satisfied and can be satisfied to successfully implement this technology in Masaya, Nicaragua.

# Chapter 2 Presentation of the results

## § 2.1 Introduction

The findings on the indicators which determine the environment in which the compost system will be placed and the composting technology needs to be implemented are presented in the annexes II to V. This information on the geographical features (appendix II), the social system features (appendix III), the input and output characteristics (appendix IV) and the technological environment (appendix V) enables us to make certain statements on a number of factors. Factors that are essential to consider when implementing a compost system and thus selecting an appropriate composting technology for the city of Masaya. These factors, as given by the UNEP-IETC (United Nations Environment Program - International Environmental Technology Centre), will be described in such a way that the definition of technology will be kept in mind. Thus the conditions that need to be satisfied to successfully implement a compost system is described according to the skills and knowledge that need to be embodied in man, machines, organisation and information.

The major factors to consider in designing a compost system are the following:

- **Scale:** The scale of the compost system can vary between backyard composting and composting at the landfill as is described in appendix VII.3. An important consideration in this case is that the UNEP-IETC has concluded from their investigations that a smaller scale facility facilitates careful composting and the formation of a good product. Other considerations are the level of community involvement and the organisational capacities within that community and at the municipal level, as well as available space to implement a compost system at a certain scale.
- **Siting:** Not only must a compost facility be sited reasonably close to the input stream and the potential users, but as well in such a way that no harm is done to the surrounding environment. Moreover precautions should be taken to assure that physical and climatic conditions of this environment (abundant rainfall, earthquakes) in their turn have a minimal disturbing effect on the functioning of the compost facility.
- **Input stream:** Although source-separated organic material guarantees the best product quality, this is in many countries not possible. Mixed wastes can be processed to yield acceptable compost, whereby the composition of these wastes plays a role in determining the way of processing.
- **Selection of an appropriate technology:** The technology chosen must be adequate for the input stream and the desired output, but has to take into account the level of economic development as well. Obviously the actual technological environment is another important determinant. The range of available sustainable technologies according to the UNEP-IETC is presented in appendix VII.4.
- **Market development:** Where in most cases the compost market is more potential than real the quantity and quality of the product will have to be considered, next to the size of this potential market. Governments generally need to stimulate the compost market or in some cases create and develop this market.

With the help of the information presented on the indicators that describe the geographical features, the social system features, the input and output characteristics and the technology environment for the city of Masaya (appendices), the findings on the above mentioned factors will be presented in the following paragraphs.

## § 2.2 Scale

Since, as will be shown in paragraph 2.6, the potential market for compost within the municipality is rather small, it is important to strive for a good quality product. As said before, a small-scale compost system can guarantee this quality. The smallest scale of composting is backyard composting. There is, however, little or no experience or knowledge on composting within the community, neither is there a sufficient level of commitment within the community of Masaya (appendix III.3). Therefore backyard composting is not an option for the city of Masaya.

The next scale is the neighbourhood- or block-scale composting, but in this case the available space within the city of Masaya where these sites can be located is rather scarce. It is, therefore more desirable to move up one scale. This scale is known as decentralised composting on the community scale. As in the case of neighbourhood-scale composting wastes from households are collected but in a greater number, since these facilities will generally be in the range of processing 2 to 50 tons of wastes per day (UNEP-IETC, 1996). For Masaya this means collecting wastes from at least 600 and at most 14,000 households. The amount of households to be collected from, for one particular site must be decided on in accordance with the space available within the city for siting these facilities.

Composting at a higher scale is not desirable for Masaya since this will have its effect on the quality of the compost. Moreover a site for a compost system at this scale is not available regarding the troubles there are at the moment in locating the landfill. Furthermore these higher scales of centralised composting require an adequate collection system of the wastes, which momentarily is not the case in the city of Masaya (appendix IV.1).

Decentralised composting at the community scale must come under the jurisdiction of the municipal authorities, which accept responsibility for its operation. A very important point to take under consideration in this matter is that this scale of composting requires a large effort from the community in which it is implemented. Let alone the efforts of community organisations and authorities to have this effort made by the people of the community. Views on how this can be established in the best possible way for the city of Masaya are discussed further in chapter 3.

## § 2.3 Siting

Most compost systems require open land for establishing and manipulating compost piles. In many ways, the kinds of land and sites available dictate the choice of the composting system. When siting the compost system a number of things will have to be taken into account.

In the first place the site must have the required size to house the compost system (the compost piles, an eventual storage facility for the compost and a shelter for the workers from sun and rain). Secondly the site must have suitable access for the form of transportation (delivering the wastes and distributing the compost). In the case of Masaya this could mean a truck or a horse and carriage. Thirdly a buffer area between the site and nearby land users is desirable, to minimise the nuisance of waste and compost odours.

Fourthly there must be appropriate soil for the absorption or collection of leachate (residual water from the compost piles) to prevent ground water contamination. For Masaya this contamination is as good as impossible where the groundwater can be found at a minimal depth of 120 meters below city level. The soil is of an intermediate type, meaning that water will be absorbed at a normal rate (appendix II.3). To be on the safe side vegetation can be planted along the perimeter of the composting site to prevent the run off of the leachate in the surface water when excessive rainfall occurs. It is however smarter to dig small ditches around the compost heaps, to prevent the heaps from being affected too much by surface water. There will be elaborated more thoroughly on this issue, when discussing the preparation of the project site in the following chapter.

Finally and fifthly, where necessary the compost could be protected from climatic and physical conditions. In Masaya the temperature is relatively high and constant, so the conditions are ideal for composting outside and there is no need to place the compost piles in a building. Measurements should, however, be taken to shelter the compost piles from the rain (the rainy season lasts approximately 7 months, appendix II.3) to not disturb the composting process too much and some kind of shelter should be put up for the workers to protect them from sun and rain.

When considering decentralised composting at the community scale for the siting of the compost system the following organisational guidelines should be added (UNEP-IETC, 1996):

- The composting site must be clearly designated with signs that all users and non-users can read or interpret.
- The composting site must be sited with the agreement of the surrounding land users.
- The composting site must have adequate fencing or control to prevent their becoming an open dump.

## § 2.4 Input stream

The material to be composted must be compostable in order to produce a marketable product. Both large- and small-scale systems can work well with highly compostable waste streams. Because mechanical pre-processing of mixed solid wastes does not work well in most cases, large-scale systems should be limited to source-separated streams unless the waste stream is already highly compostable and contaminating materials can be manually removed.

Manual pre-processing of mixed wastes does work on a small to medium scale for the highly compostable waste streams in developing countries, therefore manual or manual-assisted processing is the soundest approach to composting that can be sustainable over the long term in a technical sense. However, manual processing may not be pleasant or safe for workers (UNEP-IETC, 1996).

For the city of Masaya the solid wastes are highly compostable (appendix IV.2) and, as said in paragraph 2.2, a compost system at medium scale is preferable for Masaya, therefore manual pre-processing of the input stream is an option. With regard to the quality of the compost this process will, however, only yield acceptable compost.

The first element in quality control is controlling the inputs to the composting process. In industrialised countries, quality control rests upon clear and enforceable source separation protocols, combined with sound collection practice and pre-processing. In developing countries, where source separation is unlikely, manual pre-processing and post-processing is required to ensure the quality of the compost produced. But for both developing as industrialised countries the fact of the matter remains that input streams separated in organic and inorganic components give the best possible compost quality. In most cases source separation is not feasible in developing countries, because neither the economic nor the environmental motivation is strong enough among the general public (UNEP-IETC, 1996).

For the city of Masaya, source separation is, however, feasible, as was discovered through the field research conducted in the neighbourhoods of Masaya (Appendix III.3). In many neighbourhoods there exists experience with the separation of the solid wastes in an organic and inorganic part in the households and in most cases this experience has been satisfying. Therefore, a compost system based on a source separated input stream could very well be realised in Masaya.

Hereby taking into account that, in most cases, designing the separation protocol and separate collection system are as important to the success of composting as the selection of the technique itself. Successfully implementing source separation in the neighbourhoods of Masaya will depend on an extensive campaign (from door to door), through which the population must be educated and informed to create or enforce the necessary environmental motivation and understanding of the protocol. Furthermore the institution implementing the compost system and designing the separate collection system must keep the cost-competitiveness of the charges of the actual waste collection service, which the separate collection service system will replace, and this separate collection system in mind. This, for reasons, that in Masaya the population is far from willing and able to pay (more) for their waste collection.

## § 2.5 Selection of an appropriate technology

The United Nations Environment Program - International Environmental Technology Centre (UNEP-IETC) in their sourcebook on municipal solid waste management underlines three important factors on which the technical viability of the compost system depends. Although these have already been mentioned in the preceding paragraphs we will name them again:

- There must not be excessive dependence on mechanical pre-processing.
- The scale of composting must not be too large. In general, the more complex the input stream, the smaller must be the scale to ensure proper composting process and a good product.
- The entire system from separation and collection to final screening must be designed together to deliver the appropriate input streams and to support the biological processes of the bacteria and other organisms.

When selecting the appropriate composting technology we have to take into account the existing technology environment in Masaya and Nicaragua (appendix V). According to this technology environment we can conclude that a simple, low-cost and labour-intensive technology is the most feasible for the city of Masaya. A compost system is composed of two technological components. The first one concerns the pre-processing of the input streams and the second one the composting process itself.

### § 2.5.1 Pre-processing

Pre-processing is a technical component of almost all composting systems above the level of backyard composting. Pre-processing is usually necessary to create the conditions for bacterial action.

Pre-processing consists of three separate types of operations:

- separation or removal of oversize, non-compostable, or dangerous materials;
- size reduction, through chipping, grinding, or shredding to create many small particles suitable to sustaining bacterial action; and
- blending and compounding to adjust the carbon-nitrogen ratio, moisture content, or structure of the materials to be composted.

Where mechanical pre-processing is often the most costly part of a composting system, as well as the most vulnerable to break down, manual pre-processing is preferable. This pre-processing should be minimised to the greatest extent possible by pre-selecting the waste streams to be composted through source separation and separate collection. When taking into account the relative cost of labour in relation with capital goods and the unemployment rate in Nicaragua and Masaya (appendix III.1), the form of pre-processing that is the most labour-intensive and the least capital expensive is even more preferable. Necessary precautions should, however, be taken to ensure the workers' health and safety, especially with the first operation of separation. But, since the input stream will be source separated (as opted for in the previous paragraph) the risk to the workers health and safety will be minimised considerably. Wearing proper working clothes (including boots, gloves and facemasks) will give sufficient protection.

## § 2.5.2 The composting technology

The composting technology refers to the organisation, information and the input of labour and machines surrounding the bacterial decomposition process of the pre-processed input stream. A compost system that meets the requirements of a low-cost technology and can meet the requirements of a labour intensive technology is the active pile system.

According to the UNEP-IETC an active pile system is a sound simple form of composting that involves building piles of compostables. The piles, called windrows, form the basic environment for compost bacteria and other organisms to perform decomposition. Important considerations in planning windrows include:

- the size of the windrows, which must be of sufficient mass to allow for heat build-up; the composition of the wastes and the climate are the two primary determinants of windrow size;
- the shape of the windrows, which is related to the type of aeration that is used and the type of equipment used to aerate;
- whether the windrows are open or covered, which depends on the climate and the moisture content of the waste; and
- the spacing of the windrows, which is dependent on the size of the site and type of equipment used.

Active pile systems require manual or mechanical turning of the windrows, with crews using shovels or rakes, or with equipment such as a bulldozer, tractor or windrow turning machine. Turning aerates the piles, blends the materials, brings about additional size reduction and prevents excessive build-up of temperature to the point of spontaneous combustion.

An active pile system:

- has relatively high land use requirements;
- uses a varied amount of labour, depending on whether turning is manual or mechanical;
- has low capital cost and low-to-moderate operating cost;
- can be developed without purchase of specialised equipment;
- requires limited site infrastructure;
- imposes very limited requirements for site modification;
- may use a variety of compostable materials; and
- may well release odours during turning early in the composting cycle. A large buffer zone between the composting plant and neighbouring residences may be needed, especially if the windrows are infrequently turned.

Obviously, an active pile system for Masaya should, as in the case of pre-processing, opt for labour-intensity (manual turning).

## § 2.6 Market development

Probably the most critical factor for a compost system to succeed for the city of Masaya is the development of the compost market. Finished compost can become, but is not automatically, a valuable commodity. Its value depends on external demand for soil enhancers, on perceptions of its value, on its quality and on its accessibility to potential users in the immediate vicinity. It also depends on what alternatives to compost are available to farmers and cultivators in the region, and on the cost of those alternatives relative to the cost of the compost.

Compost marketing works when:

- the farmers or gardeners are located relatively close to the source of the compost;
- the entity producing the compost is willing to transport it to the users; and
- the compost is priced below the price of commercial fertilisers.

For Masaya this means that the price should be kept relatively low, since chemical fertilisers are subsidised by the national government and that the potential market should be searched for within the municipal limits. Considering the agricultural sector within this municipality we can see that the potential market size is far too small compared to the potential output size (appendix IV.3). The maximum possible demand (compost used on every manzana in the municipality twice a year) amongst the farmers is 237,000 quintales of compost and the potential production of compost from the domestic organic wastes in the city of Masaya amounts approximately 268,000 quintales of compost.

It is unlikely to assume that every farmer in the municipality will be willing or able to use compost. Although this part of the compost market should be developed to the fullest extent, through the education of these farmers on the use and benefits of using compost and possibly creating a financial credit system for them to be able to buy the compost, the compost market should be further expanded.

Possibilities in this area are:

- the use of compost by the inhabitants of the city of Masaya, since a large part of the population of Masaya is cultivating fruits and vegetables in its own gardens;
- the use of compost in the public sector in public works projects; and
- locating agricultural co-operations outside the municipality that are willing to use compost and guarantee a large enough demand to make the costs of transport profitable.

The roles of the government, and in this case the municipality, are essential in stimulating the compost market and include:

- use of compost in public work projects, including some high-profile demonstration projects in parks and gardens as signs that bring the use of compost to the attention of the public enhance its effect;
- specifying that government contractors use compost in government-funded construction projects;
- requiring that nurseries supplying plantings to the government use compost;
- supporting the price of compost, either for a short period or in cases where such support is justified based on an analysis of overall MSWM plans or requirements;
- removing or modifying subsidies on chemical fertilisers that compete with compost, although the power of the municipality to realise this will be rather limited, since these subsidies are provided by the national government in Nicaragua;
- providing technical assistance to composting facilities on quality control; and
- providing free or low-cost testing of compost for its nutrient value or for suspected contaminants.

These last two remarks refer to the quality of the compost. Where quality can be enhanced through carefully controlling the inputs to the composting process, the pre-processing and the composting process itself, it is essential to give farmers or other users confidence that compost is safe for use and that they will not be penalised at a later date.

## § 2.7 Conclusion

In this chapter the major factors that need consideration when designing and setting up a compost system for the city of Masaya have been looked upon. In summary, the results are as follows. The best possible scale for setting up a compost system is decentralised composting on the community scale. Site location is mainly dependent on the available space throughout the city, since the physical conditions (appendix II.3) pose few constraints. The input stream should be source separated, meaning that the households of Masaya should separate their solid wastes in an organic and non-organic part. For reasons already mentioned in this chapter, the technology choice should be labour intensive, resulting in choosing for manual pre-processing and an active pile system as the actual composting technology.

These choices indicate a number of things. First of all a commitment of Masaya's population to separating their solid wastes is necessary to guarantee an appropriate input stream. At the same time the compost system executing party should provide an accompanying, well functioning collection service. Moreover there should be a commitment of neighbourhood organisations together with the municipal authorities to accept responsibility for the operation of the compost system. This does not only imply setting up the project through preparation of the city and education of the people, but as importantly, maintaining the compost system. Thus, maintaining the site itself, looking after the collection service and keeping the people motivated to separate their wastes if necessary.

Finally, probably the most important factor deciding between success and failure of the compost system is the development of the compost market, which as of yet hardly exists in and around Masaya. This development can only be achieved through the commitment of and efforts done by the municipal authorities to stimulate and support this compost market.

# Chapter 3 Recommendations

## § 3.1 Introduction

For the city of Masaya the dedication to composting of the domestically produced wastes should be taken into major consideration, when approaching the problems there are at the moment with the management of the solid wastes. Research data in this report (appendix IV.2) found on the source and the composition of the solid wastes tell us that 85.5% of the domestically produced solid wastes are organic and thus eligible for composting. Realising that 77.8% of the municipal solid wastes is in fact produced domestically means that if the municipality should commit oneself to composting, the potential reduction of solid wastes to be dumped could amount to 63%. When at a later stage the organic solid wastes from the marketplace could be integrated in the composting process, this number will increase to approximately 70%. In other words only 30% of the produced municipal solid wastes would need to be dumped at a landfill. The calculations on these percentages can be found in appendix IV.

Before going deeper into the possibilities for composting in the city of Masaya, it must be underlined that turning to composting will only be part of the solution for the municipal solid waste management problems there are at the moment. Composting must be seen as part of the entire municipal solid waste management process. Along with implementing a compost system, the collection service of the wastes needs to be improved, the need for a sanitary landfill remains and the potential of recycling the inorganic part of the solid wastes should be investigated.

## § 3.2 Implementation of the compost system

If the municipality of Masaya should decide to commit oneself to developing a compost system for the domestic solid wastes in the city of Masaya, a number of important factors will have to be taken into account. As put forward in the previous chapter a compost system at the community scale based on source separation, manual pre-processing and the technology of the active pile system with manual turning is the most appropriate for the city of Masaya. These choices imply the following regarding the implementation and maintenance of the compost system.

**Composting at the community scale** will make it necessary for the municipality to co-operate with the neighbourhood committees to ascertain that the information will reach the entire population within the neighbourhoods. There should be collaborated with these committees on how the education about the source separation and the compost could best be executed. Moreover with their knowledge of the neighbourhood they could assist in locating an adequate site for the compost facility and finding the qualified people to work in the compost system. Where neighbourhoods are politically divided the municipality should make the effort to bring the entire population together to reach for the same goal. In practice this means co-operating more intensively with the MCN (Movimiento Comunal Nicaragüense) and both this community organisation and the municipal authority realising that either one could help out the other in executing projects that should benefit the entire community.

An important task for the MCN and the municipality lies in motivating the community members to participate in the project. Not only does implementing the practice of **source separation** in the households require an extensive educational campaign, it is imperative that the people are at the same time convinced of the benefits of a successful project. Persons should go from door to door to explain the procedure (of separation and collection) and the purpose of this source separation. This should, however, be promoted in such a way that the people actually make or see the connection between the functioning of an adequate composting system and thus an efficient garbage collection scheme and the improvement of the health situation in their own neighbourhood. Environmental and health risks concerning the dumping, burning and burying of wastes should be underlined. It is therefore advisable to make the education surrounding the composting project part of a bigger health campaign.

The health brigadiers (brigadistas de salud) active in many neighbourhoods of Masaya can be the persons to pass by the households and educate families about improving the health situation around the house. For example cooking and eating with clean hands, adequate disposal of waste water and not just throwing it out onto the street, the diseases animals carry with them, walking on shoes, and so on. Having the garbage adequately disposed of (collected for the composting project) and thus the necessity of separating the solid wastes into an organic and inorganic part should just be a part of this.

More practically containers for both the organic and inorganic wastes should be provided and reminders in the form of folders on the separation protocol and the usefulness of participating in the composting project should be left behind. Catering for the fact that still one third of the population is illiterate, these form and folders should be designed with explanatory drawings as well in order to make sure that everyone understands the separation protocol.

At the same time a collection system should be developed to pick up the organic wastes and the inorganic wastes. Using a horse and carriage in neighbourhoods, where for example trucks can not enter, must be considered. This could have the additional effect that when these horses and carriages pick up the inorganic parts and store it in a container at the compost site, the work of the garbage trucks could be relieved considerably. Because instead of passing from door to door in the neighbourhoods a stop at the compost site to empty the container would suffice.

With regard to the functioning of these horses and carriages, attention should be paid to the fact that there is good communication between these small entrepreneurs and the project executors. At the moment it is normal that the people who operate these horses and carriages charge significantly more than the municipality does for their garbage collection services. Although many neighbourhoods are badly serviced or not serviced at all by the municipal dump truck, people will still be very aware of the fact that they are paying more than they would otherwise. Agreements should therefore be made with the so-called "carretoneros" about charging the households a reasonable collection fee, whereby in return they can be guaranteed a regular collection route, thus ensuring them a fixed income.

Perhaps it is unnecessary to put this forward here, but it should be obvious that already active "carretoneros" will have to be approached to participate in the collection scheme of the composting project first. The project will only attract hostility when these people are neglected as potential participants and the project would set up its own collection scheme with new people. More importantly, the opportunity to benefit from the experience of these "informal" workers would then be wasted.

Choosing for **the technology of manual pre-processing and the active pile system with manual turning** assures a relatively low cost operation and does not make the use of specialised equipment necessary. An important asset and a useful promotion tool of the project is that some employment is created that is very welcome in Masaya. Since this work, except for the project director, does not require skilled personnel, this employment could and should benefit the people of poor resources in the neighbourhoods in which these projects will be executed.

Probably, the most crucial factor to successfully implement and, more importantly, sustain the compost system over the long run, is **the development of a compost market** within the municipality of Masaya. If this market will not develop the compost system will eventually fail. In the previous chapter the importance of this market was already underlined as well as the government stimulation that could be executed to develop this market. It is essential that the municipal authority does make these serious efforts.

Finally, special attention needs to be paid to **the maintenance of the composting system**, and thus the maintaining of the proposed composting pilot project. Although it is important, maintaining is more than just allowing for repair and maintenance of equipment used on the compost site. There lies a task for the neighbourhood committee and the municipality (for instance through its neighbourhood executive) to be aware of problems that might arise in the collection of the wastes or its separation. Lack of motivation within the neighbourhood community or financial disputes between neighbourhood members and garbage collectors are not unlikely to occur. If these problems are noticed in time, they can be solved in time, and thus, resulting problems for the compost systems operation prevented or at least minimised. Furthermore, it has to be clear that within the compost market to be developed, the maintenance of good communication with the potential and actual buyers of the compost is essential for maintaining the compost system over the long run. Using this communication as feedback, on which certain alterations can be carried out, shows commitment and dedication to actually trying to make the compost system work.

## § 3.3 Pilot project

It is recommended that the implementation of the compost system for the city of Masaya should start off with a pilot project, after which this could be evaluated. This should be decisive in expanding the compost system, that is to say before setting up other compost facilities in the city of Masaya. What needs to be evaluated at that time is whether the compost market actually has developed and whether the source separation in the households and the separate collection system are functioning adequately.

The pilot project should be evaluated after at least one full year of operation to obtain a good insight on the functioning of the project (especially the financial viability). For adequate maintenance of the project a close eye should be kept on the operation of the project, allowing for timely adjustments and improvements.

***Scale and site***

The pilot-project must be executed according to the guidelines posted in the previous chapter. Firstly we need to decide on the location of the project. We can not do this without considering the scale of the compost system. As has been motivated in chapter 2 decentralised composting at the community scale is the best option for the city of Masaya. This means setting up a number of composting plants throughout the city with a range of being able to process between 2 to 50 tons of waste per day. Considering the quality of the compost it is recommendable to make the plants as small as possible. On the other hand costs and available space constrain us and we have to acknowledge that the city offers us around 6 locations to set up a compost plant. Thus the compost plant must be able to process the wastes of approximately 3000 households equalling 10.5 tons of waste per day. Since this is a pilot project and 10.5 tons would supply us with more then 50,000 quintales (hundred pound bags) a year, we could very easily flood a not yet existing compost market. It is therefore recommendable to set up the project site for 1500 households with future expansion possibilities to 3000.

The exact location of the site would most preferably be in the vicinity of or in the neighbourhood "Jardines de la Barranca", located in the Northeast part of the city of Masaya. As became clear in appendix III.3 this is one of the few neighbourhoods, which satisfies the conditions of a unitary organisation, a motivated community with experience in source separation of solid wastes, a non-hostile and co-operative approach towards the municipal authorities and an irregular service of the municipal dump truck.

This neighbourhood and four or five of its surrounding neighbourhoods must provide the input stream for the composting process. Neighbourhoods in that particular area of the city comprise 250 to 300 households and very important: in this area of the city there is sufficient experience with the source separation of solid wastes.

***Technology and organisation***

The technology that needs to be applied is that of the active pile system. With assistance of possibly a tractor, workers manually control the delivered wastes on impurities and make the organic wastes into smaller pieces, before mixing it in the right ratio and constructing a 85 $m^3$ pile with it. Water will be added to this pile through irrigation and the piles will regularly be turned manually to allow for sufficient oxygen into the process and thus preventing unpleasant odours as much as possible. A drawing of the preferred set up of the compost site can be found in appendix VI. In the setting up of the site the experiences of the previously executed Biomasa composting project were closely followed. With regard to the actual process of composting, it is recommended to consult Biomasa on the proper processing of the organic wastes (shape of the piles, carbon-nitrogen ratio, moisture content, aeration, heat build-up and so on).

The organisation of the project should be in the hands of the neighbourhood committee of the neighbourhood "Jardines de la Barranca". Since this committee, as well as the people in the neighbourhood, is highly motivated, some of this motivation might rub off on the adjacent neighbourhoods and hopefully convince others of the benefits of working in unison for the entire community. In the end the pilot project could function as a learning facility for the other plants to be set up when expanding the compost system.

The collection of the organic wastes and inorganic wastes has yet been discussed in the previous paragraph. The informally active "carretoneros" (garbage collectors with horse and carriage) have to be approached to collect for a fixed fee, whereby in return they are guaranteed a regular route. Organic wastes should be picked up twice a week and the inorganic wastes every two weeks. Every two weeks the municipal garbage dump truck should come by to pick up the accumulated inorganic wastes and the compost rest material.

***Costs and funding***

The costs of the project are roughly calculated in appendix VI. As predicted before, unfortunately, the costs of the project exceed the revenues. Although some profit is made on a yearly basis, the initial investment is never covered by the profits made in later years. What, however, is not shown are the environmental benefits. Not only are nutrients returned to the soil and thus the use of artificial fertilisers reduced, compost is waste that does not have to be landfilled. In the case of Masaya where the percentage of solid wastes eligible for composting is very high (appendix IV.2), the reduction in solid waste to be dumped is considerable. This should be a major consideration, when deciding in favour of the setting up of the compost system.

To decrease the costs of the project one could try to find a substitute for the tractor, one should however not be tempted to increase the income of the project by increasing the price of the compost. This could only be done when in time the compost market has developed and subsidies on competitive chemical fertilisers have been lifted. In appendix VI a financial picture is presented when replacing the tractor and trailer with two more labourers and increasing the number of handcarts, thus making the project even more labour intensive. Although the initial investment is still not likely to be covered, this variant gives a much better perspective.

Finally initial funding for this pilot project will most probably have to be looked for with external organisations or institutions. In acquiring these funds and designing the project proposal the municipality should be conscious of not tying themselves to any particular demands of this organisation which would contradict with the set up of the compost system. In the long run, it should be possible for the project to pay for its re-investments, itself. Especially when the project is executed as labour intensive as possible and the tractor and trailer are thus left out.

## § 3.4 Conclusion

The implementation of the compost system for the city of Masaya should be preceded by a pilot project. This set up and maintenance of this pilot project requires serious commitment and efforts of the community, community organisations and the municipal authorities. These efforts regard the separation of the solid wastes, the set up of the collection system, the site preparation and the operation of the plant and the development of the compost market. Although the pilot project is not likely to make a profit, the environmental benefits need not to be forgotten.

The evaluation of the project should be one of the decisive factors for the continuance of the project and the expanding of the compost system. An evaluation should be performed throughout the functioning of the pilot project and this evaluation should be used to adjust and improve the operation of the project, the collection service, the separation protocol and the compost market development. Problems should be detected on time and communication between the involved parties is essential, to solve problems timely and prevent others from happening.

# APPENDICES

## Appendix 1 Indicators

In the following tables it is shown which indicators will provide us with the information about a certain feature's variable. Moreover, the method of data collection is mentioned.

**Table I.1 Geographical features**

| Feature | Variable | Indicator | Unit | Data collection method |
|---|---|---|---|---|
| 1. City characteristics | a. Size | Surface<br>Inhabitants<br>Dwellings | $Km^2$<br>Total number, urban/rural distribution<br>Total number, composition | Literature study<br>Observation<br>Open interviews |
| | b. Population density | Inhabitants per $km^2$<br>Dwellings per $km^2$ | Inhabitants per $km^2$<br>Dwellings per $km^2$ | |
| | c. Infrastructure | Road<br>Electricity<br>Drinking water<br>Waste and surface water<br>Telecommunication | Km of paved and unpaved road<br>Number of electricity connections<br>Number of drinking water connections<br>Number of sewerage connections<br>Number of phone connections | |
| 2. Climate | a. Temperature | Average temperature | Degrees Celsius | Literature study<br>Observation<br>Open interviews |
| | b. Rainfall | Period of rain<br>Average rainfall<br>Type of rain | Descriptive<br>Millimetres annually<br>Descriptive | |
| | c. Propensity for thermal inversions | Drops or rises in temperature | Descriptive | |
| | d. Winds | Direction<br>Velocity | Descriptive<br>Descriptive | |
| 3. Physical conditions | a. Topography | Average elevation<br>Variation in height | Metres above sea level<br>Descriptive | Literature study<br>Observation<br>Open interviews |
| | b. Soil characteristics | Type of soil<br>Permeability | Descriptive<br>Descriptive | |
| | c. Bodies of water | Type of bodies of water<br>Proximity of bodies of water | Descriptive<br>Distance in metres | |
| | d. Special environmental sensitivities | Protected areas<br>Natural phenomena | Descriptive<br>Descriptive | |

**Table I.2 Social system features**

| Feature | Variable | Indicator | Unit | Data collection method |
|---|---|---|---|---|
| 4. Economic environment | a. Income level | GNP per capita<br>GDP per capita | US Dollars<br>US Dollars | Literature study |
| | b. Income distribution | Income of the richest and poorest 20%<br>People living below the poverty line | Percentage<br>Percentage | |
| | c. Economic growth | Annual growth rate | Percentage | |
| | d. Inflation | Average annual inflation rate | Percentage | |
| | e. Debt service | Foreign debt<br>Foreign trade (export & import values) | US Dollars<br>US Dollars | |
| | f. Employment | Level of unemployment<br>Level of underemployment | Percentage<br>Percentage | |
| | g. Economic structure | Share in GDP of 1st, 2nd and 3rd sector<br>Share of working population of the 3 sectors | Percentage<br>Percentage | |
| | h. Relative cost of capital as opposed to labour | The cost of substituting a unit of labour for a unit of capital | Ratio<br>Descriptive | |
| 5. Political environment | a. Type of government | | Descriptive | Literature study<br>Open interviews |
| | b. Satisfaction of basic human rights and freedom | | Descriptive | |
| | c. Delegation of power and funds | | Descriptive | |
| | d. Degree and nature of decision constraint | | Descriptive | |
| | e. Importance assigned to community involvement | | Descriptive | |
| 6. Community environment | a. Kinship structure | | Descriptive | Literature study<br>Observation<br>Open interviews |
| | b. Social structure | | Descriptive | |
| | c. Quality of these structures | | Descriptive | |
| | d. Willingness within the community to participate and co-operate | | Descriptive | |
| | e. Social and cultural practises | | Descriptive | |
| 7. Educational environment | a. Primary, secondary and higher education enrolment | | Percentages | Literature study |
| | b. Educational facilities | Teachers<br>Centres | Total number<br>Total number | |
| | c. Alphabetisation | People able to read and write | Percentage | |
| 8. Health environment | a. Life expectancy | Life expectancy | Years | Literature study |
| | b. Infant mortality/disease | Infant mortality rate<br>Causes of mortality/diseases amongst children | Deaths per live births<br>Descriptive | |
| | c. Health care | Number of physicians<br>Distance to a medical facility | Physicians per population<br>Descriptive | |

**Table I.3 Input and output characteristics**

| | Characteristic | Indicator | Unit | Data collection method |
|---|---|---|---|---|
| 9. Input | a. Composition | Source<br>Type<br>Material composition | Percentage per waste producing source<br>Hazardous/non-hazardous waste<br>Percentage | Literature study<br><br>Observation<br><br>Open interviews |
| | b. Size | Weight<br>Density<br>Volume | Kilograms<br>Kilograms per cubic metre<br>Cubic metres | |
| 10. Output | a. Function | Usefulness<br>Application | Descriptive<br>Descriptive | Literature study<br><br>Observation<br><br>Open interviews |
| | b. Marketability | Quality<br>Quantity<br>Price<br>Appearance | Descriptive<br>Number of quintales (100 lbs) a year<br>US Dollars and national currency<br>Descriptive | |

| Table I.4 Technological environment features | | | | |
|---|---|---|---|---|
| **Feature** | **Variable** | **Indicators** | **Unit** | **Data collection method** |
| 11. Technology climate | a. National economic data | Same as for the economic environment in table I.2 | Same as for the economic environment in table I.2 | Literature study<br>Observation<br>Open interviews |
| | b. Political orientation, changes and stability | Same as for the political environment in table I.2 | Same as for the political environment in table I.2 | |
| | c. Education | Same as for the educational environment in table I.2 | Same as for the educational environment in table I.2 | |
| | d. Health | Same as for the health environment in table I.2 | Same as for the health environment in table I.2 | |
| | e. Population | Same as for the city characteristic: size in table I.1 | Same as for the city characteristic: size in table I.1 | |
| | f. Infrastructure | Same as for the city characteristic: infrastructure in table I.1 | Same as for the city characteristic: infrastructure in table I.1 | |
| 12. Technological capability | a. Technology stock | Type of equipment and tools<br>Number of equipment and tools<br>State of equipment and tools | Descriptive<br>Numbers<br>Descriptive | Literature study<br>Observation<br>Open interviews |
| | b. Human resources | Type of personnel<br>Number of personnel<br>Educational level of personnel<br>Experience level | Descriptive<br>Numbers<br>Descriptive<br>Descriptive | |
| | c. Natural resources | Locally available inputs in the process | Descriptive | |
| | d. Technological infrastructure | Actors involved in the process and sector<br>The role of these actors | Descriptive<br>Descriptive | |

# APPENDIX II Geographical Features

## II.1 City Characteristics

The city of Masaya is the head municipality of the department Masaya. The city is situated 11.58 degrees northern latitude and 86.05 degrees western longitude and 30 kilometres to the Southeast of the nation's capital Managua. Masaya forms an important part of Nicaragua's metropolitan zone and the main urban axis of the country. (Alcaldía Municipal de Masaya, licitación publica, 29th of April of 1998). Figure II.1 shows us the location of Masaya on the country map.

### *II.1.1 Size and population density*

The department of Masaya is the smallest of the 15 departments of Nicaragua in surface, which totals 590 $km^2$. The department is divided in 9 municipalities, of which the municipality of Masaya (extension 118 $km^2$) houses the city of Masaya as well. The city of Masaya occupies an area of approximately 12 $km^2$ (Proconsult Ingenieros, 1997). Figure II.2 and II.3 shows the position of the city in the surrounding environment and the city map, respectively.

According to a census performed by INEC (Instituto Nicaragüense de Estadísticas y Censos) the official number of inhabitants (1996) and dwellings (1995) for Masaya were as follows:

**Table II.1 Number of inhabitants and dwellings for Masaya**
(source: Inifom, 1996)

| | Inhabitants (1996) | Dwellings (1995) |
|---|---|---|
| Municipal | 117,523 | 20,492 |
| Urban | 88,971 | 14,139 |
| Rural | 28,552 | 6,353 |

When we apply the average annual growth rate of 4.01% over the years 1971 till 1995 and the average number of 6 persons per urban dwelling (Inifom, 1996), we can calculate the following numbers for the year 1998 for the city of Masaya as shown in table II.2. In this table the density numbers are shown as well, taking into account the city's extension of 12 $km^2$.

**Table II.2 Estimated numbers on inhabitants and dwellings for Masaya in 1998**

| | Inhabitants | Density (Inhabitants/$km^2$) | Dwellings | Density (Dwellings/$km^2$) |
|---|---|---|---|---|
| City of Masaya | 96,250 | 8,021 | 16,042 | 1,337 |

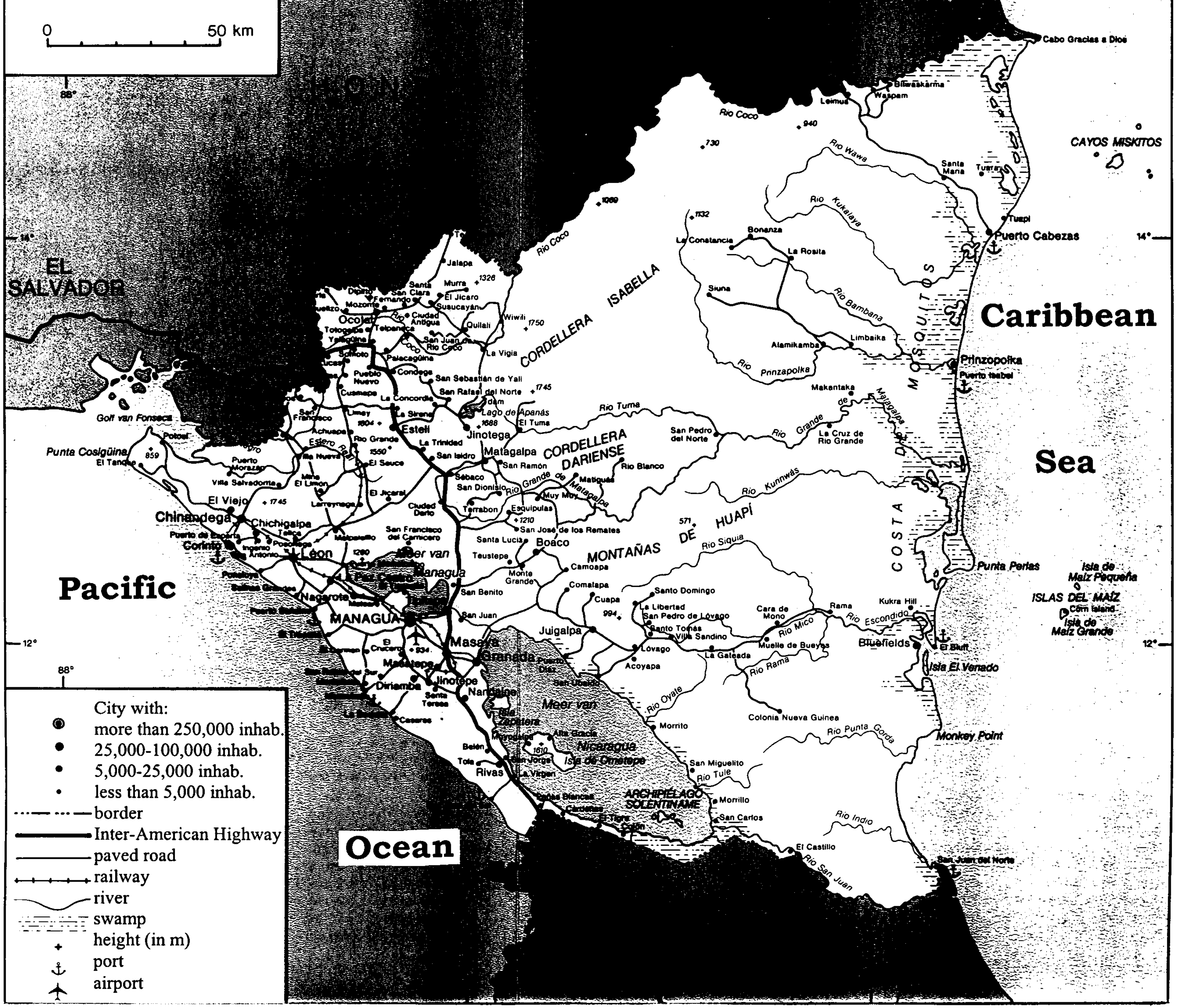



Figure II.1 Map of Nicaragua

(Source: Huysegems, 1998)

# Figure II.2 Map of the department of Masaya (source: INETER, 1998)

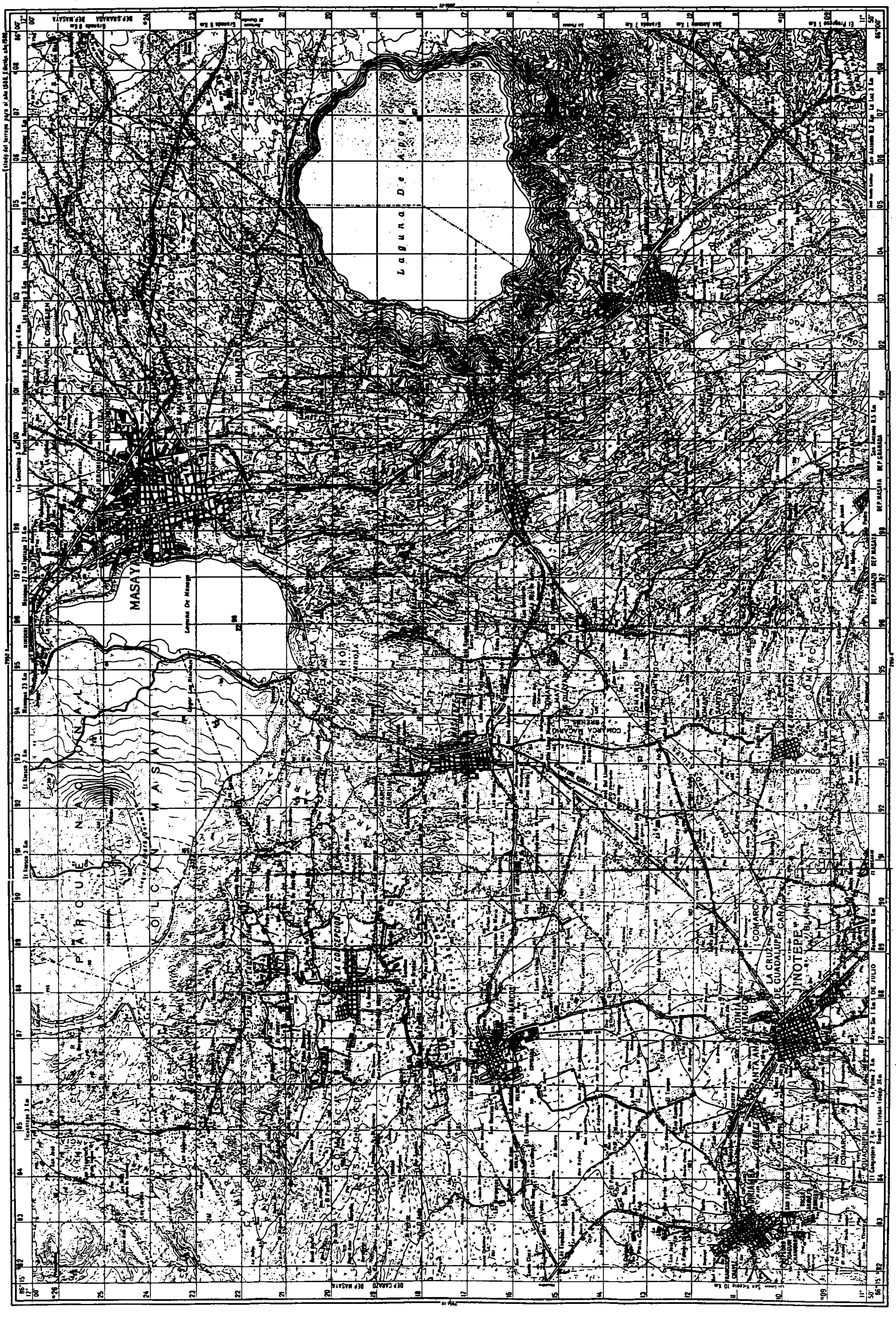


**Figure II.3 City Map of Masaya** (source: Catastro, Alcaldía de Masaya, 1998)

### *II.1.2 Infrastructure*

**Roads**

The municipality of Masaya is characterised by having access to regional routes like the Managua-Masaya-Granada "highway" and the "highway-net" to the Towns. This is a net of "highways" which connects a group of cities in the departments of Masaya, Granada and Carazo, namely the cities Nandaime, Jinotepe, Diriamba, San Marcos, Masatepe, Niquinohomo, Catarina, Diriá, Diriomo and Masaya. This net is connected to the Pan-American Highway, which connects the North, and South borders of Nicaragua as well. These regional routes are completely paved at all time (Proconsult Ingenieros, 1997).

The state of the roads of the city Masaya is far from optimal. In the urban periphery many are unpaved, meaning that they lack gutters to deal with the rainfall and therefore causing an accelerated deterioration of these roads (Proconsult Ingenieros, 1997). Off the approximately 105 km road net that the city Masaya has, 50 km is either asphalted or brickpaved, the remaining 55 km are unpaved, in this case meaning that these are dust roads (Duindam). The road net of the municipality is composed of 175.4 km, of which 26.8 km are asphalted, 27.15 km is brickpaved and 121.45 kms is unpaved. Mostly all of the paved roads can therefore be found within city limits (Inifom, 1996).

**Electricity**

According to the national census of 1995 in the municipality of Masaya 11,779 dwellings are connected to the electricity net, 9900 of these connections are within urban limits, the remaining 1879 are rural (Inifom, 1996). Combined with the numbers of dwellings we obtain the following numbers on coverage of the electricity net in 1995.

**Table II.3 Household electricity connections for Masaya in 1995**
(source: Inifom, 1996)

| | Dwellings connected | Dwellings in total | Percentage (%) |
|---|---|---|---|
| Municipal | 11,779 | 20,492 | 57.5 |
| Urban | 9,900 | 14,139 | 70.0 |
| Rural | 1,879 | 6,353 | 29.6 |

**Drinking water**

INAA (Instituto Nicaragüense de Acueductos y Alcantarillados) administrates the public service of drinking water. The drinking water is distributed through a net, which is supplied by two water tanks with a capacity of 750,000 gallons and one tank with a capacity of 450,000 gallons. The water for those tanks is subtracted from the groundwater, which is only treated by chlorine. The number and percentages of dwellings connected to the drinking water net in 1995 can be found in table II.4 (Inifom, 1996).

| Table II.4 Household drinking water connections for Masaya in 1995 (source: Inifom, 1996) | | | |
|---|---|---|---|
| | Dwellings connected | Dwellings in total | Percentage (%) |
| Municipal | 12,300 | 20,492 | 60.0 |
| Urban | 11,058 | 14,139 | 78.2 |
| Rural | 1,242 | 6,353 | 19.5 |

**Waste and surface water**

The sewerage accounts for a number of 8,135 domestic connections in the municipality, which is equivalent to 40% of the dwellings in the municipality of Masaya (Inifom, 1996). Although there are no numbers on the distribution on sewerage connections between the city and the countryside, it can be assumed that the percentage for urban connections is higher than 40%, where the percentage of rural connections will be below 40%. According to the urban/rural distribution for drinking water connections the following percentages are estimated.

| Table II.5 Household sewerage connections for Masaya in 1995 | | | |
|---|---|---|---|
| | Dwellings connected | Dwellings in total | Percentage (%) |
| Municipal | 8,135 | 20,492 | 39.7 |
| Urban | 7,314 (estimate) | 14,139 | 51.7 |
| Rural | 821 (estimate) | 6,353 | 12.9 |

According to a sample of 1,067 dwellings it was determined that for dwellings that are not connected to the sewerage system 68.2% uses traditional latrines, 23.7% uses drains, and 8% deposits their waste water in drainage channels, next to using latrines (Inifom, 1996).

The wastewater that is collected through the sewerage system is directed to a system of stabilisation lakes, where the water is treated. The affluent of this system flows into the Lake of Masaya, a body of water, which slowly is deteriorating by the constant inflow of water with a high content of algae and other contaminants (Proconsult Ingenieros, 1997).

The city of Masaya does not account for a surface water drainage system, with the exception of two streets. Normally the surface water drainage is done through the gutters in the streets, which empty in two open water channels that are crossing the city before emptying into the Lake of Masaya.

The lack of a surface water drainage system produces a number of inconveniences for the city of Masaya, among others the following can be mentioned (Proconsult Ingenieros):

1. The penetration of surface water, including sluggish that is being dragged by this surface water, into the sewerage system.
2. Utilising the streets as means to conducting the surface water to the channels obliges the construction of dips in each street mouth, causing inconvenience for the traffic.
3. Constant flooding in different parts of the city during the rainy season.

**Telecommunication**

The telephone and telegraph service for the municipality of Masaya is serviced by ENITEL (Empresa Nicaragüense de Telecomunicaciones). The city is serviced through one digitised central office and three branch offices. In 1995 their existed 4,000 domestic connections in the municipality, representing 20% of the total number of dwellings in the municipality.

## II.2 Climate

The climate of Masaya is of the type tropical savannah, which is characteristic for the entire region of Pacific Nicaragua. This climate is characterised by having a dry period of 4 to 6 months between November and April and a rainy season between May and October. The average rainfall is 1,400 mm annually, with extremes of 2,214 mm and 809 mm as respectively 5% and 95% statistical outliers. The average temperature for the year is 27 °C. Drops or raises in temperature do not exist throughout the year, meaning that thermal inversions do not have to be accounted for (Huysegems, 1998). What does has to be accounted for is that in the rainy season the rains are heavily and abundant.

The direction of the winds is from the Northeast to the Southwest throughout the entire year. At times these winds can be relatively strong, a cause of inconvenience in especially the dry season, when these winds in combination with the dry dusty roads cause an abundance of dust floating around the city. The direction of the wind is illustrated in figure II.4.

## II.3 Physical conditions

### *II.3.1 Topography and soil*

The topography of the municipality of Masaya offers two clearly marked characteristics. Firstly a slightly inclining plain to the Northeast, which is descending from a height of 900 feet, in the neighbourhood of the city of Masaya, to 200 feet near the city. Secondly a mountainous region in the outskirts of the city (Inifom, 1996). Therefore the topography of the city varies between flat and slightly uneven. The average elevation of the city is 240 m above sea level (Proconsult Ingenieros, 1997).

The types of soil which can be found throughout the city of Masaya is of one and the same type, which is classified as intermediate soil (suelo franco). Its permeability can be found between those of the two extremes sand and clay, where sand is highly permeable and clay is not permeable, meaning that this type of intermediate soil will absorb surface water but in a slow fashion (MAGFOR, 1998). This information was confirmed by a number of ground samples executed throughout the city accompanied by the director of the Masaya department of the Ministry of Agriculture and Forestry. The locations of these bore holes are shown in figure II.5.

### *II.3.2 Type and proximity of bodies and water*

Two natural lakes, which are volcanic of origin, flank the city of Masaya; these are the Lake of Masaya to the West and the Lake of Apoyo to the Southeast. The Lake of Masaya has an extension of 8.4 $km^2$ and a maximum depth of 72.5 metres. The Lake of Apoyo is much larger with a surface of 21.1$km^2$ and a maximum depth of 200 metres. The city is located in the drainage area of the Lake of Masaya and to a point near to the water outlet of the basin of the Lake of Apoyo. Because of the extension of these drainage areas there are no rivers of significance to be found in the region, only some small temporary currents (Proconsult Ingenieros, 1997).

Concerning the groundwater, which guarantees the supply of the drinking water for the city, it can be remarked that these streams are flowing between 120 and 140 m below city level in the direction of the East and Northeast. This is the direction of the flow of surface water as well, either transported by the streets (in the rainy season when flooding of the streets occurs) or by the open water channels (INAA, 1998).

### *II.3.3 Specific environmental sensitivities*

When discussing the environmental sensitivities to be encountered for the city of Masaya we will have to deal with the Volcano of Masaya in 3 aspects. Firstly, the only conserved natural area in the vicinity of the city of Masaya is the National Park of the Volcano of Masaya. Secondly, as the Volcano of Masaya is located to the West of the Lake of Masaya and is only passively active there is no danger for the city of Masaya when eruptions occur (eruptions are never violent and lava streams are absorbed by the lake). However, through its constant seismic activity earthquakes have to be accounted for.

Thirdly, since the volcano is constantly smoking and this smoke contains highly contaminating particles, it has to be kept in mind that in case of whatever meteorological phenomenon the direction of the wind changes this smoke will be blown across the city.

## Figure II.4 Direction of the wind

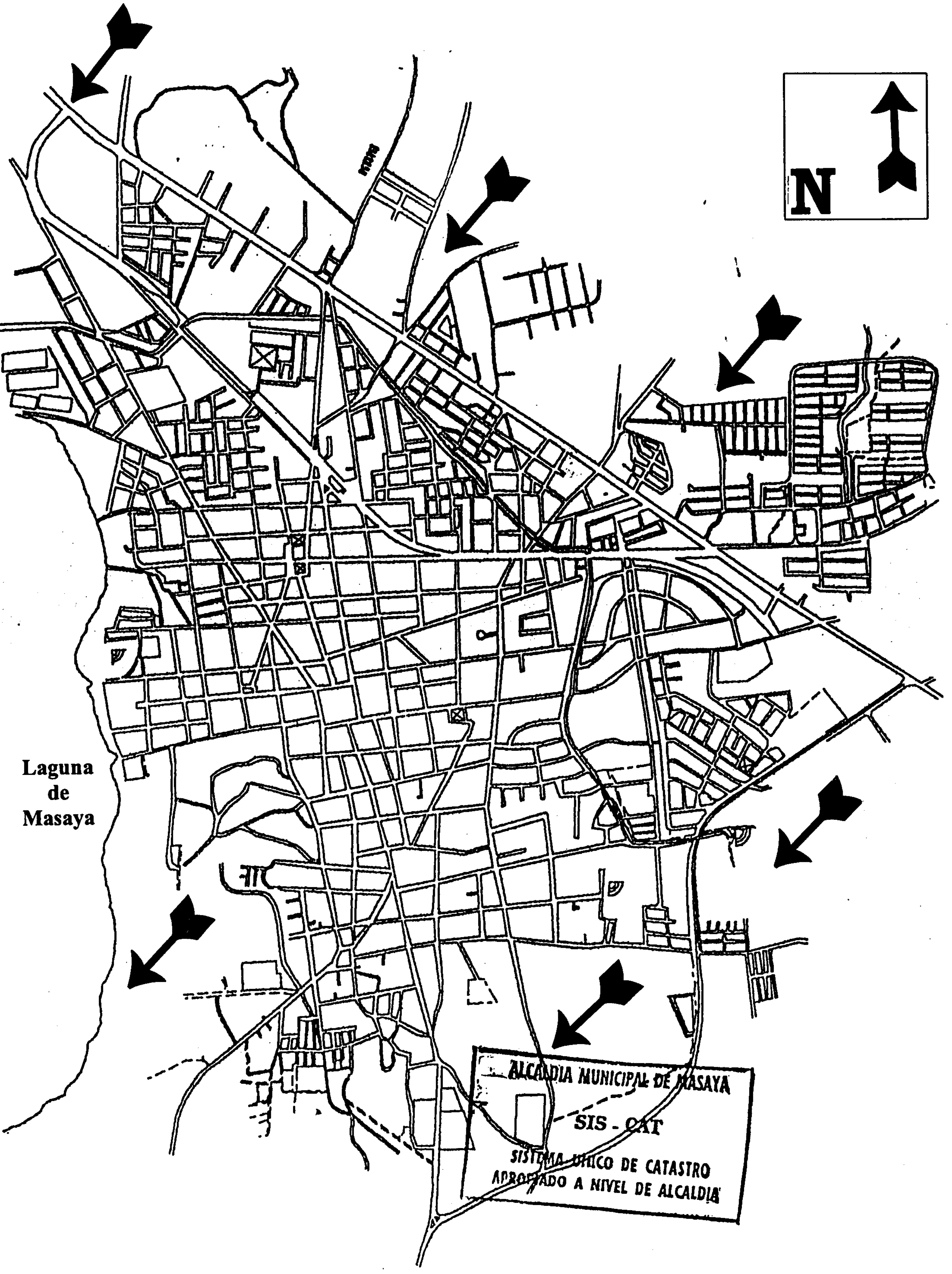
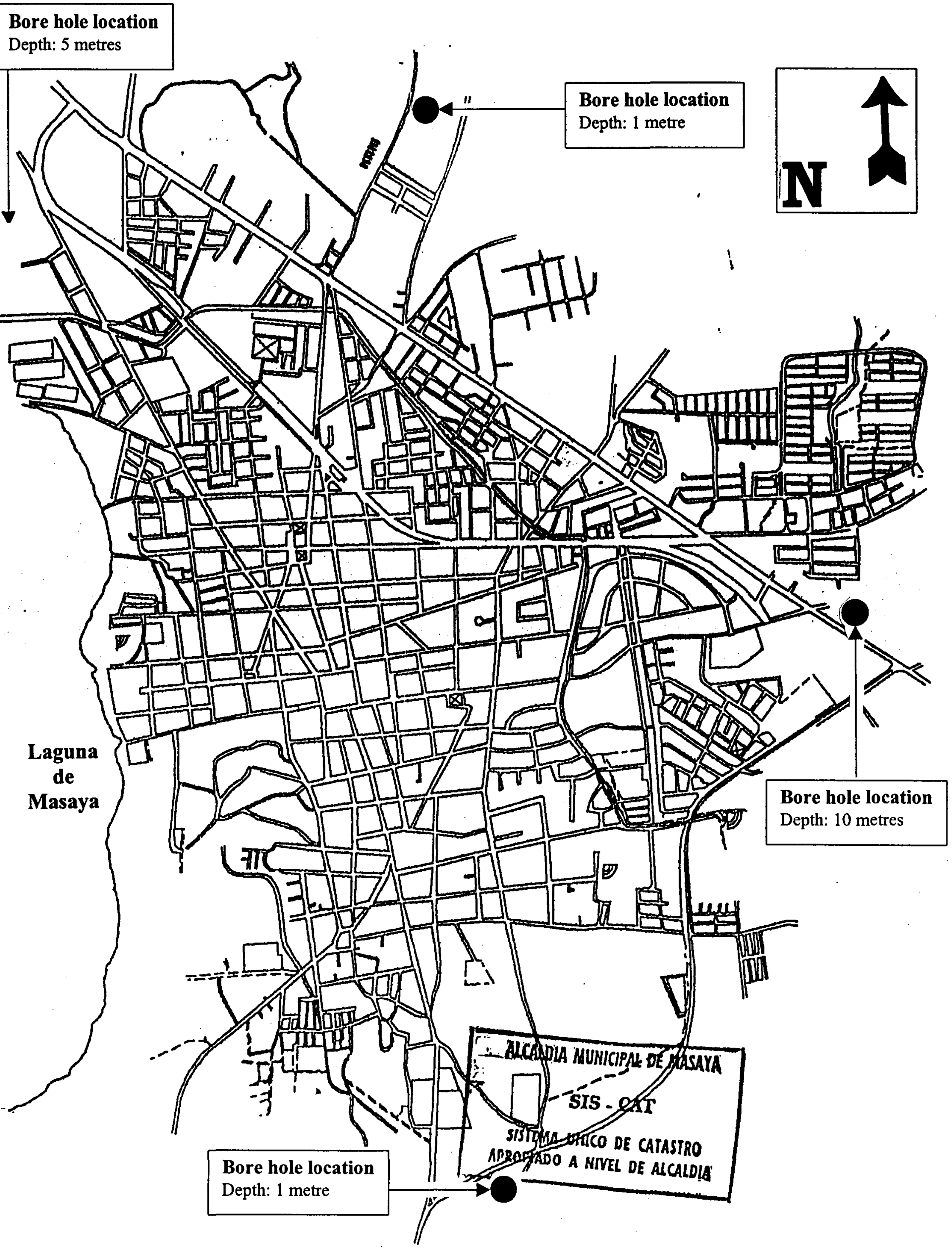


**Figure II.5 Location of bore holes for ground samples**



# APPENDIX III Social System Features

## III.1 Economic environment

### *III.1.1 Nicaragua*

The revolution in 1979 against Somoza, the following contra war, the economic boycott of the United States and the mismanagement in certain areas of the sandinists have ruined Nicaragua's economy and therefore its people. This along with regular "setbacks", which torment the Nicaraguan economy, like dryness, tornadoes and/or hurricanes and the rocking of the prices on the world market for its export products, have made Nicaragua the second poorest country on the western hemisphere behind Haiti. In 1994, following 10 years of negative economic growth, the production level was 60% below the level of 1977. The standard of living had dropped to the level of 1940 (Huysegems, 1998).

But there is hope. In 1996 Nicaragua was the fastest growing economy in Central America. This strong growth is occurring since 1994 and finds its explanation in the export of agricultural products. While traditional products like coffee, sugar and meat remain the most important export products (as they were in the 60s and 70s), there are also non-traditional upcoming products like tobacco, melons and onions. Despite this growth of the exports the trade balance remains in bad shape: the value of imports is twice as high as the value of exports (Huysegems, 1998). What moreover remains to be seen is how and if the Nicaraguan economy will recuperate from the most recent natural disaster that has left half the country in total despair and misery, hurricane Mitch. Some relevant economic data for Nicaragua are presented in table III.2 and III.3

### *III.1.2 Masaya*

The economic activity for the municipality of Masaya shows us that the economically active population of Masaya is abundantly represented in the tertiary sector (table III.4). The main contributors to this sector are the hotels and restaurants, followed by the community, social and personal services. This sector is furthermore comprised of commerce, transport and financial services (Proconsult Ingenieros, 1997).

The secondary sector is composed of craftsmanship and industry. The craftsmanship is one of the main economic activities for the city of Masaya. Standing out in this small craft industry is the branches of foods, textiles, clothing, leather, footwear, furniture and especially ceramic, wood and agave fibre crafts. Masaya is no industrial city, nevertheless some industries exist in the municipality in the branches of footwear, clothing, construction materials and metal mechanics (Proconsult Ingenieros, 1997). The agricultural and primary sector mainly consists of small family businesses and co-operatives. The municipality has 500 producers with or without property titles and 440 producers, which are associated with 55 agricultural co-operatives present in the municipality. The agricultural economic activity of the municipality occupies a total of 5,000 cultivated manzanas distributed in the following manner:

**Table III.1: The agricultural economic activity of the municipality of Masaya**
(source: Inifom, 1998)

| **Cultivation** | Beans | Corn | Peanuts | Cassava |
|---|---|---|---|---|
| **Manzanas** | 1000 | 2000 | 500 | 1500 |

**Table III.2: Relevant economic data on Nicaragua**
(source: Huysegems, 1998)

| | | | Year |
|---|---|---|---|
| GNP per capita<br>GDP per capita | $ 380<br>$ 2000 (purchasing power) | | 1995<br>1995 |
| Income distribution | • The richest 20% of Nicaragua earn 55.2 % of the national income, the poorest 20% earns 4.2%.<br>• 44% of the population lives below the poverty line (earning less than one purchasing power dollar a day). | | 1993<br>1981-95 |
| Economic growth | • -2.0%<br>• 1.1%<br>• 3.2%<br>• 4.2%<br>• 4.5 to 5% | | 1980-90<br>1990-95<br>1994<br>1995<br>1996-97 |
| Inflation rate | • 961.6% (average per year)<br>• 11.7%<br>• 11.4%<br>• 12.1% | | 1985-95<br>1994<br>1995<br>1996 |
| Foreign debt | $ 9.3 billion<br>$ 6.1 billion | | 1995<br>1996 |
| Foreign trade | Exports: Value $ 671 million<br>• Agricultural products 82%<br>• Gold 5%<br>• Basic industry products 4%<br>• Chemical products 3%<br>• Live animals 2% | Imports: Value $ 1135 million<br>• Agricultural products 14%<br>• Oil(products) 15%<br>• Basic industry products 13%<br>• Machines and appliances 9%<br>• Electrical appliances 4%<br>• Other industrial products 9%<br>• Cars and trucks 9%<br>• Chemical products 8%<br>• Medicine 5% | 1996 |
| Level of unemployment | • Official number of unemployment 15%<br>• Number of underemployment 47%<br>• Thus 62% of the working population has no or insufficient work | | 1997 |
| Economic structure | Share in GDP (1992)<br>• Agriculture, forestry, fish. 31%<br>• Mining, building, industry 22%<br>• Services 47% | Share of working population (1990)<br>• Agriculture, forestry, fishery 28%<br>• Mining, building, industry 26%<br>• Services 46% | |

| **Table III.3: Working population employed or unemployed, municipality of Masaya, 1995** (source: Ebert, 1995) | | | | |
|---|---|---|---|---|
| Total working population | Working population employed | (%) | Working population unemployed | (%) |
| 64,608 | 33,546 | 51.92 | 31,062 | 48.08 |

| **Table III.4: Working population per economic sector, municipality of Masaya, 1995** (source: Ebert, 1995) | | |
|---|---|---|
| **Sector** | **Number of workers** | **Percentage** |
| Primary | 5,278 | 15.73 |
| Secondary | 4,139 | 12.34 |
| Tertiary | 24,129 | 71.93 |
| TOTAL | 33,546 | 100.00 |

Finally an important remark can be made regarding the labour cost. Since more than half of the workers in the country are either underemployed or unemployed, Nicaragua is good for investors who are looking for lots of low-cost unskilled labourers. The hourly pay for workers is the lowest in the Americas (library.advanced.org).

## III.2 Political environment

Until the sandinistic revolution in 1979 Nicaragua and its people have suffered under the dictatorial regime of the Somoza family. The sandinists have to try to reconstruct a new and fair society, but due to their own fanatism and the war the contra-revolutionaries started against their regime with American help, these efforts failed. In 1990 the sandinists lost the free and fair elections to a broad coalition headed by Violeta Chamorro. In 1996 new elections were held and the liberal party came out as the victor with Arnoldo Alemán as the new president of the Republic of Nicaragua. The type of government of the Republic of Nicaragua is a presidential republic. Elections are held every 5 years for the presidency (re-election is possible) and the parliament (Asamblea Nacional) that counts 90 members (Huysegems, 1998).

The constitution of 1987 provides freedom of speech and freedom of the press. There is no official state censorship in Nicaragua (a key difference from the old regimes) and conflicting viewpoints are openly discussed in the media and academia. The constitution also contains the right to peaceful assembly and association, freedom of religion and freedom of movement within the country as well as foreign travel, emigration and repatriation.

The constitution is liberal in its prohibitions against discrimination based on birth, nationality, political belief, race, gender, language, religion, opinion, national origin, economic condition or social condition. Moreover all public and private sector workers are allowed to form and join unions. Thus, nearly half of Nicaragua's work force, including agricultural workers, is unionised. Workers have used their rights and have participated in many strikes, causing collective bargaining to become common in the private sector (Nicaragua country report, 1996).

### *III.2.1 Municipality of Masaya*

The municipality as well as the city of Masaya is governed and administrated by the municipal council (consejo municipal). The objective of this council is to establish the fundamental direction of the public management in the economic, political and social issues of the municipality. The municipal council is composed of ten councillors and ten substitute councillors elected according to the law and is headed by the mayor. The mayor is the maximum executive authority of the municipality and is elected by the people every four years. The mayor co-ordinates the work of the municipality with state institutions, non-governmental organisms and community organisations that realise activities within the municipality (Inifom, 1996).

Administrative and executive power and responsibility are delegated from the national government to the municipal authorities as long as this governing, of course, doesn't contradict with national policy and law. Decision constraint on municipal administration and government is therefore limited. Along with this delegated power and responsibility comes, however, a financial independence as well. The municipality doesn't receive funds or subsidies from the national government and is solely dependent on its own sources of income (taxes) and foreign funding.

The municipal source of income are the taxes (mainly property taxes), but because of the lack of an adequate registry system only 15% of the dwellings in the municipality are registered and therefore charged to pay taxes (Inifom, 1996). With regard to Municipal Solid Waste Management it should be noted that households are being charged for the collection of their wastes, but only 30% of these households do actually pay. This results in the fact that the costs of collection and disposal of MSW are far from covered by this income (Servicios Municipales, 1998).

Foreign funding is principally obtained from foreign institutions and embassies active in the country and through the city links that Masaya has with a number of cities (eleven) abroad. These incoming funds are almost in every case tied to projects set up in co-operation with these foreign institutions, embassies or cities and can therefore not be seen as finances the municipality can put to use independently.

## III.3 Community environment

### *III.3.1 Kinship structure*

The Nicaraguan household can in general still be classified as patriarchal. The "macho" male is supposed to be the main income-earner that should support his family financially and the female should be dedicated to running the household and raising the children. Although the sandinists encouraged women to enter public life and find a job away from home, founded a women's organisation and took up equality between men and women in the constitution, the traditional values and ideas about men and women have hardly changed. But through the opportunities that the revolution has offered them, many young women have become emancipated (Huysegems, 1998).

### *III.3.2 Social structures*

During the sandinistic regime the neighbourhood committees for the defence of the revolution (CDS, Comités de Defensa de la Revolución) were formed. The original task of these committees is to look after the needs of the neighbourhood population, but during the war they are responsible for the organisation of militias, the distribution of scarce food products and the handing out of letters of recommendation for solicitations. Local leaders gain power and abuse of this power does come forth. Analogously to the situation in Cuba, the committees are being used as "eyes and ears" of the revolution, in other words spying on neighbourhood members that are suspected of governmental unfriendly thoughts. After the election loss of 1990 the members of the committees begin to question the power of the party. The relation with the sandinistic party (FSLN) becomes conflictuous and the CDS, in the meantime renamed Nicaraguan Community Movement (Movemiento Comunal Nicaragüense) becomes an autonomous, strongly decentralised organisation, which on the neighbourhood level commits itself to education, child- and healthcare (Huysegems, 1998).

In 1990 the Chamorro government tried to set up an alternative system of community organisations, but these committees never really managed to function and have already ceased to exist. Because of the somewhat untying of the MCN with the sandinistic movement, more and more municipalities, including Masaya are acknowledging the MCN-committees as independent community organisations and co-operating with some of them.

At the same time, however, the municipality of Masaya has appointed neighbourhood executives (directivos del barrio) through which the neighbourhood members should communicate with the municipality. The findings in the following paragraph will show that in some cases these executives are co-operating with the MCN committees, but in the most cases they are not. The reason being that the MCN committee has kept its sandinistic ties and the appointed executive is liberal. This political polarisation in many neighbourhoods of Masaya has caused that there exist few neighbourhood committees that serve the entire community instead of just their own political crowd.

### *III.3.3 Participation and practises*

To obtain an insight in the willingness to participate and co-operate of the Masayan community in projects, as well as to find out if there exists any kind of experience with composting, a survey was executed. In 25 of the 50 neighbourhoods in Masaya the communal leaders were interviewed on project experience in their neighbourhood in general, experience with composting, the willingness to participate in a project in general and with regard to composting and the willingness to co-operate with the municipality in the project. In every neighbourhood that was included in the survey the two types of communal leaders were interviewed, that is to say the neighbourhood leader through the MCN and the neighbourhood executive appointed by the municipality. This serves two purposes. Firstly, it makes it able to check the results of one interview with the other to ascertain an objective view. Secondly, it provides us with an insight on the quality of the organisational structure within a neighbourhood. In other words does the neighbourhood committee and executive co-operate to serve the needs of the entire neighbourhood population, or does each one only look after its own people (from the same political background). The set up, execution and the extensive results of the survey is presented in appendix VIII.

**Quality of the organisational structure**

In table III.5 the percentages of neighbourhoods are shown according to their type of organisation. Organised for the entire community means that in these neighbourhoods the communal leader from the MCN and the neighbourhood executive are working together and taking part in the same neighbourhood committee, which executes projects that benefit the entire neighbourhood population. In other words the political polarisation (between sandinistic and liberal) in these neighbourhoods is non-existent or has been made inferior to the communal interest. Unfortunately, organised for part of the community means exactly the opposite, due to the political polarisation the MCN communal leader and the neighbourhood executive are not or hardly working together. Each one executes its own projects for their political part of the neighbourhood and projects that benefit the entire community are not to be found. Marginally organised means that there either doesn't exist a neighbourhood executive or a MCN communal leader, not organised means that there exist neither of he two in that particular neighbourhood.

**Table III.5 Quality of the organisational structure**

| | Percentage of neighbourhoods |
|---|---|
| Organised for the entire community | 24% |
| Organised for part of the community | 60% |
| Marginally organised | 8% |
| Not organised | 8% |

### Project experience

Table III.6 shows the project experience for the neighbourhoods in Masaya. No experience means that no projects have been executed in the neighbourhood, marginal experience 1 to 2 executed projects, reasonable 3 to 5 and much experience more than 5 executed projects in the neighbourhood. Unknown refers to the non-organised neighbourhoods where no communal leaders were to be found and therefore no interview could be executed. The projects generally concern the basic necessities of the neighbourhood, lot ownership, drinking water, electricity, public illumination, sewerage, education, child care (especially comedores infantil), street pavement and neighbourhood security (vigilantes).

**Table III.6 Project experience**

| | Percentage of neighbourhoods |
|---|---|
| Much experience | 20% |
| Reasonable experience | 52% |
| Marginal experience | 20% |
| No experience | 0% |
| Unknown | 8% |

### Willingness to participate and co-operate

Tables III.7, III.8 and III.9 show the willingness to participate in a project in general, the willingness to participate in a composting project and the willingness to co-operate with the municipality in a project, respectively.

**Table III.7 Participation in general**

| | Percentage of neighbourhoods |
|---|---|
| Yes | 68% |
| Yes, but good motivation necessary | 24% |
| No | 0% |
| Unknown | 8% |

The category "yes, but good motivation necessary" refers to the fact that remarks were added by the community leaders that although the neighbourhood population is willing to participate in a project which will in the end benefit the community, they will show little initiative. Therefore good motivation is necessary to get the community well involved in a project. In two neighbourhoods the remark was made that this motivation has to be financially.

In the case of participating in a composting project (participation should be interpreted as at least separating the solid wastes in an organic and non-organic part) this category has mainly the same explanation. One neighbourhood has to be added, however, that requires good motivation, because of a bad experience with another compost project for which the wastes needed to be separated. Another neighbourhood would be willing to participate but at the moment has a higher priority for drinking water and electricity projects. In all the neighbourhoods it was remarked that when executing a composting project (at least source separation) personal education of the neighbourhood members is a necessary requirement.

**Table III.8 Participation in a composting project**

| | Percentage of neighbourhoods |
|---|---|
| Yes | 56% |
| Yes, but good motivation necessary | 36% |
| No | 0% |
| Unknown | 8% |

**Table III.9 Co-operation with the municipality**

| | Percentage of neighbourhoods |
|---|---|
| Yes | 40% |
| Yes, but there is no confidence | 52% |
| No | 0% |
| Unknown | 8% |

Although no neighbourhood is opposed to co-operating with the municipality in a project, more than half of the neighbourhoods have no confidence in the municipality to actually execute a project successfully. These doubts find their origin in the fact that these neighbourhoods have not received or have received little assistance and/or support in earlier projects from this municipality. Another reason for this lack of faith is the poor collection service of the domestic solid wastes by the municipal services as shown in table III.10. A reason for this poor service is the lack of equipment of these municipal services to collect the domestic solid wastes regularly. Other reasons are the unwillingness of the people to pay for the collection and the fact that there are neighbourhoods in which the garbage truck can't and thus doesn't enter. Solid wastes that aren't collected are either picked up by carretoneros (who charge), burned, buried or dumped.

**Table III.10 Garbage collection service**

| | Percentage of neighbourhoods |
|---|---|
| Regularly serviced (twice a week) | 16% |
| Irregularly serviced | 40% |
| Not serviced | 44% |

### Experience with composting

The experience with composting is limited to the experience of separating the solid wastes in an organic and non-organic part for a composting project that was initiated in 1993 by Biomasa but has already ceased to exist. In three neighbourhoods this source separation had not caught on. In two neighbourhoods because of the fact that the community was just not motivated. In the remaining neighbourhood because of disgust with the project (the people in that neighbourhood were forced to pay a more expensive carretonero, since the municipal garbage truck was taken away, as agreed in the project). Experience with regard to the composting process, for instance backyard composting is hardly to be found in the neighbourhoods.

**Table III.11 Experience with composting (source separation)**

| | Percentage of neighbourhoods |
|---|---|
| Experience | 64% |
| No experience | 28% |
| Unknown | 8% |

Finally it is interesting to see if there are and how many neighbourhoods actually satisfy all the conditions that would make the implementation and execution of a composting project the most successful. That is to say a neighbourhood that satisfies the following:
- The neighbourhood is well organised, that is for the entire community.
- There is at least reasonable project experience.
- The people are naturally motivated to participate in a composting project.
- The people see no problem in co-operating with the municipality in a project.
- There exists experience with source separation of domestic solid wastes.
- The neighbourhoods are not or irregularly serviced.

This last condition probably needs some explaining, but when garbage collection is relatively poor, people are easier motivated to participate in a project in this area. Or reasoning along another line. Why should someone participate in a composting project for which this person should separate his garbage, when the garbage collection service is already functioning adequately?

Of the 25 neighbourhoods investigated there are actually three who meet the requirements laid down earlier (Fátima, Jardines de la Barranca and San Francisco).

## III.4 Educational environment

In 1979 the sandinists found an educational system that was the worst in Latin America. In the late seventies just 65% of the children attended primary school and a meagre 22% finished it. Thanks to the efforts of the sandinistic government in the eighties, among others a gigantic alphabetisation campaign, the educational situation for Nicaragua improved considerably.

Nowadays education is decentralised, meaning that private schools have developed. These private schools are mainly dependent on the parents for their financing. Public schools as well, but they can't oblige the payment of tuition money. This, however, along with the fact that children have to buy uniforms and shoes, puts up a barrier for parents to send their children to school.

**Table III.12 Educational results for Nicaragua**
(source: Huysegems, 1998)

| | |
|---|---|
| Primary education (1993) | Nearly all children between the ages 6 and 12 attend primary school |
| Secondary education (1993) | 44% of the girls and,<br>39% of the boys enrols into secondary education |
| Higher education (1993) | Enrolment of 9% |
| Alphabetisation (1995) | 66% of the population over the age of 15 can read and write |

**Table III.13 Education in the municipality of Masaya, 1995**
(sources: Inifom, 1996 & Proconsult, 1997)

| | Urban | Rural | Total |
|---|---|---|---|
| Student population | 25,600 | 7,548 | 33,148 |
| Educational centres | 61 | 38 | 99 |

| | Public | Private | Total |
|---|---|---|---|
| Educational centres | 67 | 22 | 99 |

| | Pre-school | Primary | Secondary | Total |
|---|---|---|---|---|
| Teachers | 132 | 675 | 108 | 915 |
| Educational centres | 22 | 64 | 13 | 99 |

## III.5 Health environment

Due to the war in the 1980s, many of the improvements that the sandinists have established in the health sector are lost. Vaccination campaigns have to be cancelled in war territory. The health care system is flooded with war victims and the economic deterioration leads to shortages in medicine and medical instruments. Because of the declining salaries many physicians leave the public sector. Nowadays the Nicaraguan health care system is based on three components. The elite visits private clinics and travels abroad for special treatments. Employees of the government and the industrial sector can appeal to the Nicaraguan Institute of Social Security. They and their families make up eight percent of the population, but nevertheless the institute uses up to 40 to 50% of the national health care budget. The remaining 90% of the population visits the public hospitals. These are badly administrated, badly equipped and understaffed. Health care services are concentrated in the large cities, rural areas are badly serviced.

During the government Chamorro the health care budget has remained stabile or has slightly declined. This means that with a growing population there is less money available per capita. The increased poverty has caused more sickness and the child mortality that had declined in the eighties has increased again in the nineties. Epidemics as dengue, malaria and cholera are threatening (Huysegems, 1998).

The most frequently occurring diseases within the population of Masaya are acute diarrhoea and different types of parasites, which mainly affect the child population. Other frequent diseases are among others dengue, cholera, and infections of the respiratory system, gastritis, high blood pressure, heart failure and venereal diseases (Proconsult Ingenieros, 1997).

**Table III.14 Health indicators for Nicaragua**
(sources: Huysegems, 1998; Nicaraguan Country Report, 1997)

| | |
|---|---|
| Birth rate (1996) | 33.8 births per 1,000 population |
| Death rate (1996) | 6.0 deaths per 1,000 population |
| Infant mortality rate (1996) | 46 deaths per 1,000 live births before their first year of life |
| Life expectancy (1996) | • population: 66 years<br>• male: 63 years<br>• female: 68 years |
| Fertility rate (1996) | 4.03 children born per woman |
| Health care (1988-1991) | • 1 physician per 2,000 population<br>• 83% of the population lives within acceptable range of a clinic |

# APPENDIX IV Input and output characteristics

## IV.1 Municipal solid waste management in Masaya

The city of Masaya produces an estimated 71,000 kg of solid wastes daily. Households produce 56,306 kg of this total (96,250 population x 0.585 kg per capita per day). The remaining solid wastes originate from the agricultural and industrial sector, the hospitals and public cleaning. The collection and disposal of all these solid wastes is the responsibility of the municipality of Masaya. The collection is performed by an open dump truck with a capacity of 10 $m^3$ and at times assisted by two open trucks from the municipal construction department, when construction works allow for it. Furthermore a tractor with trailer intervenes irregularly when necessary. This is however the same tractor that is used at the landfill (Proconsult Ingenieros, 1998; Servicios Municipales, 1998).

With this capacity it is only managed to collect 44% of the daily produced solid wastes, yet taking in account that collection is performed twice a week in every neighbourhood. This deficiency in collecting has led to the formation of 26 illegal dumpsites throughout the city (Proconsult Ingenieros, 1998).

The final disposition of the municipal solid wastes is done at a landfill located at 9 km North of the city. This area is temporarily lent by its landowner until another site is located. This site has not been prepared in no way whatsoever to receive solid wastes and can therefore be classified as unsanitary. The terrain empties its surface water and dragged along liquid and solid wastes in a river which in its turn empties into the pond of Tisma or in reality the lake of Nicaragua and therefore is contaminating these bodies of water (Servicios Municipales, 1998). The only treatment at the landfill at the moment is covering the wastes with soil by use of a tractor, which is supposed to remain permanently at the site, but at times assists in the collection of the municipal solid wastes (Servicios Municipales, 1998).

## IV.2 Input characteristics

### *IV.2.1 Source and type of the municipal solid wastes*

In the city of Masaya the municipal solid wastes that are collected and disposed of at the municipal landfill are generated at a number of sources, these are:

**Table IV.1 Sources of municipal solid wastes in Masaya**
(source: Servicios Municipales, 1998)

| Source | Monthly generated solid wastes ($m^3$) |
|---|---|
| Domestic | 5,312.00 |
| Public cleaning | 509.00 |
| Commercial (market) | 720.00 |
| Hospitals | 96.00 |
| Industrial | 115.25 |
| Agriculture | 76.75 |
| **Total** | 6,829.00 |

The domestically produced wastes are, as noted before, the main contributor to the total of the municipal solid wastes (56,000 of the total 71,000 kg daily).

Regarding the type of waste it can be remarked that there is no distinction made between hazardous and non-hazardous wastes and all wastes are collected together and dumped at the same landfill. At the domestic level there is no separation in hazardous and non-hazardous wastes. Hospitals do have a burning facility in which the most hazardous wastes are being burned (Servicios Municipales, 1998).

### *IV.2.2 Weight and density of the municipal solid wastes*

With regard to the weight and density of the municipal solid wastes, only the numbers on the domestically produced solid wastes are known.
The production per capita per day is equal to 0.585 kg. With a population number of 96,250 for the city of Masaya in 1998 the total amount produced is equal to 56,306 kg per day. The density of these solid wastes is relatively high and equal to 318 kg per m3. Thus a volume of 177 $m^3$ of solid wastes are produced domestically in the city of Masaya.

**Table IV.2 Domestically produced solid wastes for the city of Masaya, 1998** (source: Servicios Municipales, 1998)

| | |
|---|---|
| Production per capita per day | 0.585 kg/cap/day |
| Population number | 96,250 |
| Total amount per day (weight) | 56,306 kg/day |
| Density | 318 kg/m3 |
| Total amount per day (volume) | 177 m3 |

### *IV.2.3 Composition of the municipal solid wastes*

According to a study performed in 1990 on the solid wastes of the city of Masaya, the percentage of domestically produced organic wastes is very high, of course the organic waste is the part of the solid wastes that can be used to produce compost. This study performed by engineer Peter Duindam of the Technological University of Delft in the Netherlands in collaboration with engineer Carlos Morales of the National University of Engineering in Managua in Nicaragua shows us the following composition of the domestically produced solid wastes (table IV.3). Although these percentages are typical for the composition of the solid wastes for the city of Masaya in 1990, the department of municipal services in 1997 confirms the same figures on the composition of the solid wastes. The department of municipal services is the department within the municipality responsible for the collection and disposal of the municipal solid wastes. These percentages on the composition can therefore be used with relative certainty for the actual situation as well, assuming that they have not changed drastically up till this moment, since they did not change at all between the years 1990 and 1997. This can further be explained by the fact that the economic situation has not improved a great deal over the years, meaning that the domestic consumption pattern and therefore the domestic waste production pattern did not change a great deal either.

**Table IV.3 Composition of domestically produced solid wastes for the city of Masaya**
(sources: Duindam & Morales, 1990; Servicios Municipales, 1997)

| Material | Percentage by weight (%) |
|---|---|
| Organic matter | 85.5 |
| Paper and cardboard | 4.8 |
| Plastics | 3.2 |
| Cloth | 2.5 |
| Metals | 1.6 |
| Glass | 1.5 |
| Leather | 0.9 |
| **Total** | 100 |

### *IV.2.4 Potential waste reduction*

The numbers on the composition and the origin of the municipal solid wastes, allows for the calculation of the waste reduction when the city of Masaya decides to dedicate itself to the composting of the domestically produced solid wastes and in a later stage possibly the market wastes. According to the UNEP-IETC these two types of wastes are appropriate for composting, because they contain a high enough and suitable organic part.

Since the domestically produced solid wastes are 85.5% organic and the part of domestically produced solid waste is 77.8% (5321 $m^3$ out of 6829 $m^3$), the percentage of waste made into compost and thus does not to be landfilled, is therefore 66.5% (85.5% of 77.8%). This is not entirely true, because the composting leaves about 15% rest material that needs to be landfilled as well. This is, however, 15% of the compost that has already experienced a volume reduction of 70% (Departamento de Biomasa, 1994). Thus, to be more accurate the percentage of 66.5% needs to deducted by 3% (15% of 30% of 66.5%) giving an actual waste reduction of 63.5%.

When the marketplace solid wastes will be adopted in the composting system, this percentage will rise to 69.9%. This can be calculated in a similar way. The only difference is that the market wastes are 64% organic (Departamento de Biomasa, 1994).

## IV.3 Output characteristics

### *IV.3.1 Function and use of compost*

Compost is of great importance and use in the agricultural sector, because of the part it plays in the physical, chemical and biological conditions of the soil.

Chemically:
- It assimilates many elements present in the soil and supports fertilising elements.
- The organic matter of the compost establishes a reserve of nutrients in the soil. The maintenance of the level of humus in the soil is essential to ascertain a sufficient reserve capacity of nutrients.
- The humus and the compost have an important regulatory role with regard to the pH of the soil.

Physically:
- Because of its high content of organic matter, compost has great influence on the recuperation of exhausted and eroded soils.
- In heavy and eroded soils, with the help of compost, a better granulation is established, improving the aeration capacity and the water infiltration, supporting the rooting of plants.

Biologically:
- Compost has a stimulating effect on microbial life in the soil and the activity of the roots, acting as a source and reserve of nutrition for itself.
- Supports the abundant micro- and macrofauna present in the soil and beneficiary to the soil.

Compost can be used to enrich the soil for any type of plant. Recommended doses are:
- Cultivation (basic grains, fruits, vegetables, etc.): 2 to 3 lbs per meter.
- Nurseries: 50% compost and 50% earth.
- Young and/or adult trees: 2 to 3 lbs per meter, applying around the top of the three.

Compost can as well be applied in combination with chemical fertilisers in balanced doses to obtain optimal results for the cultivation and the soil.

To make the use of compost a bit more insightful in relation to Nicaraguan land surface measures, in table IV.4 the use of quintales (100 lbs) per manzana are shown for a number of cultivation.

**Table IV.4 Application of compost for a number of cultivation**
(sources: Departamento de Biomasa - UNI, 1994)

| | **Dose** (quintales per manzana) | |
|---|---|---|
| **Cultivation** | Minimum | Maximum |
| Beans | 11 | 15 |
| Corn, sorghum | 11 | 15 |
| Coffee* | 50 | 60 |
| Vegetables | 23 | 27 |
| Avocado | 8 | 13 |
| Pineapple | 40 | 50 |
| Sesame | 55 | 66 |
| Fruits** | 20 | 27 |

* Coffee 1 to 2 lbs per plant

** Citric fruits 10 to 15 lbs per plant

### *IV.3.2 Quality and quantity*

The waste streams composted have a large effect on the quality of the compost. Manual picking and final screening can help to enhance quality, but the best quality will be obtained when the waste stream to be composted is derived from source separation. Furthermore is has to be noted that the smaller the scale of composting, the better a proper composting process and a good product can be ensured (UNEP-IETC, 1996). Concerning the marketability of the compost it goes without saying that the better the quality of the compost, the better for its marketability.

The most common measure in Nicaragua for merchandising products is the quintal (100 lbs). Thus this quantity measure will as well be used as standard for selling the compost. To calculate the number of compost that can potentially be obtained from the domestically produced solid wastes in the city of Masaya.

The actual population of Masaya produces 56,306 kg (177$m^3$) of solid wastes a day from which 85,5% is organic matter and thus eligible to be used for producing compost. This organic material has a volume reduction of 70% in 3 months during the composting process. Of this remaining quantity 85% can be used as compost and 15% will have to be disposed of as waste material. The total amount of compost that can potentially be produced in one year from the domestic solid wastes of the city of Masaya is therefore equal to 267,678 quintales (table IV.5).

| Table IV.5 Quantity of compost that can be produced from the domestic solid wastes of the city of Masaya. (sources: Departamento de Biomasa - UNI, 1994) | | |
|---|---|---|
| | **Relevant data** | **Quantity** |
| **Volume produced per day** | Table 3.3 | 177 $m^3$ |
| **Volume produced per year** | 1 year = 365 days | 64,605 $m^3$ |
| **Volume of organic wastes Per year** | 85.5% of the wastes are organic (table 3.4) | 55,237.3 $m^3$ |
| **Volume of organic material After 3 months** | Volume reduction of 70% | 16,571.2 $m^3$ |
| **Volume of compost per year** | 85% compost - 15% rest material | 14,085.5 $m^3$ |
| **Weight of compost per year** | Compost density is 862 kg/m3 | 12,141,705 kg |
| **Number of quintales per year** | 1 quintal = 100 lbs; 1 kg = 2.20462 lbs | 267,678 qq |

### *IV.3.3 Price and appearance*

When pricing the compost, in this case 100 lbs (one quintal) of compost, it has to be taken into account that this price hardly ever can be set to make the composting process profitable. The compost has to be priced below the price of commercial fertilisers, to guarantee its marketability. In Nicaragua compost will have to compete with chemical fertilisers which are subsidised by the national government to be used in the agricultural sector. This means that the price of a quintal of compost cannot exceed 1.5 US dollars (Zelaya, 1998).

Not just the pricing and quality of the compost is important for its marketability. It is just as important how the compost appears to the possible consumer or rather how the compost is presented. Whether or not the composting facility is willing to deliver the compost to its consumers is an issue in this matter as well as whether the quality of the compost is guaranteed by a testing procedure which is supported by a governing authority. Finally presenting the compost accompanied with information on its usefulness and application, as well as information on its contents (for example, the nutrient value) and quality plays an important role in convincing hesitant or reluctant buyers.

# APPENDIX V Technological environment

## V.1 Technology climate

The indicators used for the technology climate have already been discussed in appendix III, since they coincide in great part with the social system features. In this paragraph we will therefore suffice with a summary of the findings for the technology climate variables and an explanation of the implications of these findings for the technology climate.

### *V.1.1 National economic data*

As far as the economic figures are concerned, it is a welcome development that, although Nicaragua is still struggling with the dreadful heritage of a ruined economy less then a decade ago, the economy is picking up. Economic growth figures are good and inflation is relatively controlled. On the other hand we must not forget that the foreign debt is still huge and that foreign trade figures still have a negative effect on the trade balance. Moreover income distribution and employment figures are still shocking.

From the viewpoint of these data it is therefore obvious that with regard to the technology climate and a possible technology transfer or development, a large preference must be given to a simple labour-intensive technology. Not just because of the employment opportunities it creates, but because of the low cost of unskilled labour in Nicaragua as well. When capital inputs need to be acquired for a certain process, one must limit oneself to a minimum of purchases from abroad in view of the foreign debt situation.

### *V.1.2 Political orientation, changes and stability*

For the past two decades the threat of political violence and turmoil has kept potential investors out of Nicaragua. This political turmoil has, however, been declining steadily with the last two administrations of Violeta Chamorro and Arnoldo Alemán. With a constitution that guarantees the basic human rights and a liberal economy the political basis for attracting investors is present. All that remains is a little bit of trust from these investors that the political situation is stable and will be so in the future.

### *V.1.3 Education*

The literacy rate has increased significantly since the 1980's and is nowadays up to 66%. At the moment almost every child is receiving basic education, but secondary and especially higher education enrolment is low. Therefore the supply of skilled labour is relatively low and has in this regard a negative effect on the technology climate.

### *V.1.4 Health*

The health care system and health situation are relatively poor. Medical facilities are very unevenly distributed amongst the population. From rich to poor and from urban to rural. Moreover the increased poverty has caused more sickness and an increase in child mortality as opposed to the 1980's. Epidemics are threatening, especially since the recent natural disaster caused by hurricane Mitch and sanitation facilities and drinking water supply are far from adequate. All in all the health situation does not contribute all too positively to the technology climate.

### *V.1.5 Population*

The Nicaraguan population is still growing rapidly. The average age of a mother receiving the first child is around 16. Half of the population is 15 years or younger and two thirds of the population is below 18. Urbanisation rates are still high, since rural conditions remain poor and unemployment is high, meaning that many come for the rural areas to the city hoping to improve their situation.

### *V.1.6 Infrastructure*

Nicaragua's road network is far from ideal. Especially the condition of the roads is poor. Roads into the rural areas are composed of sand and dirt and full of holes and take its toll on the transport equipment, which are not in such a perfect condition in the first place. Electricity and telecommunication connections are low, more so in the rural areas than in the urban areas and the rail network ceased to exist in 1995.

## V.2 Technological capabilities

The available technological capabilities, represented in technology stock and infrastructure and human and natural resources, in the municipal solid waste management sector will be looked upon primarily. Since composting of solid wastes needs to form an integrated part of the municipal solid waste management sector, the capabilities in this sector will eventually determine the technology choice for composting.

### *V.2.1 Technology stock*

The collection and disposal of the solid wastes is the responsibility of the municipality of Masaya, through its department for municipal services. The collection is performed by an open dump truck with a capacity of 10 $m^3$ and at times assisted by two open trucks from the municipal construction department, when construction work allows for it. A tractor with trailer assists irregularly when possible, because it is the same tractor that is used at the landfill. The equipment and tools used and owned by the municipal services department is therefore limited to the open dump truck, a tractor, a trailer and rakes and shovels. The state of the equipment is very poor and maintenance is performed irregularly or rather when necessary repairs have to be done (Servicios municipales, 1998).

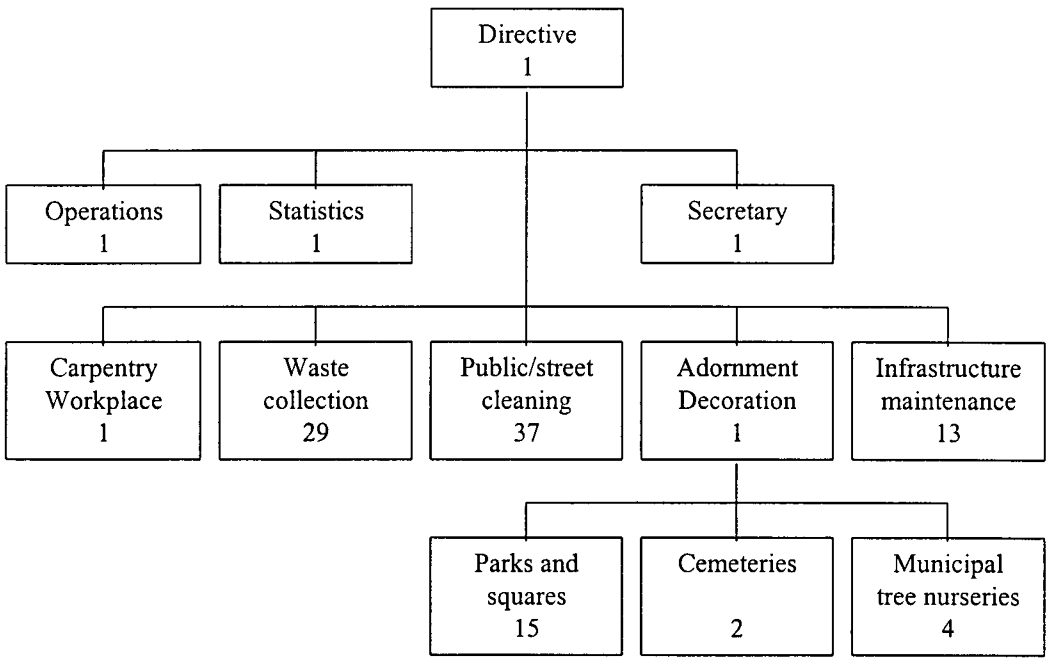
Furthermore, private garbage collectors are active in the municipal solid waste sector, since the public services are very poor and inadequate. Their equipment consists of a horse and carriage.

With regard to the composting component in the MSWM sector, the only experience so far and probably for the entire country, has been the Biomasa composting project for a part of the city of Masaya, which has, however, ceased to exist. Therefore equipment and tools to assist in the composting process are not be found locally in the MSWM sector (Clorinda Zelaya, 1998).

### *V.2.2 Human resources*

In figure V.1 the structure of the municipal services for the municipality of Masaya is shown, alongside with the number of personnel active in the department. The management personnel and the office personnel can be considered skilled, although in the case of the management personnel this skill is primarily based on the experience within the sector. The remaining personnel can be considered unskilled. With regard to skills or knowledge about composting (the actual process and the available technologies) are non-existent. The management is however convinced of the function of compost and the environmental benefits of composting as opposed to dumping.

**Figure V.1 Structure of the municipal services department of Masaya**
(source: Servicios Municipales, 1998)



The private garbage collectors, which make use of the horse and carriage, will have to be considered as unskilled labourers. The people of Biomasa, who were involved in the composting project can however be considered as skilled people with knowledge on the composting process. The employees, besides the management, of the project will have to be considered as unskilled, although they have gained experience in the field of composting.

### *V.2.3 Natural resources*

The locally available inputs in the process of municipal solid waste management are fuel for the dump truck and the tractor and soil to cover the dumped solid wastes at the landfill. Inputs necessary for the composting process as water, oxygen, organic solid wastes and the appropriate microbial environment are locally available. This holds up for possible complementary nitrogen or carbon containing organic materials as well.

### *V.2.4 Technology infrastructure*

The actors playing a role in the Municipal Solid Waste Management sector are first of all the municipality of Masaya, through its municipal services department for the organisation and execution of activities within the MSWM sector. Thus the set-up of a composting system as well. The municipality itself will, however, play an important role in supporting and promoting this composting system as well. Other important actors are the foreign municipalities, which are connected to Masaya through the city links. They can provide managerial and financial support. The previously mentioned organisation Biomasa, which is connected to the National University of Engineering, is considered a consulting institution, which can assist technically and inhoudelijk. Contact between the organisations is in general not very frequent, nor very productive. The most productive contacts are there between the municipality of Nijmegen (The Netherlands) and the municipality Prievidza (Czech Republic).

## V.3 Conclusion

Summarising the indicators on the technology climate and the technological capabilities put forward in the previous two paragraphs, we can conclude that the technological environment for Masaya and the municipal solid waste management sector in particular is not all that promising. When considering technology development and possibly technology transfer for Masaya, it is therefore, in view of these indicators, recommendable to use a simple low-cost technology that can be acquired or developed locally to obtain maximum success.

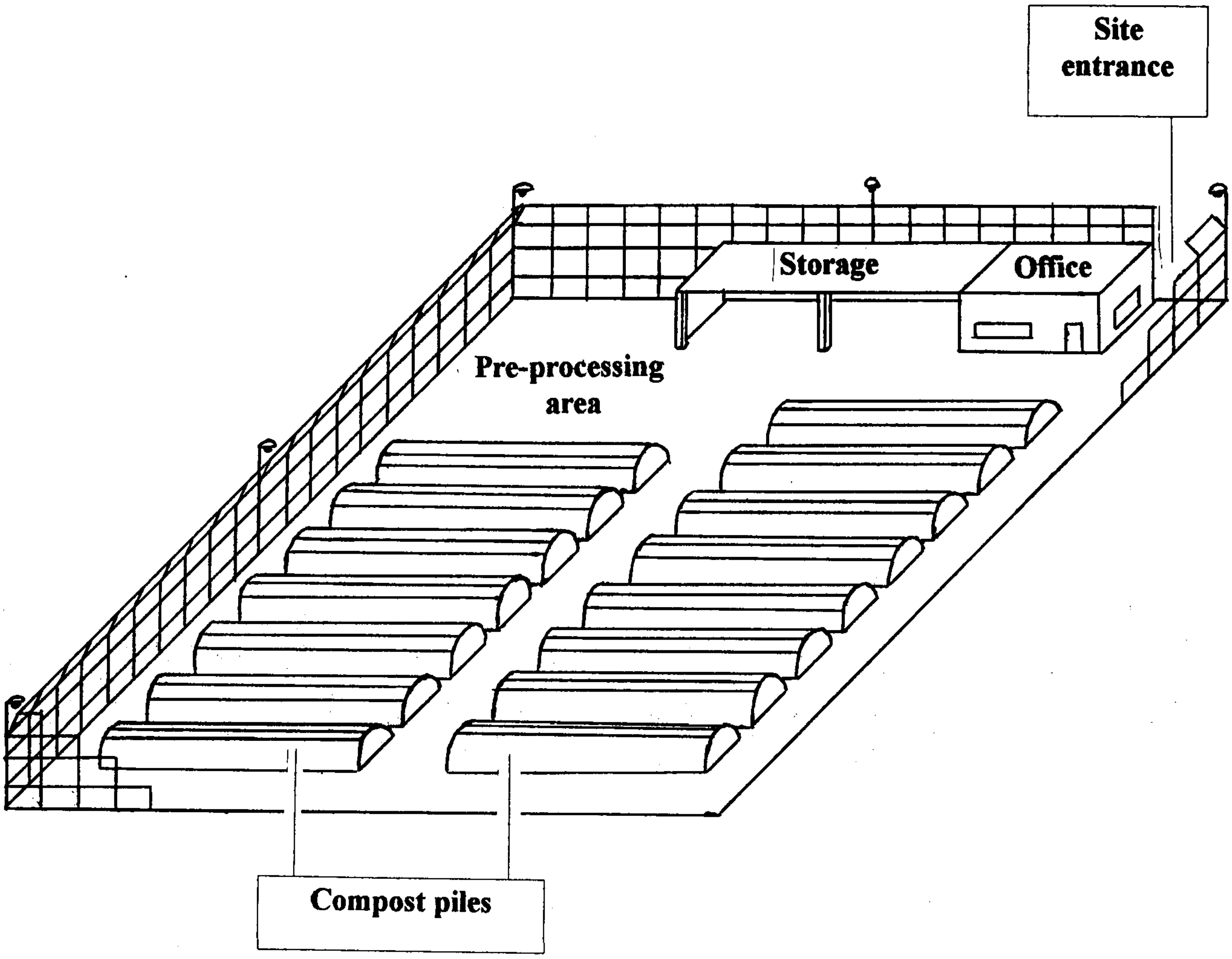
# APPENDIX VI Opportunity study for the pilot project

This appendix will give a global cost analysis of the setting up and execution of the pilot composting project as suggested in chapter 3 of this report. Conclusions based on this analysis are to be found in this chapter as well. To make everything a bit more insightful a drawing of the compost site is added to this appendix as well.

The following considerations have been made for this cost analysis.

- The plant processes the wastes of 1500 households; equivalent to 14.16 $m^3$ of organic wastes a day.
- This input produces up to approximately 25,000 quintales (100 lbs) of compost a year.
- Piles have a volume of 85 $m^3$ and a height of 1.75m. This volume coincides with constructing one new compost pile every week.
- There is room necessary for 15 piles, meaning that the site location should be at least 45 by 55m, allowing for the necessary infrastructure facilities.
- Depreciation is linear.
- Repair and maintenance is 2% of the costs on civil works, plant and office equipment.
- Working capital is the cost of four months of the less fixed costs (new investments not included) and the wages.
- Data on water supply, fuel supply, electricity and wages were derived from the Biomasa compost project proposal.

# APPENDIX VI.1 Drawing of the compost site




Scale
1 : 500

Table VI.1 Total investment costs (US Dollars)

| Total investment costs | Year 0 | Year 2 | Year 4 | Year 5 | Year 6 | Year 8 | Year 10 |
|---|---|---|---|---|---|---|---|
| **1. Total fixed investment** | **59770** | **420** | **420** | **1550** | **420** | **420** | **420** |
| **Site preparation and development** | **3500** | **0** | **0** | **0** | **0** | **0** | **0** |
| Levelling | 1000 | | | | | | |
| Fence | 2500 | | | | | | |
| **Civil works, structures and buildings** | **10250** | **0** | **0** | **0** | **0** | **0** | **0** |
| Building & storage facility | 2000 | | | | | | |
| Lighting & electricty | 7500 | | | | | | |
| Irrigation network | 750 | | | | | | |
| **Plant machinery and equipment** | **44620** | **420** | **420** | **150** | **420** | **420** | **420** |
| Tractor | 40000 | | | | | | |
| Trailer | 3500 | | | | | | |
| Scale balance | 550 | | | | | | |
| Thermometer | 150 | | | 150 | | | |
| Sieves (3) | 420 | 420 | 420 | | 420 | 420 | 420 |
| **Office equipment** | **1400** | **0** | **0** | **1400** | **0** | **0** | **0** |
| Desk and chair | 400 | | | 400 | | | |
| Archive | 400 | | | 400 | | | |
| Typewriter | 400 | | | 400 | | | |
| Calculator | 200 | | | 200 | | | |
| **2. Net working capital** | **9325** | **0** | **0** | **0** | **0** | **0** | **0** |
| Work tools | 1763 | | | | | | |
| Protection equipment | 46 | | | | | | |
| Water | 431 | | | | | | |
| Fuel | 42 | | | | | | |
| Electricity | 31 | | | | | | |
| Wages | 7013 | | | | | | |
| **Total Investment costs** | **69095** | **420** | **420** | **1550** | **420** | **420** | **420** |

**Table VI.2 Gross profit** (US Dollars)

| Gross profit | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total income** | **28168** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** |
| Sales revenues | 28168 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 |
| **Less variable costs** | **20313** | **25866** | **25866** | **25866** | **25866** | **25866** | **25866** | **25866** | **25866** | **25866** |
| Depreciation | 3653 | 3653 | 3653 | 3653 | 3653 | 3653 | 3653 | 3653 | 3653 | 3653 |
| Repair & Maintenance | 882 | 1175 | 1175 | 1175 | 1175 | 1175 | 1175 | 1175 | 1175 | 1175 |
| Wages | 15778 | 21038 | 21038 | 21038 | 21038 | 21038 | 21038 | 21038 | 21038 | 21038 |
| **Less fixed costs** | **5228** | **7390** | **6970** | **7390** | **8520** | **7390** | **6970** | **7390** | **6970** | **7390** |
| New investments | | 420 | | 420 | 1550 | 420 | | 420 | | 420 |
| Work tools | 3966 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 |
| Protective equipment | 129 | 172 | 172 | 172 | 172 | 172 | 172 | 172 | 172 | 172 |
| Water | 970 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 |
| Fuel | 94 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 |
| Electricity | 69 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| **Gross profit** | 2627 | 4301 | 4721 | 4301 | 3171 | 4301 | 4721 | 4301 | 4721 | 4301 |

| Table VI.3 Variable costs (US Dollars) | |
|---|---|
| **Variable costs** | **Annualy** |
| **1. Work tools** | **5288** |
| Machete (cane knives) (4) | 12 |
| Hand carts (4) | 140 |
| Spades (4) | 16 |
| Tridents (4) | 100 |
| Bags (25,100) | 5020 |
| **2. Protective equipment** | **138** |
| Boots (16 pairs) | 88 |
| Face masks (16) | 26 |
| Gloves (16 pairs) | 24 |
| **3. Wages** | **21038** |
| Project director (1) | 3875 |
| Tractor operator (1) | 2375 |
| Field workers (8) | 12800 |
| Guard (1) | 1988 |
| **4. Water** | **1293** |
| **5. Fuel** | **125** |
| **6. Electricity** | **92** |
| **Total variable costs** | **27974** |

| Table VI.4 Wages (US Dollars) | | | | | | |
|---|---|---|---|---|---|---|
| | Monthly income | Year income | Insurance | Holidays | 13th month | **Total** |
| Project director | 250 | 3000 | 375 | 250 | 250 | 3875 |
| Tractor operator | 150 | 1800 | 225 | 175 | 175 | 2375 |
| Field worker | 100 | 1200 | 150 | 125 | 125 | 1600 |
| Guard | 125 | 1500 | 187.5 | 150 | 150 | 1987.5 |

| Table VI.5 Water | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Time** | | **Use** | | | | **Costs** | |
| Size of Pile (m3) | Nr. of Piles | Nr. of Waterings a month | Watering per pile (sec) | Total time (sec) | Total Use (gl) | Total watering (m3) | Cleaning 20% (m3) | Total Use (m3) | Month (US$) | Year (US$) |
| 85 | 15 | 10 | 73.913 | 11087 | 23726 | 89.804 | 17.9607 | 107.8 | 107.8 | 1293 |

**Note:**
One pile of 23 m3 is watered in 20 seconds
In 5 seconds 10.7 gallons of water is used
1 m3 of water is equal to 264.2 gallons
The cost of water is 1 US$ per 1 m3

**Table VI.6 Fuel**

The weekly amount of organic wastes is equal to 85 m3 or 46,750 kg
This equals 46.75 tons
The capacity of the trailer is 8 ton
Therefore 6 trips a week need to be made
One trip uses 0.2 gallons of fuel
In one year (6*0.2*52) 62.4 gallons of fuel is used
The price of fuel is 2 US$ a gallon
The yearly costs on fuel are 125 US$

**Table VI.7 Electricity**

Electricity use is 2.5 kwh a day
1 kwh costs 0.10 US$
Yearly electricity cost: 2.5*365*0.10 = 92 US$

| Table VI.8 Depreciation (linear) (US Dollars) | | | |
|---|---|---|---|
| | Value | Lifetime | Annual depreciation |
| **Civil works, structures and buildings** | | | |
| Fence | 2500 | 15 | 167 |
| Building & storage facility | 2000 | 15 | 133 |
| Lighting & electricty | 7500 | 15 | 500 |
| Irrigation network | 750 | 15 | 50 |
| **Plant machinery and equipment** | | | |
| Tractor | 40000 | 20 | 2000 |
| Trailer | 3500 | 15 | 233 |
| Scale balance | 550 | 11 | 50 |
| Thermometer | 150 | 5 | 30 |
| Sieves (3) | 420 | 2 | 210 |
| **Office equipment** | | | |
| Desk and chair | 400 | 5 | 80 |
| Archive | 400 | 5 | 80 |
| Typewriter | 400 | 5 | 80 |
| Calculator | 200 | 5 | 40 |
| **Total depreciation** | | | **3653** |

# APPENDIX VI.3 Opportunity study 2

This second part of the opportunity study looks upon the total investment costs and the gross profit, when the tractor and trailer are replaced for two more field workers and four more handcarts. Meaning that the carrying of the wastes to the place to set up the pile and the carrying of the matured compost to the storage facility will be done by human power instead of the tractor's horsepower.

Changes from the previous opportunity study are the following:

- The tractor and trailer costs are no longer part of the total investment costs, depreciation costs and the repair and maintenance costs.
- The wages and thus the variable costs gain two more field workers and lose the tractor operator.
- The costs of the four more handcarts and more protective equipment is added on to the variable costs.
- The fuel costs that were meant for the tractor are left out in the variable costs.
- Obviously the net working capital costs change, since the variable costs have changed.

Table VI.9 Total investment costs (US Dollars)

| Total investment costs | Year 0 | Year 2 | Year 4 | Year 5 | Year 6 | Year 8 | Year 10 |
|---|---|---|---|---|---|---|---|
| **1. Total fixed investment** | **16270** | **420** | **420** | **1550** | **420** | **420** | **420** |
| **Site preparation and development** | **3500** | **0** | **0** | **0** | **0** | **0** | **0** |
| Levelling | 1000 | | | | | | |
| Fence | 2500 | | | | | | |
| **Civil works, structures and buildings** | **10250** | **0** | **0** | **0** | **0** | **0** | **0** |
| Building & storage facility | 2000 | | | | | | |
| Lighting & electricty | 7500 | | | | | | |
| Irrigation network | 750 | | | | | | |
| **Plant machinery and equipment** | **1120** | **420** | **420** | **150** | **420** | **420** | **420** |
| Scale balance | 550 | | | | | | |
| Thermometer | 150 | | | 150 | | | |
| Sieves (3) | 420 | 420 | 420 | | 420 | 420 | 420 |
| **Office equipment** | **1400** | **0** | **0** | **1400** | **0** | **0** | **0** |
| Desk and chair | 400 | | | 400 | | | |
| Archive | 400 | | | 400 | | | |
| Typewriter | 400 | | | 400 | | | |
| Calculator | 200 | | | 200 | | | |
| **2. Net working capital** | **9616** | **0** | **0** | **0** | **0** | **0** | **0** |
| Work tools | 1809 | | | | | | |
| Protection equipment | 57 | | | | | | |
| Water | 431 | | | | | | |
| Fuel | 0 | | | | | | |
| Electricity | 31 | | | | | | |
| Wages | 7288 | | | | | | |
| **Total Investment costs** | **25886** | **420** | **420** | **1550** | **420** | **420** | **420** |

**Table VI.10 Gross Profit (US Dollars)**

| Gross profit | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total income** | **28168** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** | **37557** |
| Sales revenues | 28168 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 | 37557 |
| **Less variable costs** | **18046** | **23588** | **23588** | **23588** | **23588** | **23588** | **23588** | **23588** | **23588** | **23588** |
| Depreciation | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 |
| Repair & Maintenance | 229 | 305 | 305 | 305 | 305 | 305 | 305 | 305 | 305 | 305 |
| Wages | 16397 | 21863 | 21863 | 21863 | 21863 | 21863 | 21863 | 21863 | 21863 | 21863 |
| **Less fixed costs** | **5134** | **7265** | **6845** | **7265** | **8303** | **7265** | **6845** | **7265** | **6845** | **7265** |
| New investments | | 420 | | 420 | 1550 | 420 | | 420 | | 420 |
| Work tools | 3966 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 | 5288 |
| Protective equipment | 129 | 172 | 172 | 172 | 172 | 172 | 172 | 172 | 172 | 172 |
| Water | 970 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 | 1293 |
| Fuel | | | | | | | | | | |
| Electricity | 69 | 92 | 92 | 92 | | 92 | 92 | 92 | 92 | 92 |
| **Gross profit** | 4988 | 6704 | 7124 | 6704 | 5666 | 6704 | 7124 | 6704 | 7124 | 6704 |

| Table VI.11 Variable costs (US Dollars) | |
|---|---|
| **Variable costs** | **Annualy** |
| **1. Work tools** | **5428** |
| Machete (cane knives) (4) | 12 |
| Hand carts (8) | 280 |
| Spades (4) | 16 |
| Tridents (4) | 100 |
| Bags (25,100) | 5020 |
| **2. Protective equipment** | **172** |
| Boots (20 pairs) | 110 |
| Face masks (20) | 32 |
| Gloves (20 pairs) | 30 |
| **3. Wages** | **21863** |
| Project director (1) | 3875 |
| Field workers (10) | 16000 |
| Guard (1) | 1988 |
| **4. Water** | **1293** |
| **6. Electricity** | **92** |
| **Total variable costs** | **28848** |

| Table VI.12 Depreciation (linear) (US Dollars) | | | |
|---|---|---|---|
| | Value | Lifetime | Annual depreciation |
| **Civil works, structures and buildings** | | | |
| Fence | 2500 | 15 | 167 |
| Building & storage facility | 2000 | 15 | 133 |
| Lighting & electricty | 7500 | 15 | 500 |
| Irrigation network | 750 | 15 | 50 |
| **Plant machinery and equipment** | | | |
| Scale balance | 550 | 11 | 50 |
| Thermometer | 150 | 5 | 30 |
| Sieves (3) | 420 | 2 | 210 |
| **Office equipment** | | | |
| Desk and chair | 400 | 5 | 80 |
| Archive | 400 | 5 | 80 |
| Typewriter | 400 | 5 | 80 |
| Calculator | 200 | 5 | 40 |
| **Total depreciation** | | | **1420** |

# APPENDIX VII Composting technologies

## VII.1 Introduction

In this appendix we will present the range of sustainable composting technologies as composed by the United Nations Environment Program – International Environmental Technology Centre. The range of technologies that are available for the composting process itself, to assist in the selection of an appropriate technology, will be described. Firstly, however, the siting and scale of composting will be addressed, discussing the technological options available and a brief explanation of the composting process will be given.

## VII.2 What is composting?

Composting is the biological decomposition of complex animal and vegetable materials into their constituent components. Composting is a natural process of bacteria and other organisms eating what they like in a favourable environment. The most common form of composting, aerobic composting, takes place in the presence of oxygen. Aerobic bacteria require a mix of approximately one part nitrogen to at least 30 and no more than 70 parts carbon in their food supply. Aerobic bacteria also require at least 40% but no more than 60% water in their environment, and a plentiful supply of oxygen. In the absence of any one of these four factors, the composting process will fail. The products of aerobic composting are steam, carbon, dioxide, and decomposed organic material, called humus.

Anaerobic composting, also called anaerobic digestion takes place in the absence of oxygen. Anaerobic bacteria live in the absence of oxygen and can consume mixtures with a higher proportion of nitrogen and lower proportion of carbon. Anaerobic digestion can also occur at higher levels of moisture. The products of anaerobic digestion are methane gas and decomposed organic material. To recover the gas, anaerobic systems are enclosed in a pressurised environment.

Composting bacteria operate on the surfaces of compostable materials. That means that composting works well with small particles of waste and poorly with large pieces of organic material. For this reason, size reduction or shredding is frequently required prior to composting to allow for adequate bacterial decomposition.

All solid waste composting is based on one or both of these biological processes. Differences in technology relate to input materials, pre-processing techniques, and the way in which the environment for bacterial action is created and maintained, but not to the composting process itself.

Composting is the only solid waste management technology that depends on bacteria for its correct functioning. The task of maintaining the correct environment for bacteria requires significantly different areas of knowledge and different management strategies than operating a collection system or incinerator or running a landfill. This is important to consider in any analysis of the success or failure of composting systems.

### *VII.2.1 Volume reduction in composting*

All true composting processes result in volume reduction, since the action of the bacteria transforms materials into steam and gases, while insects and micro-organisms also feed on the organics. Additional volume reduction occurs due to removal of non-compostables during pre-processing or final screening, in addition to the moisture loss and volume reduction during composting itself. Thus a 100-ton-per-day facility will produce only 30-50 tons of compost per day.

### *VII.2.2 Duration of composting*

Composting is completed when the compostable materials have been completely converted to humus. Re-wetting the material and observing if it heats up again, which indicates that there are still uncomposted materials in the pile can test stability of compost. Most aerobic composting systems include a period of active composting, generally from 21 to 60 days, and a period of curing, generally from 6 to 24 months.

Intensive aeration and inoculation of the piles with suitable bacteria can accelerate composting. More land is required when the period of composting is longer because the throughput of wastes is slower. In places where land for siting is scarce, sound practice may entail selection of more intensive management practices instead of more extensive land use.

## VII.3 Siting and scale of composting

Most compost systems require open land for establishing and manipulating compost piles. In many ways, the kinds of land and sites available dictate the choice of a composting system. Sustainable practice in siting for facilities other than backyard bins includes:

- Selection of a site with suitable access for the form of transportation;
- Availability of a buffer area between the site and nearby land users, to minimise the nuisance of waste and compost odours;
- Appropriate soil for absorption or collection of leachate; and
- The possibility of placing the compost in a building, in cases where there is a need to control climate or a greater need to buffer the surrounding environment.

### *VII.3.1 Backyard composting*

Backyard composting can be a formal strategy for the management of the organic waste stream in a region. Backyard composting represents the smallest scale of composting and is a sustainable approach when:

- A significant number of households have individual or collective yards or gardens, and there is enough room for a compost pile;
- Composting is culturally familiar to most people; and
- The waste stream to be composted contains primarily vegetable matter; since it is easier to control rodents and insects when little animal matter is present.

### *VII.3.2 Decentralised neighbourhood-, block-, or business-scale composting*

The next larger scale for composting is the neighbourhood-, block-, or business-scale composting site. Such facilities can provide a waste management opportunity to a small group of people at a relatively low cost. Small-scale composting uses the wastes of a number of households, shops, or institutions; the composting is done on unused land, beside community gardens, or in parks. This may be called multi-source or decentralised composting, in contrast to backyard composting, where the wastes are from one source. These sites, which usually process less than five tons of waste per day, can be smaller than municipal sites and generally reduce the need for movement of compostable materials.

Sustainable practice for siting neighbourhood composting sites requires that they:

- Be accessible to all who want to use them;
- Be clearly designated with signs that all users and non-users can read or interpret;
- Be sited with the agreement of the surrounding land users;
- Have adequate fencing or control to prevent the site becoming an open dump; and
- Have appropriate soil to absorb leachate.

For neighbourhood compost piles to work there must usually be a compost monitor or supervisor within the user community who takes responsibility for maintaining order and cleanliness. Sustainable practice generally requires backup from the municipal government in terms of technical and logistical support for removal of undesired items or turning of the piles.

### *VII.3.3 Decentralised composting on the village and community scale*

Composting is clearly a sustainable practice for management of compostable waste streams at the village or community scale. Centralised composting of this type, whether privately or publicly developed, must come under the jurisdiction of the municipal or community authorities, which accept responsibility for its operation. These facilities will generally be in the range of 2 to 50 tons per day, depending on the size of the community and the proportion of compostable materials in the waste stream.

Siting is important, and sustainable practice requires that the compost operation follow the siting guidelines listed above for neighbourhood composting. At this scale, it may also be necessary for the site to accommodate more turning, processing, screening and storage of the compost than at smaller scales.

### *VII.3.4 Centralised composting at the municipal scale*

Centralised composting refers to composting of animal and plant wastes from multiple sources, where the wastes are transported from several points to a facility that can receive 10 to 200 tons per day.

Municipal-scale composting plants receive wastes from a single jurisdiction, usually a city, sometimes including associated suburbs or squatter settlements. Municipal-scale centralised plants are distinguished from regional facilities by differences in scale, management, financing, and siting.

At this scale, sustainable practice for siting of the compost facility in industrialised countries must usually be a formal process that includes:

- A technical assessment of the area, soil, and geographic attributes of potential sites;
- The involvement of engineering and design professionals in site selection and design;
- Environmental assessment of the potential sites
- A formal evaluation and selection process to involve all stakeholders;
- A formal remediation or compensation program to minimise and/or compensate for nuisance effects of traffic, odour, leachate, and noise at the composting site;
- A separate collection and/or pre-processing system to ensure that only desired materials actually enter the compost system itself, with appropriate attention to the role of waste pickers or the informal sector in pre-processing and recovery of non-compostables; and
- A formal system for using and/or marketing the finished compost.

### *VII.3.5 Centralised composting at the regional scale*

Centralised regional composting facilities generally have a design capacity of more than 50 tons per day, and as much as 1000 tons per day. In addition to the siting and design requirements cited above, sustainable practice for regional scale composting includes:

- A siting process that takes into account the equity effects of siting a compost plant for many jurisdictions within the boundaries of one of them. A frequent strategy here is to distribute the sites for landfill, compost plant, and incinerator (if part of the system) between different municipalities;
- Agreements between the participating municipalities or jurisdictions for siting, design, financing, operations, maintenance, environmental compliance, and billing for services;
- Enforceable protocols for the quality and composition of the compostable materials delivered to the facility, since a failure of separation from any one can contaminate the compost for all participating jurisdictions;
- Agreements between the jurisdictions for use, take-back, and marketing of the finished compost;
- Waste delivery agreements and commitments from the various participating jurisdictions; and
- Designated routes for delivery of compostables.

### *VII.3.6 Composting at landfill and incinerator sites*

Particularly in developing countries, but increasingly in industrialised countries as well, composting facilities may be located at landfill sites. This allows separately collected organic or yard wastes to be processed at the landfill. Siting is simplified or rolled into the landfill siting process.

Sustainable practice here differs in industrialised and developing countries. In industrialised countries, sustainable practice will usually require that the composting operations be separate from the landfill, have their own scale or separate entrance, and that the resulting compost be split between low-quality product used in landfill operations as daily and final cover, and high-quality for others uses.

In developing countries, where the waste stream has a sufficiently high proportion of organic materials, wastes may be left to decompose at the landfill or dump. In such cases of "natural composting" sustainable practice requires a clear decision about the role of decomposition processes in landfill management. This includes a decision whether or not to remove the top layers of material once they are partially decomposed, either for further composting or for use in agriculture, and whether to allow farmers to remove compost from the landfill or dump.

## VII.4 Technologies for composting

All composting processes consist of bacteriological decomposition of the waste materials. The differences in the systems described here relate to the management of that biological process, to its speed and temperature, and to the strategies for controlling moisture and aeration, and not the decomposition process itself.

### *VII.4.1 Small-scale composting of animal wastes*

Composting and digestion of bones is carried out as a small industry in some developing countries. It can produce ingredients in the manufacture of fertiliser, animal feed, and glues. The traditional methods of sun-drying, breaking up bones manually, composting in pits (sometimes with the addition of household organics), and steam digestion carry various health risks, and cannot be considered a sustainable practice.

Small-scale aerobic composting of animal wastes, including manure, hide scrapings and tannery and slaughterhouse wastes can also produce fertilisers, but carry some pathogenic risks. All of these types of small enterprises generate leachate and associated bad odours, and are typically associated with poor working conditions and risks to worker health, but may be profitable and provide subsistence income. Sustainable practice could include introducing technical and health improvements, rather than eradicating the activities themselves.

### *VII.4.2 Co-ordinated backyard compost systems*

Backyard composting generally consists of household-level aerobic decomposition of household organic garden and kitchen wastes, with the resulting compost being used in the yard itself. Close proximity of yards to each other in many neighbourhoods in both industrialised and developing countries implies a need for management of the compost for vector and odour control, including periodic aeration or turning.

In recent years, a number of governments in industrialised countries have treated backyard composting as means of waste reduction, since the materials which are composted remain at home and do not enter the municipal waste stream.

Sustainable practice in organised backyard composting systems includes the following:

- Government purchase or subsidy of backyard composters, which contain the waste, prevent animal raiding, and facilitate aerobic conditions; and
- An intensive program of public education, usually including the visit of a volunteer or paid trainer to each individual household.

Such backyard composting and mulching programs, which have operated successfully in Northern Europe, North America, Australia, and New Zealand are much less costly to a community than centralised compostable collection programs. They have participation rates approaching 30%, with significant results in terms of wastes diverted from the municipal waste stream.

Particularly in developing countries, rodents and vectors are a concern in cities with high pest populations. Consequently, municipal health officers frequently advise against backyard composting, and in some places it is prohibited by the health code. The screens on vermicompost pits in Bangalore to keep out rodents are a visible reminder to the public of the need for careful management of backyard and neighbourhood composting.

### *VII.4.3 Pre-processing*

Pre-processing is a technical component of almost all composting systems above the level of backyard composting. Pre-processing is usually necessary to create the conditions for bacterial action.

Pre-processing consists of three separate systems of operations:

- Separation or removal of oversize, non-compostable, or dangerous materials;
- Size reduction, through chipping, grinding or shredding, to create many small particles suitable to sustaining bacterial action; and
- Blending and compounding, to adjust the carbon-nitrogen ratio, moisture content, or structure of the materials to be composted.

Mechanical pre-processing is often the most costly part of a composting system, as well as the most vulnerable to breakdown. For this reason, sustainable practice in composting involves minimising pre-processing to the greatest extent possible by pre-selecting the waste streams to be composted through source separation and separate collection.

### *VII.4.4 Windrow and active pile systems*

A sustainable, simple form of composting involves building piles of compostables. The piles, called windrows, form the basic environment for compost bacteria and other organisms to perform decomposition.

Important considerations in planning windrows include:

- The size of the windrows, which must be of sufficient mass to allow for heat build-up. The composition of the wastes and the climate are the two primary determinants of windrow size.
- The shape of the windrows, which is related to the type of aeration that is used and the type of equipment used to aerate;
- Whether the windrows are open or covered, which depends on the climate and the moisture content of the waste; and
- The spacing of the windrows, which is dependent on the size of the site and type of equipment used.

Active pile systems require manual or mechanical turning of the windrows, with crews using shovels or rakes, or with equipment such as a bulldozer, tractor, or windrow turning machine. Turning aerates the piles, blends the materials, brings about additional size reduction, and prevents excessive build-up of temperature to the point of spontaneous combustion. In developing countries, waste pickers may be allowed to work over the windrows to remove recyclables and pieces of wood, as was done in a windrow system in Kathmandu in the early 1990s.

An active pile system:

- Has relatively high land use requirements;
- Uses a varied amount of labour, depending on whether turning is manual or mechanical;
- Has low capital cost and low-to-moderate operating cost;
- Can be developed without purchase of specialised equipment. Mechanical turning can be done with loaders or bulldozers, which are present in almost any municipal public workers fleet;
- Requires limited infrastructure;
- Imposes very limited requirements for site modification;
- May use a variety of compostable materials; and
- May well release odours during turning early in the composting cycle. A large buffer zone between the composting plant and neighbouring residences may be needed, especially if the windrows are infrequently turned.

**Windrow turning machines**

Specially designed windrow turning machines have been developed in the US, Asia and Europe. These vary in size from a wildcat tractor attachment to the very large scarab-type turner, which straddles the windrows. The ones built in India are low cost and work effectively with the waste stream. They may provide an opportunity for South-South technology transfer, although the problems associated with imported technology persist: the need to train repairpersons and to obtain spare parts.

Windrow turning machines allow for production of more uniform compost. They decrease labour costs but increase the capital costs of active pile systems. They may increase land requirements, as the design of turning machines limits the size of the piles and imposes pile spacing requirements. Compared to bulldozers, however, specialised windrow turning machines are more effective in aerating windrows and may therefore be a cost-effective alternative.

### *VII.4.5 Static pile systems*

Static pile composting systems represent another option for sustainable technical practice. However, they have higher capital costs than active pile systems and are used more frequently in sludge composting than in composting of biowaste or yard waste.

In static pile composting systems, the windrows are not turned. Instead, they are aerated continuously or periodically using blown air systems. Static piles typically require a site with aeration channels built into the pad on which the piles sit. Piles are built over this channel, and a network of perforated piping is introduced during placement into piles of the materials to be composted. During composting, air is blown or drawn by pipe systems driven by electric or gas motors through the static piles to provide aeration.

### *VII.4.6 In-vessel systems*

The use of in-vessel systems represents a sustainable technical approach to composting in circumstances, which can sustainably accommodate a higher-technology approach. In an in-vessel system, much of the composting process is carried out indoors or inside a vessel, a large enclosed chamber in which mechanical mixing and/or forced aeration are performed where moisture, air, and temperature can be controlled to create the optimal conditions for composting.

Almost all in-vessel systems require a residence time (time physically in the vessel) of 3 to 30 days, followed by a period of 21 to 180 days of active composting in an active or static pile. Once the active composting is completed, the material is stored in piles or windrows for curing for up to two years.

In-vessel systems offer protection from weather conditions, better odour control, and shorter periods of active processing, but they are expensive to build and operate. Their status as a sustainable practice for developing countries is open to question, especially since equipment and parts typically have to be imported and paid for with foreign exchange.

They may represent a sustainable practice for industrialised or transition countries, or for industrialised areas of developing countries, for specific, at least partially source-separated waste streams and as part of an integrated waste management strategy. There are a number of common variations on in-vessel systems.

**Modular in-vessel systems**

Modular in-vessel systems represent the best practice in most cases where in-vessel composting is desired. These systems have a series of smaller vessels or divisions within the vessel. The modules can generally be purchased separately or added on to the system later. They are also set up to compost more than one waste stream at a time.

Two variations on modular systems represent particularly sustainable practice. The agitated bay system uses a vessel divided into a series of bays or stalls, which are turned by an overhead agitator. Residence time in an agitated bay system is usually 10 to 21 days. The second type of modular system uses multiple closed boxes, each up to 20 metres in length. From the outside, they resemble trailer bodies. Inside, the walls contain a forced aeration and temperature control system. Residence time in the vessels ranges from 5 to 30 days, depending on the available land for final composting or curing.

Modular systems have moderate capital costs and low-to-moderate operating costs. They control odour and leachate very well. Modular systems are a sustainable approach in densely populated areas where siting is difficult and land is scarce.

**Drum or "Dano-type" systems**

In drum systems, compostables are introduced into a rotating horizontal drum for a relatively short residence time, followed by a long period of active-pile composting. These systems are called Dano-type systems after the original Danish design, now no longer protected by patent. The large metal drums are up to 30 metres long and may be divided into separate chambers. Some have trommel screens in the first chamber to remove designated materials during composting. Dano-type systems require a large amount of land for the active pile composting.

**Tower systems**

In tower systems, the compostable material is introduced into a vertical tower and composted under forced aeration. Some tower systems also mechanically turn or agitate the material during its residence. Residence time in tower systems is typically 2 to 5 weeks, and composting is essentially complete when the material is removed to curing piles.

Tower-type systems offer more odour control during composting and require much less land, since the period of active composting takes place in the vessel. They represent a particularly sustainable practice for sludge composting or co-composting of sludge and yard wastes.

### *VII.4.7 Field composting and using compost from dumps*

The most widespread form of composting and use of compost from urban wastes in the world today results from the delivery of fresh garbage to farms by collection crews, the removal of compost from dumps by nearby farmers, and the conversion of old dump land into farms.

The best known example of garbage farming is at Calcutta's Dhapa dump, where the municipality leases out dump land for vegetable farming. The combination of dirt, dust, organics, human and animal faeces, and ash in Calcutta's garbage produces a fertile growing medium that requires no additives; the dump is in a wetland and there are numerous ponds between the ridges of garbage that provide water.

At Beijing's main dump, the authority has provided sifting machines to encourage farmers to remove compost and thereby extend the life of the dump. In Yangon Myanmar, the City Development Corporation allows small enterprises to mine the oldest inner-city dump (now closed) for metals (material dating from World War II) and screen the compost. In this way they hope to gradually remove the hill of compost so that land can be available for redevelopment. The remaining dump land is farmed in the growing season.

These largely undocumented and informal practices in many places throughout the developing world use valuable organic matter and help in waste reduction. However, they carry a risk of bacterial, glass, or chemical contamination, which can present health hazards during the work of gardening, or in the consumption of the crops in some places. At old dumps in cities with low levels of industry, the subsurface compost probably contains few heavy metals and would likely pass tests for use in farming.

If land, compost, and crops are monitored and judged safe for use, these traditions of natural composting and garbage farming could be regarded as sustainable practices for many places. Given uncertainties about quality and contamination, these practices can be endorsed as sustainable practice if soil and product testing is done regularly, or in places like Yangon where there is little industry. Sustainable practice over the long term will necessitate improving the practices themselves, rather than supplanting them and displacing their beneficiaries.

There is a need for assistance to developing countries in adequate testing and long-term monitoring, and in advice on crops that may be safely grown on old garbage dumps or on composted garbage removed from them. Sustainable practice improvements to garbage farming include:

- Development, distribution, and guided use of testing tools to check the soil, compost and crops for contaminants;
- Promotion of deposit-refund schemes for some potential contaminants (e.g., batteries);
- Support and enhancement of recovery to remove dangerous or toxic materials from the garbage prior to dumping (which would require paying people to do this);
- Education of farmers and the public. The use of solid waste on peri-urban farms, a major practice in China, requires intensive education in composting techniques and regulation to prevent direct application to soil; and
- Monitoring for parasites and other forms of contamination. Chinese authorities have not in general managed to monitor and control the practice sufficiently except within the boundaries of big cities.

### *VII.4.8 Promising innovations*

**Centralised vermicomposting**

Vermicomposting, also called vermiculture or worm composting, is a relatively cool but aerobic composting process in which certain varieties of redworms and earthworms can be used to break down organic materials. Worms mechanically break down compostables and partially decomposed materials by eating them, and biochemical decomposition occurs via bacteria and chemicals in the worms' digestive system. Vermiculture requires considerable labour and careful control of composting conditions, including temperature, moisture, and the mix of ingredients. Its successes to date are limited to relatively small-scale or pilot programs.

The use of vermicomposting in centralised or village-scale composting systems is currently being explored in pilot projects. Considerable work was done in Manila in the 1970s but the markets for the resulting worm castings did not develop.

Vermiculture can be carried out by small-scale enterprises, in a cottage-industry manner. Worms are easily affected by impurities, so the organic wastes should be source-separated domestic wastes, or from markets. Vermiculture produces a superior fertiliser-type product. However, there is not yet enough information to indicate whether sufficient markets exist to absorb worm castings on a scale that would significantly contribute to municipal waste reduction.

Vermiculture does not necessarily kill all pathogens. In particular, some viruses and parasites can survive the process. Therefore, if the input materials present a high risk of containing pathogens, the finished product could still contain pathogens. This may be of particular concern in developing countries, where wastes used in vermicomposting may not be source-separated.

### Anaerobic digestion

Anaerobic digestion is an approach to composting, which shows promise as a sustainable practice in industrialised countries. A number of facilities in France and Belgium appear to be capable of composting mixed waste under pressure and are recovering both compost and methane gas. Most anaerobic systems include pre-processing similar to that in centralised aerobic systems, followed by conveyance of the compostables to a large pressurised tank or vessel. Water must usually be added, as anaerobic bacteria generally require a liquid or semi-liquid environment.

# APPENDIX VIII Execution and results of the survey

## VIII.1 Aim of the survey

A number of possible scales in which a composting project can be executed and a compost system set up requires the involvement and/or participation of the community. Moreover, since the political polarisation plays a role in all levels of society in Nicaragua, it is important to find out how the neighbourhoods are organised and more importantly what the quality of this organisational structure is. Therefore part of this research was the execution of a survey amongst the community leaders of the neighbourhoods of the city of Masaya to acquire information and insight on the following subjects:

- Quality of the neighbourhoods organisational structure
- Willingness of the community to participate, co-operate and/or to be involved in projects, in particular projects that require co-operation with the municipality
- Experience with participatory, collaborative projects, how many, with whom and what kind of experience, in particular concerning (solid) waste
- Experience with composting of any type whatsoever:
    - Knowledge of the process,
    - Source separation of the waste
    - Backyard composting
    - Participation in a composting project now and/or in the past
    - Composting at neighbourhood level
- The servicing of the neighbourhoods by the municipal garbage truck

The questionnaire that was constructed accordingly is shown in appendix VIII.4

## VIII.2 Execution of the survey

The municipality of Masaya has 4 types of neighbourhoods, *barrios*, *villas*, *repartos* and *comarcas*. Comarcas are rural neighbourhoods and don't form part of the city. Within city limits one therefore has to deal with the remaining 3 types of neighbourhoods. Although the municipality gives no formal definition of these three types of neighbourhoods, one could make the following rough distinction:

- Barrios are the traditional and formally planned neighbourhoods of the city Masaya;
- Villas are neighbourhoods that were formally planned with the purpose of extending the city beyond the traditional core;
- Repartos are originally squatter settlements, which can be found throughout the city but mainly on the city's periphery. Most of these neighbourhoods have been acknowledged by the municipality and are thus formalised.

In general, every neighbourhood in Masaya has two community leaders: A community leader appointed by the municipality, the so-called *Directivo de barrio* and a community leader appointed by the *Movimiento Comunal Nicaragüense.* The Movimiento Comunal Nicaragüense (MCN) or Nicaraguan Community Movement operates mostly in the poor, low-income neighbourhoods of Masaya, where it has set up its neighbourhood committees. As explained in appendix III.3.2 the MCN has a sandinistic origin and in most cases still has sandinistic ties or is at least seen as such. At the same time the neighbourhood executives (directivos de barrio) are liberal, since the current municipal council is liberally orientated. Thus, the two types of community leaders that almost each neighbourhood in Masaya has, come from different political colours. It is, therefore, important to interview them both for each neighbourhood to get the most objective view of that neighbourhood. Due to time limitations it was not possible to cover all the neighbourhoods, i.e. to interview every community leader and therefore 50% of the neighbourhoods were selected through sampling. The sample draw resulted in the neighbourhoods listed below. A complete list of all the neighbourhoods (urban and rural) is attached as well in appendix VIII.5 along with a map indicating the rough location of these neighbourhoods (figure VIII.1).

**Selected neighbourhoods of the city of Masaya**

**A. Barrios**

1. Monimbó
3. Pancasan
4. San Carlos
7. Santa Rosa

**B. Villas**

4. El Candil
5. El Carmen

**C. Repartos**

1. Quing
2. La Reforma
4. Fátima
6. Germán Pomares
7. Ulises Tapia
9. Bella Vista
10. 19 de Julio
11. Gonzalo Martínez
14. Jardines de la Barranca
15. San José
16. Santa Teresa
17. Sacuanjoche
18. Faria
20. San Francisco
24. Héroes y Mártires de Monimbó
25. San Fernando
26. José Dolores Bonilla
28. El Repliegue
29. Padre Emilio Boltari

## VIII.3 Survey results

The survey results are placed in table VIII.1. The responses to the interview questions and the observations made during these interviews have been categorised with +, +/-, and -. The explanations for these symbols for each table category follows here.

### Organisation

| | |
|---|---|
| + | The neighbourhood has both a neighbourhood executive and a community leader appointed by the MCN, who are working together for the benefit of the entire neighbourhood community. |
| +/- | The neighbourhood has both a neighbourhood executive and a community leader appointed by the MCN, who are not working together at all. Meaning that each community leader is working to benefit its own part of the neighbourhood community. |
| - | The neighbourhood has either a neighbourhood executive or a community leader appointed by the MCN, who is only trying to benefit its own part of the neighbourhood community. |
| -- | The neighbourhood has neither a neighbourhood executive nor a community leader appointed by the MCN. |

This categorisation was made through observation and through additional remarks of the interviewees on this matter.

### Project experience

In this category the number of projects the neighbourhood community has participated or is participating in is given. All of these projects have been collaborative projects with the municipality, local Non-Governmental Organisations (NGO's) or foreign NGO's and embassies. The projects generally concern the basic necessities of the neighbourhood, such as lot ownership, drinking water, electricity, sewerage, education, child care, public illumination, street pavement and neighbourhood security.

### Project participation

| | |
|---|---|
| + | The neighbourhood community is willing and motivated to participate. |
| +/- | The neighbourhood community is willing to participate, but is far from motivated, because of unsatisfying experience with previous projects. |
| - | The neighbourhood community is not willing to participate. |

In the case of participation in a composting project the question was also asked if the community members were capable of participating in such a project (requiring at least the separation of the domestically produced solid wastes in an organic and non-organic part). Every interviewee responded that personal education of the neighbourhood community members would have to be a necessary requirement to capacitate them for participation.

**Co-operation with the municipality**

+ The neighbourhood community sees no problem in co-operating with the municipality in a project.

+/- The neighbourhood community has reservations about co-operating with the municipality, because they have no confidence in the municipality to actually execute a project successfully. This for reasons of previous bad project experiences while co-operating with the municipality and the poor service of the municipal garbage collection services.

- The neighbourhood is not willing to co-operate with the municipality in a project.

**Garbage collection services**

+ The neighbourhood is regularly serviced by the municipal garbage collection services. Thus, the garbage is picked up by the garbage dump truck twice a week.

+/- The neighbourhood is irregularly serviced by the municipal garbage collection services. Thus the garbage dump truck picks up the garbage once a week or in many cases less than once a week.

- The neighbourhood is not serviced by the municipal garbage collection services at all, because the people of that particular neighbourhood are not willing to pay for these services or because of the fact that the garbage dump truck can not enter that particular neighbourhood.

This categorisation was made through observation in the neighbourhoods, through remarks made by the interviewees and through information gathered from the municipal garbage collection services.

**Experience with composting**

+ The neighbourhood community members have had some kind of experience with composting. That is to say, they have been involved in a previous composting project for which they had to separate their domestically produced solid wastes in an organic and non-organic part.

- The neighbourhood community members have no experience with composting whatsoever. Thus not with source separation either.

**All categories**

Unknown refers to the neighbourhoods that were not organised. Thus, neither a neighbourhood executive, nor a community leader appointed by the MCN was operative in that neighbourhood. An interview could therefore not be performed for these neighbourhoods and no information was gathered on project experience, project participation and composting experience for these neighbourhoods.

| Table VIII.1 Survey results | | | | | | | |
|---|---|---|---|---|---|---|---|
| Neigh-bourhood | Organisation | Project experience (Number) | Project participation | | Co-operation with municipality | Garbage collection service | Compost experience |
| | | | General | Compost | | | |
| A1 | +/- | 3 | + | + | + | +/- | - |
| A3 | -- | Unknown | Unknown | | Unknown | + | Unknown |
| A4 | +/- | 3 | + | + | + | +/- | + |
| A7 | +/- | 3 | + | + | +/- | +/- | - |
| B4 | +/- | 3 | +/- | +/- | + | - | - |
| B5 | +/- | 3 | + | + | + | +/- | + |
| C1 | +/- | 1 | +/- | +/- | +/- | +/- | + |
| C2 | +/- | 3 | + | +/- | + | + | - |
| C4 | + | 4 | + | + | + | +/- | + |
| C6 | +/- | 1 | +/- | +/- | +/- | - | - |
| C7 | +/- | 2 | + | + | + | +/- | + |
| C9 | - | 1 | + | + | + | - | + |
| C10 | +/- | 3 | + | + | +/- | +/- | + |
| C11 | + | 9 | + | +/- | +/- | + | + |
| C14 | + | 6 | + | + | + | - | + |
| C15 | +/- | 1 | +/- | +/- | +/- | - | - |
| C16 | +/- | 6 | + | + | +/- | +/- | + |
| C17 | - | 3 | +/- | +/- | +/- | - | + |
| C18 | + | 5 | + | + | +/- | + | + |
| C20 | + | 4 | + | + | + | - | + |
| C24 | +/- | 3 | + | +/- | +/- | - | - |
| C25 | -- | Unknown | Unknown | | Unknown | - | Unknown |
| C26 | + | 6 | + | + | +/- | - | + |
| C28 | +/- | 6 | + | + | +/- | +/- | + |
| C29 | +/- | 3 | +/- | +/- | +/- | - | + |

## VIII.4 Questionnaire

Good morning/afternoon/evening, my name is Dennis van Hunen and at the moment I am collaborating with the municipality of Masaya. I am investigating the possibilities for the city of Masaya to set up a composting project or rather making compost from the organic part of the domestically produced solid wastes.
To help decide on how this can best be done and on what scale I would like to ask you some questions about the involvement and participation of the community in projects, since one of the possibilities is to execute the project on a community scale. Moreover I would like to find out if there has been any experience with the composting process in this neighbourhood. This interview will take approximately 20 minutes.

Neighbourhood:
Name:
Movement:
Date:

1. Has the neighbourhood community participated, co-operated or been involved in projects or are they at the moment?

    1a. What kind of projects were they? (subjects, in co-operation with whom)

    1b. How were or are these projects experienced by the community and why?

2. Would the neighbourhood be willing to participate in a project in general?

    2a. Why or why not?

3. Is the community of this neighbourhood willing to co-operate with the municipality in such a project?

    3a. Why or why not?

4. Is there any knowledge on or experience with composting in the neighbourhood? For instance:
    - knowledge of the process,
    - source separation,
    - backyard composting,
    - composting at neighbourhood level,
    - participation in a composting project now and/or in the past

5. Are the people in this neighbourhood willing to participate in a composting project?

    5a. Why or why not?

6. Are the people in this neighbourhood capable of participating in a composting project?

    6a. Why or why not?

## VIII.5 Urban and rural neighbourhoods of Masaya

### A. Barrios

1. Monimbó
2. San Juan
3. Pancasan
4. San Carlos
5. San Jerónimo
6. El Pochotillo
7. Santa Rosa
8. San Miguel
9. Paises Bajos
10. La Bolsa

### B. Villas

1. San Jerónimo
2. Bosco Monge
3. 10 de Mayo
4. El Candil
5. El Carmen
6. Holanda
7. Gracias a Dios
8. 12 de Mayo

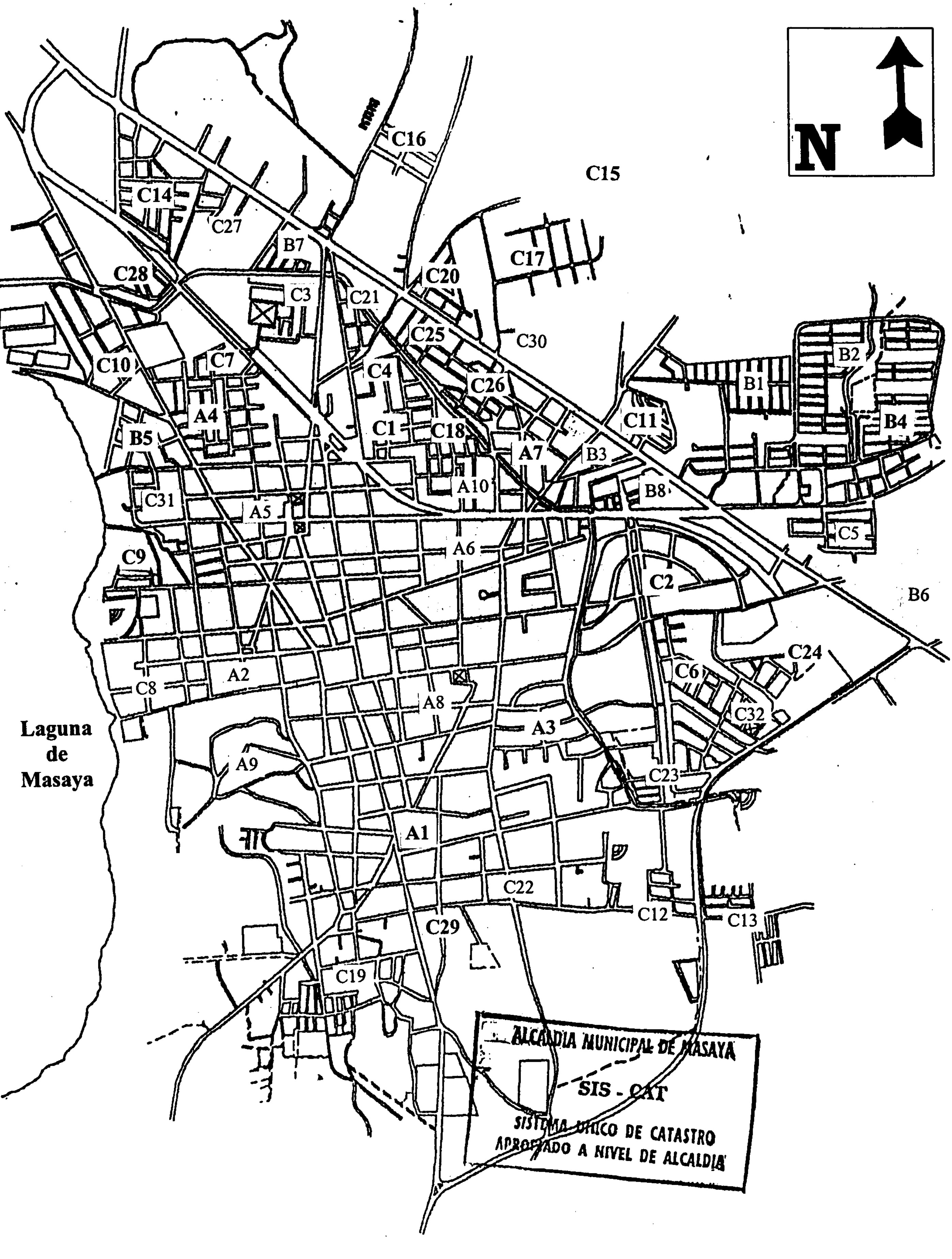
### C. Repartos

1. kHUING
2. La Reforma
3. El Fox
4. Fátima
5. 1 de Mayo
6. Germán Pomares
7. Ulises Tapia
8. Cailagua
9. Bella Vista
10. 19 de Julio
11. Gonzalo Martínez
12. Silvio Reñazco
13. Camilo Ortega
14. La Barranca
15. San José
16. Santa Teresa
17. Sacuanjoche
18. Faria
19. Oscar Pérez
20. San Francisco
21. San Ramón
22. San Jerónimo de Monimbó
23. Danilo Aguirre
24. Héroes y Mártires de Monimbó
25. San Fernando
26. José Dolores Bonilla
27. Chilamate
28. Padre Emilio Boltari
29. El Repliegue
30. Nimboja
31. 5 de Junio
32. Las Malvinas

### D. Comarcas

1. Los López
2. El Arenal
3. Los Manguitos
4. Las Conchitas
5. Las Pilas Orientales
6. Las Pilas Occidentales
7. La Ceibita
8. Las Flores
9. El Comején, No.1,2,3,4
10. Llano Grande, No.1,2
11. El Edén
12. Los Cocos
13. Tabla Amarilla
14. La Reforma, No.12
15. El Hatillo
16. Valle de la Laguna
17. Diriomito
18. El Túnel
19. Pacayita
20. El Jocote
21. El Pochote
22. El Mojón
23. El Chilamate
24. Buena Vista
25. Sector los Martínez
26. Cruz Amarilla
27. La Poma

## Figure VIII.1 Neighbourhoods of the city of Masaya



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