Waste Management in the Metropolitan Area of the Valley of Mexico: A Methodological Approach

by

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ABSTRACT

Because of diverse demographic, institutional, economic, environmental, social and political factors, waste management in the Metropolitan Area of the Valley of Mexico constitutes a complex system. The present behavior of the system, based on institutional boundaries that are not congruent with the physical, demographic and economic boundaries, is inefficient from an economic point of view, and unsatisfactory from an environmental perspective. The size of the population, the topographic, geological and climatological characteristics of the Valley, as well as economic and social restrictions, all combine to conform a frame of reference in which adequate strategies must be designed and implemented.

A detailed description of the present characteristics of the different relevant subsystems: environmental, technological, economic, socio-political, administrative -including the legal and regulatory frame work-, is presented, as well as an assessment of the probable evolution of those subsystems for different scenarios. It is concluded that a metropolitan approach to the handling and disposal of solid waste is essential for the implementation of economically efficient and environmentally sound solutions in this field. On that basis, the proposal for a planning process and structure, adequate for the present and expected political and social characteristics of the system is developed.

Different System Analysis tools are discussed regarding its suitability for the support of diverse stages of metropolitan waste management planning. Because of the need of an open planning process, that takes into consideration the interests and relative influences of all the stakeholders, collective decision making, utilizing diverse tools, including multiattribute trade-off analysis, is recommended as the most adequate procedure for the search and selection of robust strategies in the case at hand.

Thesis Supervisor: Dr. David H. Marks

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Acknowledgments

I have been lucky enough to learn through direct experience, during the already long span of my life, that any really satisfying achievement is a combination of two kinds of ingredients. One of them, of course, is whatever effort one is able to put into the undertaking. But the required effort is not even possible without a second, more important ingredient, which is the support that in many different ways numerous people are willing to provide. The case of the present work is not an exception.

That being so, it is not possible in the short space awarded here for that purpose, to mention all the people that one way or another, directly or indirectly gave support so that this goal could be accomplished. Although my thanks are for all of them, I will be able to mention only some of the most direct participants.

When I first arrived at MIT, John R. Ehrenfeld offered useful advice and orientation and influenced, perhaps unintentionally, the course that the work eventually took. To Ernest G. Frankel, I am indebted mainly for his penetrating questions and his always enjoyable and solid balance between theory and practice, which sometimes one tends to forget when doing academic work. David H. Marks supervised the thesis; he often had a word of motivation, and his directions were always wise. Had I heeded them more, the work would surely have been less heavy, and worthier.

In México, my special thanks go to Paula Noreña and José Piña. Without Paula's help, most of the field information would have been much more difficult to get; she also gave important insights regarding waste management in the Valley of Mexico. José, as so often has along the years, offered intelligent comments and, as well, important information. Fernando Favela, Raúl López, Carlos Casasús, and Sergio Reyes supported the idea all along the way. Diverse officials in the government of the Federal District and of the State of México not only contributed information; they also granted useful advice and insights.

My children also participated in the effort, Gabriela with her good spirits and a continuous word of encouragement; Ruben, almost an Engineer himself by now, also dispensed useful advice regarding computers, as well as a hand in the edition chores. Last, but not least, my wife, Silvia, put up with the many inconveniences derived from the work mostly with a smile; without that, the effort would have not come to a good end.

CONTENTS

1. INTRODUCTION

1.1. The Subject.

The subject of the present work is the study of a real-life decision making system in the field of public services in a large urban area, as well as the proposal of a systematic approach to policy definition and to the search and selection of robust solutions in that area. Decision making is treated in the context of a process concerned with the future effect of decisions, i.e., a planning process. The work refers specifically to the case of solid waste management in the Metropolitan Area of the Valley of Mexico.

1.2. A Conceptual Approach.

If one considers, according to a classical definition, that a system is a set of subsystems, each of them having an effect, not only in the behavior of the system, but also in the behavior of at least one of the other subsystems, even a cursory exploration of the subject of public services in large metropolitan areas, leads to the conclusion that the planning, implementation and operation of public services in such areas constitute complex, dynamic systems.

As it is shown in the present work, the context in which the decision making process regarding public services in large metropolitan areas takes place, is one of increasing complexity in many dimensions. The sheer volume of services to be provided and managed, the need to consider multiple technological options, the pertinent legal and institutional framework, the existence of ever more strict financial and economic constraints, growing environmental

concerns, changing political situations, all interact with the interests, desires, objectives, and the resulting positions of diverse social groups, creating a complex system. Complexity in this type of systems depends, not merely in the number of its components, but also, and more importantly, on the hetereogenety of those components and in the multiple ways in wich they may interact to define the behavior of the system.

In that respect, it is important to note that, as a result of a general trend towards democratization and political plurality that is evident in many countries, including Mexico, the decision making process regarding urban services and environmental matters, is no longer the exclusive field of a few governmental authorities and political leaders, but must include, and will more and more include, as active actors of the process, many diverse social groups that, in one way or another, will be affected by the decisions and will affect the process. Those groups have acquired indisputable personality and demand to have their saying in the decision making process. Indeed, the very possibility of implementing a decision may depend on the active, responsible participation of those groups. An important related issue, is the need to find an adequate balance between two coexisting and opposite tendencies that are particularly relevant in large metropolitan areas: centralization and decentralization, of proposals, of decision making, of implementation and management of the adopted solutions.

As a result of the above mentioned factors, decision making processes regarding public services in metropolitan areas must take into account the interplay of many different variables, not only those of a technical, financial, economic and environmental nature, but also those that define the socio-political attributes and behavior of the system. Decision making that leads to robust solutions that have the higher probability of satisfying the largest possible number of relevant stakeholders in the short, medium and long terms, must then be the result of both scientifically-technically-based and politically oriented considerations and measures. What are usually called "rational analysis" and "political considerations" are both essential in sound policy definition and decision making; the dichotomy between those two approaches, even if useful for taxonomic purposes, must be considered artificial. There exist in the fields of physics and economics, real, cause-effect, rational, usually well understood, relationships that are commonly

utilized for quantitative analysis. There are also cause-effect relationships in the socio-political world. That the latter relationships are fuzzy, complex and instable, and because of that, more difficult to understand, does not make them less real, or the attempt to take them into consideration less rational. And, of course, in decision making, both types of relationships are relevant elements of a system.

Today, the tools to model the interplay of diverse physical and economic variables have reached a high degree of sophistication. The methodologies to asses the technical, financial and economic feasibility of engineering projects, including those in the area of public services are well developed. There is also a growing understanding of the environmental effects of those projects. On the other hand, the availability of satisfactory tools to evaluate ex-ante the feasibility of the success of a certain solution, taking into account the -very real- effect of socio-political variables, may lie well in the future, if such tools are ever developed. However, important advances have been made -and are being made- in the design and application of methodologies that allow decision makers to consider in a systematic manner the interplay of all relevant variables in different scenarios. The design and utilization of planning structures and processes, that not only allow, but also stress, the utilization of those methodologies, will undoubtedly increase the probability of the selection of robust solutions in the field of urban services, including those of waste handling and disposal in large metropolitan areas.

1.3. Objectives.

In accordance with the above expressed concepts, the aim of the work is to present the case of urban waste management in the Metropolitan Area of the Valley of Mexico, as well as to propose a systematic approach to decision making regarding urban waste, that takes into account all pertinent variables. The specific objectives are:

- To discuss the relevant variables that affect urban waste management in the Area.

- To define the main characteristics of a decision making process that takes into account those variables, as well as to discuss alternate organizational structures for the implementation of the process.

- To present and discuss the available systems analysis tools that can be utilized in the decision making process.

- To propose a specific planning procedure, adequate for the search and selection of robust strategies for waste management in the Metropolitan Area of the Valley of Mexico.

1.4. Structure and Contents.

The initial parts of the work are devoted to the presentation of relevant variables and actors. Chapter 2 addresses the general background in which waste management activities take place in the Metropolitan Area of the Valley of Mexico, and discusses the main characteristics of that background: physical, institutional, socio-economic, environmental, that must be taken into account both in the design of a planning process and in the definition of concrete alternatives regarding waste management in the Area. Because of the relevance of the subject, often underestimated, Chapter 3 is devoted in its entirety to discuss the existing legal and regulatory framework.

In chapter 4 the characteristics of actual waste generation, as well as an estimation of future waste generation volumes are presented. The chapter also contains a description of present urban waste management installations and practices, as well as of standing plans in that respect, essential for the understanding of relevant variables that might affect any decision making system, and that might also impose constraints to future actions.

Chapter 5 contains a description of the main actual or potential, direct or indirect

participants in the decision making process. Because of its being out of the scope of the present work, no attempt was made to undertake a systematic, detailed analysis of the relative influence of the different actors in the decision making process, which would have been of a speculative nature.

Based on the material presented in the previous chapters, in the first part of Chapter 6 a synthetic characterization of the present waste management system and of the corresponding decision making process is made. That characterization is then utilized to discuss likely future scenarios, and to develop the proposal of a decision making process whose purpose is the search and selection of robust actions to deal with the foreseeable conditions that waste management in the MAVM is likely to face in those scenarios. Chapter 6 ends with the discussion of alternative organizational structures that, in fact, must be an integral part of the decision making system.

The utilization of adequate analytical tools is an essential element in a decision making process. Chapter 7 contains a presentation of the available tools of systems analysis that may be utilized in the different stages of the process that is proposed in Chapter 6. Stress is put in techniques suited for the selection of general strategies, rather than in those utilized for the more detailed analysis of particular strategies or of specific actions. Relevant tools are discussed in terms of their comparative applicability to the specific subject of the work.

In accordance with one of the basic intentions of the work, that of presenting relevant information as regards a real life-case, Chapter 8 discusses a specific procedure to conduct strategic planning, fitting to the present and expected future conditions of the waste management system in the MAVM. Finally, a brief conclusion is presented in Chapter 9.

2. General Background.

2.1. Physical Setting.

The Metropolitan Area of the Valley of Mexico (MAVM) lies within what is known as the Basin of the Valley of Mexico, at a subtropical latitude (190 01' 18" to 200 09' 12" north latitude and 980 31' 58" to 990 30' 52" west longitude). The Valley has a total area of 9600 km2, a maximum length in the north-south direction of approximately 130 km, and a maximum, east-to-west width of nearly 90 km; it is closed to the east, west and south by high mountains, with less important and lower ranges to the north. East of the Valley, the Sierra Nevada with its two main volcanoes, the Popocateptl (5452 m above sea level) and the Iztaccihuatl (5386 m) divides the Valley of Mexico from the Valley of Puebla. To the southwest, the Sierra de las Cruces, whose main summits reach up to 3000 m. above sea level separates the Valley of Mexico form the Valley of Toluca. To the south, the Sierras of Ajusco and Chichinautzin (4000 m.) constitute the natural boundary with the Valleys of Cuernavaca and Cuautla.. Within the Valley, the Sierra de Guadalupe to the north-center, and the Sierra of Santa Catarina to the east, that today are surrounded by the urban areas, create an atmospheric and hydrologic microbasin with particular ecologic characteristics. The flat, low areas of the Valley of Mexico have an average elevation of 2240 m above mean sea level. In its natural form, the Valley was a closed hydrological basin, which up to the end of the last century constituted a vast lake complex. Today most of the lakes have disappeared, mainly as a result of the construction of important drainage and desiccation works, undertaken during several centuries, since precolumbian days and up to the present, in order to protect the Valley from the floods that plagued Mexico City until a few decades

ago, and that even today are a latent danger in some areas of the Valley. Perhaps it is in the nature of things that the success of this persistent Civil Engineering effort is one of the origins, either directly or indirectly, of other present, serious environmental problems that affect the Valley. Human settlements occupy now a good part of what used to be the lake areas, as well as some of the mountainous areas surrounding the basin, so that of the total extension of the Valley, 46% (4450 km2) is considered now to be part of the Metropolitan Area. (Figure 2.1).

Geologically, the Basin of the Valley of Mexico is the result of multiple interactions among diverse volcanic and tectonic processes. Most of the mountainous formations consist of diverse andesites and basalts. In the old lake areas, there exist sediments with depths of up to 2000 m below the surface. The main origin of this sediments is threefold: volcanic ashes and sands, near the volcanic formations; deposits of fluvial origin mainly in the central part of the Valley, where the most important thickness of sediment exists; lacustrine medium and fine clays on top of the fluvial formations, with depths of up to 300 m in the central part of the Valley.

There are diverse types of aquifers within the Valley, which correspond to the main geological formations. The most important aquifers are, on the one hand, those related with the andesitic and basaltic formations, that because of its degree of fracturation constitute the main areas for the recharge of all the aquifers within the Valley, and on the other, the alluvial-lacustrine formations from which most of the underground water is drawn. Approximately 70% of the fresh water utilized in the Valley is taken from the aquifers, that have been subject to serious overexploitation for many years. According to official figures, the average recharge is equivalent to 23 m3/s and extractions add up to, in average, to at least 42 m3/s, with some estimates reaching 45 m3/s. Degradation of the quality of groundwater has been detected in some areas due both to the extraction of fossil water and to the infiltration of contaminant flows originating in the surface.

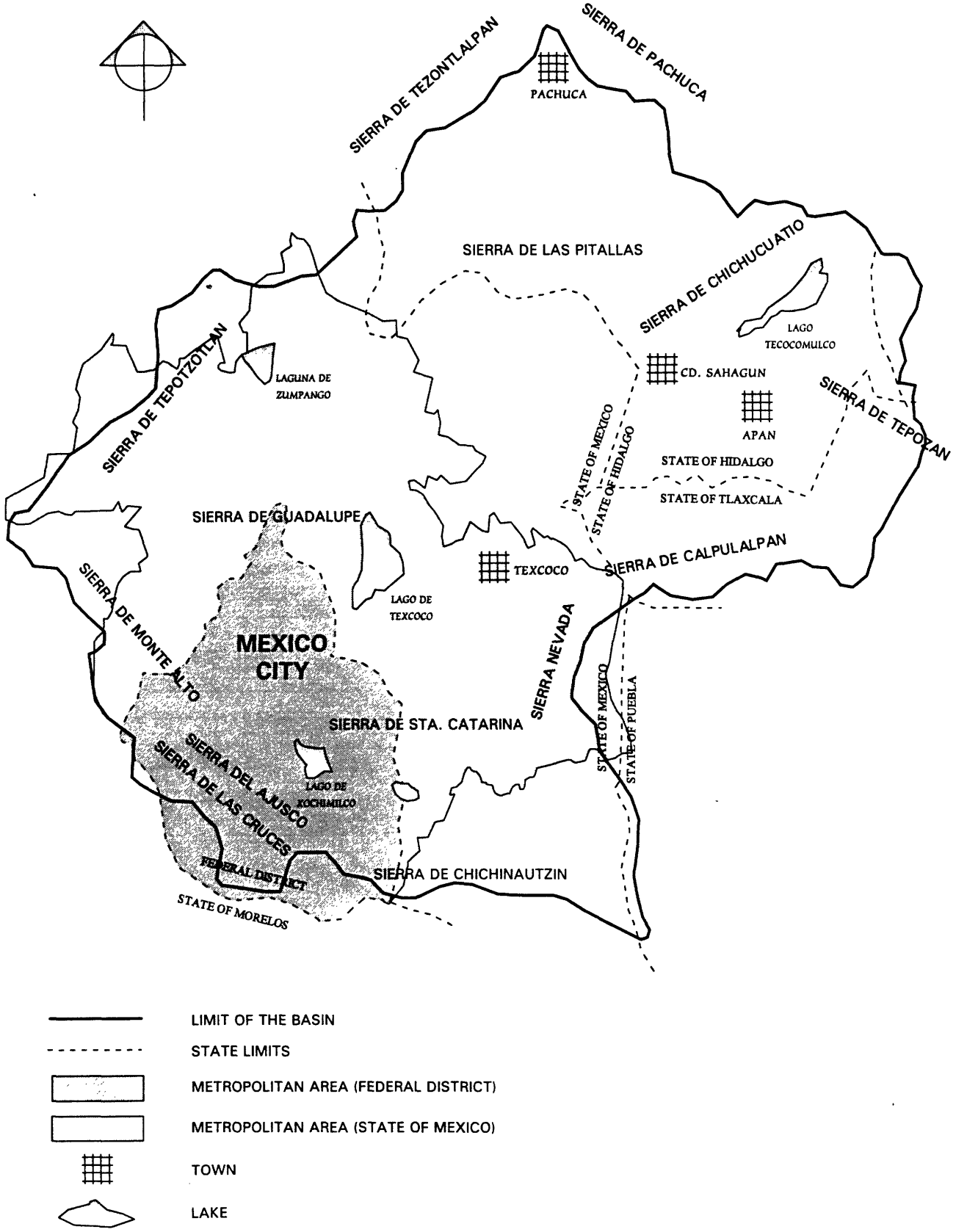


FIGURE 2.1.- THE VALLEY OF MEXICO AND ITS METROPOLITAN AREA

Most of the Valley has a temperate climate, with a mean annual rainfall of 670 mm and a well defined rainy season lasting from May to October, the most intense precipitations taking place from June to August, with rains occurring almost every day. Regional average rainfall increases from northeast to southwest, with annual means in the range of 530-550 mm for the northeastern dry-steppe-like plains of Apan, and of more than 700 mm for the mountain ranges south and west of the Valley. Mean daily temperatures are 100 C minimum and 230 C maximum. Prevailing winds come into the Valley from the northeastern openings through the low altitude ranges, into what constitutes a closed bowl. The only, rather restricted opening, leeward of the prevailing winds, located to the south-east of the Valley, is the Yautepec Pass to the Valley of Cuautla, between the Nevada and Chichinautzin Sierras.

The influence on any future waste management strategy, of this briefly stated elements of the physical setting will be discussed in somewhat more detail in Section 2.6 (Environmental Issues).

2.2. Territorial Division. Institutional and Administrative Issues.

Since soon after the creation of the Mexican Republic, that took place in 1821, the territory of the Valley of Mexico has been divided between two different political entities: the Federal District, seat of the Federal government (political subdivisions: Delegations), and the State of Mexico, one of the 31 States that, together with the Federal District, make up the Mexican federation (political subdivisions: Municipalities). The Federal District was created in 1824 and its present limits were established in 1898. The judicial basis of the Federal District as they exist today, were laid down in the Constitution of 1917, as a confirmation of the convenience of avoiding the spatial coexistence of the Federal and State governments.

During more than a hundred years after the territorial division of the Valley of Mexico, Mexico City kept on growing inside the limits of the Federal District.

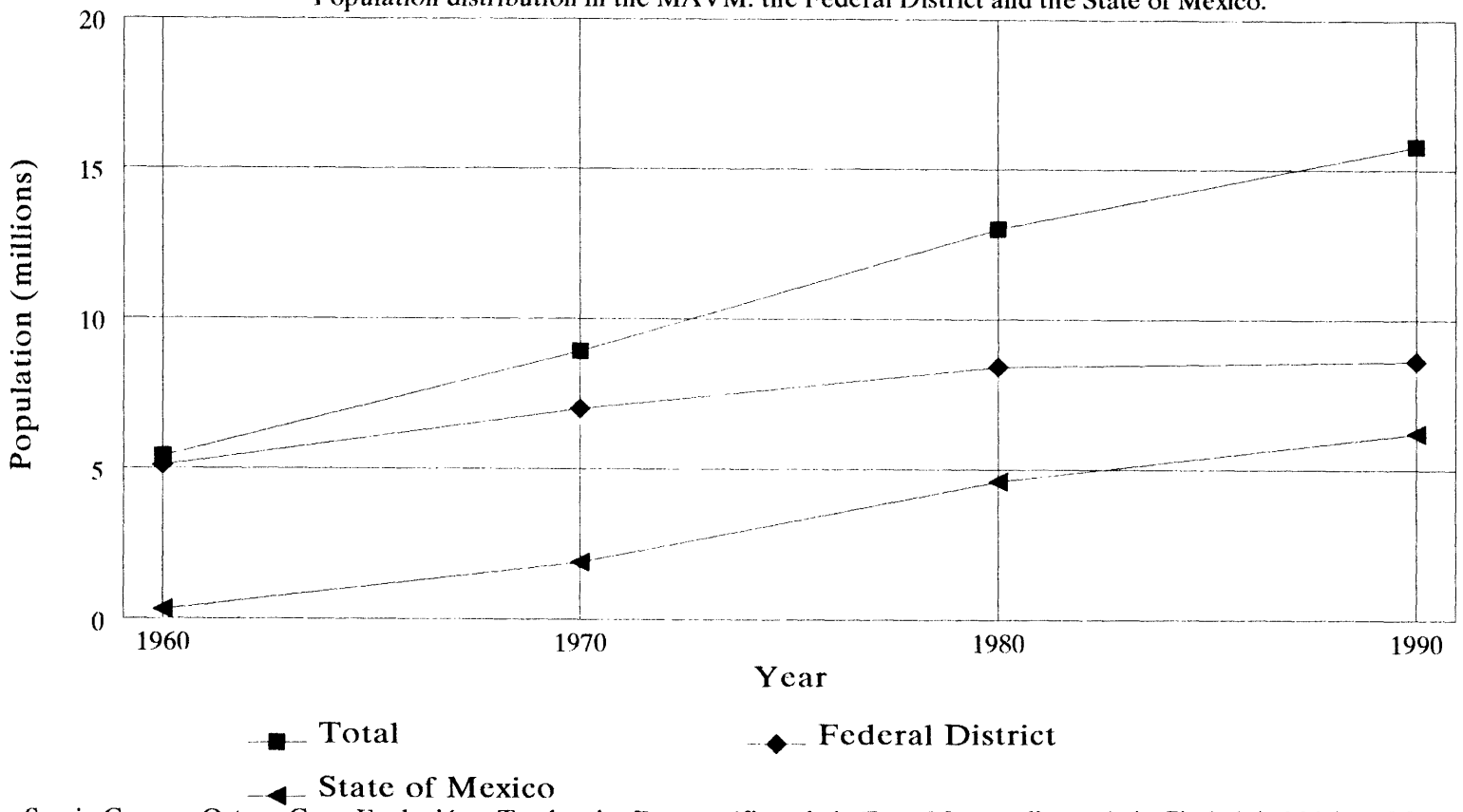
However, as a result of the accelerated economic and demographic expansion, the urban area went beyond those limits during the decade of the 50's of the present century. Due to the curious coexistence of the restrictive policies undertaken by the government of the Federal District in those years -as a result of the already existing preoccupation as regards the results of explosive growth-, and of the incentives given to industry by the State of Mexico -willing to attract economic activity and employment to the State- population growth in this latter entity accelerated since then, tendency that has kept to the present day. The population of the Metropolitan Area of the Valley of Mexico grew more than five times from 1950 to 1990, period during which it went from 3.0 million to more than 15.7 million inhabitants. However, in 1960, 94% of the population of the Metropolitan Area dwelt in the Federal District, whereas at the present time this latter political entity has 55 % of the Area's population, and the tendencies show that soon a majority of the inhabitants will dwell in the State of Mexico's portion of the Metropolitan Area (Figure 2.2). Today, the Metropolitan Area includes the 16 Delegations of the Federal District and 27 Municipalities of the State of Mexico (Figure 2.3; Table 2.1).

Although the present and increasing relevance of the State of Mexico's Municipalities in the context of the Metropolitan Area is clear, it is also evident that there exists a disparity between the Federal District and the State of Mexico in respect the resources devoted to public works and public services in each of the two entities: the Federal District's budget is more than 3 times greater than the State of Mexico's and federal public investment is 8 times as great in the Federal District as that in the State of Mexico. This is reflected not only in the relative quality of some of the infrastructure and services but also in the comparative level of sophistication of the technical and administrative staffs of Municipalities and Delegations.

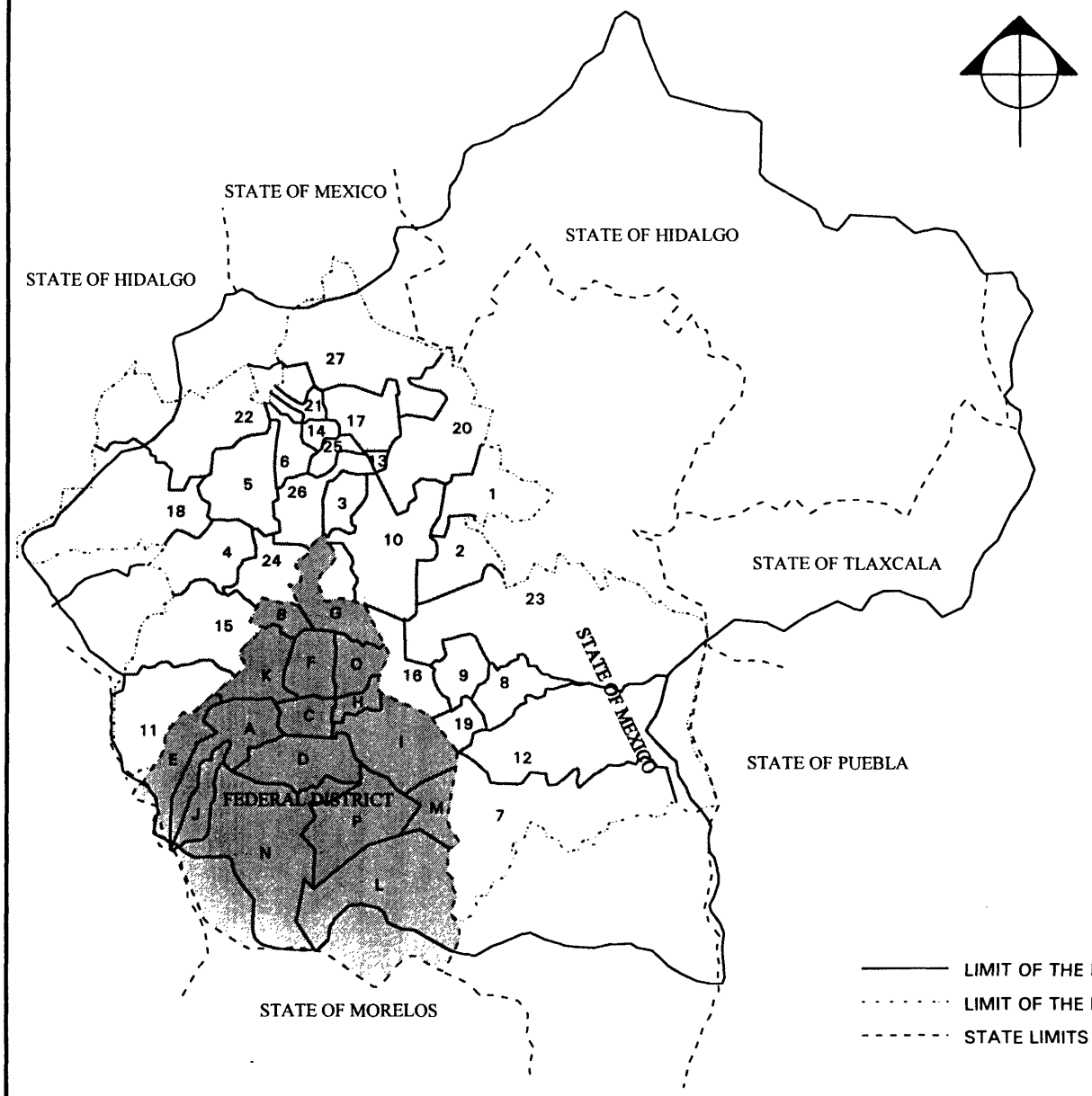
It is a generally recognized fact that the territorial and administrative division of the Metropolitan Area, that cuts through an otherwise continuous urban territory, and

Figure 2.2

Population distribution in the MAVM: the Federal District and the State of Mexico.



Sergio Campos Ortega Cruz. Evolución y Tendencias Demográficas de la Zona Metropolitana de la Ciudad de México. CONAPO



FEDERAL DISTRICT

A	ALVARO OBREGON
B	AZCAPOTZALCO
C	BENITO JUAREZ
D	COYOACAN
E	CUAJIMALPA
F	CUAUHTEMOC
G	GUSTAVO A. MADERO
H	IZTACALCO
I	IZTAPALAPA
J	MAGDALENA CONTRERAS
K	MIGUEL HIDALGO
L	MILPA ALTA
M	TLAHUAC
N	TLALPAN
O	VENUSTIANO CARRANZA
P	XOCHIMILCO

STATE OF MEXICO

1	ACOLMAN
2	ATENCO
3	ATIZAPAN DE ZARAGOZA
4	COACALCO
5	CUAUTITLAN IZCALLI
6	CUAUTITLAN DE ROMERO RUBIO
7	CHALCO
8	CHICOLOAPAN
9	CHIMALHUACAN
10	ECATEPEC
11	HUIXQUILUCAN
12	IXTAPALUCA
13	JALTENCO
14	MELCHOR OCAMPO
15	NAUCALPAN
16	NEZAHUALCOYOTL
17	NEXTLALPAN
18	NICOLAS ROMERO
19	LA PAZ
20	TECAMAC
21	TEOLOYUCAN
22	TEPOTZOTLAN
23	TEXCOCO
24	TLALNEPANTLA
25	TULTEPEC
26	TULTITLAN
27	ZUMPANGO

FIGURE 2.3.- POLITICAL DIVISION OF THE MAVM (FEDERAL DISTRICT AND STATE OF MEXICO)

Table 2.1.1 Population in the delegations of the Federal District.

Federal District		
Delegation	Pop.	Rate of growth 1980-1990
Benito juárez	424	-1.71
Venustiano Carranza	540	-2.07
Cuauhtémoc	619	-2.16
Miguel Hidalgo	423	-2.16
Azcapotzalco	494	-1.69
Coyoacán	673	1.66
Cuajimalpa	127	3.52
Gustavo A. Madero	1323	-0.96
Iztacalco	467	-1.65
Iztapalapa	1572	2.66
Magdalena Contreras	205	1.99
Milpa Alta	67	3.01
Alvaro Obregón	675	1.17
Tláhuac	219	4.50
Tlalpan	513	3.97
Xochimilco	286	3.22
Total	8628	0.21

Note: Population in thousands. Rate of growth in %.

Source: Sergio Campos Ortega Cruz; Evolución y Tendencias Demográficas de la Zona Metropolitana de la Ciudad de México. Conapo,1992.

Table 2.1.2 Population in the metropolitan municipalities of the State of Mexico.

State of Mexico		
Municipality	Pop.	Rate of growth 1980-1990
Acolman	46	
Atenco	22	3.39
Atizapán de Zaragoza	337	7.65
Coacalco	161	5.12
Cuautitlán Izcalli	351	9.23
Cuautitlán de R. Rubio	52	4.49
Chalco	309	15.22
Chiautla	16	3.38
Chicoloapan	61	8.51
Chiconcuac	15	3.02
Chimalhuacán	265	15.84
Ecatepec	1299	6.49
Huixquilucan	141	7.08
Ixtapaluca	147	7.72
Melchor Ocampo	28	
Naucalpan	830	2.63
Nezahualcóyotl	1315	0.31
Nicolás Romero	196	5.57
La Paz	143	4.83
Técamac	131	5.00
Teoloyucan	45	
Tepozotlán	42	
Texcoco	148	3.51
Tezoyuca	13	
Tlalnepantla de Baz	737	0.82
Tiltepec	51	
Tultitlán	264	8.52
Total	7166	4.59

Note: Population in thousands. Rate of growth in %.

Source: Sergio Campos Ortega Cruz; Evolución y Tendencias Demográficas de la Zona Metropolitana de la Ciudad de México. Conapo,1992.

the lack of efficient means of intergovernmental coordination, negatively affect the rational allocation of resources for public services and the efficient operation of those services, waste handling and disposal among them. This is a fact that most be dealt with in the analysis of any alternative solutions for future waste management in the area.

Details of the administrative organization both of the Federal District Government and of the Government of the State of Mexico, as regards the responsibilities for urban waste handling and disposal are given in Section 3.3.

2.3. Some Socio-Economic Factors.

The Metropolitan Area of the Valley of Mexico is the dominant urban center in the Republic of Mexico. It seats most of the Departments of the Federal Government, it is the corporate, financial and communications hub of the country and it houses its most important technical, educational, cultural, and political institutions. With 15.7 million inhabitants in 1990, it is one of the most populated cities in the world.[1] It accommodates 18.6 of the population of the Republic, and accounts for almost 37% of the GNP , as well as for 45% of the country's manufacturing production value[2] Due to different factors, among them the high relative accumulated investment in infrastructure and services, the productivity of the MAVM is higher than the national average: 37% on national output is achieved by 26.5% of the total economically active population of the country.

Traditionally, the main economic activities in the MAVM have been those related

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[1]One interesting comparison is that the MAVM has more population than 80% of existing countries: 166 out of 209.

[2]The GNP of the MAVM is almost equal to that of Argentina's.

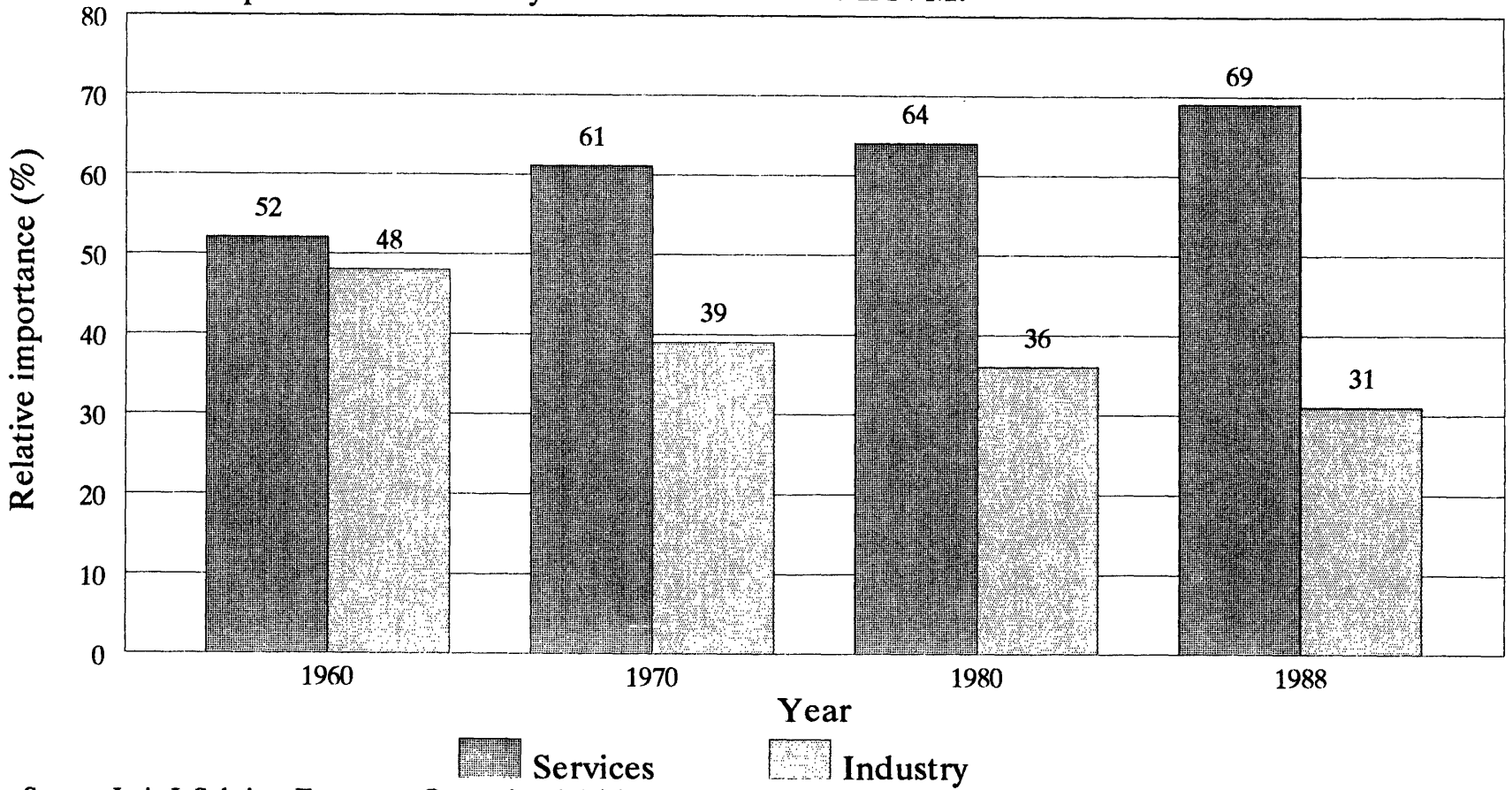
with government, and manufacturing, as well as educational, health, financial, and commercial services. Analysis of the sectorial composition of employment shows a constant tendency during the last decades to an increasing importance of the services sector, as the dominant activity in the area, and to the almost complete disappearance of activities in the primary sector. In 1990, 1.1% of employment took place in the primary sector, 33.3% in the secondary sector and 65.6% in the services sector. That tendency includes an important decrease in the participation of the governmental and manufacturing sectors in total employment. Regarding governmental activities, that is a result, on the one hand, of decentralization efforts that have located some important federal government activities in other cities, and on the other, of the search of efficiency of governmental activities, including privatization. In respect industrial activities, diverse factors have restricted further industrial development in the area, among them: high costs of land and water, increasing costs of environmental control, and the growing importance of industrial exports, for which other regions offer locational advantages[3]. In contrast, important employment growth has taken place in private services, where the Metropolitan Area is particularly competitive. This notwithstanding, much of the employment is in low-productivity commercial activities, including an increasingly important informal subsector. (Figure 2.4).

For many years the MAVM, and in a very special manner the Federal District, received important subsidies from the federal government. Part of those subsidies had its origin in federal taxes collected in other regions of the country, giving ground to accusations of a nationally subsidized MAVM . Main receptors of those subsidies have been in the public services sector, such as urban transportation systems, including huge investments in the Metro, urban waste handling and disposal, as well as water supply

[3]During recent years no medium or large sized industries have been located in Mexico City. Only 10% of construction licenses granted for uses different to housing, were for industrial installations.

Figure 2.4

Relative importance of industry and services in the MAVM.



Source: Luis J. Sobrino. Estructura Ocupacional del Sector Servicios en la Ciudad de México, 1960–1968. CONAPO, 1992.

and sewage systems, that also represent extremely high investment and operation costs. Policies regarding subsidies to the Metropolitan Area are changing rapidly, and it is expected that in the near future most of the total cost of services will be paid for by the inhabitants of the region, either trough taxation or through direct charges for services. To maintain a dominant role in the country's economic system, the MAVM will have to offer additional competitive advantages, among them a better quality of life, to offset the effect of the increasing cost of life in the region. This will of course require careful fiscal and financial consideration.

Another important factor regarding the planning of urban services - including the selection of technologies- in the area is the strong inequalities that exist in the distribution of income among the population[4] and, the fact that the average income is low as compared with the standards of fully developed countries: only 26% of the employed population earns more than 2 minimum salaries; the minimum salary is presently about $135 US per month.

The figures that have been presented in this section are relevant regarding different factors, among them: a) The importance of providing adequate public services to a huge and increasingly demanding population; b) The scale of the required actions; c) The dynamics of waste generation and composition; d) The selection of adequate technologies, including cost elements; e) The design of mechanisms for the financial recuperation of the investments and operational costs related with any waste management strategy.

2.4. Transportation Infrastructure.

As befits the importance of the Area, the density of its transportation infrastructure is relatively high. Relevant for the purpose of this work are the internal

[4]45% of the total income goes to 20% of households in the upper income brackets.

links and those that communicate the Area with adjacent regions. In respect the internal road links, notwithstanding its density, a recent analysis shows that nearly 75% or the main network is congested during peak hours. As for the road links with adjacent regions, the Area is well communicated with them through highways and toll roads and railroads, the most important being those that connect the MAVM with the cities of Queretaro to the north-east, Pachuca to the north, Puebla to the east, Toluca the west, and Cuernavaca and Cuautla to the south. However, it must be taken into account that highways and toll roads, being in some of its sections part of the internal links, are also subject to congestion. It also must be realized that urban development has taken place in a radial pattern, following precisely those interregional links, and that there is a lack of enough concentric and transverse roads, necessary to interconnect the radial roads, specially within the State of Mexico.

In respect the railroad system, its main lines serve the same adjacent regions that the road system, with the advantage that they have available capacity. Both regarding the road and the railroad systems, those connecting the Metropolitan Area with the arid, much less densely populated regions to the north and north-east, are of particular interest for the possibility of long-haul solutions for the urban waste management system (Fig. 2.5).

2.5. Demography. Evolution and Projections.

2.5.1. Evolution.

With a population that for 1994 is estimated to be in the neighborhood of 17.0 million inhabitants, what we call nowadays the Metropolitan Area of the Valley of Mexico (in its origin: Tenochtitlan and then Mexico City) has been for many centuries, and for the standards of each epoch, a large urban concentration: it has been estimated that just before the conquest by the Spaniards in 1521, the city had a population of about

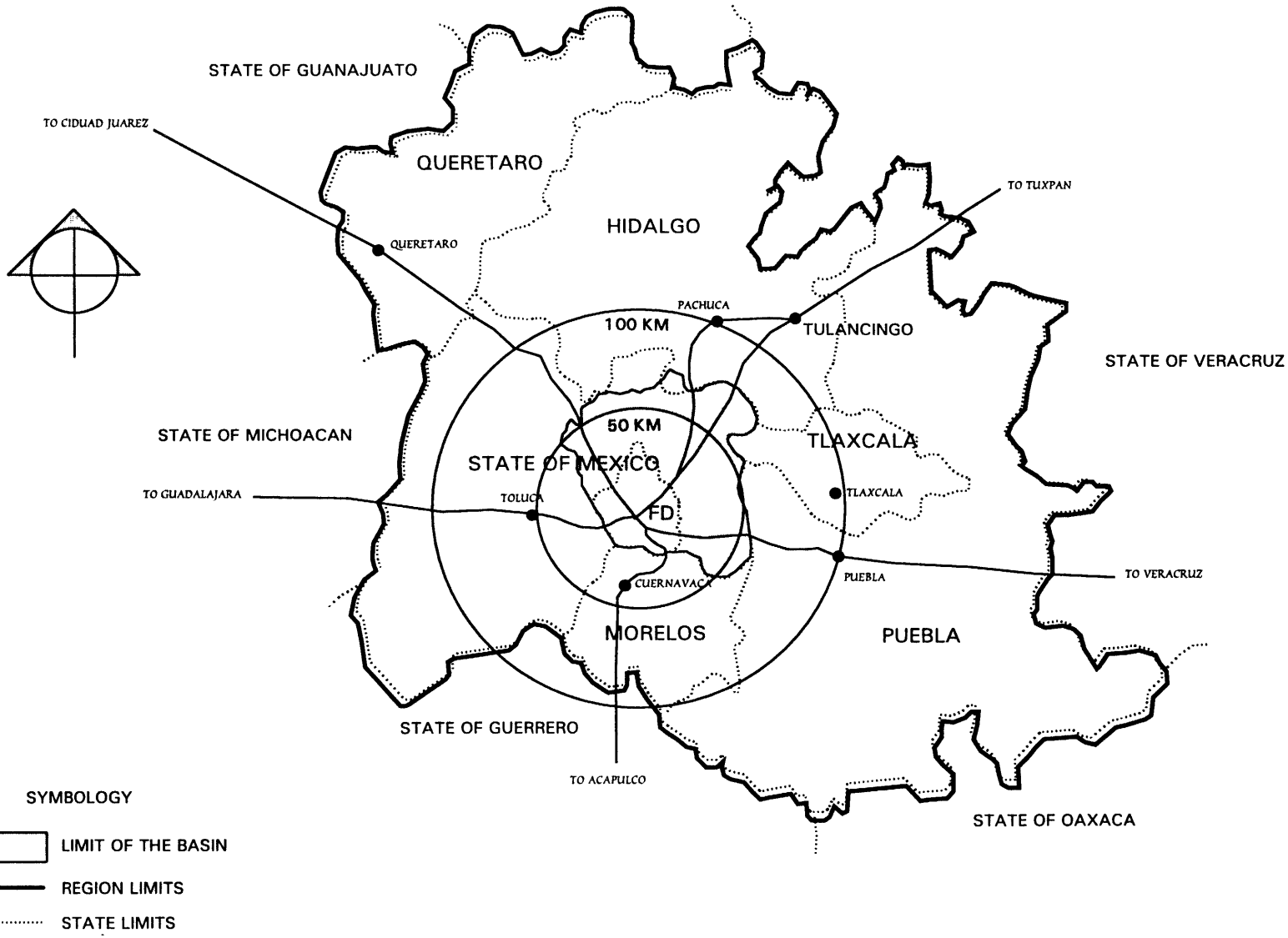


FIGURE 2.5.- CENTRAL REGION TRANSPORTATION SYSTEM

70,000 inhabitants; by the beginning of the present century the population was 340,000 inhabitants. However, the explosive population growth is a phenomenon of the present century, and specially, percentage wise, of the years between 1920-1930 and 1940-1970. Among the main causes of this growth have been cited: the general increase of the population, typical of a developing country as sanitary conditions improve and birth control concepts and measures are slowly accepted; the apparently inevitable urbanization and metropolization, also characteristic of developing countries tendencies caught in a self reinforcing loop of political power and economic centralization[5]. This also explains the increasing importance of the population of the Area in relation to the population of the entire country: 8.4% of the total population in 1940, 14.7% in 1960, 18.6% in 1990.

Starting with the decade of 1970-1980, it begins a decrease in the aggregate rates of population growth for the Area as a whole. However, the aggregate figures are composed by two different tendencies, as it was mentioned before: a marked decrease in the rates of growth within the Federal District, and still high rates of growth of the population within the State of Mexico. This happens not only as a result of the contrasting policies (Section 2.2) adopted by the Federal District's and State of Mexico's authorities during the decades of the 50's and 60's, but also as along the years different components of the Metropolitan Area underwent different typical stages of development: accelerated growth, decrease of acceleration, stabilization. Summary information regarding the demographic evolution of the Metropolitan Area is presented in Table 2.2.

2.5.2. Projections.

It has been known for some time now that -fortunately- the catastrophic

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[5]Of the world's largest cities in 1950, 11 were in the developing countries. By the year 2000, 12 of the largest cities will be in the developing countries.

Table 2.2 Demographic evolution in the MAVM.

Territory	Population (thousands and % at mid year)					Rate of growth (%)			
	1950	1960	1970	1980	1990	1950–1960	1960–1970	1970–1980	1980–1990
Total	3136	5439	8910	13021	15794				
MAVM	100	100	100	100	100	5.66	5.06	3.87	1.95
Federal	3105	5109	7035	8447	8682				
District	99.2	93.9	79	64.9	54.6	5.11	3.25	1.85	0.21
State of	31	330	1875	4574	7166				
Mexico	0.8	6.1	21	35.1	45.4	26.68	18.97	9.33	4.59

Source: Sergio Campos Ortega Cruz: Evolución y Tendencias Demográficas de la Zona Metropolitana de la Ciudad de México. CONAPO, 1992.

projections made by demographers in the 70's, that predicted a population in the range of 30-35 million inhabitants for the MAVM by year 2000, grossly overestimated what has proven to be a somewhat more manageable -if still impressive- population size. Notwithstanding that fact, the results of the 1990 census came in as a surprise. The lower population estimations for that year estimated a figure around 18 million persons for the MAVM; the census figures resulted in only 15 million persons. It has been disclosed now that the government department in charge of the 1980 census introduced some adjustments to account for omission errors, and that in the case of the MAVM the adjustments were beyond the reality for about 1 million inhabitants. This of course affected the projections made on the basis of the 1980 census. Several demographic studies are under way now, trying to clarify the situation, and an official release of population projections for the MAVM is still pending. Available information shows some important discrepancies in the projected figures, as they make different assumptions, both regarding the amount of the 1980's census population overestimation (apparently the 1990 census has proven to be reasonably trustworthy), and the value of some basic demographic factors such as fertility, mortality and migration rates. Figure 2.6 shows what can be regarded as low and high estimates of the MAVM's population up to 2020. Some representative ranges are: 17.7-20.5, 20.3-23.9 and 23.1-27.0 million inhabitants for the years 2000, 2010 and 2020, respectively[6].

2.6. Environmental Issues.

The explosive growth of the urban areas, and of productive activities in the Valley of Mexico, without due attention to the preservation of an adequate ecological balance has led to grave alterations of the original conditions of the Valley, among them

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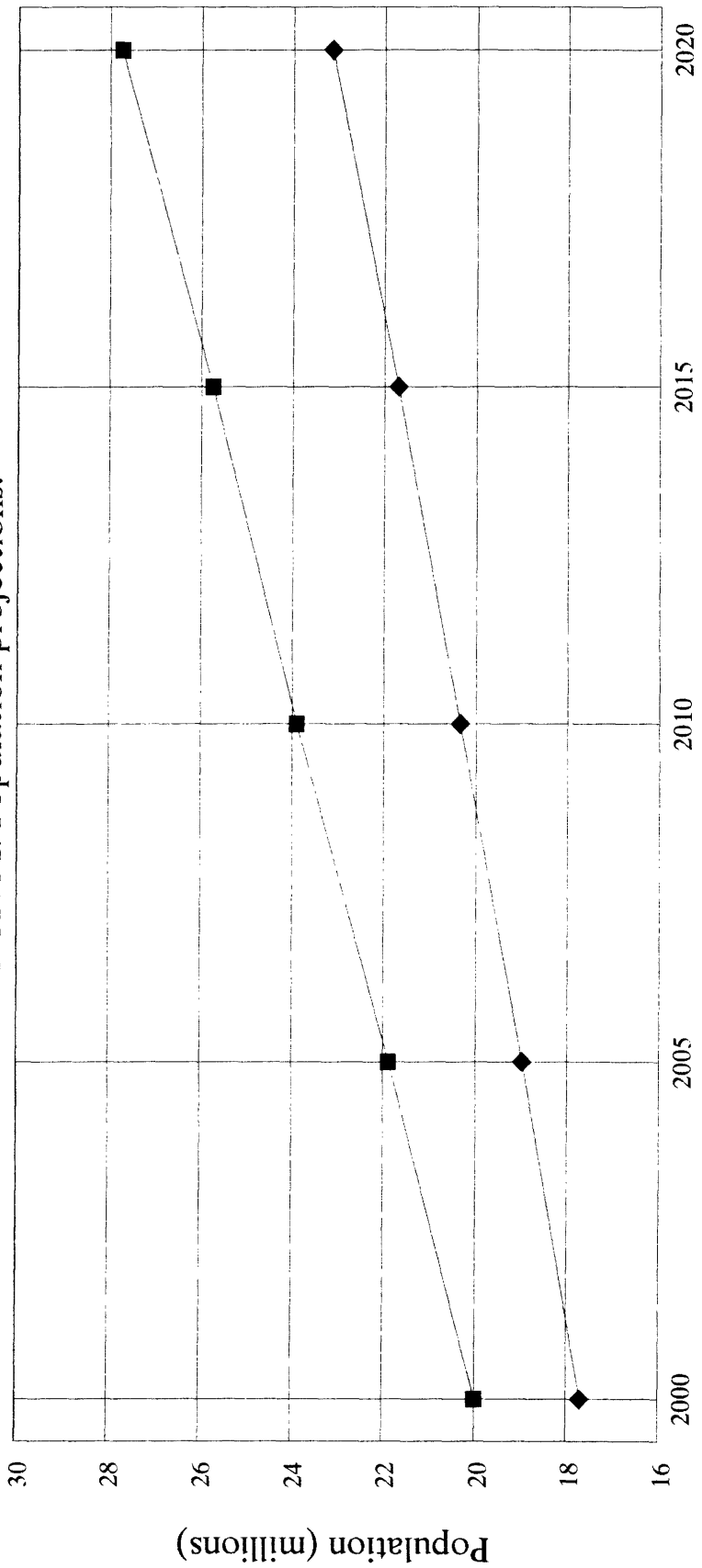
[6]Data developed by Sergio Camposortega C. and published by CONAPO (Consejo Nacional de Poblacion), and by Paula Norena (Universidad Autonoma Metropolitana) is generally utilized for population estimations in the present work. See references.

Figure 2.6

MAVM: Population projections.



Source: Paula Noreña F. Planificación para el Saneamiento Básico de la Cuenca del Valle de México. México, 1994.

the elimination of 73% of the woods, deterioration of grasslands, desiccation of 99% of the lake areas and wetlands with the virtual disappearance of the corresponding ecological systems, as well as serious modification of the surface and ground hydrological conditions. It is a well known fact that today environmental conditions within the MAVM are far from satisfactory, specially as regards air pollution, but also in respect soil an water contamination. Any waste management strategy must take into consideration its possible effects in the already serious environmental conditions of the Valley. Some information in respect two of the main environmental concerns -air pollution and the contamination of the aquifers-, as they relate to waste management and disposal, is given in this section.

2.6.1. Atmospheric Contamination.

Notwithstanding diverse important efforts that have taken place in recent years to fight atmospheric contamination, the MAVM faces a severe air pollution problem due to a combination of circumstances. As it was discussed in section 2.1 (Physical Setting), the Metropolitan Area is located in a high mountain basin at a subtropical latitude. The prevailing northeasterly winds and the topography of the basin inhibits dispersion of pollution, and contributes to wintertime thermal inversions which further trap pollutants near the surface. Approximately 30,000 industrial establishments are located in the MAVM, of which 1,500 to 1,800 fall in the category of medium and large industries. There are more than 12,000 commercial and service facilities utilizing combustion processes and a large number of non-combustion sources such as dry cleaning, printing and solvent uses. The transportation sector includes nearly 3.3 million vehicles, the railroad network, and airport facilities. Fuel consumption in the MAVM is large: more than 40 million liters every day. There exist other pollution sources, most of them natural, such as dust particles that are carried by the strong winds, mainly during the height of the dry season (January to March), from what used to be lake and woodland areas. More than 4.3 million ton of contaminants are produced yearly in the area (Tables

Table 2.3 Emissions to the atmosphere in the Valley of Mexico (ton/day).

Sector	SO_2	NO_x	HC	CO	Particles	Total
Energy	73028	9846	31843	53205	4699	172621
Industry and services	87792	32871	40102	16282	12711	189758
Transport	44774	133691	300380	2853778	9549	3342172
Others	131	931	199776	27362	423640	651840
Total	205725	177339	572101	2950627	450599	4356391

Source: Rodolfo Lacy. La Calidad del Aire en el Valle de México. El Colegio de México, 1994.

Table 2.4 Emissions to the atmosphere in the Valley of Mexico (percentages)

Sector	SO_2	NO_x	HC	CO	Particles	Total
Energy	35.5	5.6	5.6	1.8	1.0	4.0
Industry and services	42.7	18.5	7.0	0.6	2.8	4.4
Transport	21.8	75.4	52.5	96.7	2.1	76.7
Other	0.1	0.5	34.9	0.9	94.0	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Same as above.

2.3 and 2.4).

The local topographical and urban pattern strongly contributes to the general problem. During early morning, slow surface winds, that have its origin in the convergent nocturnal drainage flow, concentrate great part of the emissions above the central part of the city, where the pollutants will react due to solar radiation at sunrise. Before noon, wind direction is mainly southwest, and most of the pollutants are trapped by the Ajusco Sierra, and react there or, eventually, are returned downtown in the late evening, when the night winds flow northwards (Figure 2.7). Because of the subtropical location of the Valley of Mexico, solar radiation plays an important chemical activation role, that in conjunction with the high level of hydrocarbons and nitrogen oxides emissions, makes ozone formation the main atmospheric pollution problem of the area.

Also related with the topographical and methereological characteristics of the Valley, are the frequent thermal inversions that are specially relevant to the concentration of air pollutants. Thermal inversions are present in the Valley during every month of the year, being more frequent and lasting longer in the winter season. During that period, thermal inversions typically are present in more than 25 days out of 30, may last up to 7 hours, and may reach a thickness of pollutants mix of up to 550m (Fig. 2.8).

Many different actions have been taken by governmental authorities with the support of society, in attempt to control air pollution: modification of fuels for automobiles and industry -including a more widespread utilization of oxygenated gasolines and natural and liquefied gas-, growing utilization of catalytic converters, more stringent verification of vehicle emissions, restrictions to the circulation of vehicles, important investments in mass transport, reforestation., etc. It appears that those measures are beginning to take a positive effect. Official reports show that, as of mid year 1994, concentrations of Pb, SO2, and CO in all the subregions of the Metropolitan

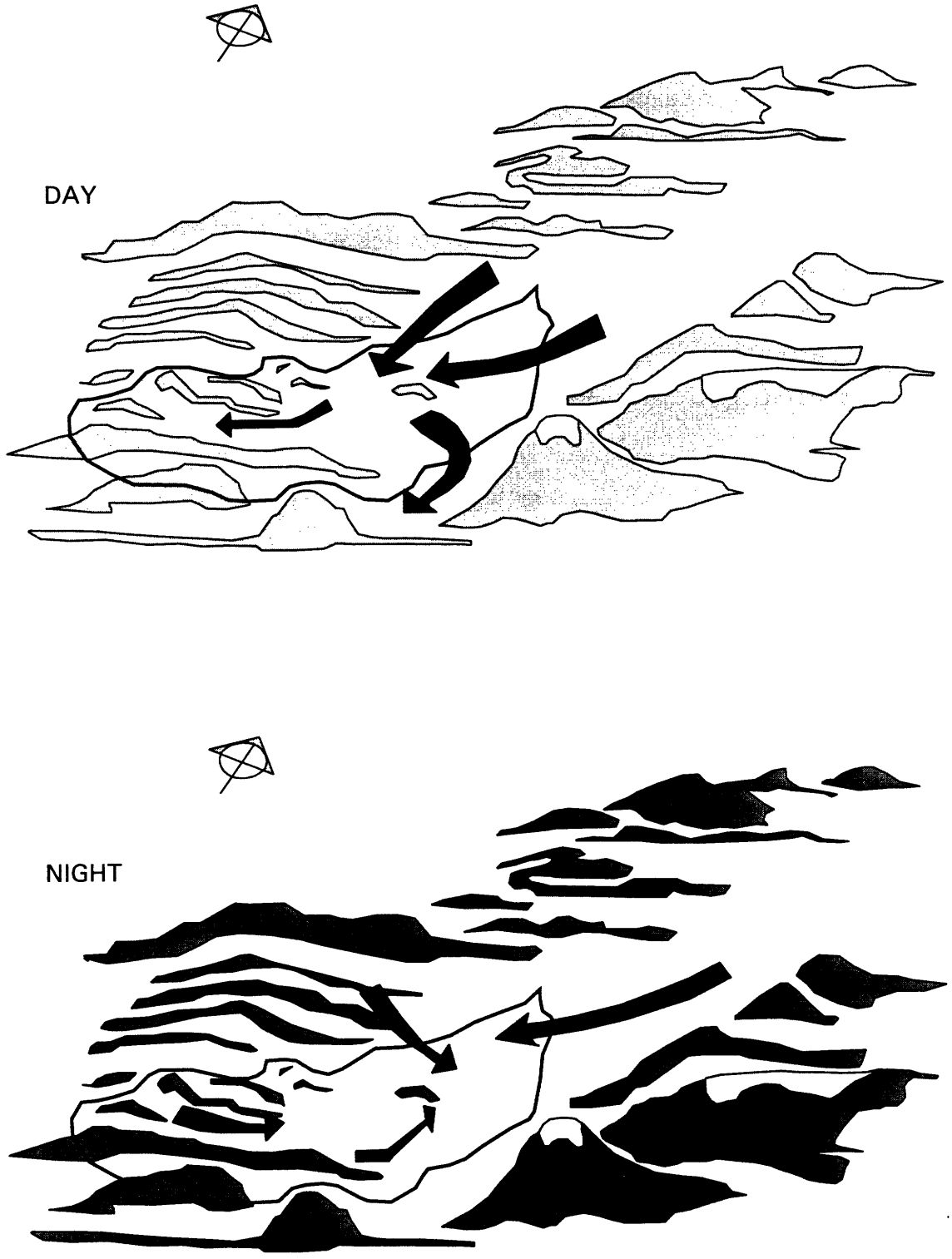
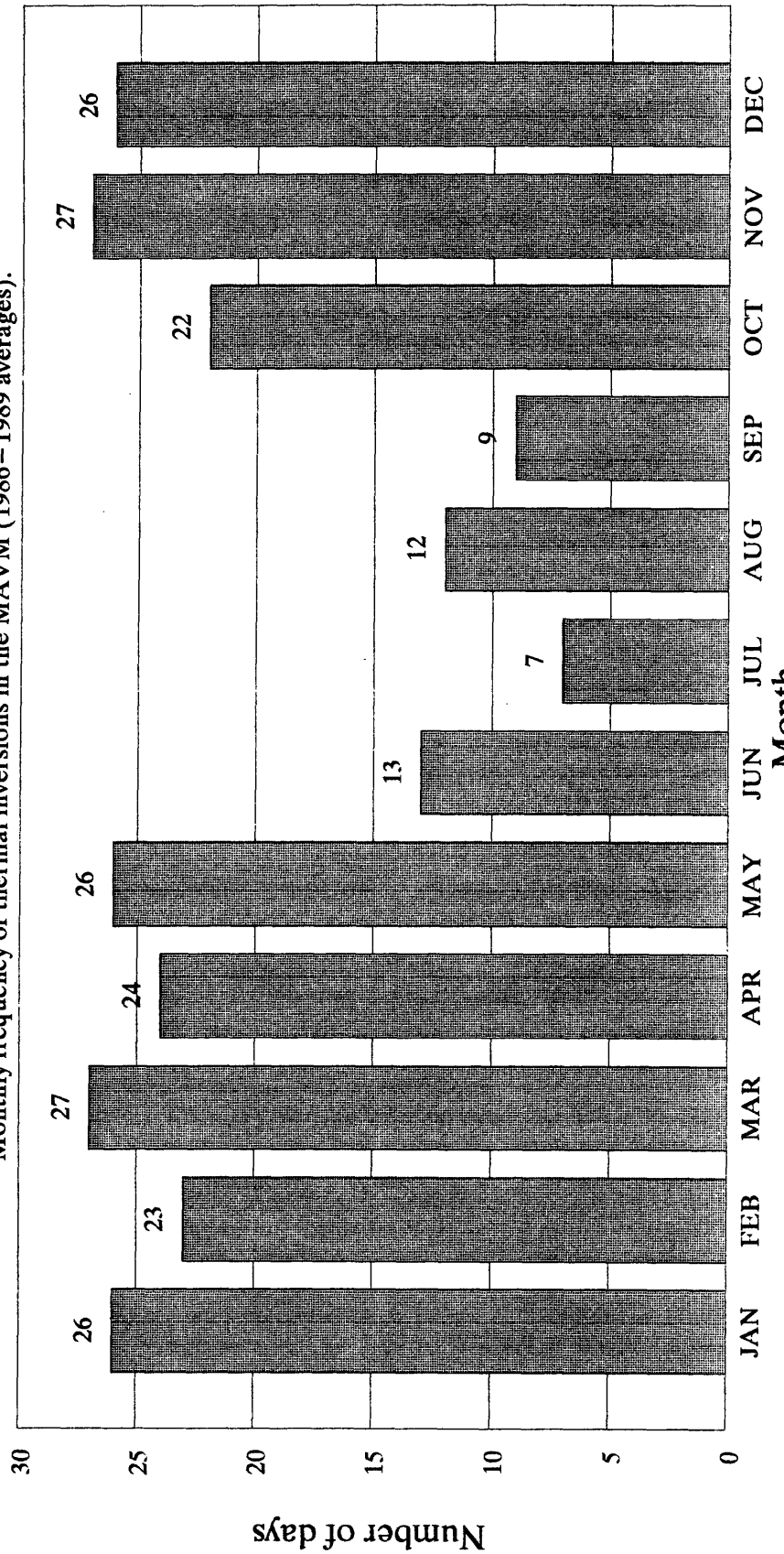


FIGURE 2.7.- ATMOSPHERIC FLOWS IN THE VALLEY OF MEXICO

Figure 2.8

Monthly frequency of thermal inversions in the MAVM (1986–1989 averages).



Source: Programa Integral contra la Contaminación Atmosférica. DDF, 1991.

Area, had been within norms for more than 24 months, as no violations had occurred had during that period[7]. However, concentrations of NOx, particulates -including those below 10 mm-, and especially ozone, are far from satisfactory (Figure 2.9).

Among steps taken in respect air pollution in the MAVM, there are those whose objective is a better understanding of the behavior of the system, in order to asses the feasibility and the effect of diverse actions. One of the most recent ones, that is of interest to the present work is the Mexico City Air Quality Research Initiative (MARI), that utilizes a systems approach including computer modeling, measurement of air pollutants, environmental chemical reaction studies and socioeconomic analysis. Sponsors for the initiative are Mexico's Petroleos Mexicanos (Pemex) and the U.S. Department of Energy (DOE). Project leadership is provided by the Instituto Mexicano del Petroleo (IMP), and the Los Alamos National Laboratory (LALN). Among the modeling tools, a full three dimensional airshed model, first developed at the California Institute of Technology and further developed at Carnegie-Mellon University, is being utilized to evaluate and simulate photochemistry.

The MARI project is still underway and no specific simulations have yet been made regarding the possible effects of actions related to waste management, such as incineration in different parts of the Valley. During informal discussions members of the project team were inclined to consider that the installation of substantial incineration facilities, should if possible be avoided, specially in the northern and central parts of the Valley, and that additionally, any proposal to proceed with that type of installation would face strong social opposition. Before the existence of this very interesting tools, others had reached a similar conclusion: the two main power generation plants within the Valley (Jorge Luque and Valle de Mexico) have been transformed so as to utilize

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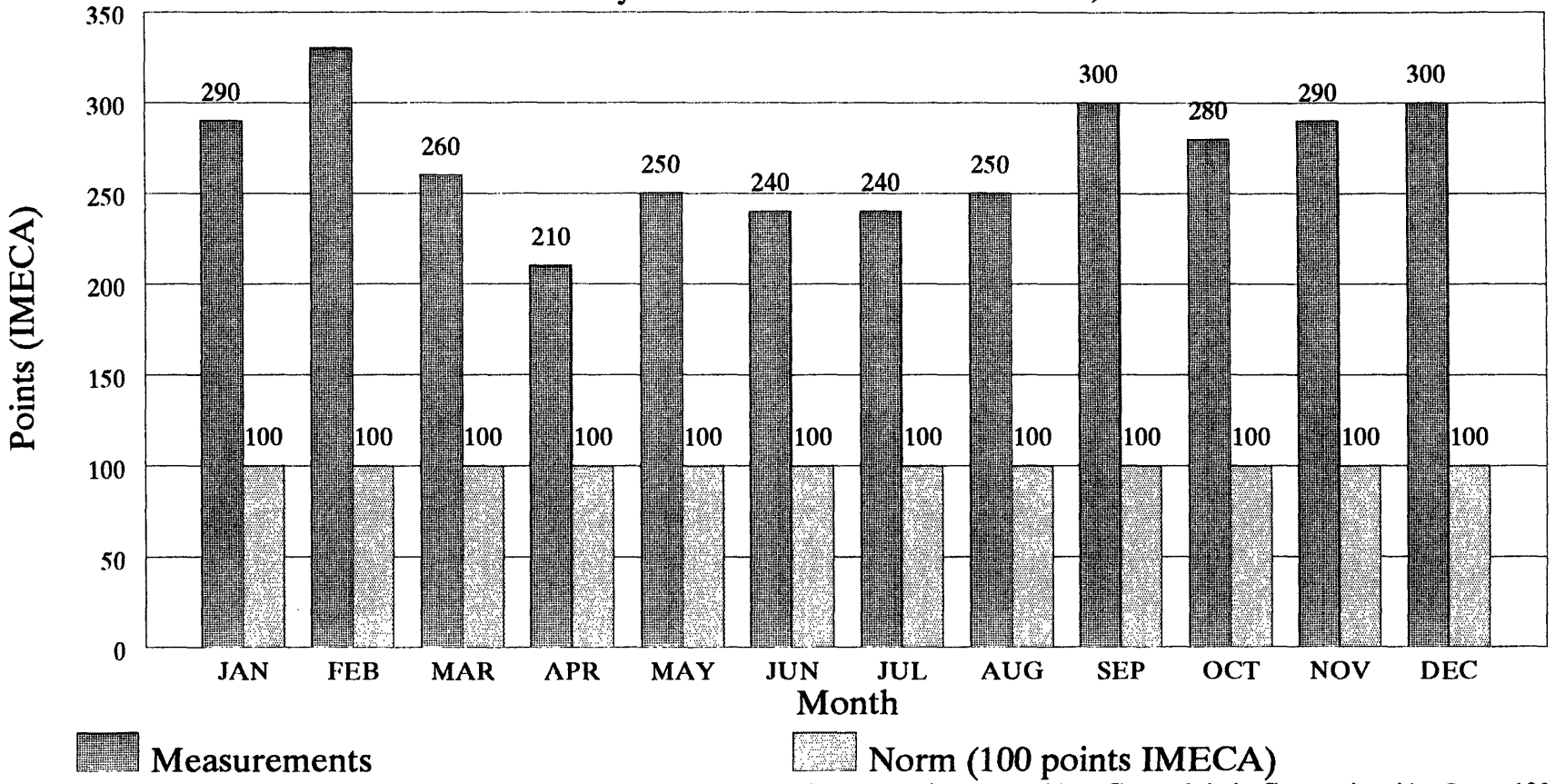
[7]Comision Metropolitana Para la Prevencion y Control de la Contaminacion Ambiental en el Valle de Mexico. Informe Ejecutivo de la Calidad del Aire. Junio, 1994. See References.

Figure 2.9

Monthly Ozone maxima in the MAVM, 1993.



Source: Informe Ejecutivo de la Calidad del Aire. Comisión Metropolitana para la Prevención y Control de la Contaminación. June, 1994.

natural gas, and will be closed as soon as they reach their planned useful life.

2.6.2. Ground Water Contamination.

As it was briefly discussed in Section 2.1., diverse geological formations constitute the Valley of Mexico. As regards its capacity to receive infiltrations, and to circulate and store groundwater, those formations may be grouped in 5 different units: a) Lavas and piroclastic formations of basaltic nature whose main characteristic is its high permeability; they are the main components of the Santa Catarina and Chichinautzin Sierras. b) Andesites that are found in the Sierra de las Cruces; they have medium permeability. c) The Tarango sandy-clay and tuff formation, of low permeability, to be found mostly in the eastern slopes of the Sierra de las Cruces. d) Alluvial materials, found in what used to be lake areas, with medium permeability. e) Lacustrine sediments, that have a very low permeability and are deposited on top of the alluvial materials in most of the low areas of the Valley[8].

The aquifer is the most important source of fresh water in the Valley of Mexico: almost 70% of fresh water supplies have that origin. The main recharge areas for the aquifer are the Sierras to the west, south and east, from where groundwater flows in an approximately radial direction towards the center of the Valley. The aquifer is reached at different depths: 20 to 50 m in the central areas; 50 to 180 m in the western and south slopes. There is a potential danger of contamination to the aquifer from leachates originating in waste disposal sites, as well as in urban areas where domestic waste water is disposed of in badly- constructed or ill-maintained septic tanks, or where there not exist sewage facilities. Several studies have been carried out in recent years to obtain more precise information regarding the characteristics of the geologic formations, the

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[8]Transmissibility varies from 0.5 m^2/s in the basalts and piroclasts, to around 0.1 m^2/s in the alluvial formations, and to as low as $5x10^{-7}$ m^2/s in the lacustrine clays. However, there exist cracks in the clay formations that permit infiltration to the aquifer through them.

aquifer levels, the direction of underground flows, as well as water quality. This information has been utilized to evaluate the condition of the aquifer in the most potentially dangerous areas, and to model the ground water flows when they are subject to infiltration from leachates. The general conclusion of those studies show that: a) There exists contamination of the aquifer in certain areas of the Valley. b) The contamination has a relationship with the existence of open waste dumps and with the surface flow of waste water. c) In the contaminated areas of the aquifer, the pollution varies from serious (it has already caused the closure of several wells), to slight. d) As was to be expected, contamination of the aquifer is more important where basalts and piroclasts coexist with polluted surfacewater. e) The areas of more serious potential contamination are in the lower slopes of the Sierra de Chichinautzin, to the south, and to a lesser degree in the outcrops of volcanic rocks in the Sierra de Santa Catarina and other minor such outcrops within the Valley, Cerro de la Estrella and Cerro del Marques, in the east central part of the Valley.

As regards actual or potential contamination caused by infiltration of leachates from solid waste, specific cases show different effects on the aquifer, depending on the relative position of the waste deposits and the well fields, as well as on the geologic characteristics of the area. For example, in the case of the Santa Fe dump -later transformed into a sanitary landfill of rather low specifications and finally closed during the first half of 1994-, located in the western Tarango formation, studies revealed that the leachates reach the aquifer after crossing approximately 150 m of a non-saturated zone, where part of the contaminants are retained. When the lecheates reach the aquifer, the flow takes them to the east, to the central part of the Valley where there exist important well fields. It was estimated that it takes the lecheates approximately 90 years to reach the zone where the well fields are located. In other cases, such as that of old dump sites - all of them now closed, with the exception of one- that exist in the eastern part of the Valley, in the vicinity of the Cerro de la Estrella and the Sierra de Santa Catarina, serious contamination of the aquifer has been detected from direct infiltration of lecheates in nearby wells. It is not known as yet the extent of the damage to the aquifer, although it

has been estimated that contamination would take around 50 years to reach some of the most important well fields within the Valley. That notwithstanding, systematic analysis of the water extracted from wells shows that up to now, no generalized pollution exists in the aquifer . More hydrogeological studies, covering wider areas of the Valley in more detail are required to reach a better understanding of the behavior of the aquifer, and of potential dangers of additional contamination.

In respect possible location of waste management installations, in particular landfills, it can be concluded that, both for geological and socio-demographic factors, there are no suitable sites for them within the limits of the Federal District. Additional sites for landfills should be looked for preferably somewhere else, either in the northern part of the Valley -within the territory of the State of Mexico-, or outside of the Valley.

3. Legal and Regulatory Framework.

The knowledge of the structure of government in its different levels, and of the existing legal framework, is necessary for a) The identification of some of the most important participants in the decision making process regarding urban services and environmental matters. b)The understanding of the interrelationships among the different levels of government, as well as of the roles that the participants play in that process. c) The feasibility of any proposal to modify the present waste management system in the MAVM. Accordingly, this section presents a description of the structure of Mexican government and of the most relevant elements of the existing legal framework that are pertinent to the objectives of the work.

3.1. The Structure of Government.

Mexican government has three levels: Federal, State and Municipal. From a juridical perspective, the Constitution of the Republic, that is the supreme law of the country, clearly defines those levels, as well as the explicit attributions of the Federal Government. In general, the attributions of local governments are defined in the Constitution by exclusion, with the explicit distribution of responsibilities between state and municipal governments being left to local state congresses. Given its special juridical character as seat of the federal government, in the specific case of the Federal District, there exists another type of local government: the Department of the Federal District, that from certain perspective could be compared to a State Government, but in other -basic-

respects is completely different.

3.1.1.Federal Government.

It is based in the concept of three separated powers: Executive, Legislative and Judiciary. The head of the executive branch is the President of the Republic, who is elected by direct universal vote every six years, without possibility of reelection. For administrative purposes, the executive branch of the federal government consists of a) A centralized body formed by specialized ministries ("Secretarias") and departments, and b) State corporations ("Paraestatales"), that in general are in charge of the direct participation of the State in productive, financial, and other activities related to economic development[9]. The most relevant organisms of the executive branch of federal government as regards solid waste management are a) The SEDESOL (Secretaria de Desarrollo Social - Secretariat for Social Development-), two of its main Departments being the National Institute of Ecology and the Federal Office of Environmental Protection; b) The SS (Secretaria de Salud -Health Secretariat-), in charge of matters related with public health; c) The Secretariat for Communications and Transport, related with the interstate transportation of waste, and d) the Secretariat for Commerce and Industrial Development, in charge of diverse technical norms. The legislative branch of the Federal Government is the Congress, which has two Houses or "Camaras": the House of Representatives, whose members have 3 years terms, and the Senate, members of which are elected every 6 years. The judiciary power of the federal government is deposited in a Supreme Court of Justice and in diverse lower courts. Members of the Supreme Court are proposed by the President of the Republic and approved by the Senate. Members of the lower courts are appointed by the Supreme Court.

General and specific Federal laws proposed by the executive branch must be

[9]During the past ten years the number of State corporations has been drastically reduced, either by closure or trough sale to the private sector.

approved by both Houses. Regulations are then developed, and published, under the corresponding laws, by the pertinent Ministry. In some cases the Ministries have the power to enforce the law through administrative measures, such as fines. It is the role of the Judiciary branch to oversee and manage the administration of Federal law.

SEDESOL. Of those federal government ministries that play a role in environmental matters, the most relevant is SEDESOL (Secretaria de Desarrollo Social - Ministry of Social Development), created in May, 1992. Its immediate predecessor had been SEDUE (Secretaria de Desarrollo Urbano y Ecologia -Ministry of Urban Development and Ecology) that had been created in 1982 in a first effort to integrate different aspects of urban policy and management in a single organization. It is considered that because of the broader functions and political importance of SEDESOL, the relevance of environmental issues has been enhanced with the more recent reorganization. The main operative organisms of SEDESOL dealing with environmental matters are the INE (Instituto Nacional de Ecologia -Nacional Institute of Ecology-), that has technical and regulatory faculties and the PROFEPA (Procuraduria Federal de Proteccion al Ambiente - Federal Agency for Environmental Protection-), with faculties related with environmental control and care of social environmental demands.

The main functions or the INE related with the present work are:

- To define, propose and evaluate the general ecological policy of the country.
- To define and propose specific polices, programs, technical norms, criteria and technical procedures for the protection, preservation and restoration of the environment.
- To define the ecological technical norms for the operation of systems related with municipal solid waste.
- To evaluate and to resolve in respect of environmental impact studies related with public and private projects and activities, when they

correspond to federal jurisdiction.

- To grant licensees, concessions, authorizations and resolutions in matters of environmental federal jurisdiction.

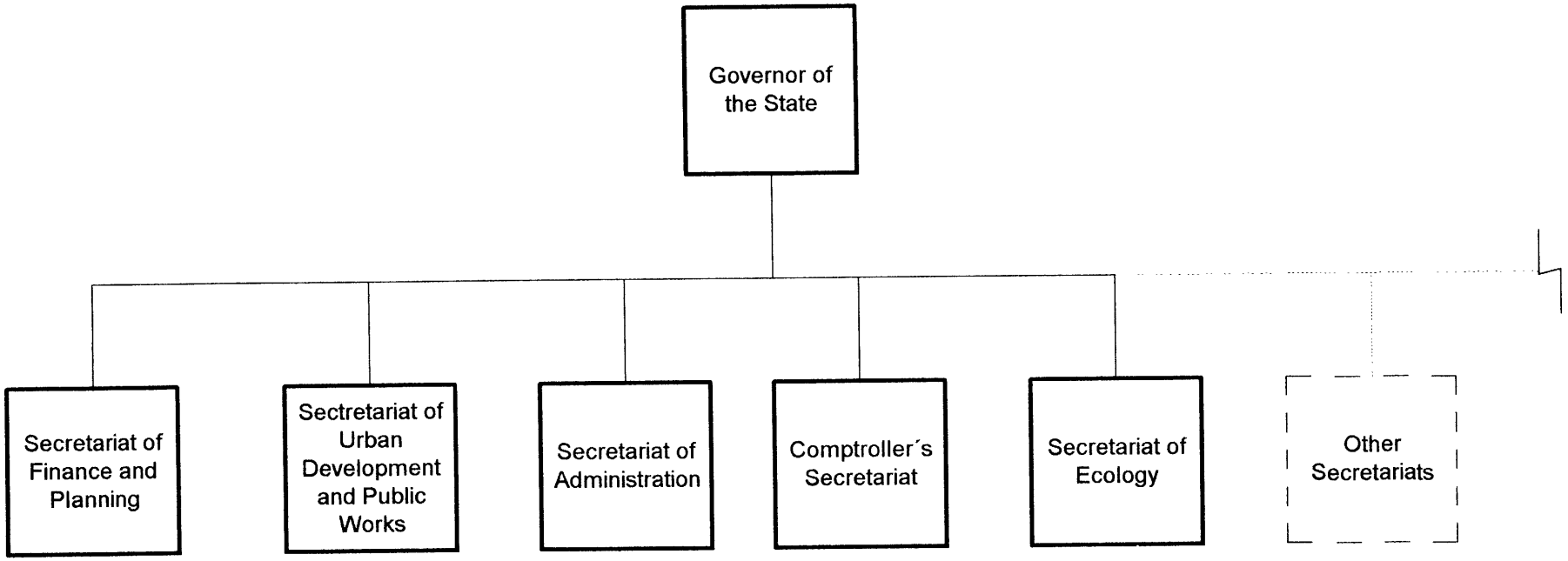
As for the PROFEPA, its main responsibilities related with federal participation in solid waste handling and disposal are:

- To represent the interests of the people in matters of environmental protection.
- To define criteria for social participation and responsibility in environmental matters.
- To promote social participation and responsibility in environmental matters.
- To establish and operate the system for public denunciation of environmental law violations.
- To conduct environmental audits in all matters of federal jurisdiction.

3.1.2. State Government.

Because of the federal character of the Mexican Republic, the associated states have self-determination in internal matters, as long as they respect in their own local constitutions the basic form of government of the country (republican, federative, representative, popular), and have the Free Municipalities as the basis of its territorial, political and administrative organization. The structure of state governments reflects in a smaller scale that of the Federal Government. State governments are headed by the State Governor, elected by universal vote every 6 years, have a single House of Representatives, also elected by universal vote and a State Judiciary system. State's executive branches have diverse specialized Secretariats and Departments, similar to Federal ministries, as well as State corporations. Figure 3.1 shows in a schematic manner the organizational structure of the government of the State of Mexico.

Figure 3.1 Government of the State of Mexico: Summarized organizational structure.



Source: Ley Orgánica de la Administración Pública del Estado de México.

3.1.3. Municipal Government.

In accordance with the Constitution of the Republic, the Municipality is the basic unit of the political organization. Each of the municipalities is governed by a Municipal Council (Ayuntamiento), which is elected by universal vote. The Municipal Council has the character of a joint body or assembly whose main function is the resolution of administrative matters brought to its attention; the execution of the resolutions of the Municipal Council corresponds to the Municipal President who also heads the Council. In addition to the Municipal President, the Municipal Council includes Municipal Councilors ("Regidores") and Trustees ("Sindicos"). The former are responsible for controller functions, the latter of supporting the Municipal President in diverse specialized aspects, among them waste management. The actual organizational structure of municipal councils varies in accordance with the size and relative complexity of the municipality. Figure 3.2 shows a typical organizational structure for a medium to large sized municipality of the State of Mexico within the MAVM.

Regarding legislative matters, municipalities are subject to the regulatory frame established by State congresses. However, they have the faculty to set its own specific decrees and regulations within the frame set by state regulations, in matters regarding internal municipal affairs.

The term of office for Municipal Councils, including the Municipal President is 3 years, widely recognized as insufficient for the planning and implementation of actions beyond certain scale, in any matter regarding public services. The duration of Municipal Council terms no doubt constitute a serious obstacle for the implementation of long term polices and concrete solutions to waste management issues, and most be taken into account in the design of any distribution of responsibilities and coordination scheme among the different levels of government that interact in the MAVM.

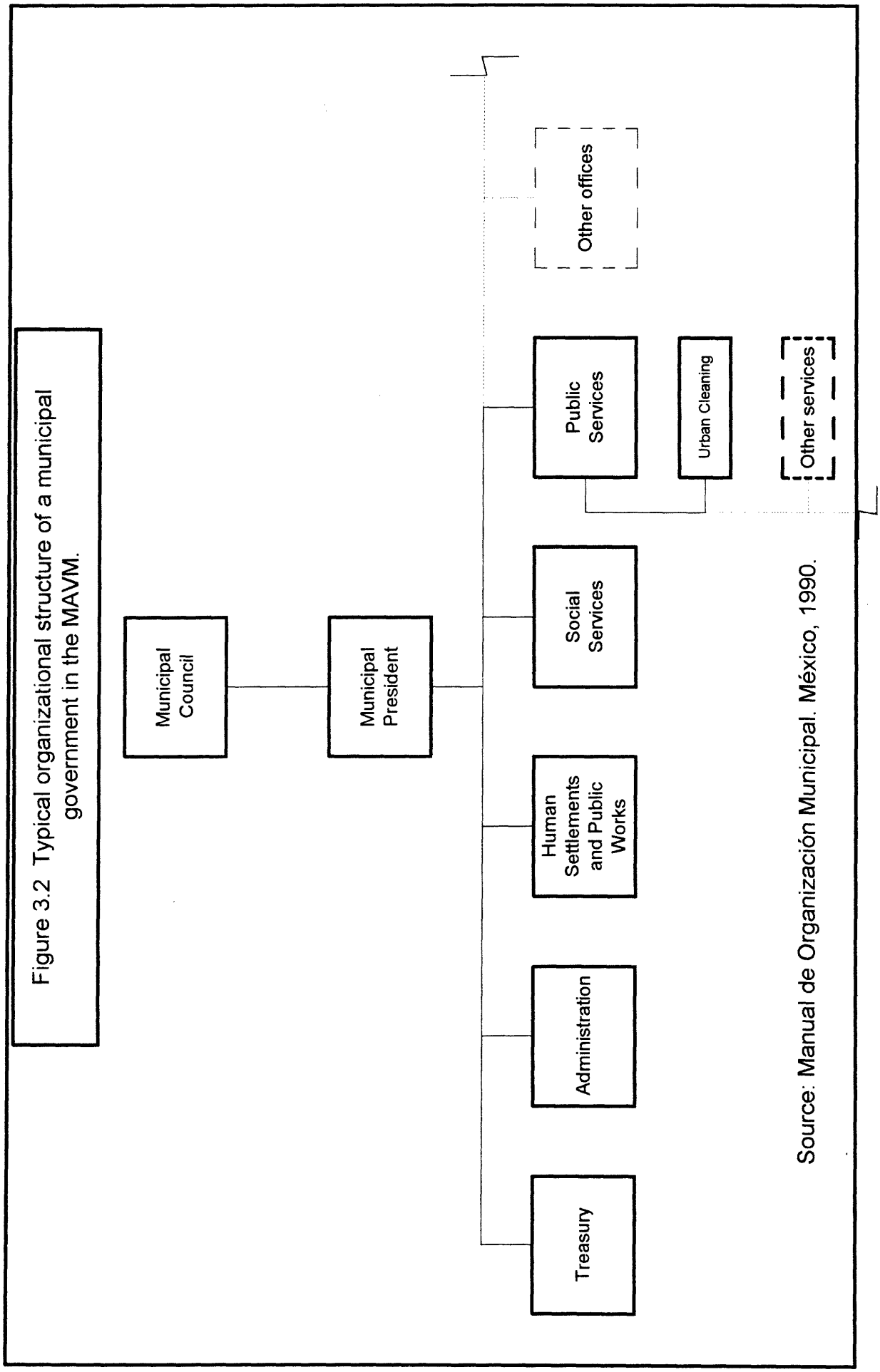


Figure 3.2 Typical organizational structure of a municipal government in the MAVM.

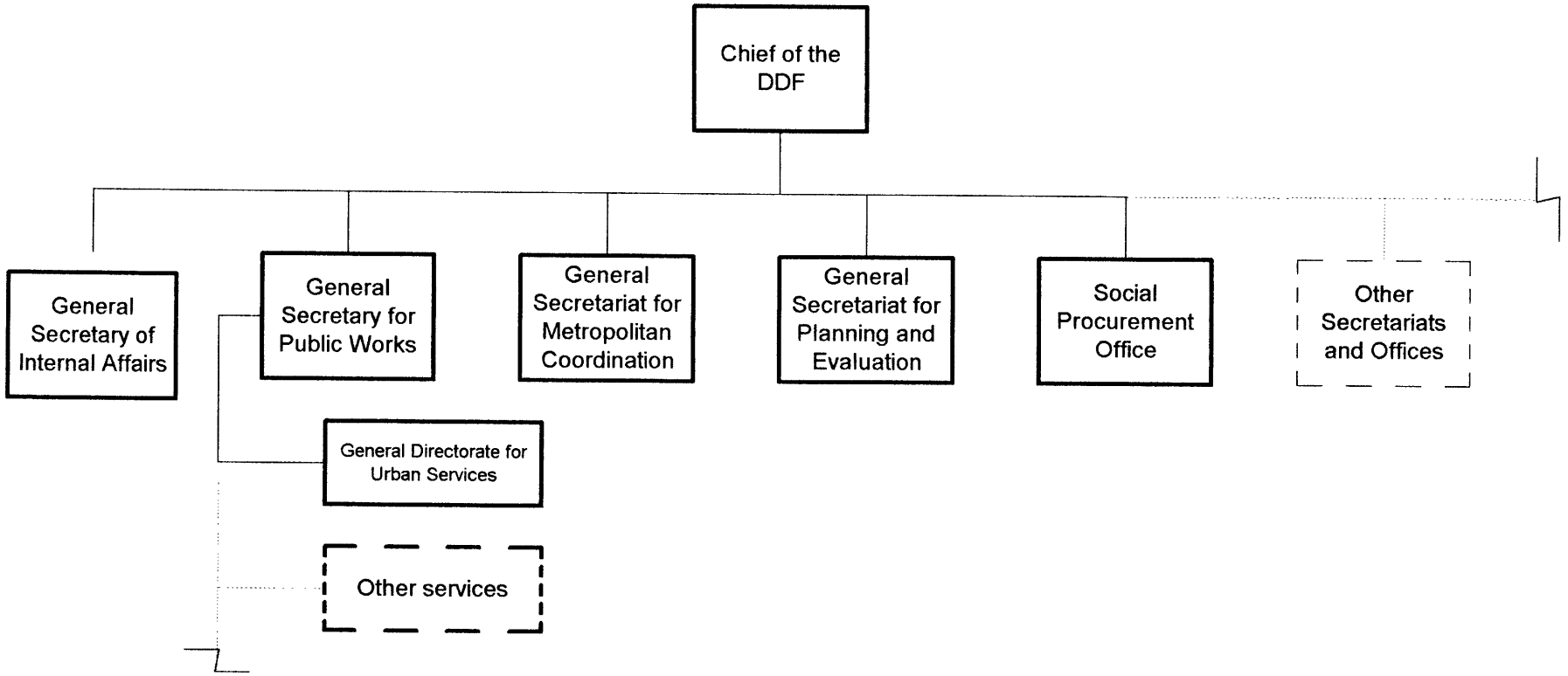
Source: Manual de Organización Municipal. México, 1990.

3.1.4. Federal District Government.

The present Constitution establishes that, in order to avoid the spatial overlapping of State and Federal Governments, a special territory, the Federal District is the seat of the Federal Government, confirming in that way the existence of a politically neutral area, out of the territory of the rest of the entities that constitute the Union. As for the political structure, and up to now (see below), the Federal Executive and Legislative branches constitute as well the local Executive and Legislative branches of the Federal District government, i.e. the President of the Republic is the head of the Federal District Government and the Federal Congress substitutes for the local Congress that exists in the case of the states. As for the Judiciary branch, there exists the Federal District Supreme Court as the main tribunal for the territory. Administratively, the Executive branch of the Federal District Government is the DDF (Departamento del Distrito Federal -Department of the Federal District) headed by the Chief of the Department (or "Regente"), who is directly designated by the President of the Republic. The Chief of the Department coordinates and directs a complex organization that includes three main kinds of organisms a) specialized General Directorates -among them the one in charge of solid urban waste processing and disposal, and that in charge of overseeing environmental matters- ; b) Delegations, that in number of 16 are decentralized administrative entities, in charge of certain functions, such as local and/or minor public works, street cleaning, waste collection, construction licenses, and commercial permits, in specific portions of the territory of the Federal District. The heads of Delegations ("Delegados") are also designated directly by the President of the Republic, on suggestion of the Chief of the Department; and c) Public Sector companies, in charge of certain services, such as the Public Transport System. A general organization chart of the Department of the Federal District is shown in Figure 3.3.

The political structure of the Federal District has been subject for a long time to criticism on the basis that its inhabitants are the only citizens in the country that do not

Figure 3.3 Government of the Federal District: Summarized organizational structure.



Source: DDF. Official Structure, 1991.

directly elect the official responsible of the government of the territory (the "Regente"), neither have their own local congress. This will change from 1997 on, when the Chief of the Department of the Federal District will be selected from the ranks of the political party that wins, in the local elections, the more seats to the ARDF (Asamblea de Representantes del Distrito Federal -Federal District's Assembly of Representatives-), a body of elected councilors that up to know has acted as and advisory body to the Federal District Government as regards citizen's demands, and that will from then on act as the local Congress, two of whose functions, among others will be the authorization of budgets for public services, as well as overseeing its application. It is to be expected that in the future the ARDF will play increasingly important and active legislative, as well as control roles in all matters related with urban services in the Federal District, including of course, waste handling and disposal.

3.1.5. Coordination Bodies.

In several of its articles the Constitution establishes the need of coordination among different political entities in matters of common interest. Nowhere is the need more clear than in the case of the MAVM, and diverse mechanisms have been attempted since the process of metropolization became evident. The more recent are a) The Commission of the Conurbation of the Valley of Mexico, that although still has a juridical existence, does not operate for lack of its technical secretariat; b) The Council of the Metropolitan area, created in October of 1988, and c) The Metropolitan Commission for the Prevention and Control of Pollution, in existence since January, 1992. The latter has a high degree of visibility and has coordinated important actions, mainly regarding the control of air pollution. However, no comparable degree of coordination has been achieved regarding solid waste management, mainly because of political reasons. A coordination structure and process, that is viable from the legal, political and operational points of view, must be implemented if more effective and efficient public services are to be provided to the inhabitants of the MAVM.

3.2. Legal Framework.

Diverse laws, regulations and norms, for federal, state and municipal level, constitute the legal framework regarding solid waste management in Mexico in general, and in the MAVM in particular. A presentation and discussion of the most relevant elements of that legal framework regarding follows.

3.2.1. The Constitution.

As it was mentioned in one of the previous sections, the Constitution is the supreme law of the Republic. Its present basic form dates from 1917, and has important social and welfare elements. Article 27 establishes since its original version, that it is a responsibility of the State to adopt measures so as to ensure the conservation of natural resources and the welfare of the population; this part of the text has remained in its original form through several revisions of the article. The 1917 Constitution also establishes in its article 73 that the Federal Government, with direct supervision from the President of the Republic, is responsible for different matters related with public health. Those concepts are the basis of several modifications and additions that, since 1971, have gradually included more detailed constitutional provisions regarding environmental matters. In that year, the first explicit reference to environmental protection was introduced to the constitution in its article 73, adding the prevention of pollution and the fight against contamination to the explicit responsibilities of the Federal Government.

Today, several articles of the Constitution deal directly or indirectly with environmental matters and public services and are the basis for the legal framework that regulates solid waste management in Mexico. Those articles and its relevant contents are briefly discussed in what follows:

Article 4. Establishes health protection as a general right of the people. It leaves to specific laws the definition of the way in which the Federal and State Governments will

share responsibilities in that respect.

Article 25. Defines the responsibilities of the State as the director of the economic development of the country. Establishes the joint participation of the public, private and social sectors in achieving that development. More specifically, introduces in the constitution the concept of environmental protection as an element to be considered in economic development, stating that public and private companies must conduct their activities in a manner consistent with the public interest, "...taking care of the conservation of resources and of the environment".

Article 26. This article is of interest to the implementation of concrete environmental actions and projects, as it defines a "system of democratic planning", one of which main instruments is the participation of the diverse social sectors in a process of public consultation. This concept has been later introduced in other legal instruments, including environmental law.

Article 27. This is considered to be one of the main outcomes of the revolution of 1917 as regards the role of government. Contents relevant to the present work, some of which became additions or amendments to the Constitution in recent years are: a) The nation has the right to impose on private property the characteristics best suited to the public interest. Specifically, the nation will prescribe the measures required to "..preserve and restore the ecological balance....and to avoid the destruction of natural resources...", and b) "The generation, distribution, and supply of electrical power for public service pertain exclusively to the nation. In this respect, no concessions will be granted to the public sector...". For many years this was an insurmountable obstacle to private participation in the financing and operation of power generation projects, included, for example, those related to energy recovery from landfills and waste-to-energy projects. Recently, in order to allow for the increasingly important role that privatization is playing in many different economic sectors in the country, this restrictions have been formally relaxed, and now private participation in power projects is allowed under certain

conditions, contained in the LSPEE (Ley del Servicio Publico de Energia Electrica -Law for the Public Service of Electrical Power-), of which more details are given later in this work.

Article 73. Defines the faculties of the Federal Congress. Among them, that of prescribing laws and regulations that define the areas of responsibility of the federal government, the governments of the states and the municipal governments regarding environmental protection and the preservation and restoration of ecological balance.

Article 115. Refers the role of the municipalities within the government system and prescribes ways of interaction with the other levels of government. This is also the fundamental article regarding the provision of all kinds of public services to the population. Its main contents are:

- The basis of the territorial division and of the political and administrative organization of the county is the municipality.
- Each municipality has its own legal personality and will manage its own resources and patrimony.
- The municipalities, under the norms established by the state congress, will have the faculty to prescribe regulations for the better government of the municipality.
- The municipalities, with the participation of the state government, when that participation is agreed as necessary and the law so permits, will have the responsibility of providing public services, among them that of waste collection, handling and disposal.
- Municipalities that belong to the same state are enabled to coordinate among themselves and/or associate in order to better provide public services.
- When two or more urban centers located within municipalities that belong

to different states, form or have a tendency to form in the future a single urban continuum, the federal government and corresponding state and municipal governments will plan and regulate in a coordinated manner the development of that urban continuous entity.

Article 116. Refers to the general structure of the political and administrative system of the Republic, that has been described above. It also contains provisions regarding the possibility of the participation of the federal and state governments in matters that -in principle- are the responsibility of municipal governments, when specific instances of social and economical development makes that participation necessary, in terms of the corresponding laws.

Article 122. In its recently modified form, it is particularly relevant to the possibility of coordination of actions among different political entities and different levels of government in the Metropolitan Area of the Valley of Mexico. It states that:

- Federal, State, and Federal District governments may sign agreements for the constitution of metropolitan commissions in matters related to human settlements, environmental protection, preservation and restoration of ecological balance, transportation, water supply, sewage, collection, treatment and final disposal of solid waste, as well as to public security, .
- Each commission, in accordance with the respective laws of each of the participants, will define its functions, structure, and procedures.
- Each commission will define: a) The basis on which the participants agree on its territorial scope and specific functions, regarding the execution and operation of projects, the provision of public services, or of any other action related with the subject of the article, b) The basis on which human, financial and material resources will be contributed by each of the participants, and c) Rules for the coordinated development of the areas within the administrative scope of the commission.

3.2.2. The General Law of Ecological Balance and Environmental Protection.

The LGEEPA (Ley General del Equilibrio Ecologico y Proteccion Ambiental - General Law of Ecological Balance and Environmental Protection) is the fundamental federal law pertaining environmental matters in Mexico. It regulates the constitutional provisions regarding environmental protection, as well as those that pertain to the preservation and restoration of the ecological balance. It was published on January, 1988 and it went in force as of March 1st, 1988. It represents the actual evolutionary stage of a general federal law referring to environmental matters in Mexico. It predecessors were the Federal Law for the Prevention and Control of Environmental Contamination -published in 1971-, and the Federal Law for Environmental Protection -published in 1982-. The characteristic of the LGEEPA is that of a "legal frame of reference", in that its provisions are superimposed on those, more specific sectorial regulations, contained in diverse existing laws that cover certain aspects related directly with environmental and health matters[10]. This is a result of the evolution of the environmental legislation, and, -according to some detailed legal analysis- in certain instances might create conflicts in the interpretation of the different laws.

The LGPEEA contains diverse specific references to the handling and disposal of solid waste. In this respect, Article 134 states that:

- The prevention and control of soil contamination is a joint governmental and social responsibility .
- Waste handling and disposal processes must be controlled, as they are the main cause of soil contamination.
- It is necessary to rationalize the generation of municipal and industrial

[10]Examples of those, more specific laws and regulations are: the General Health Law; the Law of National Waters; the Law of Plants and Cattle Sanitation, among others.

wastes, as well as to adopt adequate technologies for its recycling and reuse.

It must be stressed here that the control of hazardous wastes management is a responsibility of the federal government, whereas the control of non-hazardous solid waste management is a responsibility of local governments -state and municipal-. In this respect, Article 138 of the LGPEEA states that SEDESOL will promote coordination and consultation agreements with state and municipal governments regarding the adoption and betterment of systems for the collection, treatment, recycling, reuse and final disposal of municipal solid waste. However, the federal government maintains an important degree of control over those activities, as all state and municipal regulations must conform to ecological technical norms (NTE) or Mexican Official Norms (NOM), produced by SEDESOL (Art. 137).

One of the most important issues regarding environmental legislation in general, is the treatment of the relative responsibilities of central or federal government, state governments and local or municipal governments, as well as of the complementary character of those responsibilities and the necessary coordination among different levels of government. This of course relates to one of the main themes of the present work, namely the need of achieving an adequate equilibrium between two opposing, complementary and necessary tendencies: a degree of centralization so as to ensure the general effectiveness, from a holistic point of view of environmental protection systems, and a degree of decentralization, necessary for the efficient operation of specific subsystems at a local level. Some necessary details, manly regarding the manner in which the LGEEPA deals with the issue of the distribution of responsibilities among the different levels of government, but also in respect other relevant environmental provisions, are given in what follows.

Federal Government's Responsibilities. The subjects that according to the LGEEPA are of the direct responsibility of the federal government are those of national scope and

those that, because of its nature are of special interest to the federal government. Some of the federal government's responsibilities that are relevant to solid waste management in the MAVM are: a) The definition of general ecological criteria, that must be applied in the design of specific ecological policies; b) The definition of specific technical norms and regulations, including those related with the handling and disposal of solid urban waste; d) The direction or direct implementation of actions related with issues that are considered of federal concern, either because of its complexity, or because they involve the ecological balance of two or more political entities. It follows from this condition, that the federal government might have a direct role to play in projects related with metropolitan management of solid waste in the MAVM.

State and Municipal Governments' Responsibilities. According to the LGEEPA, all those subjects that are not specifically defined as a specific federal concern, are a responsibility either of the state governments or of the municipal governments. As a matter of clarification, the LGEEPA presents a listing of those subjects that includes, among others: a) The definition of local ecological policy; b)The prevention and control of air pollution, when it is produced in areas or by sources of state or municipal jurisdiction; c) The definition and application of regulations regarding maximum emission levels, of noise and odors, among others; d) The provision of urban services, including urban cleaning; d) The handling and disposal of non-hazardous solid wastes (handling and disposal of hazardous waste is a federal concern).

Special Provisions for the Federal District. As it was mentioned above, being the seat of the federal government, the Federal District has a particular legal personality, different from that of the states; correspondingly, the LGEEPA establishes special provisions for environmental matters within its territory. According to those provisions, the administration of environmental matters within the Federal District is a joint responsibility of the executive branch of the federal government, through SEDESOL (Secretaria de Desarrollo Social -Ministry of Social Development-, see below) and the Federal District government. As regards non-hazardous waste, SEDESOL, in conjunction

with SS, is responsible for the prescription of technical norms for the collection, treatment and disposal for all kinds of waste. The Federal District government is responsible for proposing to the Federal Executive (in fact, to SEDESOL), specific regulations regarding the activities of collection, treatment and final disposal of non-hazardous wastes, regulations that must comply with federal policies and norms. The Federal District is responsible as well for implementing the systems necessary for non-hazardous waste handling and disposal, within the territory. This marks an interesting difference with the provisions for other local governments: they are not supposed to submit their regulations to the Federal Government for approval.

In general, in most environmental issues, the LGEEPA prescribes that SEDESOL, sometimes in conjunction with pertinent federal ministries, is responsible for general policies and technical norms, and the government of the Federal District is responsible for the prescription of specific regulations that most take into account federal polices and norms, as well as for the implementation and control of concrete actions. Similarly to the case of the states of the federation, the Federal District Government must comply with all ecological-technical norms regarding the provision of public services, including those referring to urban cleansing, as well as urban waste handling and disposal.

Coordination of Environmental Management. Based on article 116 of the constitution, the LGPEEA contains rather general prescriptions that allow for the coordination between the federal government, the states and municipalities (in this latter case, with the participation of state governments). It also allows for the participation of SEDESOL in the role of a consultant to state and municipal governments, when they so request.

Social Participation in Environmental Planning and Management. The Federal Law of Planning (1983) defines a System of National Democratic Planning. Responsibility for national planning is deposited in the federal government, the main instrument of national planning being the National Development Plan that each federal administration must define

and that contains general economic and social objectives. All sectorial, institutional, regional and specialized programs (in fact, partial plans), must be subordinate to the National Development Plan. That is the case of the present National Environmental Protection Program, one of whose specific objectives is "...the prevention and control of soil contamination, through the appropriate treatment of municipal and industrial solid waste and the correct handling of hazardous substances".

The national planning system includes the concept of "people's consultation" in the public sector's planning processes. This concept has been utilized in the formulation of the National Development Plans for 1983-1988 an 1989-1994. This concept has also been included in the LGPEEA regarding different environmental matters, among them: the definition of general ecological policy; the formulation of ecological plans; environmental planning assessment; the declaration of protected national areas; and of special interest for this work, in matters related with soils contamination.

The concept of "people's consultation", as defined by the LGPEEA, can be considered of a clear corporative nature, as the consultation process is carried out through the participation of the representatives of different social sectors that in the law are exemplified as "...organizations of workers, businessmen, farmers, as well as representatives of communities, of educational institutions, of private non-profit organizations and other representatives of society, so that they can express their opinions and proposals".

The Instruments for Environmental Management in the LGPEEA. The LGPEEA prescribes different instruments for environmental management, some of them related to general development measures, such as fiscal and financial support policies, some other of a preventive nature, examples of which are environmental impact assessment regulations, as well as technical norms, and finally, other whose function is environmental control. Those than can be considered more relevant to the present work, are discussed in the following paragraphs.

-Development Policies. The more important legal provisions regarding these policies as instruments for environmental management are those related with fiscal and financial policies.

As for fiscal policies, the LGPEEA contains provisions that establish activities whose purpose being environmental protection, have priority as subjects of support through fiscal policy. However, the actual allocation of fiscal stimuli and subsidies is conditioned to the provisions of periodic Federal Income Laws. During several years those laws gave specific power to the SHCP (Secretaria de Hacienda y Credito Publico - Ministry of the Treasury) to grant support to activities related with environmental protection. Those powers have disappeared in recent years from the Federal Income Laws, so that in practical terms, environmental protection activities are no longer subject to fiscal stimuli.

Regarding financial measures, it is a function of the SHCP the formulation of policy regarding the application of public financial resources to specific purposes, and it corresponds to SEDESOL the promotion of and support to financial mechanisms for environmental protection. There also exist some legal provisions regarding financial public sector mechanisms, such as the creation of specific funding sources and trusts for environmental purposes. Some of those mechanisms will be discussed in some detail in Chapter 8.

-Environmental Impact Assessment (EIA). The LGPEEA establishes that the federal government, through SEDESOL, is responsible of the authorization of all actions that might affect the environment and that are subject to federal jurisdiction, as defined in articles 28 and 29 of the law. Such authorization must depend on the execution of the appropriate environmental impact assessment procedure (Art. 32). The authorization of all other actions that might affect the environment, is a responsibility either of the state governments or of the municipal governments, in accordance with what is defined by the

law of each of the states of the federation. Those authorizations must also be dependent on an appropriate EIA procedure. Article 35 states that the federal government will assist state and municipal governments in the execution of environmental impact assessments, when those governments demand such assistance. The detailed regulations of the LGPEEA define the procedures for the EIA, that consist either of a preventive report of a formal EIA report; the latter may have three different levels of detail, depending on the characteristics of the works or actions, authorization for which is being demanded. Depending on those characteristics, an assessment of environmental risk might also be required in order to obtain authorization (Art. 32).

-Technical Norms. Because of diverse changes to pertinent legislation, the responsibility for the definition, and even the denomination of environmental technical norms in Mexico has gone through several changes since ecological issues received specific attention in the legal framework. The definition of technical norms is a responsibility of the federal government, that has been exercised through different governmental bodies. Up to 1988, the definition of environmental technical norms was a responsibility of SECOFI (Secretaria de Comercio y Fomento Industrial -Ministry of Commerce and Industrial Promotion-). Those norms were designated as NOM (Norma Oficial Mexicana), and several of them are still in vigor. From 1988 to 1992, SEDUE was independently responsible for the definition of technical norms. The norms published during that period are known as NTE (Norma Tecnica Ecologica -Ecologic Technical Norm-). From 1992 on, SEDESOL has been responsible for the definition of technical norms, but following the general rules established by SECOFI. This norms have again the denomination of NOM. All technical norms in vigor are mandatory for the three levels of government (federal, state, municipal). The issuing of NOM is an ongoing, dynamic affair, and there are still different aspects of environmental legislation to be satisfactorily complemented by adequate technical norms. (See table).

-Inspection. Federal law empowers SEDESOL to oversee, in conjunction with state and municipal governments, the fulfillment of environmental laws and regulations. This

function is carried out by the PROFEPA, mainly by a procedure of domiciliary visits. However, in what is an interesting decentralization mechanism, the law states that the federal government may sign coordination agreements with states and municipalities, so that they fulfill those inspection obligations. Domiciliary visits must comply with specific procedures, defined in articles 162 to 169 of the LGPEEA.

-Popular Denunciation. According to the LGPEEA (Art. 189), "...any action against, or omission of, federal environmental regulations, that have adverse effects on ecological balance or produces environmental damage...may be a matter of popular denunciation". Popular denunciation may be done by any person, sufficing the provision of information regarding the location of a contamination source, as well as the name and address of the person making the denunciation. Specific rules are set forth in the LGPEEA regarding the legal procedures that follow an environmental denunciation (Articles 190 to 193).

-Administrative Penalties. This may consist of any or all of: a) fines; b) temporary of definitive closing of installations; c) administrative detention (Art. 171). Application of administrative penalties must be accompanied by an order to make specific corrections to the situation that was the origin of the penalty, in a definite period of time. Failure to do so may result in additional daily fines, additional detention time and definitive closing of installations.

-Penal Actions. The LGPEEA in its articles 182 to 188 defines as federal criminal actions a) Illegally carrying out environmentally dangerous activities b) The illegal handling of hazardous materials or hazardous waste c) Air pollution d) Water pollution e) Soil pollution d) Illegally producing excessive noise, vibrations and energy release (light, heath). Depending on the gravity of the criminal behavior penalties may be up to 9 years of prison and the value 20,000 days of minimum wages (approximately $100,000 dollars). In addition to those penalties the guilty party may have to pay compensation for damages.

3.2.3. General Health Law.

In respect to urban solid waste, the General Health Law refers to matters related with residues, mainly from a sanitary point of view and as they relate to the disposal of death bodies and organs, and is relevant to the handling and disposal of hospital waste. In accordance with the law, it corresponds to the SS the regulation of the disposal of any kind of animal product, byproduct and dead bodies. The law establishes incineration as the only acceptable way for the disposal of human tissue, whatever its origin, and might have to be revised as new technologies, now in the development stage, are accepted by the scientific community, and become commercially available.

3.2.4. The Law for the Public Service of Electrical Power.

As it was mentioned before, Article 27 of the Constitution of the Republic states that "... the generation, transmission, transformation, distribution and supply of electric energy, for public service purposes, corresponds exclusively to the Nation..". This restrained for many years the possibility of private sector participation in all matters related with the production and distribution of electric power. The restriction included, of course, all kinds of projects dealing with electric power generation from solid urban waste. As a result of recent trends towards the privatization of many different activities, the LSPEE (Ley del Servicio Publico de Energia Electrica -Law of the Public Service of Electric Power) was modified in 1992 to allow for private sector participation. This was achieved through a definition of what do not constitutes "public service", while the constitutional provision remained without any change. According to the modification, the following activities are no longer classified as public service:

- Electric power generation produced for self-supply purposes or through cogeneration, as well as small scale production.
- Electric power generation that is carried out by independent producers

(meaning different to Comision Federal de Electricidad -Federal Electric Power Commission-, the governmental utility), for exclusive sale to CFE.

- Electric power generation for exportation purposes, including cogeneration, independent production and small scale production.

Projects of 30 MW capacity or less, are considered to be small scale production. Projects above that capacity are considered to be independent production. All projects of the categories enlisted above can include transmission, transformation and delivery of power and in all cases require previous revision and approval by CFE. All proposals for the supply of power to be added to or substituted for, power being produced by CFE, will be evaluated in terms of the technical feasibility of the proposal, as well as of the long term costs, stability, quality and safety of the supply.

The modifications to the LSPEE and to its regulations (1993) have allowed the direct participation of private companies in Build-Operate-Transfer and Build-Lease-Transfer type projects. Those modifications have also eliminated the legal constraints that existed regarding waste-to-energy projects, that now must be evaluated in terms of its own merits concerning its technical, economical, financial, environmental, and socio-political feasibility.

3.2.5. Federal District's Regulations.

Because of its juridical status, that defines a special relationship with the Federal Government, the Federal District does not still have its own Ecology Law, being subject directly to the provisions of the LGEEPA. There exists, however, a preliminary draft of the LPMADF (Ley de Proteccion y Mejoramiento al Ambiente del Distrito Federal -Law for the Protection and Improvement of the Environment-), that will be the basis of the local environmental law when it is approved -probably in 1995- by the ARDF. One or its main provisions states that: "The Federal District will promote and support the creation of an organism for metropolitan coordination, with the participation of the governments

of the states of Mexico and Morelos, and of its metropolitan municipalities, so as to coordinate, uniform and control policies, programs, projects and actions that the participants undertake for the protection and improvement of the MAVM and its ecological area of influence." This is an indication of the existing trend to seek ways towards a more efficient management of metropolitan matters.

The Department of the Federal District has a recent (1989) Regulation for the Urban Cleaning Service. Some of its more relevant articles deal with the distribution of responsibilities among the central government (DDF), and its delegations:

- The DDF will:
  - Enforce the standing ecological provisions regarding the collection, treatment and final disposal of solid waste.
  - Design, build and operate, directly or through concessions: transfer stations, solid waste treatment plants and final disposal facilities.
  - If the demands of the service and of the inhabitants so advised, to award concessions in the field of urban cleaning.

- The Delegations will be in charge of street sweeping, waste collection, and of the transportation of waste to the sites designated by the DDF.:

3.2.6. State of Mexico's Regulations.

Foremost at state level are the State Ecology Laws, that have been adopted by almost all states, among them the State of Mexico and that are consistent with the federal General Law for Ecologic Balance and Environmental Protection. There are, in the case of the State of Mexico, other relevant provisions, the most important being the specific regulations of the State Ecology Law, and the State Health Law.

State Ecology Law. The relevant provisions of the LPAEM (Ley de Protection al

Ambiente del Estado de Mexico -Environmental Protection Law of the State of Mexico-) and of its specific regulations, regarding solid waste management are:

- The State Government has the power to:
  - Intervene in matters that impose special environmental risk in specific areas of the State; or in those that because of its nature so require; or in those that affect the environment of two or more municipalities.
  - Sign agreements of coordination, and for the execution of specific actions, with the Federal Government, other states, and with municipalities, regarding environmental issues.
  - Advise Municipal Councils in environmental matters, when they so demand.
  - Issue state norms and regulations pertaining environmental protection and improvement.
  - Assess the environmental impact of proposed waste management installations, and authorize the implementation of all related projects.

This is one of the examples where a State Law contains provisions that could be considered to run contrary to the spirit of Article 115 of the Constitution, regarding the sovereignty of municipalities. It constitutes a matter of constant discussion among legal experts.

State Health Law. It contains very general statements regarding as a responsibility of the State Government "...prevention and control of harmful effects of environmental factors on human health". Similar to the Federal Health Law, the LSEM (Ley de Salud del Estado de Mexico -Health Law of the State of Mexico-) contains provisions regarding the sanitary control of commercial activities. It also refers to the sanitary control by state authorities of activties of urban cleaning.

3.2.7. Municipal Regulations.

Few of the Municipal Councils have adequate regulations related with solid waste management; in this respect the State of Mexico municipalities within the MAVM are not an exception. However, some of the most advanced ones, contain interesting provisions regarding source separation and recycling.

3.2.8. Some Legal Aspects Regarding Private Participation in Solid Waste Management Activities.

According to the Mexican legal framework, municipal public services, including waste management and disposal are a governmental responsibility. During many decades and up to recently this was almost universally interpreted as a) The exclusion of the private sector from activities connected with the investment in, and the operation of, such public services as potable water supply and waste management b) A justification, often utilized for political purposes, for not charging the full cost of services (or not charging costs at all) to the beneficiaries of the services. Demographic growth, demands for a better quality of life, the increasing cost of services, and the financial, technical and administrative weakness of many local governments, among other factors, have generated a change of interpretation, and more and more municipalities, state governments and of course, private companies, are starting to look for ways through which the private sector can actively participate in the financing and operation of public services.

From the legal point of view, the participation of private companies may have different forms, the most important being: -listed in an order of what those forms imply in terms of increasing financial commitment of the private company, and of length of the agreement- a) Administrative contract; b) Authorization, license or permit; c) Concession. All of this forms have been used recently to regulate the participation of private companies in public services, including those related to solid waste management and

disposal. However, oftentimes existing local legal frameworks do not favor, and in some instances even tend to block, private participation in public services. Although this situation is changing rapidly, special attention most be paid to particular local juridical conditions, specially those related to the specific recognition of the participation of private companies in public services activities, as well as to the restrictions imposed to municipal authorities as regards commitments that time-wise go beyond their 3 year term of office[11].

3.2.9. Closing comments on the legal and regulatory framework.

During the past 20 years Mexico has been developing a system for the definition of environmental policy, and for environmental management, including a specific legal and regulatory framework. In its initial stages, that system had characteristics of extreme centralization, a high degree of sectorial isolation and allowed little social participation. The system and the corresponding legal framework has evolved during recent years, specially after the publication of the LGPEEA), so that now it promotes the implementation of a more decentralized environmental management, with intersectorial coordination and with a more intense social involvement in different steps of the process . Notwithstanding this recent tendencies and the evident progress that has been achieved, an effective environmental management system has not yet been consolidated and there are still things to be done, in order to fulfill the objectives of the existing legal framework, that can be considered adequate, although in need of some adjustments. There are different causes for this not completely satisfactory situation. Among them: the relative political weakness of the administrative bodies that have been in charge of environmental matters; the difficult financial situation that the country underwent during most of the past ten years; the lack of effective means of real social participation; the lack of decision making power of the diverse coordination organisms that have been attempted.

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[11]In most states, any commitment, that is intended to last beyond the municipal term of office, made by a Municipal Council, requires approval of the State's congress.

It can be expected that, as the different components of the system are tested and the input from a growing number of practical experiences is assimilated, environmental management in Mexico will become a more mature, effective tool for present and future betterment of the quality of life. As for the legal framework for urban services, and particularly solid waste management, adjustments will have to be made in respect several aspects, some of the most important being a) A more specific and clear division of responsibilities between state and municipal authorities in local laws, in accordance with recent modifications to the constitutional and federal legal frame work, as the required adjustments have not yet been made in many cases, and b) The building of a more actualized and complete body of technical norms and regulations, as a support for more effective waste management practices.

As a conclusion of the contents of the present section, Tables 3.1 and 3.2 summarize two important aspects regarding the legal framework regarding solid waste management and policy, as it relates to the decision making process: a)The way in which the responsibility for the management of diverse residues is distributed among the different levels of government and its departments; and b) The specific regulations, federal, state or municipal, that apply to the diverse stages of the process.

Table 3.1 Distribution of responsabilities for waste among different levels of government.

		Levels of government							
		Federal				Federal District	State		Municipal
Type of waste		SEDESOL	SS	SCT	SECOFI	DDF	State's ecology office	Other	Municipal organisms
Solid		B, C			B	A	B, C	C	A, B
HAZ	Medical	A, B	A, B	A, B	B	B, C	B, C	C	C
	Industrial	A, B		A, B	B	B, C	C	C	C

A: Direct operational and/or regulatory responsability.
B: Normative responsability.
C: Optional participation through coordination agreements.

Table 3.2 Specific standing legal frame work for waste management.

Type of waste	Activity	Components of the standing legal framework and its scope.													
		LEEPA	RFRP	RFIA	RFCA	LGS	RFOT	RFCS	NOM	LPAEM	RECS	REIA	LSEM	MR	LSPEE
Solid	Street cleaning													*	
	Collecting													*	
	Recycling	*		*						*	*	*		*	
	Treatment	*		*						*	*	*		*	
	Incineration	*		*						*	*	*		*	*
	Landfilling	*							*	*	*	*		*	
Medical	All	*	*			*	*	*		*		*	*	*	
Industrial	All	*	*	*	*										

LGEEPA: General Law of Ecological Balance and Environmental Protection.
RFRP: LGEEPA's Regulations for hazardous waste.
RFIA: LGEEPA's Regulations for environmental impact.
RFCA: LGEEPA's Regulations for atmospherical pollution.
LGS: General health law.
RFOT: LGS's regulations for organic waste.
NOM; Mexican official norms.
LPAEM; Environmental protection laws of the State of Mexico.
REIA: LPAEM's Regulations for environmental imoact.
LSEM: Health law of the State of Mexico.
LSPEE: Law for the public service of electrical power (applies only to waste of energy projects).

4. Solid Waste Management in the Metropolitan Area of the Valley of Mexico.

Actual and expected volumes and characteristics of waste constitute the basis for any planning effort regarding waste management. Also necessary in the decision making process is the knowledge of the different elements of the present waste management system, as well as the understanding of its characteristics. This section presents, in the first place, information regarding actual waste generation as well as an estimation of the future waste quantities that will have to be dealt with in the MAVM. It also contains information regarding present waste generation installations and management practices, both in the Federal District and the State of Mexico.

4.1. Waste Generation. Present Situation and Projections.

4.1.1. Present Situation.

It is possible that the single most important set of basic data for the analysis of a waste management policy and the selection of viable solid waste programs, is the existing and projected quantity and composition of the waste that must be handled, processed and sent to final disposal facilities. It is also perhaps the most difficult data to accurately define in many cases.

Waste quantities are usually estimated on the basis of data gathered by conducting

a waste characterization study, using previous waste generation data, or some combination of the two approaches. It is important to take into consideration that oftentimes solid waste generation rates reported in the literature are actually based on measurement of the amount of waste collected, rather than on the actual amount generated. In any case, commonly accepted practice consists in develop per-capita weight generation rates, that might either differentiate among domestic generated waste and other types of solid, non-hazardous wastes (commercial, industrial, etc.) or integrate existing information in a single, total municipal solid waste generation rate. In the case of the MAVM, as it was to be expected, different sources report diverse average generation rates, that for total municipal generation are in the range of 0.9 to 1.05 kg per-capita/day. Recent studies utilize an average rate of 1.0 kg per-capita/day, stressing the subregional differences that exist due to the varying degrees of urbanization and levels of income. The generation rate of 1.0 kg per-capita/day, utilized in conjunction with the estimated population of the MAVM for 1994 (17 million), results in 17 000 ton of total daily solid waste generation -of which 11,000 ton/day are generated in the Federal District- and an annual figure of over 6.2 million ton. This is equivalent to nearly 1.8 ton/day for each of the 9600 km2 of total area of the Valley of Mexico. It is not commonly perceived that, if the Valley of Mexico were to be considered -for waste generation purposes- as a self-contained entity, that assumption would put the Valley above the Netherlands and in the same rank as Japan, in terms of waste generation per unitary territorial area (Fig. 4.1).

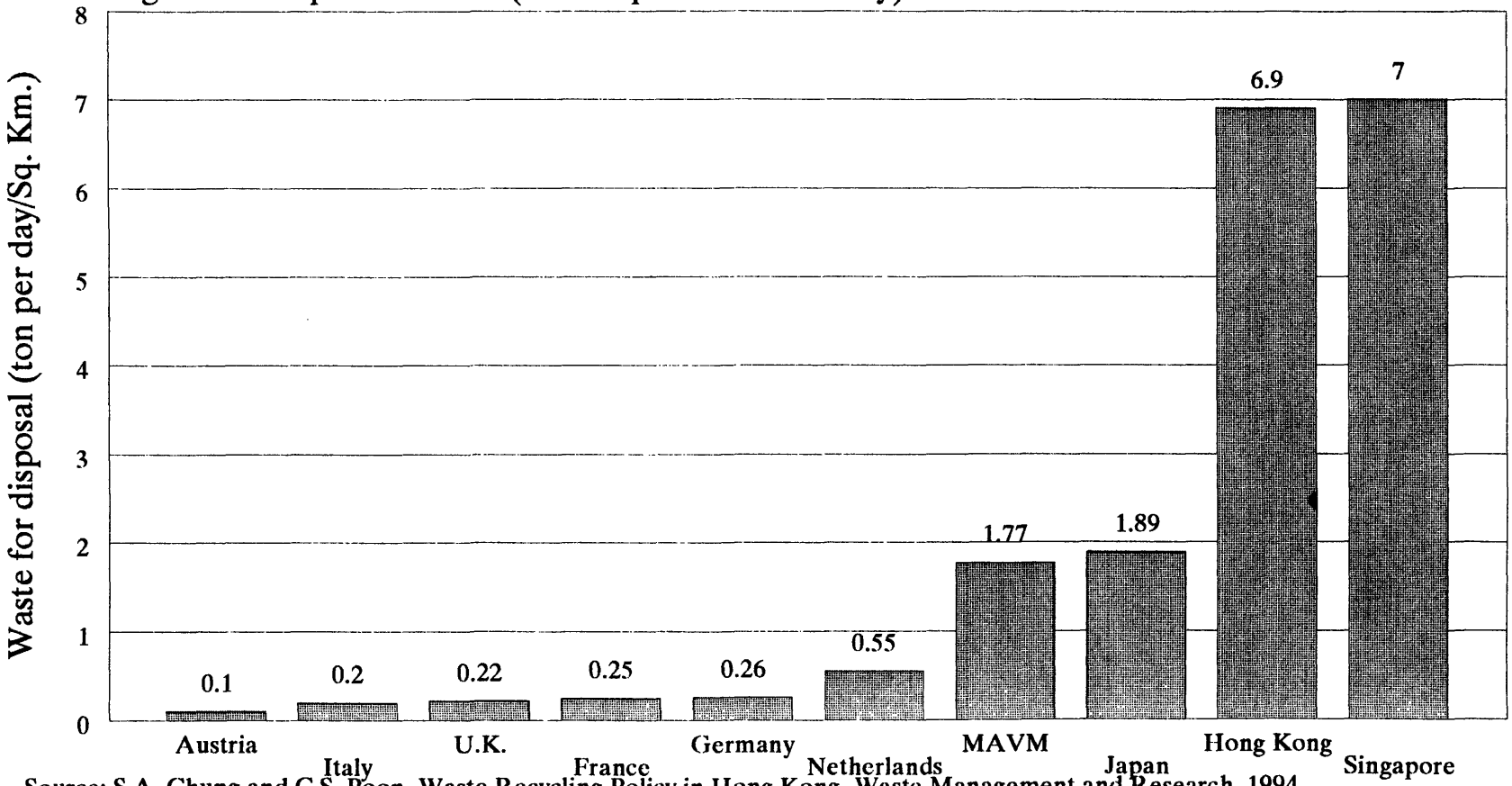
4.1.2. Projections.

It was not possible to obtain reliable information regarding expected waste generation for the MAVM. Therefore, a preliminary estimate has been made for this work, in order to asses, even if in an approximate manner, the expected ranges of waste generation.

For the above purpose, the population projections from section 2.5.2. were utilized as one of the inputs. As for the probable evolution of per-capita generation rates, it can

Figure 4.1

Waste generation per land unit (TPD/Sq. Km. of territory).



Source: S.A. Chung and C.S. Poon. Waste Recycling Policy in Hong Kong. Waste Management and Research, 1994.

be assumed that it will depend, basically in variables such as relative economic growth in the region and its subregions, the corresponding distribution of house-hold incomes, consumer habits, the composition of the waste stream, the adoption of waste reduction policies (product design, packaging design, increase of durability, decrease of disposable, service rate structures, etc.) and the degree of success of those policies. As the development of a model that took into account those and other relevant variables was outside the scope of the present work, the estimations were made utilizing a few basic, evidently oversimplifying, but workable assumptions: a) There would be a "normal" growth tendency of average per-capita waste generation for the MAVM, such as to get, in 2010, to the value that the same indicator had in the U.S.A. in 1990 (approximately 1.95 kg per-capita/day)[12]; b)Per-capita generation would level off afterwards; c) The maximum effect of waste reduction policies would be a gradual decrease of up to 10% of expected generation based on the "normal" tendency[13]; d) This effect would take place starting in 2000, reaching its maximum value in 2010.

The results of this projections, made for different combinations of the main assumptions are shown in Figure 4.2. Of course the validity of the figures, whatever it might be, decreases as the projection period increases. However, it seems to be clear that any waste management strategy will have to deal with yearly generation that for 2005, ten years from now, will be approximately 11.5 million ton, plus or minus 20 %.

4.1.3. Waste Composition.

An as much as detailed knowledge of the components of the waste stream is essential for the planning and design of waste management systems and installations. Composition of waste is a variable whose value depends, among others on cultural,

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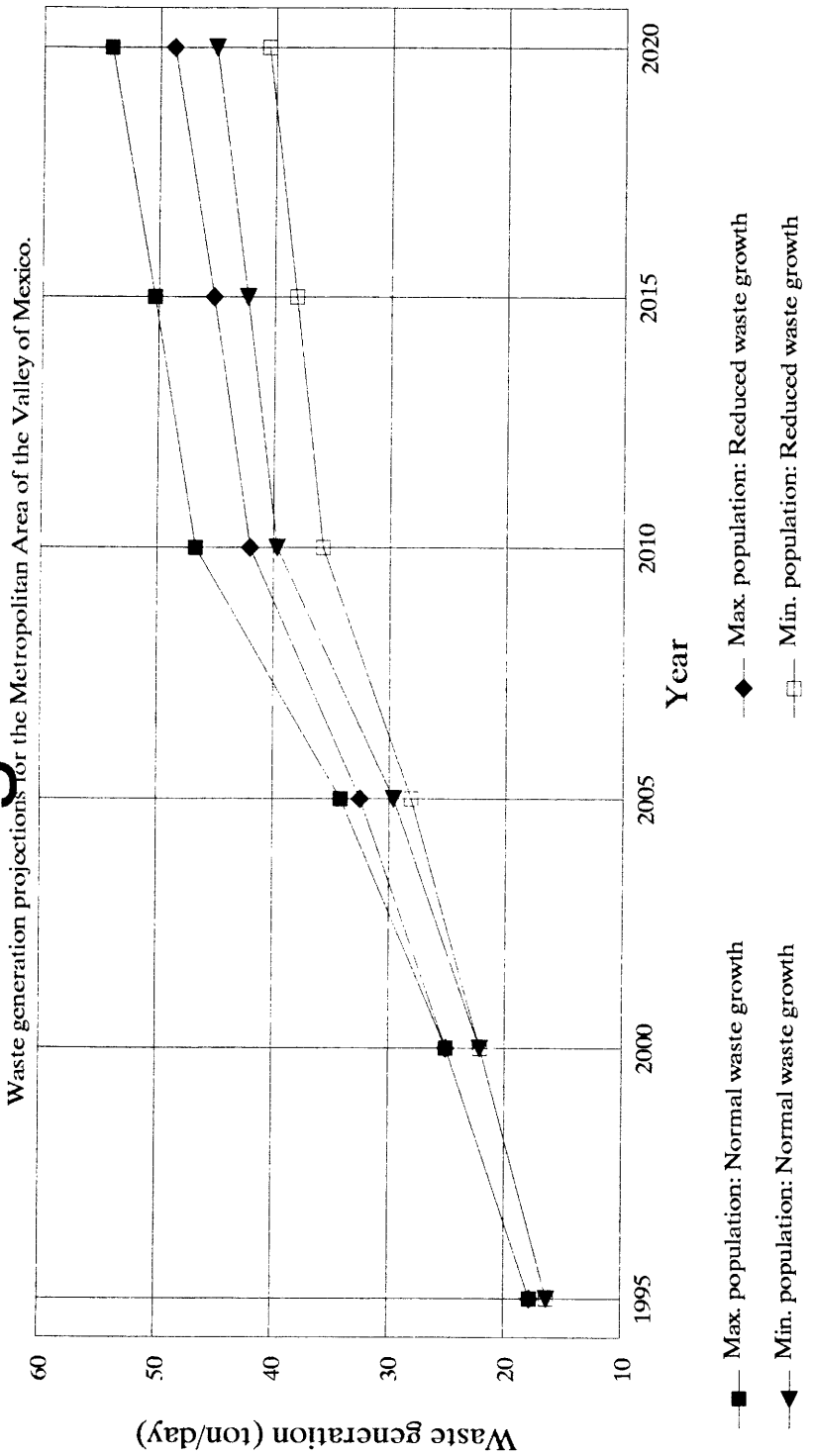
[12]EPA,Characterization of Solid Waste. 1992

[13]Gilreiner. 1994

Figure 4.2

Waste generation projections for the Metropolitan Area of the Valley of Mexico.



economic, climatic, waste management practice and regulatory factors. Within the MAVM, there exist considerable differences, not only in the per-capita generation of waste among the different subregions, but also in the components of the waste generated in those subregions. As for contrasts with other countries, Table 4.1 shows a comparison between the average composition of waste generated in the MAVM, and the average composition of that generated in the USA, on a percentage basis. The most important differences are in the relative contributions to the waste streams of paper and paper board, on the one hand, and food wastes, on the other, with considerable higher percentages of paper and paperboard in the case of the USA, and very high percentages of food waste in the case of the MAVM. Differences are also significative in the case of wood, and yard trimmings.

4.2. Waste Management in the Federal District.

This section contains a brief description of: a) The present administrative structure; b) The existing waste management installations and practices; and c) The standing plans for future wadset management, -as those aspects pertain to the Federal District-.

4.2.1. Administrative structure.

As was pointed before (Section 3.1.4), the DDF (Departamento del Distrito Federal -Department of the Federal District) constitutes the governmental body in the Federal District, its main elements being a central body and local delegations.

The way in which the responsibilities for urban waste handling and disposal are distributed among the central areas and the delegations of the Federal District government is a good example of an attempt to reach a workable balance in the ever present and coexisting tendencies towards centralization -the need of an integral conception of a complex system, and the search of effectiveness in its operation-, on the one hand, and decentralization -the need of design subsystems in direct contact with problems, and to

Table 4.1 Comparative composition of waste (percentages).

Materials	MAVM 1990	USA 1990
Paper and paperboard	18.9	37.5
Glass	7.7	6.7
Metals:	2.8	8.3
Ferrous	2.2	6.3
Nonferrous	0.6	2.0
Plastics	11.6	8.3
Rubber and leather	1.4	2.4
Textiles	1.7	2.9
Wood	0.6	6.3
Food wastes	42.0	6.7
Yard trimmings	7.7	17.9
Other	6.6	3.0
Total	100.0	100.0

Sources: SEDESOL. Mexico, 1992.
EPA: Characterization of Solid Waste. 1992 Update.

operate those subsystems in an efficient manner-, on the other.

In general terms, the central area of the Federal District government is responsible for the definition of policies and strategies of all matters regarding solid urban waste, for the definition of technical norms, for the design, construction and operation of treatment and final disposal facilities, for the design and construction of transfer stations, for secondary transportation, as well as for providing technical support to the delegations. The central area authorizes all major investments proposed by the delegations (eg. in collection equipment) and provides the necessary funding. The central area also coordinates interdelegational issues and has played an active role in the efforts that have been carried out (with little success up to now) in the search of metropolitan coordination with the State of Mexico in waste management matters. The Delegations are responsible for all activities regarding the cleaning of urban areas (with the exception of the main network of urban freeways and streets, that is a responsibility of the central body), as well as for the collection and primary transportation of waste; they also operate the transfer stations located within their territory, although with a high degree of support from the central area of the government. This distribution of responsibilities has proved to be a successful one, and it is considered as one of the reasons of the gradual improvement that waste management conditions have undergone in the Federal District, since its inception in 1985.

The areas belonging to the Federal District's central governmental body, that play a principal role in decision making, implementation and operations in the field of solid waste management are described in the following paragraphs.

The Chief of the DDF. As head of the Federal District Governments, is direct responsible for all decisions regarding general policies and strategies.

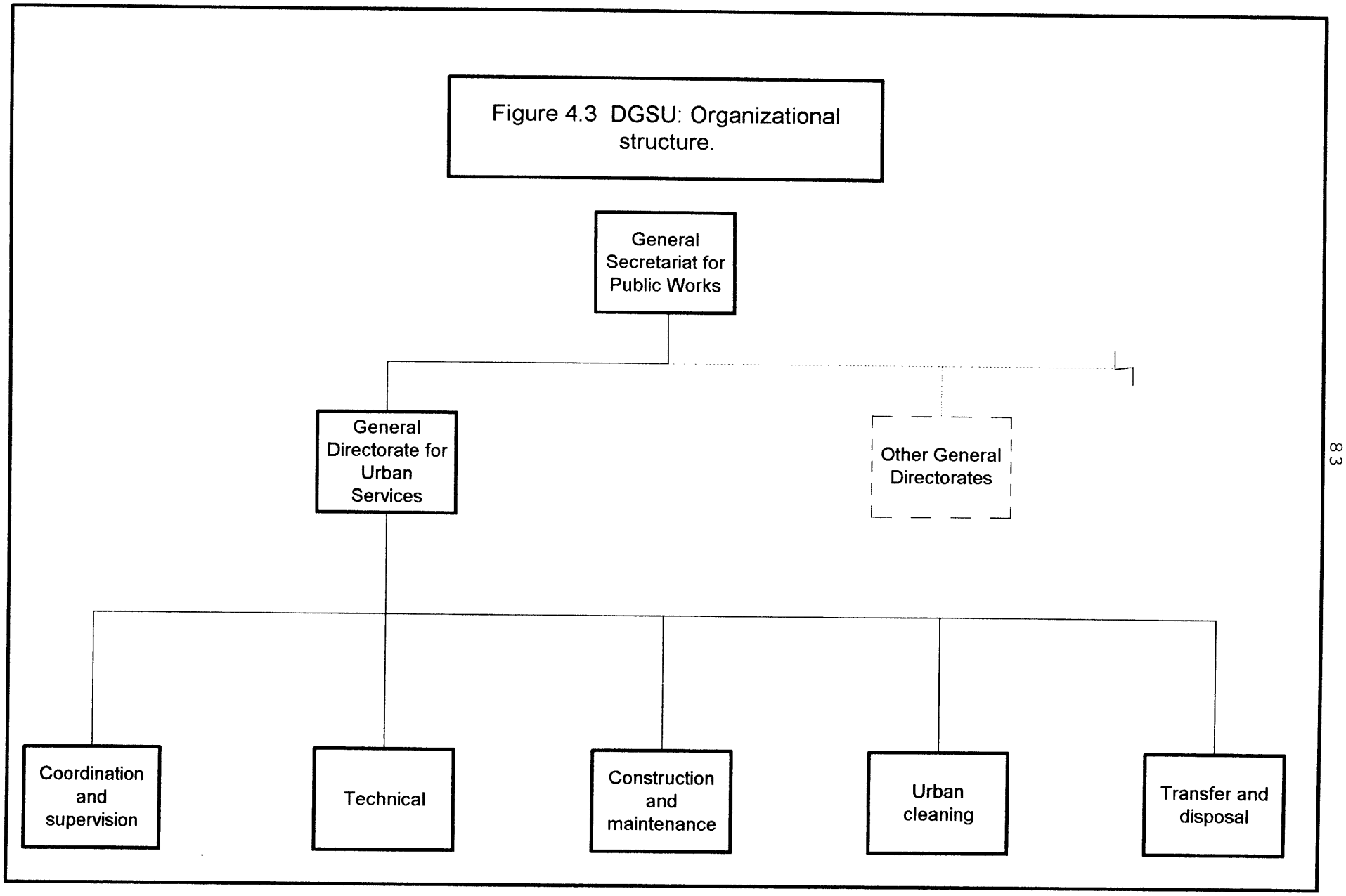
The DGSU (Direccion General de Servicios Urbanos -General Directorate for Urban Services-), within the SGO (Secretaria General de Obras -General Secretariat for Public Works-). The functions of the SGO include those of "...directing, promoting and coordinating the program of solid waste treatment and disposal...". Directly in charge of those functions is the DGSU through its different organisms (Fig. 4.3). As described in previous paragraphs, the actual activities of the DGSU, being responsible for all solid urban waste technical and operational matters that pertain to the central governmental body, go well beyond of what the succinct definition of functions suggest.

The SGPE (Secretaria General de Planeacion y Evaluacion -General Secretariat for Planning and Evaluation). This powerful body, through the Tesoreria (Treasury) and the DGPP (Direccion General de Programacion y Presupuesto -General Directorate for Programming and Budget-), authorizes and provides all funding within the DDF, including that needed for the implementation of proposals presented by the DGSU and Delegations. It also controls the application of funding.

The SGB (Secretaria General de Gobierno -General Secretariat for Internal Affairs). One of the main function of this body is the supervision of the activities of the delegations, as well as the coordination of delegations among themselves and delegations with other bodies of the DDF. It plays an important political role.

The DGE (Direccion General de Ecologia - General Directorate for Ecology-). This organism, inserted in the SDS (Secretaria General de Desarrollo Social -General Secretariat for Social Development), plays a role as regards environmental regulation and control within the Federal District. However, it is devoted mainly to matters regarding air pollution, that has a high political visibility, and up to now has had little, if any, intervention in waste management issues.

Figure 4.3 DGSU: Organizational structure.



The SGACM (Secretaria General Adjunta de Coordinacion Metropolitana -General Adjunct Secretariat for Metropolitan Coordination). Contrary to what its name suggests, the role of this body has been restricted mainly to the resolution of border definition issues with neighboring states.

As for the Delegations, within the organizational structure of each of them there exist, depending mainly on the particular size of the territory and the demographic importance, either a Department or a Directorate directly in charge of the waste management functions assigned to the Delegation, as they were described above.

4.2.2. Existing waste management installations and practices.

A brief description of the present situation of installations and operational practices in the Federal District in what can be considered a "downstream" order, is presented in what follows.

Source Reduction. No generalized source reduction practices have been reported, although it is known that some localized promotion and actions are being carried out by some corporations, by groups of environmentalists and by neighborhood organizations. This actions, although interesting from the point of view of spontaneous social organization and well deserving of research and expansion, do not seem yet to be important from a quantitative point of view.

Source Separation. Similar to the situation in source reduction. It is believed that percentage wise it is very small. There are some isolated examples of corporations and neighborhoods that have tried to establish programs for the separation and commercialization of recyclable, most of which have not been successful, for lack of access to adequate marketing channels for the recyclable, of for insufficient economies of scale.

Urban cleaning, collection and primary transport. As it has been already pointed out, this part of the system is a responsibility of the Delegations. It employs nearly 20,000 workers and utilizes about 2800 vehicles (Table 4.2). The efficiency of the collection process is greatly reduced, as separation for recycling purposes is carried out aboard most of the vehicles by the crew, that includes helpers -not in the DDF's payroll- in addition to the official personnel, before reaching the landfills[14],; in fact, it has been reported that most collection vehicles have become a small business units, whose members -the crew- share the product of the sale of recyclable and of the special collection services that they perform for large generators of waste. The numbers of this "support personnel" have been estimated in the vicinity of 4,300 persons; this situation conforms one of the socio-political factors to be taken in consideration in any modifications that are proposed to the system. In addition to domiciliary collection, as of August 1994, the process included special collection services to 136 collective sites, of which 58 were large medical installations. It also includes the systematic cleaning of about 1,200 locations that are classified as illegal waste deposit sites, that for some reason it has not been possible to eliminate. There are no available official figures regarding the coverage of the collection system. Personal estimations seem to indicate that the overall coverage of the solid waste collection system in the Federal District might be in the range of 85% to 90%, whereas the general coverage for the MAVM has been estimated to be 80%.

Transfer and secondary transport. There are 13 transfer stations in the Federal District (Table 4.2, Figure 4.4), with a total nominal capacity of 55% of total waste generation. There are no storage facilities in any of the transfer stations, as all of them are of the direct discharge from collection vehicles to transfer trucks type. Most of the transfer stations are in fact operated by the DGSU and 8 of them receive waste from

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[14]However, this practice -as regards on board separation- is not dissimilar to the one that was in use by private "scavenging" companies in San Francisco, Cal., and other places of the U.S.A. apparently with satisfactory economic results, up to the mid 50's of this century (Blumberg and Gottlieb).

Table 4.2 Waste management equipment and installations in the Federal District.

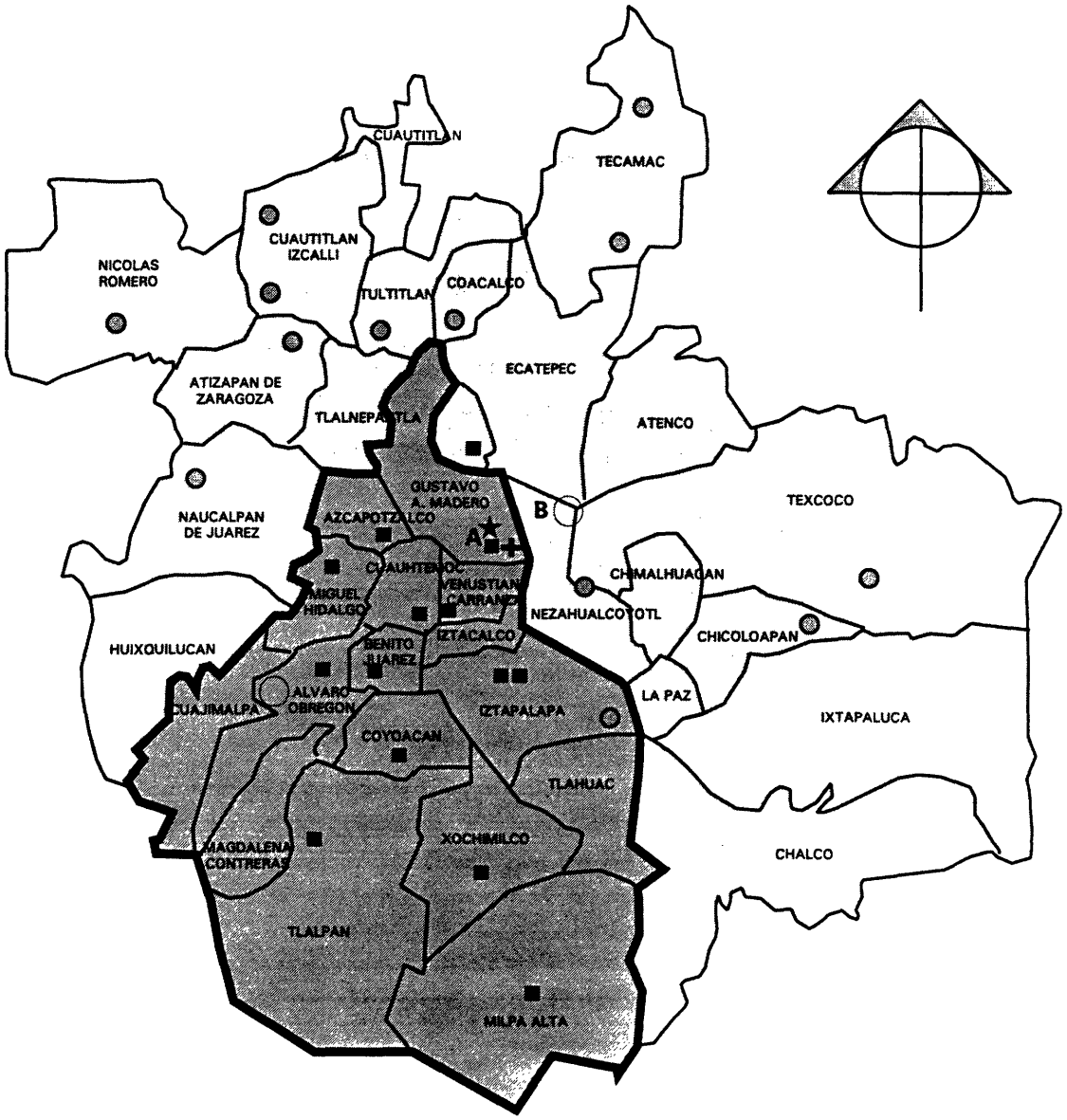
A) Vehicles	
Sweeping	239 units
Collection	1950 units
Transfer	193 units
Total	2382 units

B) Transfer Stations	13 units

C) Separation and recycling	
San Juan de Aragón: 5 modules with a total capacity of:	1500 ton/day
Bordo Poniente: 3 modules with a total capacity of:	1500 ton/day
Total	3000 ton/day

D) Incineration	50 ton/day

E) Final disposal	
Bordo Poniente (Sanitary landfill, 100 ha)	5000 ton/day
Prados de la Montaña (Sanitary landfill, 30 ha)	3000 ton/day
Santa Catarina (Dump, 32 ha)	3000 ton/day



SIMBOLOGY

- ■ EXISTING AND PROPOSED TRANSFER STATIONS
- ◎ OPEN DUMPS
- ○ SANITARY LANDFILLS
- ✚ INCINERATION PLANT
- ★ COMPOST PLANT
- **A** SAN JUAN DE ARAGON SITE
- **B** BORDO PONIENTE SITE

- METROPOLITAN AREA (FEDERAL DISTRICT)
- METROPOLITAN AREA (STATE OF MEXICO)

FIGURE 4.4.- EXISTING INSTALLATIONS FOR WASTE MANAGEMENT IN THE VALLEY OF MEXICO

more than one Delegation. The more recent three stations are modern facilities with closed installations, acoustic walls, efficient washing, and air extraction and purification systems, etc. This notwithstanding, the construction of the stations faced strong social opposition from different groups: associations of neighbors, schools, ecologists' associations. The process through which the stations were finally accepted so that they operate now in a normal fashion constitutes an interesting case study of a "Decide-Announce- Defend" situation, although according to Mexican usage, the solution was not arrived at in the courts, but rather through negotiation between the government on one side, and social groups on the other[15]

Recycling. Until some years ago, most of the on site separation and recycling (as different from that which is carried on board collection vehicles) was carried out by "pepenadores" (scavengers), in practically all of the landfills and dumps within the Federal District, in very unsatisfactory working conditions. This situation has gradually changed, as a program designed and carried out by the Federal District, that includes the closure of old dumps, has been successful towards eliminating the practice of scavenging, that now is carried out in only one of the old final disposal sites operated by this entity (Santa Catarina). It has been reported that the practice will be completely eliminated in the Federal District during the present year, when that dump is closed, if the negotiations that are taking place with the scavenger's labor Union are successful (See Section for a discussion on the role of the Union).

In September of 1994, two new separation and resource recovery plants built by the DGSU became operational, one of them in San Juan de Aragon and the other in Bordo Poniente. The function of those plants is to increase the recycled component of the waste stream, and to replace the scavenging activities that have been eliminated as part of the above mentioned program. Each of the plants has a nominal capacity of 1500 ton/day and

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[15]Rosalba Cruz. Aspectos Sociales del Manejo de los Residuos Solidos. See references.

employs 700 workers, as the plants are of a not fully automated design. This decision was taken in order to provide employment to at least some of the scavengers that have been displaced. In another interesting social experiment, the scavengers, that have been organized in a new commercial corporation, will be trained by the DGSU, organism that will also give administrative support to the new corporation, until it is capable of self-conducting its operations. It is planned that when that occurs, the corporation will receive a concession for the operation of the plants. It will be interesting to follow the development of this corporation, as it represents an optional model to find compatibility between efficiency and modernization objectives on the one hand, and on the other, socio-political needs derived from situations that are a reality in many large urban areas of developing countries. It is expected that, out from the 3,000 ton daily input to both plants, from 400 to 450 ton -consisting of paper, cardboard, plastics, glass, cloth and ferrous and non-ferrous metals - will be recuperated for direct commercialization. The refuse from this first stage will be sent, for the time being, to landfilling. However, according to the standing plans, it will eventually be subject to additional resource recovery and treatment processes (See corresponding Section below). The available information puts the present percentage of overall recycling for the MAVM in the range of 10 to 15% of generation, with the more reliable sources reporting 11%.

Treatment. During many years there have been in Mexico efforts directed to establish sustainable treatment facilities, mostly composting. Few, if any have been successful. Many have lacked the required technical and/or financial resources that make sound operation and maintenance possible, situation that is typical in most of the municipalities in the country. Those installations that have been reasonably well operated and maintained, have experimented serious financial troubles, because of a very weak market for their product. That is the case of the composting plant that the DGSU operated until recently in San Juan de Aragon. As for incineration, there is a tentative, medium size installation (100 ton/day, in two 50 ton/day non-energy-recovery modules, of which only one is in operating conditions at the present moment) in the Federal District, intended mainly for the treatment of obsolete pharmaceutical products and discarded foodstuff. It

has not been operating regularly, mainly for the lack of appropriate emissions reduction equipment. Once this problem is solved, it is intended that it becomes a part of an integral facility in San Juan de Aragon.

Final disposal. The Federal District Government, through the DGSU, owns and operates three final disposal sites for urban solid waste (Table 4.2, Figure 4.4). Two of them, Bordo Poniente and Prados de la Montana are sanitary landfills that comply reasonably well with existing regulations. Bordo Poniente, built in federal property within the State of Mexico, is the most important of them, and the only one that offers the possibility of expansion. It is located on clays of very low permeability in what used to be wetlands of the ancient Texcoco lake, with some -minor- risk of flooding. Once the other sites are closed in the near future, and if no Metropolitan solution is implemented, this site will have to be used as the exclusive landfill facilities for all the urban refuse generated in the Federal District. In those conditions, and at the expected rate of generation, the useful life of this site can be expected to be 10 years at the most. Presently, Bordo Poniente is receiving an average of 5,000 ton/day of solid waste. The second landfill, Prados de la Montana has a daily capacity of 3,000 ton and it is about to be closed because of its proximity to new, important urban development projects. Finally, the third site, the Santa Catarina dump, has been subject to some works to better its conditions but does not comply with regulations. In addition, due to the high permeability of the geological formations in the zone, the Santa Catarina site is considered to be a serious environmental risk as regards contamination of the aquifer (See Section 2.6.2.) and will have to be closed as soon as possible. At the present time Santa Catarina receives waste at an average rate of 3,000 ton/day. In addition to the three sites destined to the final disposal of common urban waste, the DDF operates 2 sites for the disposal of construction debris, one in Iztapalapa, the other in the Becerra Ravine. Once the capacity of the existing facilities is reached within the next few years, environmental considerations and social opposition to the construction and operation of landfills in the vicinity of inhabited areas will make it very difficult to open new facilities of this type within the limits of the Federal District.

4.2.3. Standing plans.

An analysis of the evolution of the plans that have been developed in the Federal District during recent years regarding solid waste handling and disposal, reveals how the lack of effective coordination mechanisms between the Federal District and neighboring states, specially the State of Mexico, has forced the responsible authorities to abandon plans that were based on a Metropolitan conception of the future waste management system, and that were reasonably solid from the technical, economical and environmental points of view, to favor more locally oriented, less satisfactory solutions, but that are considered by those authorities to be more realistic, given the existing circumstances. Up to 1992, the DDF devoted a considerable amount of effort, with the support of the government of the State of Mexico, in the planning of waste management metropolitan actions. Inial steps were taken regarding closure of old dumps in that neighboring state, as well as the upgrading of some others. However, apparently for political reasons, the interest in coordination eventually waned. For the past two years, the Federal District has thus adopted and started the implementation of plans whose physical boundaries are either those of the Federal District territory, or of those areas whose use has already been granted to the Federal District, such as the Bordo Poniente areas. Within those restrictions, the standing plans are oriented towards the minimization of volumes for final disposal; they consider: a) Waste reduction, mainly by the way of the modification of packaging standards and practices. b) Resource recovery, including recycling, waste-to-energy incineration, and composting . c) Landfilling.

More specifically, the Federal District now bases its future treatment and disposal strategies on the development of "Ecological Centers" -in fact, multiple process facilities- located in the two only sites that in the near future will be still available -San Juan de Aragon and Bordo Poniente- as very probably, it will very difficult to develop additional places within the Federal District territory. Of the available sites, San Juan de Aragon has been conceived as a separation and resource recovery center, and Bordo Poniente as a separation, resource recovery and final disposal facility, with the more extensive treatment

facilities being located in Bordo Poniente, some of whose inputs will have its origin in the outputs of San Juan de Aragon (Table 4.3).

Facilities in San Juan de Aragon: a) Segregation and recovery of recyclables. This part of the process is already on operation. b) Primary trammel process, whose input will be the non-recyclable obtained form the previous process, the outputs being sent partially to waste-to-energy incineration and partially to a secondary screening process, both of them to be located in the Bordo Poniente site c) Sterilization of medical waste. Refuse to be sent to Bordo Poniente for landfilling. d) Non-energy-recovery-incineration: Two modules to process discarded pharmaceuticals and foodstuffs. Ashes to be sent to Bordo Poniente for landfilling.

Planned facilities for Bordo Poniente: a) Segregation and recovery of recyclables, as well as primary trommel process, similar to those in San Juan de Aragon. b) Waste-to-Energy-Incineration. To be fed with refuse from the primary trammel processes, both from San Juan de Aragon and Bordo Poniente itself. c) Composting process, including separation/secondary screening, and digestion of organic matter. d) Dehydration and grinding of vegetal refuse from the Central de Abastos (Central Wholesale Food Market) for animal food production.

When the system becomes fully operational, it is expected to reduce the requirements for landfilling to about 60% of total waste collection (Table 4.4), the most important reduction being in the composting and incineration processes (43% and 30%, respectively of total weight reduction). This is no doubt a worthwhile objective, that however, might not be easy to achieve, mainly because of obstacles that high costs and environmental considerations present to incineration, specially within the Valley of Mexico, and the difficulties to find a sustainable market for compost.

Table 4.3 Federal District: Standing plans for recycling and treatment.

Process	Nominal cpacity (input)		
	Location		Total
	S. J. de Aragón	B. Poniente	
Separation and recycling	1500 (1)	1500 (1)	3000
Primary trommel–a	1300	1300	2600
Primary trommel–b	–	2000	2000
Composting	–	2800	2800
Animal food production	–	250	250
Conventional incineration	100 (2)	–	100
Waste–to–energy incineration	–	1500	1500
Sterilization	230	–	230

Notes: (1) Already in operation.
(2) 50 ton/day already in operation.

Table 4.4 Federal District: Summary balance of materials for standing plans.

Item	Weight (ton/day)	%
Total waste input	11000	100
Materials recovery	730	6.6
Compost production	1190	10.8
Animal food production	60	0.6
To sanitary landfill	6750	60.4
Sinks	2270	20.6

4.2.4. Financing.

It was not possible to obtain any information regarding the costs of waste management in the Federal District. No direct fee is charged for the service by the DDF or the Delegations, the only costs to users being those of the tips that almost invariably are given to the personnel in charge of collection. An approximate calculation taking into account diverse cost estimations, mainly that of the OPS (Organizacion Panamericana de la Salud -Panamerican Health Organization), puts the cost of waste management in the Federal District in a range of 200 to 250 million dollars per year.

4.2.5. Private Sector Participation.

Traditionally, the participation of the private sector in waste management activities in Mexico in general, and in the Federal District in particular has been scant. The situation regarding collection and recycling has already been described in one of the preceding sections: because of sociopolitical reasons there is no participation of the private sector in those activities, that for the moment seem to be restricted to it. Even the way the present local regulations are stated, make the intervention of private companies difficult. For the moment that type of participation is taking place only in some landfilling activities in Bordo Poniente, and in the subcontracting of some of the secondary transport operations. That is not the general case in the country, as a growing number of municipalities of important cities has been opening biddings so as to privatize waste management operations[16]. This might be also the case in the Federal District in the near future, where some parts of the systems might be opened to private participation, especially in down stream operations, such as incineration and landfilling.

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[16]It has been reported that no less than 15 private companies have been participating in different bidding. Most of those companies have some type of relation with American, Canadian or European waste management companies.

4.3. The State of Mexico.

4.3.1. Administrative Structure.

As it has already been pointed out, in what constitutes a fundamental difference with the Federal District, there is little direct intervention of the intermediate level of government -in this case the State Government-, in waste management matters, which, according to the existing legal framework, are an almost exclusively municipal responsibility. Municipalities are directly in charge of urban cleaning, collection, transportation, treatment and final disposal of solid waste, usually carried out through an Urban Cleaning Department in the Area of Municipal Services. The State Government plays a normative, supervisory and consulting role; however, it keeps important powers, not only of veto, but also of potential participation in waste management matters. The main State Government's actor is the SE (Secretaria de Ecologia -Secretariat of Ecology-), with other Secretariats playing a secondary role in environmental matters.

4.3.2. Existing waste management installations and practices.

Distribution of responsibilities in the State of Mexico, as well as the concurrence of other factors, such as the traditionally weak financial condition of municipalities, and the short term of office of municipal authorities, result in waste management installations and practices whose level of quality is quite variable and, as an average, well below that existing in the Federal District. The state of collection equipment and the quality of corresponding practices varies within a very wide range in different municipalities. Some services are comparable or even superior to those in the Federal District, and some others are of a level that could be considered as primitive. It was also not possible to obtain consistent information regarding final disposal installations that operate in the State of Mexico, the lack of integrated information being, apparently, a result of the independent nature of the municipalities as regards the State Government. However, a detailed

inventory of all equipment and installations in all municipalities is being prepared by the Secretariat for Ecology, and some isolated information has already been produced. There are 13 official recognized dumps in as many municipalities, without any of them having the characteristics of a sanitary landfill; programs are being carried out in order to rehabilitate some of them.

4.3.3. Standing Plans.

It was not possible to make an inventory of the standing plans of the 27 different municipalities in the State. As for the State Government, apparently it has started the preparation of a Master Plan for Waste Management whose details have not been made public.

4.3.4. Financial Aspects. Private Participation.

No information was available regarding the overall cost of waste handling and disposal in the State of Mexico's metropolitan municipalities. An approximate estimation of that cost is in the range of 100 to 150 million dollars per year.

As for private participation, several municipalities are currently conducting negotiations with private companies, that are, in principle, interested in receiving concessions for waste management activities. No success has been reported up to now in this respect.

5. Present and Potential Actors in the Decision Making Process. Interests. Relative Influence.

There is a considerable number of participants or actors that play a relevant role in the decision making process related with the urban waste management system in the MAVM, of which they constitute a fundamental subsystem. Whether their role is formal or informal, direct or indirect, their capabilities, positions, interests and relative influence shape the planning process, its outcome and, of course the feasibility and robustness of any alternative course of action that might be selected. Thus, the knowledge of the relevant actors, of their present and potential attributes, and of their roles, is essential for the understanding of the actual waste management system, as well as for the success of any modifications that might be proposed to it.

It is necessary to note that the subsystem of participants, as well as their positions and relative influence is a very dynamic one, due to the diverse and important changes that the Mexican socio-political system is undergoing at different levels at the present, changes that no doubt will continue to happen in the near future.

In this section the main actors, as well as the role that they play in the decision process, are presented in the first term. The section then goes on to make a preliminary attempt in the characterization of the actors as regards their relative influence and positions.

5.1. Actors.

5.1.1. Users.

5.1.2. Governmental Actors.

Please refer to Sections 3 and 4 for a presentation of the governmental actors - Federal, Federal District, State, and Municipal governments-, as well as of the roles that they play in the urban waste management´s decision and operational processes.

5.1.3. Non-Governmental Actors.

For many years, and up to now, most of Mexico's elected officials at the three levels of government have belonged to the PRI (Partido Revolucionario Institucional - Revolutionary Institutional Party). Also, the socio-political life in Mexico has been dominated by a strong participation of government. Most social organizations, such as trade unions, peasant organizations, and guild-type associations have had an important influence from the government, which in fact has controlled many of the channels of communication that link it to civil society, in a system that has been often described as having corporative
characteristics.

However, with a beginning which is commonly dated in the decade of the 1970's, gradual but clearly accelerating changes have been taking place in the Mexican political system. A detailed description and discussion of those very important changes is well beyond the scope of the present work. For its purposes, it may be sufficient to point out that during the last two decades, civil society has grown much more autonomous from the state, with many diverse movements addressing a wide range of issues. Increasing political

openness and plurality has favored the birth of numerous non-governmental-organizations, that constitute an alternative channel for the social participation of citizens, including users of urban services. As in other parts of the world, environmental protection is one of the issues that has deserved particular attention from society, and has been the origin of many NGOs in Mexico. In addition to what are usually known as NGOs and similar organizations, non-governmental actors whose influence, whether direct or indirect, is actually or potentially relevant to the waste management system in the MAVM, include diverse labor unions and groups, professional associations, industrial guilds, commercial guilds, the academic and scientific community, a nascent but dynamic private waste management industry, political parties, the media and others.

Non-Governmental-Organizations. NGOs relevant to the present work are of diverse nature and cover a wide range of interests, types of organizational structure, number of members, sources of financing, etc. In one extreme there are associations of neighbors that get together for the promotion of a positive action[17], or for the defense from actions they consider as a threat to the quality of life of their particular neighborhood; because of its objectives, those associations have a limited scope and a limited life span. In the other extreme of the range, there are associations with more general interests, of a permanent nature, with a rather stable organizational structure and reasonably solid financing. Within that wide range there are those organizations that belong to what commonly, and in a rather loose manner, is called the "ecological movement". In fact, there has never been a community of interests and objectives among environmentally oriented Mexican NGOs. They have profound differences in respect their ideological origin and their political aims, and are a good example of the difficulties of the integration of an unified, wide based ecologist movement. However, they have on occasion exerted a considerable amount of influence on public opinion and on governmental positions. One common classification of environmental NGOs in Mexico would recognize several

[17]Positive in the sense of being an action which purpose is to modify an existing situation, rather than maintaining a status-quo.

different types[18]:

a) Conservationists. In its origins this associations, whose promoters belonged mainly to the intellectual and scientific community had as their objective the defense of ecological reserves, the protection of endangered species and the dissemination of environmental information. More recently, these organizations have established links with agrarian and urban groups of popular origin integrating their origin aims with more immediate social demands. They constitute the better financed and structured, as well as the more resilient of environmental NGOs.

b) Environmental groups of popular origin. This groups also favor the defense of natural resources, but link their conservationist interests with a high degree of political activism in relation with social causes, and keep close relations with groups of farmers and urban social movements. They are considered to be an important part of a new leftist-oriented environmental tendency, and in recent times have been receiving growing financial resources form international organisms and foundations. Its relations with the state are of a contradictory nature, as on the one hand they try to keep a very critical position as regards governmental actions, and on the other they depend, at least partially, from official financial support that they actively seek.

c) Neighbors' Associations. They exist mainly in medium-class urban neighborhoods and have a long tradition of activism, specially in relation with the defense of very specific local interests, such as the promotion of public services[19], the preservation of parks and other green areas, the opposition to new transportation infrastructure, and of

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[18]Gabriel Quadri de la Torre. See References.

[19]One very interesting case regarding public services is that of the Asociacion de Colonos de Ciudad Satelite, a medium class neighborhood in the metropolitan area of the State of Mexico with more than 50,000 inhabitants. Under an special agreement with the state's and municipal authorities, the Association satisfactorily managed most of the neighborhood's urban services for several years.

particular concern to this work, the opposition to the construction and operation of waste management facilities (NIMBY). Because of their direct involvement, its educational standards, and its resources -among them their relationships- they constitute one of the main influences that must be taken into account in any decision process regarding waste management actions. Because of the same reasons they also constitute a difficult but usually reasonable, interlocutor and negotiator. Some times these associations receive technical and political support of other NGO's, specially of those described in paragraph b) above. In a recent example, one such alliance fought against the installation of a transfer station in the south-western part of the Federal District; the project went on only after the DDF agreed to provide certain urban improvements in the neighborhood, such as park areas, parking lots, an additional lane to the main road interconnecting the area with adjacent neighborhoods, etc. In another, less successful example of negotiations, similar alliances are generally considered to have been the main influence that effectively stopped the 1990-1992 combined efforts of the DDF and the government of the State of Mexico towards a metropolitan management of urban waste: the NGOs blocked the sitting of the very first landfill that would have been jointly utilized, and that according to plans was to be located within the State of Mexico's territory. Similar to neighbors' associations, there also exist associations that group, for example, commercial establishments that are located in a common urban neighborhood, and that because of that share the same interests.

d) Municipal Committees for Environmental Protection. These citizens' committees, that exist in the State of Mexico, were initially promoted by the municipal authorities, and as such were widely regarded as another effort to give a corporative structure to environmental matters. However, they have gradually becoming more and more independently minded and they might become an additional relevant actor carrying local influence,its objectives being somewhat more general than special-purpose neighbors' associations.

e) The Scientific and Academic Community. Many of the concerns regarding

environmental matters have traditionally come form the academic and scientific organizations. The increasing deforestation and erosion of the land has been a widely discussed issue since the at least the 1950's, and already in the 1970's some members of those communities were sounding the alarm on the generalized destruction of natural resources and on the increasingly worrisome environmental situation of the main cities in the country. That not much of practical value came out from those old worries, does not speak highly of the degree of real influence that scientists exerted at that time. In more recent years scientists and academicians have participated more actively in concrete environmental studies of many diverse types and have an increasingly important participation in public life. Contrary to what seems to be happening in other countries, the scientific and academic community enjoys in general terms the confidence of the public, and has an important influence in the environmental conscience of society. Occasionally members of these communities have close relations with the government, although they try to maintain a certain political distance, in accordance with their main role.

A recent inventory of Mexican NGO's compiled by SEDESOL[20] lists 510 organizations that can play some role on environmental matters. Most of them are of a reduced size: another report shows that only 20% have more than 50 permanent members.

Environmental NGOs in Mexico have been playing an active role during a relatively short period of time. Up to now they have as its most important achievements, the place they have gained in the media, and its collaboration in the creation of an environmental conscience in the general public. They have also begun to exert its influence by blocking certain governmental actions. No doubt in the near future they will become an increasingly influence to be dealt with in all environmental matters.

Perhaps the most important problem that some of the NGO's still have to solve is that of financing. This is linked to possible conflicts of interest that may exist when some

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[20]Directorio Verde -Green Directory-. See References.

organizations receive financial support from the government, mainly through the carrying out of environmental studies and consultation[21].

Labor Unions. These organizations play a fundamental role in all matters related to waste handling and disposal in the MAVM. Workers in the DDF's payroll, active in the waste handling and disposal system, from street cleaning and domestic collection to final disposal, number more than 20,000 persons, and are members the powerful Section 1 of the "Sindicato de Trabajadores del Departamento del Distrito Federal" -Union of Workers of the Department of the Federal District-. The influence that the members of this union have is shown, for example, by the fact that it has not been possible to eradicate the practice of on-board separation that is carried out on collection vehicles with the participation of "support personnel", in what constitute a system of literally thousands of small business ventures (See Section 4.2.2). The interests, positions and influence of the members of that system have to be considered as an important element in any decision making process regarding waste management in the MAVM. As for labor unions of municipal workers in the State of Mexico, they represent a much less important force, due to the fact that they are in fact employees of 27 different organizations (the municipalities), and have difficulties to act as an unified force. It is interesting to note that, from the point of view of conflict resolution, some waste management officials of the Federal District consider that a greater independence of Delegations -that would undermine the coordinative capacity of the central Federal District government, making the system less efficient from the technical and economical points of view-, would be welcome, among other reasons, because it would open the possibility of independent personnel contracting in the Delegations.

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[21]It has been reported ("Politica Ambiental en Mexico. El Papel de las Organizaciones No Gubernamentales". See References), that 75% of NGOs have some kind of tie with the government, and that nearly 30% of them receive direct financial support from it.

Scavengers' Unions. The existence in the urban areas of developing countries of: a)Important numbers of people with a low level of income with scarce opportunities for social mobility, that represent a manpower of very little cost, willing to work in extremely difficult situations, b) Ever growing quantities of urban waste, and c) An attractive market for recyclable, all of those combine to give birth in those countries to large scavenging operations that represent a way of living to many persons, and that with time evolve into structures of interests and influence that must be taken into consideration as an important part of the waste management system, as well as of decisions pertaining to it. "Faks" and "Teugs" in Dakar, "Wahis and "Zabaleen" in Cairo, "Gallinazos" in Colombia, "Scavengers" in English speaking countries, "Pepenadores" and "Resoqueadores" in Mexico, are different names to designate the same type of person: the one that makes a living out of waste picking in what usually are less than human conditions.

In the case of the MAVM, after decades of that kind of activity "pepenadores" had reached the state of a lowly regarded social caste, whose members were born, subsisted and died in the dumps, generation after generation, with their own social and working organization. Eventually, under the direction of some of the more politically oriented and entrepreneurial of its members, groups of pepenadores organized in "Unions" for the defense of their interests. The story of the evolution of those unions and of their leaders, as well as of their struggles for power constitute very interesting reading[22]. For the purpose of the present work it is enough to note that by the mid 1970s, the unions of "pepenadores", specially in the Federal District, had become a real political force. Rafael Gutierrez Moreno, leader of the "Union de Pepenadores de los Tiraderos de Basura del Distrito Federal", an organization that consolidated most of prior groups, was for several years a representative to the Federal Congress, and reputedly, a man of ample economic means. At the peak of its power it was reported that the union grouped more than 10,000 "pepenadores" and constituted an important force for political activism in the Federal

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[22]See, for example "La Sociedad de la Basura: Caciquismo en la Ciudad de Mexico", by Hector Castillo Berthier.

District. The death of Rafael Gutierrez Moreno in 1987, with the resulting division among his closest followers of the power he used to exercise, the social work that the DDF has done among the families of the pepenadores as a way to open other opportunities to them, and the gradual closure of most of the dumps that existed in the Federal District, with the corresponding operation of more modern separation and disposal facilities, are all elements that have interacted with a relative loss of power of the "pepenadores" unions. Today there exist in the Federal District three main unions[23]; each of them controls one of the three important installations owned by the DDF: San Juan de Aragon, Santa Catarina and Bordo Poniente (See Section 4.2.2). Notwithstanding the fact that apparently the peak of the power of this unions is now past, they still are an element to consider. Their position regarding the existing plans to close the Santa Catarina final disposal site, that represents a danger to the environment, has been mentioned as the main reason why the closure has not yet taken place. As for the state of Mexico, similar to what happens in the case of the municipal workers' unions, their influence is relatively minor, as a result of the decentralized nature of municipal governments.

Professional Associations. There are several types of professional associations, whose opinions influence on occasion decisions regarding waste management, because of the technical prestige the enjoy. Among them are large organizations that group professionals of a certain general specialization: Associations (sometimes called "Colegios") of Civil Engineers, Chemical Engineers, Mechanical Engineers, etc. Most of them participate in the corporative structure of Mexican politics. There exist also more specialized, smaller and more technically oriented organizations, whose members are professionally active either in the public or private sectors. Those organizations exert a considerable amount of technical influence in the decision making process regarding waste management, two of the most active being the SMISA (Sociedad Mexicana de Ingenieria

[23]The heads of those unions are, respectively, the widow of Rafael Gutierrez Moreno, one of his sons (that now is also a representative to the ARDF), and a former second in command to RGM.

Sanitaria y Ambiental - Mexican Sanitary and Environmental Engineering Society) and the AMCRESPAC (Asociacion Mexicana para el Control de los Residuos Solidos y Peligrosos -Mexican Association for the Control of Solid and Hazardous Wastes-).

Industrial and Commercial Guilds. According to Mexican law, businesses of a similar commercial or industrial branch must group for the promotion and defense of their interests in associations called "Camaras". Consequently there exist a large number of such associations of a specialized and/or local nature that carry a considerable amount of influence at local level. At a national level those local associations group in "Camaras Nacionales" -National Chambers or Guilds-, that play a relevant role in the political interplay of the country. Examples of those national associations are the CANACO (Camara Nacional de Comercio -National Chamber of Commerce), the CANACINTRA (Camara Nacional de Industrias de la Transformacion -National Chamber of Manufacturing Industries), and umbrella associations such as the CONCAMIN (Confederacion de Camaras Industriales -Confederation of Industrial Chambers) or the COPARMEX (Confederacion Patronal de la Republica Mexicana -Confederation of Business of the Republic of Mexico-),the top umbrella business association in the country. Of those, CANACINTRA is the one that has played a protagonist's role in environmental matters, in relation with air pollution in the MAVM, playing the role of a consultant and supporting the government in many of the measures that have been taken in that respect. Up to now no similar role has been played by one of these associations regarding urban waste, but they remain a potentially important actor in this field.

Private Companies. As it is discussed in other places of the present work (see preceding paragraphs regarding unions, and sections 4.2.5 and 4.34), participation of private companies in the management of waste in the MAVM has not been extensive up to now. In the Federal District collection, transportation, recycling and materials recovery activities are mostly controlled by the labor and scavengers unions, while there is an incipient participation of minor private companies in landfilling activities. This is a system that, notwithstanding its peculiarities, is in place, and whose performance has been

improving during the past few years. Given the standing plans of the DGSU, it is not to be expected that radical changes in the system occur in the immediate future in the Federal District, as regards private participation. In the State of Mexico, private participation is not extensive, either. However, because of the scarcity of technical and financial resources that is common in most of the municipalities, there is a growing opening to the concept of extensive private participation in waste management activities. There are even some indications that this participation might be integral, covering all of the stages of waste management. For this to happen, however, congruence must be found first among the different technical, economic and socio-political variables. Diverse private companies are already working, or bidding for contracts in other important cities in the country, and are proposing different schemes that would allow their extensive participation in the MAVM.[24]

Political Parties. In the recent past, Mexican political parties have begun to include as their own, some social environmental demands, although it is generally considered in what might be called the environmental community that parties still show serious ideological and programmatic deficiencies regarding ecological issues. The dominant party, the PRI, has included the environment as a part of its political agenda since 1990 and is the one that shows a more coherent and integral approach to the subject, but without giving the subject a really deep consideration. As for other parties that have an important electoral position, the PAN (Partido Accion Nacional -National Action Party- conservative), reflects in its environmental considerations the lack of an integral approach to environmental matters, with sectorial treatment of diverse problems, among them those that are a concern to its important middle-class urban electoral base, such as environmental protection in large cities. The third electoral force, the PRD (Partido de la Revolucion Democratica -Democratic Revolution Party- center left) has adopted an approach to environmental matters that favors the conservation and rational utilization of natural

[24]An informal survey showed that nearly 20 private companies, many of them associations between large Mexican construction groups, and important American, Canadian or European waste management companies, are bidding for work in other cities, more open to private participation.

resources as the basis of a new economy, with strong regulatory participation from the government. Of the three main parties is the one that up to now seems to show the least integral and coherent approach to environmental matters.

It is to be expected that the increasingly open democratic atmosphere that Mexico is experiencing will continue to bring to the political arena many subjects, among them that of the means to fight urban pollution, that until recently were treated and solved in rather subdued, techno-economic grounds. In this atmosphere, political parties will very probably try to play a more active role regarding environmental matters that the one they have chosen to play up to now, even using the environment as a way to pursue other political aims. It can be concluded that political parties are indirect, but potentially very important actors in matters related with waste management in the MAVM.

The Media. There is no doubt that mass media has played and continues to play a relevant role in creating an environmental conscience in the civil society, in bringing environmental matters to public attention, and in offering a forum for the open discussion of environmental issues. In regards the MAVM, having begun its active participation in relation with subjects such as atmospheric contamination, and the depletion of the aquifer, the media has now a constant flow of information and discussions regarding all kinds of urban environmental matters, including waste management. There is general agreement in that mass media have become a reliable means of communication among government, non-governmental organizations and the public regarding ecological concerns and actions. There is no doubt that the media will continue to be a fundamental, if indirect actor, in urban and ecological issues.

5.1.4. Evaluation of actors.

If any kind of rational analysis is to be attempted so as to predict the behavior of a system where several actors play a role, an as thorough as possible understanding of the relative influence that those actors have in the behavior of the system is one of the

essential elements. A solid grasp of that understanding is also extremely difficult to achieve, the difficulties being diverse and of different natures. This very difficulties are an important factor in the selection of the instruments that should be utilized to support the decision making process regarding systems that include socio-political variables. A detailed systematic analysis of the relative influence of the multiple actors that play an actual role, or might play a role in a planning process for urban waste management in the MAVM is beyond the scope of this work. However, the present section contains a general conceptual discussion on the subject of relative influence, whose main motivation has a methodological origin, but also has the purpose to underline some difficulties that defining such influence for the specific case of the MAVM would face.

It is commonly considered that "influence" is a relation among actors in which one actor induces other actors to act in some way they would not otherwise act[25]. If we consider only 2 actors, A and B, then A exercises manifest influence over B to the extent that A's influence-attempts cause a change in B's behavior, including in the definition of behavior concepts such as predispositions, feelings, attitudes, and beliefs as well as overt acts. An influence attempt is successful to the extent that the change in B's behavior caused by A's actions, results in B's doing what A wanted him to do when A attempted to influence him. This common-sense approach to influence might appear to be simplistic. The difficulties of performing such an analysis in a system that includes several actors, where the influences that each of them has on each of the other actors must be understood and evaluated, become apparent when one thinks about the kind of questions that must be answered in order to perform the analysis for the specific case of the MAVM:

- On the network of influence: What are the actors over which each of the actors has an influence? Does a specific environmental group have influence over a municipal authority? Over some newspaper? Or rather, the newspaper has influence over the environmental group? To what extent?

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[25]Robert A. Dahl. Modern Political Analysis. See References.

- On the range of particular influences: On what kind of subjects does an actor influence the others? Does a professional association influence decision making as regards environmental regulations? Over technical solutions?
- On the kind of political resources: What are the amount and type of political resources that each actor has and might utilize? Prestige? Economic means? Legal coercion? Indirect actions?
- On the reliability of influence: How reliable is the influence of an actor over other? Does the Federal Government usually have influence over local governments? Does sometimes local electoral situations erode Federal influence?
- On the relative strength of influence: How strong is each particular influence? To what extent will go a municipality to comply with the desires of a local environmental group? To accept a metropolitan plan proposed by the State Government? To include the recommendations of a professional association in the specific design of a disposal site?
- On the cost of exerting influence: How costly is for an actor to use his influence over other actor? Will a political party utilize political capital to influence a union, knowing that capital might be used in some other instance?

The matter is further complicated by: a) The fact that, as in any social issue, influences constitute a dynamic system in which actors constantly exert and receive influence over and from other actors, b) The dynamics of such systems usually include the formation and destruction of alliances that must also be understood, and c) The system responds not only to the rules of individual economic advantage as they have been defined for rational behavior, but also to other, much less understood, social rules that include moral values, common interests, collective purposes and actions, loyalty, cooperation, etc. And, of course, in the realm of decision making, the real question relates to the way in which all those considerations will condition the utility functions of each of the

participants and its preferences, that in this context become also part of a dynamic system. Still, decision makers must find systematic ways of selecting, among all the possible courses of action, those that have the higher probability of becoming robust responses to social needs, as represented by all the actors that play a role in the process. More about this will be presented in Chapter 7, that refers to the available tools for systematic analysis, whose degree of usefulness depends, in good measure, on its capacity to deal with this type of variables.

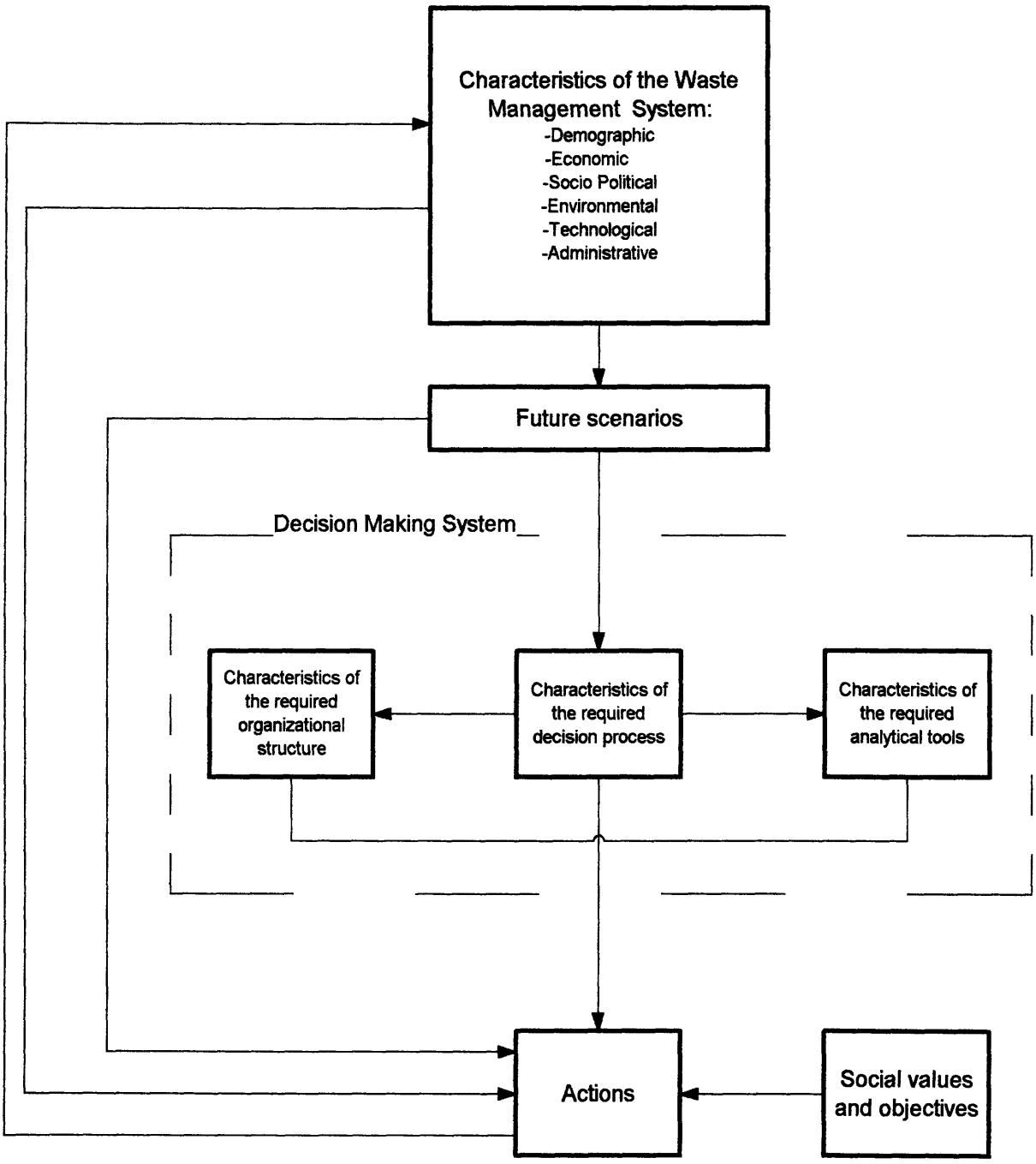
6. Decision Making. Proposal of a Planning Process and Structure.

The systematic search for, and selection of, robust strategies and specific actions in the field of waste management in the MAVM, requires the utilization of a decision making process whose nature must be determined by the characteristics -present and expected- of the elements that constitute the waste management system in the Area, of which the decision making subsystem itself becomes one of the main components. Figure 6.1 shows in a simplified manner the relationships among those subsystems.

In what follows, the decision making process is referred to in a planning context. It is also considered, as was pointed out in the preceding paragraph, that: a) The decision making process must be directly conditioned by the characteristics of the present and expected waste management system, b) Decision making consists of two coexisting, interacting but distinct phases, the first being the decision process itself, the second being constituted by a decision making structure wherein the decision making process takes place, c) The design of the decision making structure, being in fact a tool for the process, must be determined by the characteristics of the latter, and d) The actions that are the output of the decision making system will modify the characteristics of the waste management system (Fig. 6.1).

With basis on the material developed in preceding Chapters, Chapter 6 presents in a synthetic form, the characteristics of the subsystems that conform the waste management system in the MAVM, as it exists today. Taking into account that characterization, and

Figure 6.1 The waste management and decision systems.



the probable evolution of the constituent subsystems, different future scenarios for the waste management system are discussed. Then, a proposal of the main conditions that must be satisfied by a decision process for waste management in the MAVM is developed, as a result of the interactions among a planning concept, the present characteristics of the waste management system, and the characteristics of future scenarios for waste management.

6.1. Characterization of the Waste Management System in the MAVM.

Because of the multiple interactions among the different elements that together conform waste management systems, there are many ways, all of them somewhat arbitrary and -of course- controversial, in which the subsystems of such systems can be identified for the purpose of analysis. Here, the different components of the waste management system in the MAVM have been grouped in 5 subsystems:

- A socio-economic subsystem, that includes all the factors that have a role in the dynamics of the demand for services, as well in the possibility of the allocation of resources for the provision of those services.

- A socio-political subsystem, constituted by the different societal stakeholders and indirect actors that exert an influence on, or are affected by the behavior of the system.

- An administrative subsystem, conformed by the institutional, legal and regulatory frameworks, as well as by the decision making system related with waste management in the Area.

- A technological subsystem, whose constituents are all available means to

achieve a predetermined, desired physical behavior of the system.

- An environmental subsystem, conformed by the natural and existing physical conditions of the Area, and that takes in consideration all aspects related, both with the use of the environment as a source for the provision of waste management services, and as a sink of the refuse generated by that provision.

In the following paragraphs, the main characteristics of each of the subsystems are presented in a synthetic manner.

6.1.1. The Socio-Economic Subsystem.

- The Area is one of the most populated urban concentrations in the world: 17.0 million inhabitants in 1994. It will be well over 20 million within 15 years.
- Waste generation is estimated to be 17,000 ton/day at the present moment. It is expected to be more than 40,000 ton/day in 2010.
- The Area is the political, economic, financial and communications hub of the country. It has been, and continues to be, the receptor of huge investments in all kinds of infrastructure. Infrastructure and services have been highly subsidized.
- The Area accounts for 37% of the country's GNP, as well as for 45% of the value of manufactures.
- For several years now, there has been a well defined trend towards the increasing importance of the services' sector in the regional economy. The growth of the sector includes a mix of high quality, high priced services, and of services with very low added value.
- There exists a wide range of income stratification among the inhabitants of the Area.

- Distribution of income is highly unequal, and there exists a large number of the population with very low income, when compared with international standards.
- Inequalities of income exists among the inhabitants of the same subregion in some cases, as well as among the inhabitants of different subregions.
- Average income is low: only 26% of the employed population earns more than $270 US per month.
- There are increasing, national pressures to eliminate subsidies to the Area.

6.1.2. The Political Subsystem.

- There is an accelerated trend to a more plural and open political system.
- Political competitiveness among parties has increased during the past years, especially in large urban areas. This trend is expected to continue.
- In that evolving political framework, more open debate regarding diverse issues is to be expected.
- Different social groups have become more and more organized, active and articulate in the defense of their interests. Those include diverse labor unions that have a considerable influence in decision making regarding urban waste.
- There is a growing demand for more and better public services. Environmental quality has become a relevant issue for the inhabitants of the MAVM.
- During the past years the role of NGOs has been one of increasing importance. These organizations are especially active in environmental matters.
- There is a growing list of instances where direct political action from social groups has been a successful alternative to corporative channels in negotiations with governmental authorities.

- What has been called the "NIMBY" syndrome is now a reality among social groups in the MAVM. That fact most be considered in any decision making regarding urban matters.

6.1.3. The Administrative Subsystem.

- The administration of the territory of the MAVM, that constitutes a continuous urban area, is the responsibility of two different governmental structures -Federal District and State of Mexico-.
- Coordination between those structures has proved to be difficult up to now.

- Waste management administration within the Federal District has reached a workable balance between centralization and decentralization. This balance might be, altered when recently approved modifications to the institutional framework are implemented in 1997.
- Coordination of actions among the municipalities of the Sate of Mexico requires considerable effort. It is expected that growing political plurality will require additional efforts in the future, in order to coordinate the actions of local governments (16 Delegations in the Federal District, 27 municipalities in the State of Mexico).
- There is a strong imbalance between the important waste management responsibilities of the municipalities within the State of Mexico, and the scarce resources -technological, financial, administrative- of those municipalities.

6.1.4. The Technological Subsystem.

- There are important imbalances in waste management installations and practices between the Federal District and the State of Mexico.
- Technology utilized in the Federal District is of medium level of

complexity, and can be considered adequate for the socio-economic circumstances, if not necessarily so for the environmental conditions.

- Different municipalities within the State of Mexico have quite different levels of technology, with a range that goes from the very primitive to a level similar to that of the Federal District.
- The preferred method for final disposal in the Area is landfilling.
- Existing landfills within the Federal District have an estimated useful life of no more than 8 years, if all plans for recycling and treatment are implemented in a timely fashion. There are no more suitable areas for landfilling within the Federal District.
- Most municipalities within the State of Mexico do not have adequate final disposal facilities, or medium and long range plans for waste management.

6.1.5. The Environmental Subsystem.

- Because of the geological conditions of the Valley of Mexico, and the heavy dependence on ground water for domestic uses, it is generally considered that no more landfills should be allowed within the territory of the Federal District.
- From the technical point of view, there are adequate sites for landfilling in the territory of the State of Mexico, within the Valley.
- There are also adequate sites for landfilling, outside of the Valley of Mexico.
- There is still much to be known about the potential effects of massive incineration within the Valley. However, because of the still serious conditions of air quality in the Valley, incineration can be regarded, at the least, as a politically controversial option.

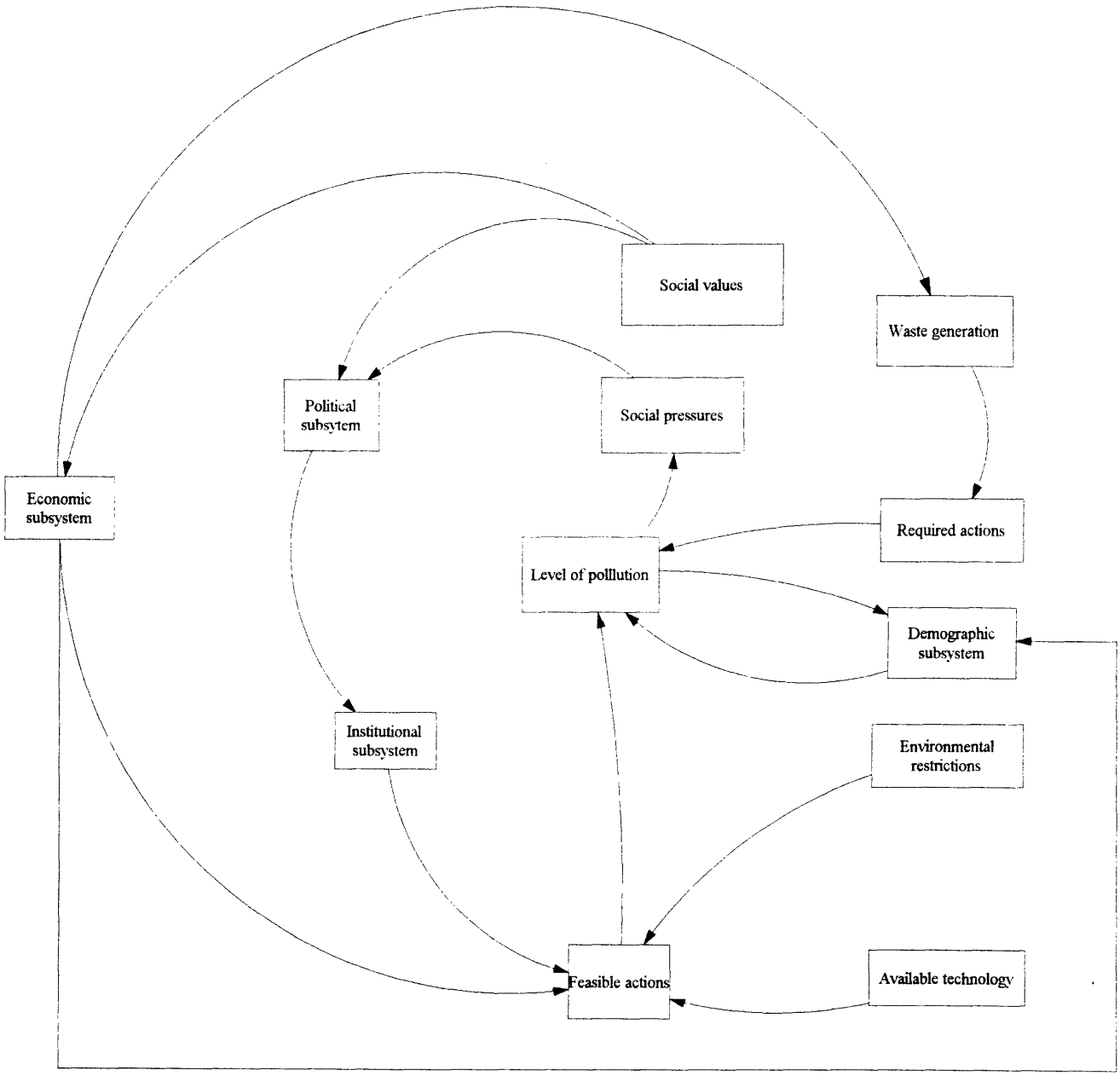
Examination of the different subsystems that constitute the waste management system in the MAVM, proves one of the main propositions stated at the onset of the

present work: waste management in the MAVM constitutes a complex system, not only because of the number of its subsystems, or because of the number of intervening variables, but also because of the heterogeneity of those variables, and because of the multiple interactions that exists among the different subsystems. Figure 6.2 shows in a schematic form some of those interactions.

6.2. Future Waste Management Scenarios.

It is to be expected that the evolution of the waste management system in the MAVM will go through stages during which its behavior can be predicted with reasonable certainty, and stages when the behavior presents a high degree of indetermination. The failure of certain actions regarding the provision of urban services may be found in the fact that, even if the technical feasibility of the project has been proved, the corresponding behavior of the other subsystems has not responded to expectations. It is necessary, form the very design of a decision making process, to define different scenarios in which waste management might take place in the future, depending on the probable behavior of the subsystems. The characteristics of those scenarios would then be utilized, in conjunction with a planning concept, to define the general attributes of decision making processes adequate for each scenario or, hopefully, of a decision making process that might prove to be useful for different scenarios. A preliminary attempt to define some characteristics of future scenarios, through the examination of alternative future conditions of the subsystems, and of the relationships among them, is made in the following paragraphs. In the following discussion it is assumed that a democratic, increasingly open political atmosphere is a characteristic of all scenarios.

Figure 6.2 Schematic lay-out of interactions.



It also seems reasonable to assume (Figure 6.3) that:

- A certain status of Economic Conditions (EC), -that includes multiple aspects, such as present and past rate of economic growth, competing social demands, income distribution, financial structure, fiscal policies, atmosphere for private investment, etc.- will condition the availability of resources (RA) for the supply of public services and for the attainment of a socially acceptable level of environmental quality.
- Resource availability will determine the type of technology that can be utilized for waste management purposes (feasible technology, FT). High resource availability will make it feasible the utilization of more refined, efficient technologies, a lower level of available resources will restrict the range of feasible technologies.
- Administrative Coordination (AC), between the Federal District´s and the State of Mexico´s governmental bodies, and among the different levels of government, will define the institutional scope (IS) in which the decision making process will take place[26]. A high degree of administrative coordination will allow wider, metropolitan approaches for decision making and for the implementation of resulting actions (the capacity of conflict management at a metropolitan level is assumed to be a part of the AC subsystem); a low degree of administrative coordination will restrict the institutional scope, leading to local approaches to decision making and to the corresponding solutions.
- The institutional scope will directly determine the level of technology (required technology, RT), that is necessary to achieve a certain level of

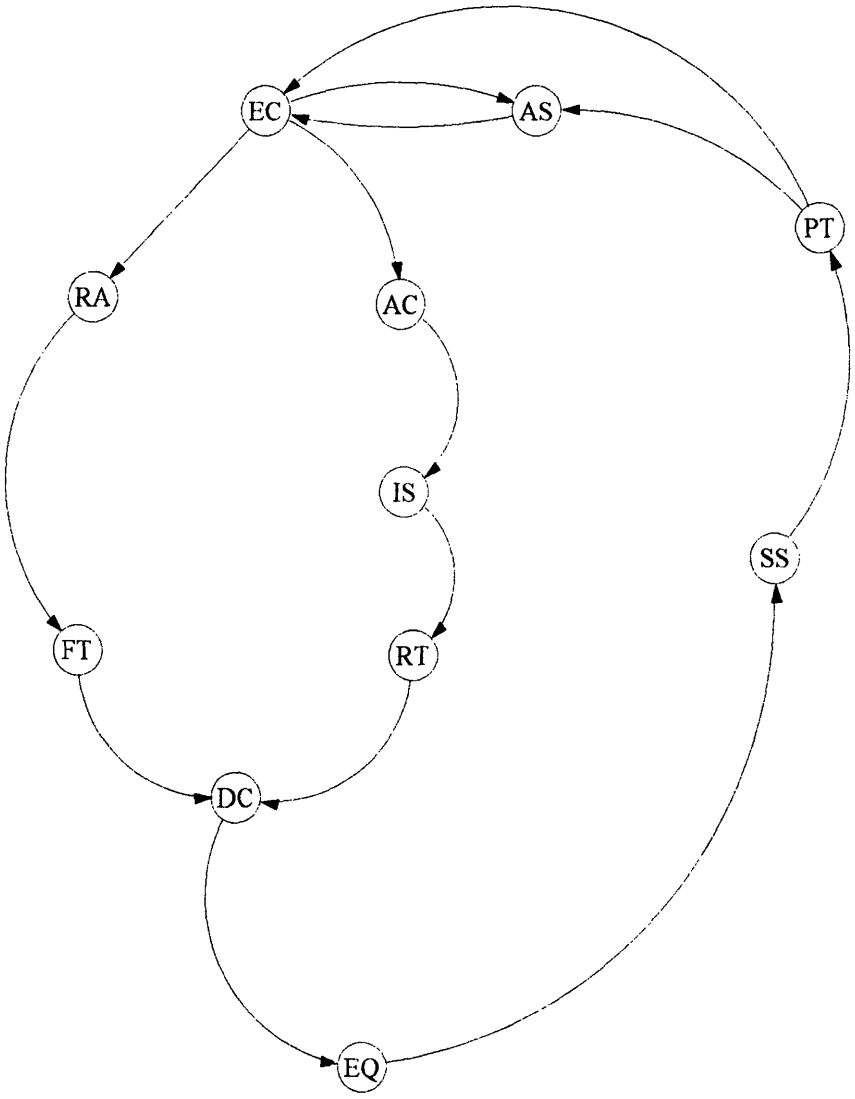
[26] This is a fundamental assumption that will be discussed in one of the following Sections. It relates to the role that different approaches assign to governmental action, in an epoch of growing private participation.

service and of environmental satisfaction. A wider institutional scope will allow the utilization of a flexible, efficient mix of technologies. On the other hand, a narrow institutional scope, will make it necessary the implementation of highly local solutions (municipal or delegational institutional scope); because of the demographic and environmental conditions of the MAVM, an acceptable level of environmental satisfaction would be more difficult to achieve in those circumstances, making it necessary the utilization of more refined, expensive technologies.

- The degree of congruence (DC) between required and feasible technologies (RT and FT, respectively), will determine a certain level of compliance with social demands regarding public services and environmental quality (EQ), which will then condition a degree of social satisfaction (SS); lack of congruence, when the degree of refinement of the required technologies is higher than that of the feasible technologies, will result in a low level of social satisfaction, increased political tensions (PT) and conflict. The level of environmental quality would also influence the regional economic condition -for example, through the comparative capacity of the region to attract new investment in services with large aggregate value-.
- The degree of social conflict generated would define a level of pressure on the Administrative Subsystem (AS). If the level of pressure were high enough, the administrative subsystem would be compelled to act, either on administrative coordination, or on the economic condition. Social conflict would also affect in some complex manner the economic condition.

For example, a scenario that combined high resource availability with a low degree of administrative coordination, would make it necessary the search for local solutions that would in term require expensive technologies to achieve environmental satisfaction. However, the availability of resources resulting from a favorable economic situation would make it feasible the utilization of those technologies. Congruence between required and feasible actions would rise little or no social tensions.

FIgure 6.3 Configuration of Scenarios



See Pags. 86 to 88 for definition of nodes.

A scenario combining scarcity of resources with a low degree of administrative coordination, would require local solutions without the availability of the necessary resources, and would generate social tension, that would be translated into pressure on the administrative system. The administrative system would then react in order to minimize and/or bound conflict. There are several ways in which that could be achieved, including the alternative of doing nothing, or of recurring to strictly political or publicitary actions. Those, however, would very probably only insert a delay in the behavior of the system. Eventually, possible courses of action left to the administrative subsystem to take would include: a) To influence the economic condition so as to increase the availability of resources, and b) To act on the administrative coordination, in order to indirectly modify the level of required technology.

This type of analysis could be made much more systematic and rigorous, utilizing, for example the tools of System Dynamics, of which more is said in Chapter 7. That approach would indeed open an interesting, needed and rewarding course of investigation, that might result in a better understanding of the relationships between the different - economic, administrative, technological, environmental and political- subsystems of the waste management system, as well as of the behavior of those subsystems along time. However, even a very simplified analysis, such as the one that is presented here, may shed some light on the relative probability of occurrence of diverse scenarios.

Table 6.1 presents nine different scenarios, that result from the combination of three different possible states for each one of the subsystems RA and AC. As discussed above, each of those scenarios results in a degree of congruency between FT and RT, and in a corresponding degree of PT. Examination of the resulting level of ST (social tensions) for each of the scenarios shows that: a) Low resource availability always will produce relatively high social tensions, no matter the existing level of administrative coordination. b) Acceptable levels of ST occur generally only for the combination of medium to high levels of availability of resources, with medium to high levels of administrative

Table 6.1 A preliminary analysis of scenarios

State of subsystem		Feasible institutional scope	Type of technology		Degree of congruency	Potential social tesions
Resource availability	Administrativ coordination		Required	Feasible		
L	L	MD	H	L	VL	H
L	M	SDF	M	L	L	M
L	H	MET	M	L	L	M
M	L	MD	H	M	L	M
M	M	SDF	M	M	S	L
M	H	MET	M	M	S	L
H	L	MD	H	H	S	L
H	M	SDF	M	H	S	L
H	H	MET	M	H	S	L

- Resource availability:
  - L: low
  - M: medium
  - H: high

Administrative coordinatio
- L: low intensity
- M: medium intensity
- H: high intensity

Institutional scope:
- MD: local (municipal, delegational)
- SDF: intermediate (State Federal District)
- MET: Metropolitan

Type of technology:
- L: low cost
- M: medium cost
- H: high cost

Degree of congruency:
- VL: Very low
- L: low
- S: satisfactory

Potential social tensions:
- L: low
- M: medium
- H:high

coordination. c) The only case when low levels of administrative coordination (AC) coexist with low levels of ST, is in the case of high resource availability; as it was to be expected, high RA would, in all AC scenarios, result in a relatively low generation of political conflict. It should be borne in mind that these type of conflict has a different origin than that of the seemingly inevitable conflict that will arise from the sitting process of any installation necessary for waste management in the Area and that also will have to be dealt with in the decision making process.

It is necessary, of course, to also analyze the relative probability of occurrence of each of the RA scenarios. Consideration of the present economic situation and of its outlook for the region in the foreseeable future, leads to the conclusion that, speaking in per-unit terms (per-capita income, costs-per-ton of waste handled and disposed of), a high probability should be assigned to a low-to-medium availability of resources, as compared with those of more developed countries, with a low probability being assigned to the occurrence of a high RA.

As for the probability of occurrence of the different AC scenarios, it is interesting to analyze the courses of action that would be open to the administrative subsystem in case of social conflict that had its origins in lack of congruence between FT and RT. In essence the AS would have two options or combinations of those: to act on the economic situation, trying to increase the availability of resources, or to act on administrative coordination, looking for a more flexible, less costly combination of technologies. It is, of course possible to try to influence some aspects of the EC, looking for effects in the short term. For example, a combination of private participation with some direct or indirect recuperation of at least part of the real financial costs of services, is already being tried in a few towns in Mexico, and several promotional efforts are being made by private companies in that respect in the MAVM. However, the real financial soundness of those projects is still to be proved, as, inevitably it will depend on the factual overall availability of resources in the economy. More immediate and solid results could be achieved by the

AS by acting on the level of administrative coordination, which is a relevant variable, and over which AC has more direct control[27]. It is to be expected that, as social tensions originated in the existing level of service and in its environmental consequences increase, so will the attempts for a higher scope of administrative coordination become more intense, both at intermediate level (internal coordination within the Federal District among the Department of the Federal District and its Delegations, on the one hand, and a separate internal coordination among the government of the State of Mexico and its Municipalities, on the other). In fact that is already happening: notwithstanding the failure of previous efforts towards metropolitan coordination, both the Federal District -that already has achieved a reasonably successful level of internal coordination- and the State of Mexico, are again considering a metropolitan approach to waste management. Simultaneously, the State of Mexico is trying to establish a more effective coordination among its municipalities within the metropolitan Area.

From this simplified discussion on the future scenarios of waste management in the MAVM, some interesting conclusions, that will affect the design of the decision system can be derived:

- There is a high probability that conflict originated in the lack of congruence between required and available technologies will be continuously present in the decision making process, in addition to other conflicts of different origin.

- In search of efficient solutions for waste management, attempts for more effective administrative coordination are to be expected, at Federal District, State of Mexico, and Metropolitan levels. This attempts will be the result,

[27]Of course, this would not impede the search for a higher availability of resources, including the participation of the private sector. It would enhance the probabilities of that search being successful.

both of preemptive measures by governmental bodies, and of social conflict.

- A more intense participation of the private sector in waste management activities in the MAVM is to be expected.

- There will be a growing tendency to the application of a wider range of technologies, with preference to those of a low to medium level, both cost-wise and sophistication wise.

6.3. A planning concept.

A search of diverse definitions that have been attempted for planning is useful to reveal the essential characteristics of what is usually encompassed by the concept. Planning has been defined as the design of a desired future and of effective ways of bringing it about; its reason of being is the creation of controlled change in the environment. A relevant characteristic of planning is its goal-seeking, decision making nature, the conscious determination of courses of action designed to accomplish specific purposes, and of the required resources. It includes the identification of alternatives, the analysis of each one, and the selection of the best ones. The decisions of planning normally constitute themselves a system: the effects of every decision depend at least from other decision of the set. And again, as in every system, the complexity of a planning system depends, above all, on the multiplicity of the interrelationships among the different decisions, rather than on its number or on its individual complexity.

The difficulties of sound, realistic, planning processes become evident when it is considered that: a) The behavior of the system being planned, and of the environment where it is nested, are usually subject to modifications, often of an unexpected, discontinuous nature, and b) Planning decisions include those of a long term, strategic

nature whose effects cannot be easily reversed. In that respect an useful distinction is normally made between what is considered "strategic planning" and "tactical planning", with strategy being related to long range, integrated, more important decisions, that become more "tactical" when they relate to more limited, detailed, short range issues. Even if the distinction is fuzzy, and sometimes it is difficult to define what will really become an important, strategic decision, it is a useful one, as planning is normally carried out by stages, with general directions for action being determined in a first, strategic stage, with tactical, more detailed, easier to modify actions defined in subsequent stages.

It has been noted that the main obstacle to strategic planning is uncertainty. In fact, the concept of "flexible planning" rises from the desire to find compatibility between a well defined, rather rigid course of action, which is the main product of traditional strategic planning, and the need to respond quickly to unexpected changes in the system being planned, including changes in its environment, that are difficult, if not impossible to forecast. The fundamental dilemma of planning is that of having to reconcile the concurrent but conflicting demands of change and stability. From this point of view, flexible planning is a contradiction, an oxymoron, "a reflection of vain hopes rather than practical realities"[28]. Another common critique to traditional strategic planning refers to its strong centralizing nature, that tends to sniffle creative participation from areas or components of the system being planned, where essential information and experience exists.

Recent specific discussions on planning processes in the field of environmental management and public services, also underline the difficulties of making decisions regarding systems whose component subsystems, including those of a socio-political nature, are expected to have an uncertain behavior. Stress is being put in the need of

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[28]Henry Mintzberg in "The Rise and Fall of Strategic Planning" (See References). Mintzberg´s book contains a highly critical, penetrating, acid, and still constructive treatment of strategic planning.

complementing traditional planning concepts and practices with new, more realistic approaches, in order to select solutions that will be effective on the face of different future, uncertain states of the system. Some of the more interesting concepts in this respect are presented in the following paragraphs.

Scenario Building. This concept is proposed as a way of dealing with uncertainty. A scenario is not a forecast, but one possible future structure of the system whose behavior is being planned. The definition of future scenarios involves the determination of the causal factors that generates the scenarios, the identification of uncertainties, and the assumption of how the causal factors combine to create the scenarios, with a probability of occurrence assigned to each of them. The process then seeks to find robust strategies, i.e., strategies that have a satisfactory probability of achieving the objectives set for the system in the face of the different scenarios. The concept of scenario building is complemented with that of contingency planning, the creation of alternative plans to deal with different scenarios.

Planning as Political Process. There is growing, explicit recognition that planning regarding public services and environmental matters is, in good measure, a political process. As such, it will inevitably generate conflict among the different actors, each of them having different interests and positions regarding the behavior of the system of which they are constituent parts. In a democratic society, conflict, to be productive, has to be bounded and subject to a process whose aim is to find consensus through negotiation. In this context, some of the elements of planning are then: a) To identify the interests of the actors, b) To define objectives that are acceptable to them, c) To search for satisfactory courses of action for the attainment of objectives in relevant scenarios, d) To make explicit the effect of the different courses of action on the interests of the different actors, and to provide all necessary information so as to facilitate trade-offs and consensus among them, and e) Provide information to actors regarding the actual behavior of the system, for the control and, if needed, correction of the process.

Planning, in this concept, also performs a fundamental function, that of providing a framework for disputing, without which, there is no mechanism for exploring common objectives, and no means to reach joint commitments. Without organized analysis, knowledge degenerates into advocacy of the different participants, everybody´s experts trying to show the superiority of their arguments. By contrast, planning in a framework of active negotiation is a process in which conflict can proceed productively.

One relevant aspect of planning in this context, is that it also becomes a learning process, because of: a) the interaction it stimulates among the participants, b) the reciprocal understanding of their different interests, c) the common knowledge it generates on the behavior of the system, and d) the feedback generated by the control system.

A corollary of the concept presented in the preceding paragraphs, is that special importance must be given to the tools of analysis that allow the planning process to fulfill its objectives, that in a strategic context are no longer the definition of the "best" course of action, but rather, the orderly analysis of the effects, on the various attributes that are important to the participants, of different courses of action, in diverse scenarios to facilitate tradeoff and consensus. Systems analysis tools and concepts developed in recent years are particularly interesting in that respect. More conventional tools of system analysis, among them those oriented towards optimization, are conveniently utilized in the initial stages of the process to eliminate weak, definitively non-dominant options, as well as in the in the tactical stages of the planning process, in defining details of the general courses of action selected during the strategic stage.

An also interesting issue regarding planning, is the combination between the "hard" and "soft" approaches to decision making. There is no doubt that the development of the tools of system analysis, and that of the computer, have made it possible for central planners to systematically analyze problems of ever growing complexity. A group of good system analysts, when they have access to hard data, are able to reach usually rational and useful conclusions regarding the behavior of a system, in an efficient

way. Still, "hard" analysis is still eluded by certain variables, mainly those of a socio-political nature when they are part of complex systems. Soft information, that oftentimes is only accessible to the operative, decentralized participants of the process, and an intuitive, "soft" approach,is then useful in the planning process. "Soft" analysis "suggests an approach in which it is more important to pose the right question than to find the precise answer, to incorporate an appreciation for soft data alongside the necessary analysis of hard data. It depends on people comfortable with numbers but not obsessed by them, capable analytic types who also have intuitive skills and are not shy about using them"[29]. It most be concluded that any effective planning process benefits for the concurrence of both the "hard" and "soft" approaches, of the complementary approaches of analysis and intuition.

Public Participation. The explicit recognition of the highly political, conflict generating, nature of planning as it regards public services and environmental issues, and the many costs of diverse types incurred in trying to implement decisions that did not take into account that fact, have given rise in recent years, through what has been in fact a process of social learning, to a growing body of theory and experience regarding public participation, much of it related to the sitting of installations for waste management.

The United States´ Environmental Protection Agency, for example, stresses public involvement and risk communication and evaluation techniques as an important part of its proposed sitting strategy. According to EPA, lessons from successful sites include[30]:

- Successful sitting efforts require both political and technical expertise by public officials and citizens.
- The various segments of the public should be consulted at every stage of

[29]Henry Mintzbeg. Op.Cit.

[30]Sites for Our Solid Waste. A Guidebook for Effective Public Involvement. See References

the decision-making process.

- Successful sites require an informed opposition, and a good risk communication program establishes an exchange of information among the various participants.
- Credible technical information is crucial to resolving conflicts in the sitting process.
- The sitting process must be flexible; all characteristics are negotiable.

Addressing the problem of sitting facilities that are viewed as beneficial by a region as a whole, but perceived as dangerous or harmful by the community or state asked to host them (LULUs: Locally Unwanted Land Uses), leading experts in the field of decision-making and dispute resolution have developed a "facility sitting credo"[31] :

- Institute a broad-based participatory process.
- Achieve agreement that the status quo is unacceptable.
- Seek consensus.
- Work to develop trust.
- Choose the solution that best addresses the problem.
- Guarantee that stringent safety standards will be met
- Fully address all negative aspects of the facility.
- Make the host community better off.
- Use contingent agreements.
- Seek acceptable sites through a volunteer process
- Consider a competitive sitting process.
- Work for geographic fairness.
- Set realistic timetables.
- Keep multiple options open at all times.

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[31]Aarts, Kunreuther, Susskind: The Facility Sitting Credo. Guidelines for and Effective Facility Sitting Process.

In other countries, different from the U.S., the growing need for waste management installations, combined with increasingly active social awareness, and an atmosphere of more political openness is leading to a similar attitude as regards planning and implementation of waste management projects. For example, the eventual success of what started essentially as a "DAD" (Decide-Announce-Defend) problematic process for the installation of a transfer station in the Federal District[32], depended heavily on:

- The active promotion of a broad public support, that included utilization of diverse means of communication.
- The creation of groups of social workers, to discuss all aspects of the project with potentially affected neighbors at different levels: individual, families, interest groups, regional.
- The stress on the need to find an environmentally solid solution to waste management, both in the specific neighborhood, and in the region.
- Negotiations to reach agreement between the different actors.
- The definition of concrete commitments from the different participants. Those included important investments to be made by the authorities in upgrading services in the directly affected area.
- The creation of a Citizens´Commitee to oversee the fulfillment of the terms of the agreements.

It can be concluded that active participation of all relevant actors in an open process of negotiations regarding waste management actions, will become a standard element of corresponding planning procedures, as a means of trying to control one of the main uncertainties affecting the process: that of the future behavior of the socio-political system.

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[32]Rosalba Cruz Jimenez. Aspectos Sociales del Manejo de los Residuos Solidos. See References.

Balance Between Centralization and Decentralization. It is especially pertinent to metropolitan matters, that tension between centralized knowledge and decentralized experience is ever present, and will inevitably generate conflict. Because of its very nature, integral, centralized planning has to deal with complex aggregations of information, and has to take into account the multiple interactions that exist among the diverse subsystems. That leads to a wide angle, but abstract and oversimplified view of the system´s behavior. Tradeoffs between the different components of the system, that seem to have an implacable logic at central level, are incomprehensible or unjust from the local perspective. Local participants, whose experience is firsthand, and whose responsibility and information do not include factors important to the overall stability and other integral-system issues, are bound to consider the way the center sees things as incomplete or ignorant. In trying to achieve the overall efficiency of the system, central planning will distribute the costs and benefits among the different stakeholders in such a manner that conflict will be generated. Hence the need of specific, systematic ways for the interaction of central and local levels of government, and of an adequate balance between centralized and decentralized decision-making. This is one of the main issues regarding public services in large urban areas in general, and the management of waste in particular.

Implementation. Another fundamental issue is that of the implementation of planning. If planning is to be something more than an intellectual exercise, and if it is to fulfill its basic role of supporting the attainment of a desirable future, practical ways have to be found to make that the products of planning, i.e. plans, are implemented. It is then essential that the planning process is linked to, has the support of, and is considered as the main guiding force -the brains-, of a strong organism whose function is precisely that of making things happen. The field of metropolitan services is full of examples -and the MAVM is no exception- of reasonably good plans, that never had any practical relevance because of the divorce of the planning process from the implementation stage.

6.4. A Proposal for the General Characteristics of a Planning Process.

The ideas developed in the preceding sections make it possible to define some of the main characteristics that an effective planning system for waste management in the MAVM should have. In accordance with the concepts presented in the opening paragraphs of Chapter 6, the planning system may be conceived as consisting of two coexisting, interacting phases: a planning process, and the organizational structure where the planning process takes place, structure that in fact should be considered as an instrument of the process.

As for the planning process, it is proposed that it should:

- Have a wide geographic and institutional approach, searching for integral solutions of a metropolitan nature, or at least of a state level.

- Provide for a balanced participation of central and local levels of government, as well as for their efficient interaction.

- Provide for the open participation of all relevant, real stakeholding, actors during the different stages of the process.

- Constitute a framework for bounded disputing among different conflicting interests, in the search for consensus in decision-making.

- Utilize the analysis of alternative scenarios to deal with uncertainties.

- Have the capacity to:
  - Identify the interests of the actors.
  - Define objectives that are acceptable to them.
  - Search for satisfactory courses of action for the attainment of

objectives in relevant scenarios.

- Make explicit the effect of the different courses of action on the interests of the different actors, and to provide all necessary information so as to facilitate trade-offs and consensus among them.
- Provide information to actors regarding the actual behavior of the waste management system, for the control and, if needed, correction of the planning process.

- Provide the means so as to constitute planning as a systematic learning process for all the participants.

- Have a balanced approach between the utilization of the tools of system analysis and operations research, and the recourse to the intuitive decision-making capacity of experienced participants.

- Utilize solid, credible, technical information, in all the stages of the process.

- Take into account the possible application of a wide range of actions and technologies, especially those of a low to medium level of cost.

- Be intimately linked to a strong organism, responsible for the implementation of plans.

- Make adequate, active utilization of the existing tools of systems analysis.

Several of the characteristics of the planning process proposed here, run contrary to the more common "Decide-Announce-Defend" approaches still widely utilized, or to the also widely utilized corporative approach to public participation. In fact, it implies

different way of understanding the relationships among government and society. As such, the proposed process will very probably also require modifications to some of the existing structure of government, or at least, make full use of the options that exist in the actual legal framework. However, it should prove to be, in the long run, a more efficient one for the search, selection and implementation, of robust solutions for future waste management in the Metropolitan Area of the Valley of Mexico.

A specific planning procedure, fitting to the process that has been outlined here, should include the following steps:

- Identify the relevant actors or stakeholders that influence the decision making process.
- Define the issues and specific objectives on which the analysis should concentrate on.
- Define the attributes that will be used to compare the performance of alternative strategies.
- Develop scenarios to take into account uncertain future events.
- Examine the performance of alternative strategies when faced with the different scenarios.
- Select dominant strategies in terms of the different objectives.
- Explore system behavior by observing the possible tradeoffs between attributes for the different dominant strategies for the diverse scenarios. Develop better strategies based on this information.
- Define the preferences of the participants by observing which strategies are acceptable to each party, which uncertainties affect them and how they ponder the various attributes relative to one another.
- Seek consensus on one strategy.
- Repeat.

6.5. General Characteristics of a Structure for Planning.

As it was pointed out, a planning process such as the one that has been proposed in the preceding section is, of course, only a concept, an intellectual construction, that requires of an organizational structure to really come into being, if is to play a significative role in the waste system of the MAVM. It is not one of the objectives of the present work the design of a detailed structure for the proposed planning process. Rather, the intention of the present section is to discuss the basic characteristics of the organism that should be responsible for the process and, also, it must be stressed, for the implementation of the resulting actions. The most relevant of those characteristics are discussed in the following paragraphs.

Metropolitan Scope. For what has been discussed up to now, it is evident that a metropolitan approach to waste management in the MAVM will result in more efficient solutions. It is necessary to overcome, at least from an operational perspective, the illogical situation where what is a single, continuous urban area, is subject to the constraints imposed by a political division that was reasonable in the 19th century, when it was devised, but that today imposes different types of unnecessary, avoidable costs to the system. Even if the rate of demographic growth in the MAVM has decreased during recent years, projections show that an important increase of waste generation is to be expected in the future, with the result of higher costs. The Federal District will soon run out of sites for the adequate, economical final disposal of its wastes. The State of Mexico, where some possibilities for acceptable sites for treatment and disposal of waste still exist, would benefit from the technical, financial and political support that the Federal District can provide, not only now, but also in the future, when diverse circumstances might make treatment and final disposal of waste outside the Valley a competitive option. Those considerations, and growing political pressure, as was discussed in the preliminary scenario analysis (Section 6.2), should provide enough motivation in the different pertinent governmental bodies to look for a metropolitan approach to waste management.

Short of a full metropolitan approach, an integrated approach in each of the political entities that conform the metropolitan area should be stressed. In fact, the Federal District started moving in that direction almost 10 years ago, with the creation of the DGSU (Section 4.2), and with the distribution of responsibilities for waste management among the Delegations and the central governmental body (DDF). This distribution of responsibilities, with urban cleaning and collection in the hands of the local Delegations, and with integral planning, technical consulting, as well as treatment and final disposal being a central responsibility, has worked well up to now, and is one of the reasons of the comparatively better management practices that exist now in the Federal District. As for the State of Mexico, there seems that there is still much to be done to reach a satisfactory state of practical coordination among the different municipalities and the State Government, that might lead to at least a state-wise integral approach to waste management in that part of the Metropolitan Area, notwithstanding the efforts that are being made in that direction, mainly by the State Government.

However, an independent effort by each of the political entities that conform the MAVM, towards "integral solutions" (another oxymoron?), even if understandable as a result of the difficulties to find effective means of metropolitan action, falls short of what is really needed: a solution to the present lack of congruence between the boundaries of the urban, physical and environmental subsystems (and realities), on the one hand, and the boundaries of the institutional-political and resulting waste management operations, on the other. The need of some sort of organism with a metropolitan scope, responsible for the planning and implementation of waste management actions in the MAVM must be emphasized.

Strong Coordinative Power. A second issue regarding the structure for planning, is that of the need of providing the responsible organism (again: the indispensable combination of planning and action), with a strong executive capability. Without that capability, coordination of political bodies that might have different time scopes, political stances, and interests, becomes an aleatory and very difficult endeavor.

As it was shown in Chapter 3, there is no lack of support in the existing legal framework to the possibility of coordination among the different levels of government, for the purpose of a more efficient provision of public services in metropolitan areas. Articles 115 and 116 of the Federal Constitution provide the general basis for that coordination, and article 122, in its fraction IX specifically addresses the question in a direct manner, through the possibility of the constitution of metropolitan commissions for specific purposes.

However, up to now, the efforts towards coordination for joint actions of the pertinent governments in the MAVM, either on basis of previous legal frameworks, or on the present one, have had little success, due to the lack of explicit, permanent executive capacity of the commissions that have been created. In fact, the successful operation of the commissions has depended on the coexistence of the political will of incumbents to high positions in the different Federal, Federal District and State governmental bodies, whose tenure is ephemeral by nature.

Power of juridical, political, financial, and technical nature must be held by the intended organism, if it is to fulfill an useful role.

Balanced Approach to Central and Local Decisions and Actions. This is a concept that has already been discussed in several sections of the present work, and successful operative examples of that balance exist in Mexico and elsewhere. It must, however, be stressed here that the participants, objectives, functions and structure of any organism dealing with metropolitan waste management must be carefully selected and designed in order to enhance that balance, and, of course, in accordance with the existing laws and regulations.

Governmental Participation. It is possible to imagine organizational structures for waste management in which governmental intervention is very limited, leaving most of the operative functions to private companies, with the efficient functioning of the whole

system being a result of market forces and of the free interplay of those companies[33]. However, even assuming that, when possible, free market competition in all respects might be the best of ways to achieve efficiency in public services, it is doubtful that this might be the case in the MAVM, where: a) As is the case for the entire country, the Constitution assigns a clear role to the government in the conduction of diverse matters, including those of an environmental nature, b) The legal framework in fact assigns complete responsibility for the provision of urban services to the public sector, c) Three different levels as well as two differently conceived structures of government coexist, d) In addition, there exists a long tradition regarding the provision of public services on an almost completely cost-free, highly subsidized basis, that will change only gradually.

It must also not be forgotten, that one of the roles of the planning process and of its corresponding organizational structure, should be that of managing conflict and organizing disputing parties, so that bounded conflict results in constructive solutions. Even if it is widely recognized that governmental organizations often become contending parties in public services and environmental disputes, it is difficult to conceive that duly constituted government, as a formal depositary of social will, can renounce to the role of mediating in that disputes.

Private Sector Participation. In conjunction with the governmental characteristics that, for the reasons expressed above, should be assigned to an organism dealing with the metropolitan coordination of waste management activities in the MAVM, it seems clear that the design of such an organism should include clear channels and mechanisms for an as active as possible participation of the private sector, in conditions such as to enhance the level of service and its efficiency. In addition to the higher efficiency that assumedly

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[33]One example is the London metropolitan area, the level of quality of most of its public services having reportedly increased (notwithstanding the opinion of many Londoners), since the abolition of the Greater London Council gave way to a more active participation of private companies.

the private sector brings to the supply of public services[34], the fact that it can also contribute much needed additional financial resources and technology, are reasons to seek its active involvement as a part of the waste management system in the MAVM.

Permanence. Another of the main attributes the organism that is being discussed should have, is that of permanence. The reasons for this are obvious, as waste management planning, implementation and control in almost any conditions, but certainly in those of large metropolitan areas, is a matter of strategic, long term actions and consequences. As it is discussed somewhere else in the present work, one of the reasons why municipal governments can not be expected to achieve by themselves medium and long term efficiency in the supply of several public services, is its extremely short tenure -three years-. Even the duration of State and Federal government terms -six years- is short as compared with the horizon in which waste management planning, implementation and control most be conducted. Means must be found to ensure the permanence of the organism through the various political, economic, and other vicissitudes that it would surely encounter in trying to achieve its goals.

Conceptual Congruence. The last, but not the least, of the essential characteristics that the organism should have, is the capacity to adopt as part of its nature, a planning process that corresponds to the one proposed here. This is of course, one of the main reasons of being of the organism, understood as an instrument for the decision making and implementation processes. In order to be true to that desired nature, the organizational nature should be a combination of what has been called "The Advocacy Organization", characterized by its capacity to carry out expert work in highly dynamic settings, where the experts must work cooperatively in project teams, and that of a "Professional Organization", where rather independent and influential specialists carry out expert work

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[34]This assumption seems to hold. Recent research carried out in several large cities in Latin America, concluded that private provision of waste management services can be successful in terms of cost containment and quality of service, as long as the conditions for contestable markets are met. (Bartone, Carl R. et al. See References).

in relatively stable settings. Planning areas of the organism would have predominantly "adhocratic" characteristics, while areas related with implementation and operations would be of a predominantly "professional" nature.

6.6. Alternative Layouts for a Metropolitan Waste Management Organism for the MAVM.

6.6.1. The Legal framework.

A basic consideration regarding specific alternative layouts for the organism being discussed is that of the legal framework with which the organism will have to comply. As it was pointed out in Section 3.2.1, recent modifications and addenda to the Constitution (Article 122-IX) recognize the need of metropolitan coordination for the specific case of the Federal District and of the surrounding states. According to the present legal framework, the Federal District and the Federal District, may agree to create joint commissions for specific purposes, among them, the collection and disposal of solid waste. Those commissions have ample faculties regarding the scope of its activities, its structure, its specific functions, and the way in each entity will contribute to the financing of the activities of the commission.

Previous legal provisions addressed the issue of metropolitan coordination in less precise terms. Reference was made in rather vague terms to the desirability of the coordination among the different political entities. That legal framework was the basis for several unsuccessful attempts towards coordination. It is considered that the present provisions, with its better definition of the purposes of the metropolitan commissions, and with the flexibility it provides for its aims, ways of organizing, functions and procedures, open a better possibility for effective metropolitan coordination in specific subjects. The main deficiency that may be attributed to the existing provisions is that they do not specifically address the concept of integrated urban planning. However, the possibility that actions in the fields of water supply, transportation, waste management, security and

others, may be coordinated, each of them for its specific purposes, has several immediate practical advantages. Additional legal and organizational steps will have to be taken in the future to ensure the congruence between the different specialized actions.

In fact, during the discussions that resulted in the present form of Article 122 , other alternatives were considered, among them, the creation of a new state of the Republic, whose territory would be that of the Valley of Mexico. That option would have solved many of the coordination issues, but would have created other problems of political and economical nature; it was not approved, and it does not seem likely that it will be in the near future. Another option that was analyzed was that of the creation of a Metropolitan Council of the Valley of Mexico, where the Federal, and metropolitan state and municipal governments would concur. The Council would coordinate metropolitan actions, with a strong support of the Congress of the Union, that would create a specific juridical framework for all matters related with urban development and public services in the MAVM. This proposal was also not approved, apparently because of the issues it raised regarding the sovereignty of the states.

Continuity of the existing legal framework will be assumed in what follows, as this will not particularly affect the lines of the discussion.

6.6.2. Some Experiences in other Metropolitan Areas.

This section presents some information regarding the structure through which public services in general, and waste management services in particular, are provided in several large metropolitan areas. The stress is put in cases of waste management in Latin-American large cities, whose conditions are in certain respects similar to those existing in the MAVM.

New York. Through the years, the management of public services in New York´s metropolitan area has had different approaches, in fact related to the balance of power

between the Major´s office and its City Planning Commission, local municipal and community governments, and semi-independent metropolitan authorities. During the last decades, there seems to have been a decrease in the relative power of the Major´s office, as most of the investment and operation of public services is made by metropolitan public authorities: The Port Authority of New York and New Jersey, The New York State Development Corporation and the Municipal Water Finance Authority, among them. These specialized authorities have a high degree of autonomy, based mainly on its capacity to manage its own budget and financial matters. In general, their charters contain provisions according to which they are subject to supervision from diverse governmental bodies, local authorities and the City Council. It is generally considered that this system has resulted in better planning, in more efficiency in the provision of services, and in the improvement of the overall financial status of the provision of public services. The main critiques against the system are related to the lack of an integrated intersectorial coordination, as well as to the unequal distribution of benefits and economic and social costs among the different social groups.

London. As it was pointed out, since the abolition of the Greater London Council in 1986, there has been a clear trend to privatization of certain public services in London´s metropolitan area, that coexist with public administration of others, with scarce coordination among the different sectors. In search of efficient sectorial solutions, the possibility is being explored of the creation of London-wide public authorities, for example, in the case of urban transportation. This would be a solution similar to that of New York´s authorities. Another possibility being explored, that not necessarily would be mutually exclusive with the metropolitan authorities, is that of joint public and private investment, through organizations that in fact would have the characteristics of a trust.

Buenos Aires. Greater Buenos Aires, with a population of 12 million inhabitants, includes the City of Buenos Aires (2.9 million), that is also the Federal District, and 19 municipalities. An organism of the government of the Federal District, the DGLU (Direccion General de Limpieza Urbana -General Directoriate for Urban Cleaning), is

responsible for waste management services in the City of Buenos Aires. For the rest of the Greater Buenos Aires Area, a state company, CEAM (Coordinacion Ecologica del Area Metropolitana -Ecological Coordination for the Metropolitan Area-), is the responsible organism. CEAM is also responsible for waste management planning for the whole metropolitan area. Operational activities are distributed among the different levels of government, with an important participation of private companies. Two large firms are in charge of urban cleaning and collection services in the City of Buenos Aires. Fifteen firms are under contract of different municipalities to perform waste management services; CEAM contracts out transfer and landfilling services to 3 firms.

Caracas. The metropolitan area of Caracas has a population of 3.6 million, living in territory of 4 large municipalities. Of those, 2 constitute the Federal District and the other 2 are within the territory of the State of Miranda. Responsibilities for waste management, including planning are centralized in the IMAU (Instituto Metropolitano de Aseo Urbano -Metropolitan Institute for Urban Cleaning). Most of the collection, street cleaning and transfer services, as well as part of the landfilling operations are contracted out to private firms.

Sao Paulo. With 11 million inhabitants, Sao Paulo is one of the largest cities in the world. However, regarding governmental structure, 33 administrative regions constitute a single municipality. LIMPURB (Limpieza Urbana -Urban Cleaning-), a central municipal organism, is in charge of all matters related to urban waste management, including planning. It subcontracts practically all operations -including composting and incineration- to 6 private firms.

Rio de Janeiro. With an administrative organization similar to that of Sao Paulo, the municipality of Rio de Janeiro (5.5 million) is constituted by 28 administrative regions. All matters regarding solid waste management are a responsibility of a corporation 99% owned by the municipality: COMLURB (Companhia Municipal de Limpeza Urbana -Municipal Company for Urban Cleaning-). COMLURB carries out all

its activities with internal resources, without no contracting-out to private companies.

Even if its validity might be not representative, due to the smallness of the sample, some preliminary conclusions might be attempted from the analysis of the structure for waste management in the towns discussed above:

- There is a clear tendency to the existence of strong, autonomous, specialized public organisms, in charge of waste management in metropolitan areas.
- The responsibilities of those organisms include that of metropolitan planning of waste management.
- Direct responsibility for operational activities are distributed among the different levels of government in diverse manners (Table 6.2)
- In most cases, there is an important participation of private companies in waste management activities.
- Political-institutional complexity (coexistence of different levels and structures of government, with a large number of local administrative jurisdictions) results in complex operational arrangements.

6.6.3. Alternative Organizational Structures for Waste Management in the MAVM.

From what has been discussed here regarding the characteristics of an organism for waste management in the MAVM, it has been concluded that it should: a) Be of a metropolitan, governmental nature, b) Have a as strong as possible juridical, political, financial and technical autonomy, c) Support a balanced approach between central and local decision making and action, d) Allow an intensive participation of the private sector, e) Be of a permanent nature, and f) Have as a guiding concept, the utilization of an open, participative, conflict bounding, technically reliable, learning oriented planning process.

As for the metropolitan, governmental nature of the organism, the existing legal

Table 6.2 Activities and providers of waste management services in some Latin American urban areas.

Activity	Buenos Aires	Caracas	Rio de Janeiro	Sao Paulo	Santiago
Planning	M	M	M	M	L
Collection	P/L (70%/30%)	P	M	P	P (90%)
Srteet sweeping	P	P	M	P	P
Transfer	P	P	M	p	-
Resource recovery	M/I	I	M/I	P/I	M/I
Landfilling	P/M	P	M	P	P/M (50%/50%)
Billing	L	M	M	L	L
Construction and supervision	M/L	M	M	M/L	L

M: Metropolitan authority.
L: Local jurisdiction authority.
P: Private contractor.
I: Informal private sector.

framework opens the possibility of the creation of a metropolitan commission for waste management, through an specific agreement among the interested governments. This juridical figure could be utilized as the initial, governing body of the desired organism. It is clear that the participant governments should be, at least for the time being, those of the Federal District, the State of Mexico, and the governments of the metropolitan municipalities of the State of Mexico. If additional municipalities or states became part of the MAVM, the composition of the Metropolitan Commission would be modified accordingly.

However, a commission such as the one described, being a necessity because of diverse legal and political reasons, does not fulfill many of the characteristic desired for the organism. The main role of the commission would then be the creation and general overseeing of a body that could really have the required attributes. According to Mexican Law, there are several figures that can be utilized for that purpose. Because of its capacity to integrate different governmental participants, the most interesting of those figures are:

- A Decentralized Public Corporation.

- An Administrative Trust.

The main general characteristics, advantages and disadvantages of each of those alternate figures are presented in Tables 6.3 and 6.4. Any of those could be utilized as an effective instrument for the needed planning and implementation processes. If, for example, a Decentralized Public Corporation were selected as the more appropriate figure, more specific characteristics of the metropolitan waste management organism would be:

Members of the Board of Directors. The Federal Government (probably through SEDESOL and the SHCP); the Government of the Federal District (probably through the SGO and the SGPE): the Government of the State of Mexico (probably through the

Table 6.3. Intergovernmental Decentralized Corporation

Characteristics	Advantages	Disadvantages
-The Charter of the Corporation, stating all of its relevant objectives, functions and characteristics, must be approved by each of the congressional bodies of the participant governments: Congress of the Union; Congress of the State of Mexico; Assembly of Representatives of the Federal District. -It has its own juridical personality, and its own patrimony and financial means -Its general internal juridical regime is that of public law, but its commercial transactions are ruled by civil law. -It is liquidated by agreement of the participants, with previous approval of the relevant congressional bodies.	-It is an autonomous organism. Participant governments control and oversee operations, through the Board of Directors. -Through the Board of Directors participants may agree on a balanced approach between long and short term objectives, and between central and local actions. -It can utilize the regime of a commercial society, contracting out services. -Its policies, structure and managerial procedures can be similar to that of a private company. -It may select and hire capable personnel according with its own rules -It manages its own resources, and it may collect fees for services it supplies.	-There is no complete isolation from some undesired and non-functional political influences.

Table 6.4 Public Trust

Characteristics	Advantages	Disadvantages
-It is not necessary that the Trust, or the trust instrument be approved by the congressional bodies of the participants. -All kind of resources owned by the settlors may be endowed to the Trust. -Diverse administrative authorities may endow property to the trust, when the direct settlors are appointed by those authorities. -It is not necessary to name a specific beneficiary of the actions of the Trust. -A Technical Committee, constituted by the fiduciary (trustee) and the settlors, defines the application of the Trust´s resources under predefined rules. -Liquidation ensues by accord of the settlors.	-Through its presence in the Technical Committee, participants may reach a balanced approach between short and long term objectives, and between central and local actions. - Participant governments oversee performance Through its presence in the Technical Committee, -It can receive resources from diverse origins. -It can constitute organisms to fulfill the objectives of the Trust. The structure, policies and managerial procedures of those organisms may be similar to that of a private company. -Its organisms may select and hire capable staff according with its own rules. -It may contract all type of services. -It manages its own resources, and it may collect fees for the services supplied by its organisms.	-There is no complete isolation from some undesired and non-functional political influences. -Procedures of the Technical Committee may impose unwanted rigidity on operations.

State´s Secretariats of Ecology, of Health, and of Finance); Municipal Councils of the metropolitan municipalities.

President of the Board of Directors. To be rotated on a yearly basis among a representative of the Federal District, and a representative of the State of Mexico.

Corporate Philosophy. Based on the need of an open, participative and balanced approach to decision making and implementation, with the support of strong technical capabilities and credibility.

Functions. The planning of all strategic actions regarding waste handling and disposal in the MAVM. The planning, design, construction and operation of all installations and equipment for transfer, secondary transport, recycling, treatment, and final disposal of solid waste in the MAVM. The provision of technical consulting regarding all tactical plans and investments for waste collection and primary transport proposed by local authorities (municipalities and delegations) , who would be responsible for those activities.

Operational Policies. Main activities of the organism would be related to planning, supervising and consulting. Most of its direct responsibilities regarding solid waste handling and disposal, to contracted out to private companies, on a competitive bidding basis. All transfer, transportation, recycling and disposal fees, to be charged by the organism to local authorities.

Financial Objectives. To reach economic and financial self-sufficiency in the medium term.

Staffing Policies. All personnel to be selected on the basis of its specific capacity for the job.

If an Administrative Trust were selected as the preferred figure, the characteristics of its operational organism would be similar to that of the Public Corporation. The general organizational structures for both options are presented in Figures 6.4 and 6.5.

Figure 6.4 Intergovernmental decentralized corporation.
General structure.

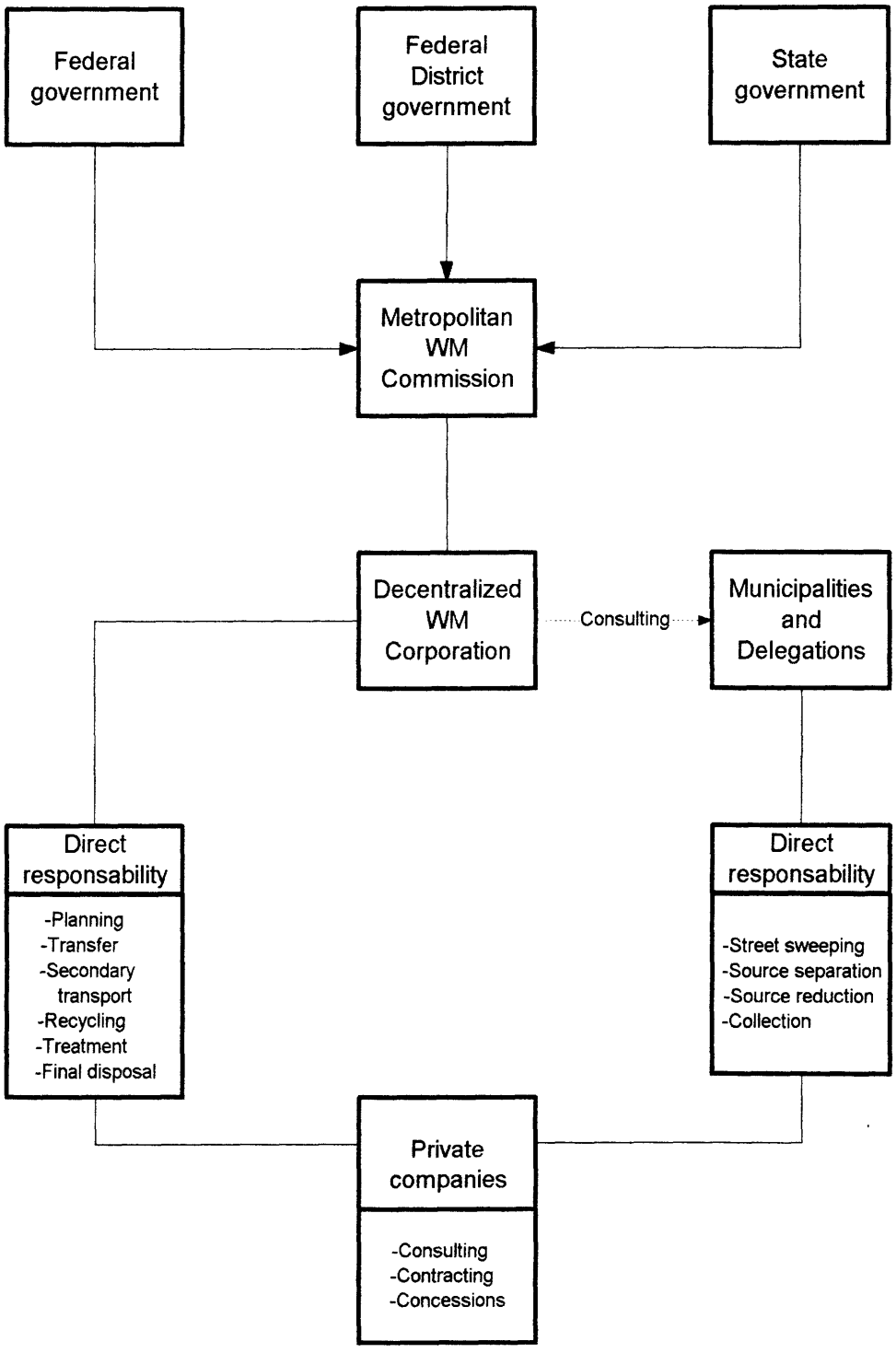
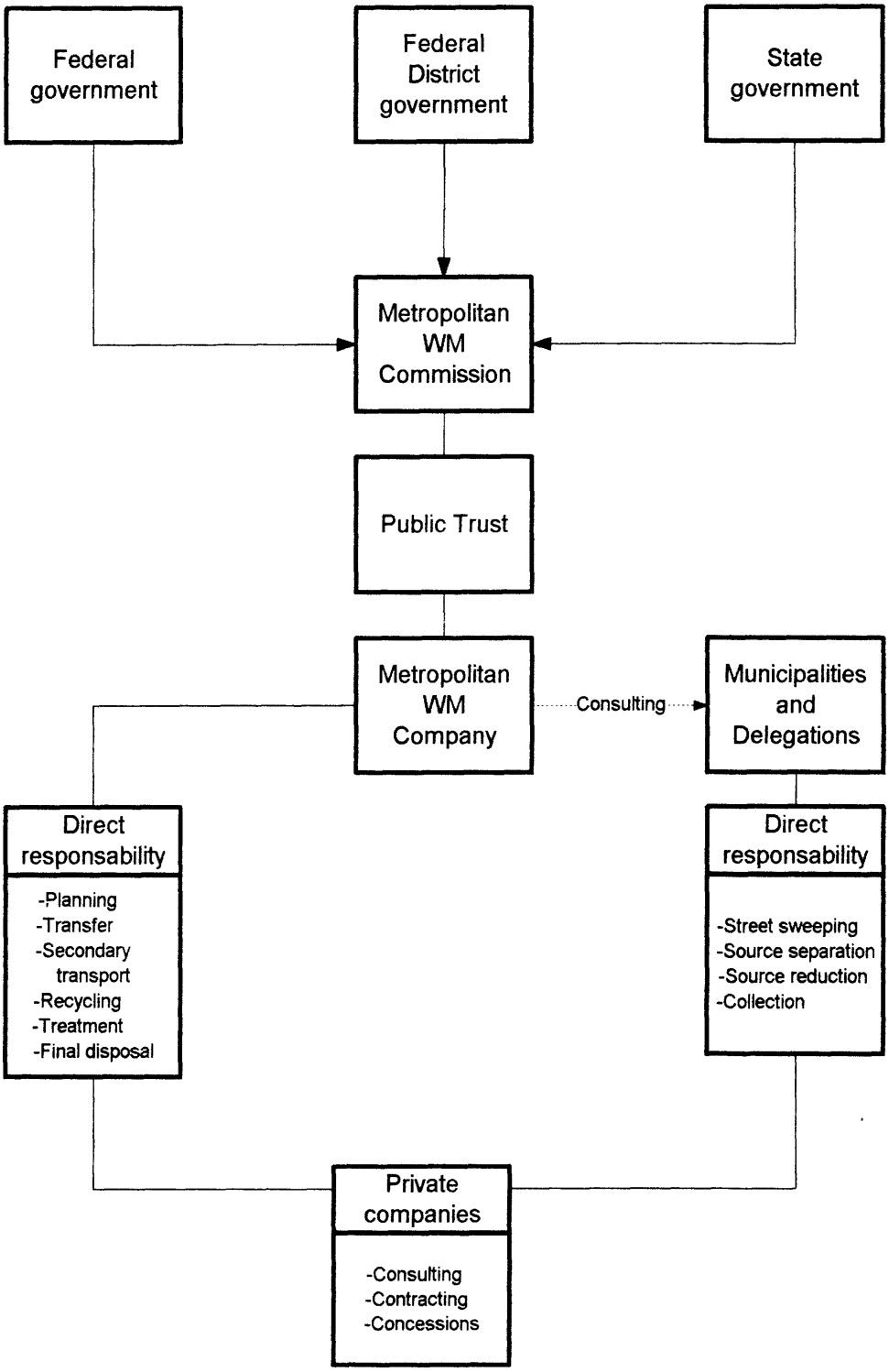


Figure 6.5 Public Trust



7. Tools for the decision making process.

Chapter 6 was devoted to the discussion and presentation of proposals for a planning process and for a corresponding organizational structure, both of them suited to the present and expected characteristics of the waste management system in the Valley of Mexico. The present chapter refers to the tools required for the systematic analysis of information and of alternative courses of action. The three elements in conjunction: planning process, organizational structure, and analytical tools, constitute a decision making system. The tools of Systems Analysis must then be considered as an essential part of the decision making system regarding waste management in the MAVM.

7.1. A General Inventory of Tools.

Many techniques have been proposed along the years for its utilization regarding the search for more efficient solutions in the field of waste management[35], in different aspects of decision making, in a range that includes from strategic planning to the design of detailed operations. Most of the practical applications have been in relation with: a) Regional models for the selection of the type and location of a system of installations for waste management, utilized mainly for strategic decision making, b) Models utilized in a more tactical context, usually in the design of more efficient waste collection and transportation systems, including simulation to account for uncertainties, c) Diverse

[35]See for example, Marks, D.H., or Greenberg, M.R., in References.

techniques for decision making regarding more specific operational aspects, such as choice of equipment, maintenance scheduling, crew size and others, and c) A number of other applications, that in recent years include a growing consideration of environmental and social issues -e.g. specific landfill siting, or the diffusion of atmospheric pollutants.

A partial inventory of the techniques employed in Systems Analysis includes:

- Linear programming.
- Non-linear programming.
- Integer programming.
- Geometric programming.
- Dynamic programming.
- Special algorithms.
- Queuing theory.
- Inventory analysis.
- Financial analysis, cost-benefit analysis.
- Decision analysis.
- Game theory.
- Simulation.
- Multiobjective optimization.
- Multiattribute analysis.

There seems to be no scarcity of tools to support a systematic approach to decision making in the field of waste management, neither of practical applications of those tools in real-life situations.

7.2. Availability of Tools vs. Real Life Applications.

Notwithstanding the diversity of tools that are available, recent years have

witnessed a growing concern, both for the lack of a more extended utilization of the tools of Systems Analysis in real life decision making, and for the lack of implementation of the solutions that result from systematic analysis, whenever it is carried out. The development of more powerful, sophisticated tools of analysis, that takes place mainly in the academic world, and the proposals made by informed practicing professionals for the application of those tools, does not seem to run parallel to its actual application.That concern seems to be widespread among Systems Analysis practitioners everywhere and has not been limited to the field of waste management in less developed countries[36]. As for this latter case, diverse reasons have been cited for the lack of a more ample utilization of System Analysis in real life decision making, among them:

- Lack of technical and financial resources. This is very clear in the case of local governments, specially in municipalities, but also not uncommon in central decision making bodies[37].
- It is widely felt that sophisticated mathematical models would not be understood by some those whose day-to-day responsibilities are not of a highly technical nature.
- Time constraints preclude the utilization of models in the decision making process.
- Models, that are ever more complex and require more computational capacity, often fail to take into account the variables that concern more the decision makers. Because of that, solutions that constitute the output of systems analysis are often not implementable.

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[36]See, for example "Use of Systems Analysis in Water Management". P. Rogers and Myron Fiering, in References.

[37]It also must be considered that, until a few years ago, waste management was not one of the cardinal concerns of the diverse levels of government. That was -and still often is- commonly reflected in the allocation of budgets and in the assignment of relative bureaucratic power.

Similar considerations have been made by specialists in a wider area, that of policy-making, regarding the limitations of analysis[38]. And still, it is not possible to rationally deny the need of a systematic, well informed approach to decision making, that takes into account the relevant outcomes of proposed actions and its effects on the different actors, as the best way for the search and selection of robust actions in any field. Recognizing these facts, during the past years, while efforts have been devoted to additional developments in the search of more efficient and powerful Systems Analysis' tools for optimization, there has been also a clear tendency to the development and utilization of those that are suited for the support of decision making as regards complex systems that include variables of different technical and social nature, for which most of the traditional techniques are ill-equipped. It is to be expected that those developments, together with the dramatic increase in commonly available computing power and speed, will make it possible the growing utilization of a systematic approach to decision making processes in waste management.

That possibility must, of course, be enhanced by a rational distribution of responsibilities among central (preferably metropolitan), and local authorities. Central authorities, that have access to more important technical and economical resources, must play a decisive role in the adoption of a systematic approach to decision making. They must strive for that approach, not only in the matters in which they have direct operative responsibility, but they must also act as consultants for the local authorities, that very often do not have neither the resources nor an adequate time frame for systematic decision making, and support them in the development and application of Systems Analysis in matters of local concern. As it is discussed in detail in other sections of the work, an adequate distribution of responsibilities, and a corresponding organizational structure, are essential for achieving overall efficiency in the waste management system

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[38]C.E. Lindblom (see References), for example, considers analysis to be limited because: a) It is fallible, and people believe it to be so, b) It cannot wholly resolve conflicts of value and interests, c) It is too slow and costly.

of the MAVM.

7.3. Levels of Decision Making in Waste Management.

A systematic approach to the search for preferred, robust policies and plans whose purpose is the modification of the behavior of complex systems, and the detailed design of the components of those plans, require of a careful selection of the adequate tools of analysis, more so when the intervening variables are of different natures, and its relative importance varies along the different stages of the decision making process. Strategic decisions, that have a long lasting effect on the different elements of the waste management system, have to consider the interplay of many different variables -technical, financial, economical, environmental, social, political-, along lengthy periods of time. The fact that some of those variables are difficult to state in quantitative terms, does not make them less real, or its influence in the system less important. Tools must be utilized that take into account the effect of those variables in the system, and that permit the analyst and the participants in the planning process to deal with its inherent uncertainties. Those tools, some of them still in a stage of development, should also support one of the main characteristics required from the process: its capacity to bound unavoidable conflict into constructive, productive channels. At the other end of the decision making spectrum, detailed operational decisions must deal mainly with the technical and economical efficiency of specific parts of the system, under rather well defined, previously agreed-upon constraints, and more conventional tools of Systems Analysis can be utilized. All along the decision making spectrum, diverse variables might have different relative relevance and different degrees of certainty regarding its behavior, affecting the appropriateness of the different tools. And of curse, there is the issue of the comparative availability of resources for the analysis itself. Complex tools, costly to develop and apply, are no more adequate for local, day to day decision making, than preliminary screening techniques based exclusively on financial considerations are suitable for the final definition of a metropolitan final disposal system. In any case, a systematic, rigorous

approach to decision making depends, in good measure, on the utilization of the adequate tools of Systems Analysis for each particular situation.

Perhaps the most reasonable way of addressing the relative adequacy of the different Systems Analysis tools, for its application in waste management practice, would be through the combined examination of different relevant aspects such as: a) The organizational level where the decisions are commonly made, b) The frequency with which those decisions must be made, c) The duration of the effect of the decisions, e) The relative effect of the decisions on financial, economic, social and political issues. A rigorous treatment of the subject is out of the scope of the present work. However, the consideration of the above mentioned aspects would lead to a definition of levels of decision making similar to the one that is presented in the following paragraphs.

Short Term Operating Decisions. This level includes decisions mostly made by line mangers in direct contact with day to day operations; the decisions often are made on a daily basis, and usually take into account only direct, short term financial and economical considerations[39]. Examples would be the efficient routing of bulk collection vehicles when the demands are of a random nature, emergency re-scheduling of work fronts in landiflls, emergency re-scheduling of processes in treatment plants due to unexpected changes of workloads or to internal breakdowns. This type of decisions are clearly of an operational nature and are subject to specific constraints: it is necessary to provide a predetermined level of service with the available equipment and work force, within a given budget.

Medium term Operating Decisions. This level is also concerned with operational decisions; however. this type of decisions are made only a few times a year and have

[39]However, its effect on the overall efficiency of the system must not be disregarded. Wrong decision making in apparently minor issues all across the system may be very costly indeed.

mid-term effects on the effectiveness and efficiency of the system. Normally, decision makers would be top local mangers, often with the support or/and authorization of central officials or managers. Examples of this kind of decisions would be the choice of collection equipment, repair-or-sell decisions, the definition of maintenance schedules, the definition of collection districts, the routing of collection vehicles, the scheduling of work fronts in landfills. Another type of decisions -fundamental, among other things for its very important effects on the overall costs of the system- that belong to this level of management, but that, given its importance, are taken less often, are those related with the level of service to be offered, within given budgetary constraints. Decisions related to the level of service include aspects such as the possible effect of waste separation or waste reduction campaigns, the selection and promotion of specific storage systems, the frequency and place of collection, the attainment of acceptable levels of noise, odors and visual contamination, among others. Because of its time span and the organizational level where they are made, this type of decisions are near the -normally fuzzy- border between medium term operating decisions and those of a long term, strategic nature. Due to its relevance as regards the efficiency and effectiveness of the system, they might well be regarded as strategic.

Strategic Decisions. The meaning assigned to the term "strategic" in this context is that of decisions that have a long lasting effect in the different components -technical, financial, economic, environmental, socio-political- of the system. This type of decisions are taken once every several years; they benefit in diverse ways and for a long time, some of the actors, and impose costs on them, or in other, different actors of the system. They usually refer to elements of the system that do not represent, by themselves, the most relevant cost item. However, rational decision making at these level is also essential. Wrong decisions would not only impose important costs in all the different subsystems: They might well make the whole system inoperative, especially in environments such as that of the MAVM. As such, these type of decisions should be made at central or metropolitan level, with the participation of all the relevant actors. The most evident example are decisions regarding the selection of a general strategy for

waste management, that includes the selection of a mix of technologies, as well as the siting and dimensioning of transfer, recycling, treatment and final disposal facilities.

As it was pointed out, different tools of systems analysis have been proposed for all the levels of decision making, even if efforts must still be made to achieve a wider real-life, practical application of those tools. From the point of view of its potential for cost-saving, applications in the field of districting and routing for collection are particularly attractive: between 75% and 85% of all the costs incurred in waste management are incurred there. However, given the scope of the present work, one of whose main lines is the need to approach the waste management system in the MAVM from a metropolitan, regional point of view, only the tools for strategic decision making, as it has been defined above, will be discussed.

7.4. Tools for Strategic Planning.

Different ways of classifying the tools of System Analysis appropriate for planing decisions in the field of waste management may be proposed. One of them is to relate the tools to the types of decisions that are taken along the different stages of planning, and the environment in which those decisions are taken -or should be taken.- Then one could speak of tools apt for decisions that:

- Are taken by a single decision maker, in relation with problems that have a single objective, or objectives that can all be reduced to a single evaluation criterion. This would be, for example the case of typical constrained optimization techniques.
- Involve different objectives which cannot be reduced to a single evaluation criterion. The decision is the responsibility of a single decision maker, or of a group of decision makers with similar objectives and utility functions. Also, the outcome of the process is a clearly dominant strategy or

solution. Multiobjective optimization would be a fitting tool in this case.

- Relate to situations similar to the ones described in the paragraph immediately above, when the outcome is not a clearly dominant strategy. Then, the relative importance of the different objectives must be defined in a systematic manner. Multiattribute utility theory and processes are useful in this case.
- Involve different actors, each of them having a relevant degree of influence over the outcome of the decision process, with each of the diverse actors pursuing various objectives, that may be in conflict with those of other actors. This is the realm of collective decision making. Specific approaches, generally referred to as multiattribute trade-off analysis, are being developed to support this class of decision making processes.

A brief discussion on the tools suitable for the strategic planning of waste management systems is presented in the following sections.

7.4.1. Mathematical Programming.

Of the tools of Systems Analysis, those commonly designed as mathematical programming -linear programming and related techniques, such as separable programming, non-linear programming, integer programming, fixed-charges problems- are perhaps the most widely utilized in the analysis of waste management problems.

Linear programming is the most powerful technique available for constrained optimization. It can deal with problems involving many thousands of variables and thousands of constraints, that could simply not be solved utilizing other methods. Linear programming is also particularly attractive for design, because it facilitates sensitivity analysis, the process of investigating the dependence of the optimal solution to changes

in the way the problem is formulated -e.g. through modifying constraints, or through the manipulation of relevant variables. This is of course very important in assessing the robustness of a solution to changes in the conditions assumed for the problem, as a model is at best an approximate representation of some present or expected reality. The possibility of the relatively easy manipulation of variables and constraints is also very useful when, for example, tradeoffs between constraints and the value of the objective function must be analyzed, characteristic that can be especially relevant in the analysis of waste management problems..

The central assumptions of linear programming are, of course, the linearity of the objective function and of all the constraints. Additionally, the decision variables are assumed to be continuous and non-negative. This imposes limitations to the problems that can be directly tackled with the method, and alternative techniques of mathematical analysis have been developed, based in similar approaches to optimization. Separable programming, for example, deals with the fact that the objective function is often non-linear with respect to the value of the decision variables, because of decreasing or increasing returns to scale. Non-linear objective functions can be represented in linear programming by a piecewise linear approximation consisting of a sequence of line segments. Another technique, that of integer programming, has the capability of taking into account the fact that real problems are often discontinuous, oftentimes when the inputs occur in integer amounts. A particular type of discontinuity is that of fixed charges, that occur, for example in the case of installations that have a fixed cost of investment and operations, disregarding the level of utilization. This, in fact, presents a situation of a concave function, and the problem cannot solved directly by linear programming. This deviations from the conditions of the basic linear programming problem require of special algorithms for its solution, and usually imply increased computational difficulties.

Fortunately, achievements made during recent years, both in the operations research field -in developing enhanced or new algorithms for optimization problems-, and

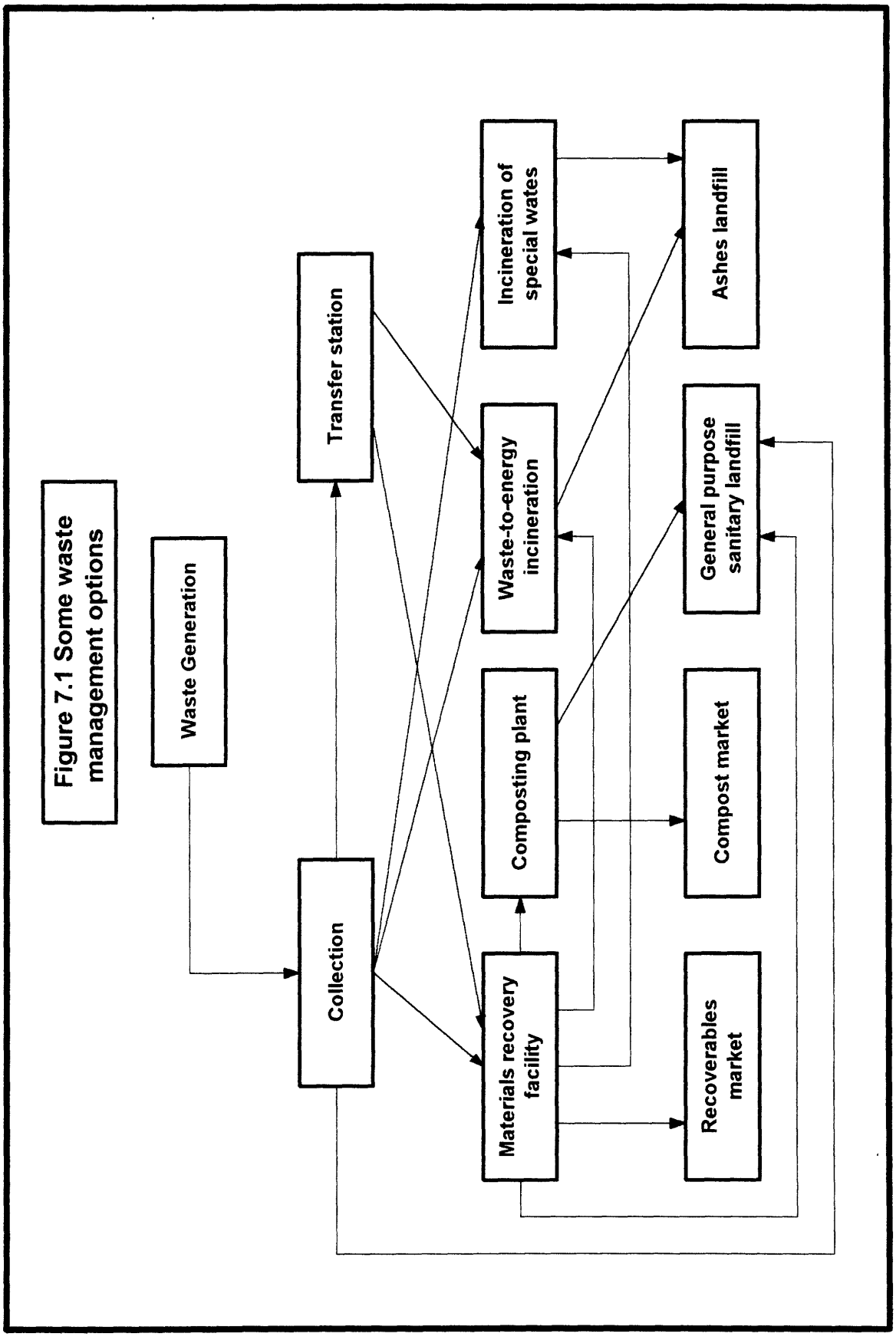
Figure 7.1 Some waste management options
Waste Generation
Collection
Transfer station
Materials recovery facility
Recoverables market
Composting plant
Compost market
Waste-to-energy incineration
Incineration of special wates
Ashes landfill
General purpose sanitary landfill

in computational capability -in dramatically increasing storage and speed- make it possible today the handling of problems whose analysis, less than a decade ago, still presented serious practical obstacles. Some or the most important changes have occurred in the size and complexity of mathematical programming problems that can be solved in a personal computer[40]. Commercially available software accommodates linear, non-linear, and mixed integer optimization problems, as well as special cases of simultaneous linear or non-linear systems, with the most convenient algorithmic methods being utilized without changing the user's model representation. This, of course, has importantly increased the availability of the technique to users within the field of real-life decision making.

Mathematical programming can be used to optimize the design of many different kinds of systems, including those related with what are generally designed as "transportation problems". The basic formulation is that of optimizing the distribution of a single product or commodity over some network, the question being where to send things, from what origin to what destination, at a minimum cost. The optimum design defines the quantities moving between any two points on the network. This basic formulation can be extended to a wide class of situations where decisions have to be made about distribution over a network, among them those fundamentally relevant to strategic planning in metropolitan waste management, dealing with the optimum nature, number, size, and location of waste management installations. In this latter case, the problem usually involves (Figure 7.1):

- A large number of waste-generation districts.
- Variable, normally increasing amounts of waste generation in the different

[40]A recent (1992) test reported the solution of linear programming problems with as many as 367,000 non-zeroes, 16,000 rows or 69,000 columns on a desktop machine in about two hours. And those figures have no doubt been bettered today.

districts.

- A number of existing or possible facilities for the transfer of waste.
- Alternative methods of transporting waste from transfer stations to processing or final disposal facilities.
- A number of intermediate existing or possible processing facilities, that might include one or more different types of technologies (recycling, composting, incineration, etc.).
- A number of existing or possible final disposal sites.

Many different formulations have been proposed for the solution of this type of problem utilizing a mathematical programming, transportation approach, normally seeking for the minimum cost solution. A simple, basic formulation is of the form[41]:

$$MIN. \quad Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} \cdot X_{ij} + \sum_{g=1}^{a}\sum_{j=1}^{n} C_{gj} \cdot X_{gj} + \sum_{g=1}^{a}\sum_{i=1}^{m} C_{gi} \cdot X_{gi}$$

Where:

m = Number of final disposal sites "i".

a = Number of intermediate processing or transfer centers "g".

n = Number of waste generation areas "j".

C_{ij} = Unit cost of transportation of waste from waste generation area "j" to final disposal site "i".

C_{gj} = Unit cost of transportation of waste from waste generation area "j" to intermediate transfer or processing facility "g".

C_{gi} = Unit cost of transportation from intermediate facility "g" to final disposal site"i".

X_{ij} = Units of waste transported from waste generation area "j" to final disposal site

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[41]See, for example: "Solid Waste Management in Metropolitan Regions". Greenbeerg et al.

"i".

X_{gi} = Units of waste transported from waste generation area "j" to intermediate facility "g".

X_{gi} = Units of waste transported from intermediate facility "g" to final disposal site "i".

subject to constraints regarding the capacity of intermediate and final disposal facilities,and the need to have a final destination for of all waste generated.

This formulation requires the model to be run independently for each of the years of the planning horizon for which a solution is being sought. The path of growth of the facilities along the planning period must then be defined either by logical examination of different runs of the model, or by a dynamic programming approach. Even if the process seems to be cumbersome, some analysts have preferred this approach for the detailed insight that multiple, rather simple runs, may provide.

A more sophisticated formulation, that takes into account within the basic solution the capacity of existing facilities, its required expansion along the time, and the overall cost of the solution in the planning horizon, and so intoduces a dynamic concept to optimization, is one of the standard approaches being used today for this type of problem[42]:

$$MIN. \quad Z = \sum_{i=1}^{m}\sum_{t=1}^{p} k_t \cdot G_{it}(p_{it}) + \sum_{t=1}^{p}\sum_{j=1}^{n}\sum_{i=1}^{m} k_t \cdot C_{ijt} \cdot X_{ijt} +$$

$$\sum_{t=1}^{p}\sum_{i=1}^{m} k_t \cdot F_{it}(y_{it}) + \sum_{t=1}^{p}\sum_{h=1}^{m-a}\sum_{g=1}^{a} k_t \cdot C_{ght} \cdot T_{ght} \qquad (1)$$

Subject to:

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[42]J.F. Hudson, D.S. Grossman, D.H. Marks: "Analysis Models for Solid Waste Collection".

$$\sum_{i=1}^{m} Xijt \geq W_{jt} \qquad \textit{for all j,t.} \qquad (2)$$

$$\sum_{j=1}^{n} X_{ijt} - P_{it} \leq 0 \qquad \textit{for all i,t.} \qquad (3)$$

$$P_{gt} - \sum_{t=1}^{t} y_{gt} - Q_{go} \leq 0 \qquad \textit{for all g,t.} \qquad (4)$$

$$\sum_{t=1}^{t} P_{ht} - \sum_{t=1}^{t} y_{ht} - Q_{ho} \leq 0 \qquad \textit{for all h,t.} \qquad (5)$$

$$f_g \cdot P_{gt} - \sum_{h=1}^{m-a} T_{ght} \leq 0 \qquad \textit{for all g,t.} \qquad (6)$$

$$\sum_{t=1}^{p} y_{it} \leq S_i \qquad \textit{for all i,t.} \qquad (7)$$

$$X_{ijt} \geq 0 \qquad \textit{for all i,j,t} \qquad (8)$$

$$T_{ght} \geq 0 \qquad \textit{for all g,h,t.} \qquad (9)$$

$$y_{it} \geq 0 \qquad \textit{for all i,t.} \qquad (10)$$

$$P_{it} \geq 0 \qquad \textit{for all i,t.} \qquad (11)$$

Where:

Z = Total net present value of the system in the planning horizon.

W_{jt} = Waste load generated at area "j" in time period "t".

m = Number of feasible facility sites "i".

a = Number of feasible intermediate processing or transfer centers "g".

n = Number of waste generation areas "j".

$m-a$ = Number of feasible final disposal sites "h".

p = Number of time periods "t" considered in the analysis.

Q_{go} = Initial capacity at intermediate facility "g".

Q_{ho} = Initial capacity at final disposal facility "h".

S_i = Total expansion capacity of site "i".

f_g = Weight reduction factor for intermediate facility "g".

C_{ijt} = Unit cost of transportation between waste generation area "j" and facility "i" in period "t".

C_{ght} = Unit cost of transportation between intermediate facilities "g" and final disposal sites "h" in period "t".

$G_{it}(P_{it})$ = Net cost of processing "P_{it}" units of waste at site "i" in period "t".

$F_{it}(P_{it})$ = Cost of expanding capacity at site "i" by "y_{it}" units in period "t".

X_{ijt} = Units of waste transported from "j" to "i" in period "t".

T_{ght} = Units of waste transported from intermediate site "g" to final disposal site "h" in period "t".

P_{it} = Units of waste processed or disposed of at site "i" in period "t".

P_{gt} = Units of waste processed at an intermediate site "g" in period "t".

P_{ht} = Units of waste disposed of at final disposal site "h".

y_{it} = Capacity added to facility "i" at the beginning of period "t".

y_{gt} = Capacity added to intermediate facility "g" at beginning of period "t".

y_{ht} = Capacity added to final disposal facility "h" at beginning of period "t".

k_t = Financial discount factor for period "t".

The objective function(1), whose value is to be minimized, is the net present value of all investments and operational costs of the system in the planning horizon considered. It takes into account the costs of transporting waste between the generating areas and the different facilities, the corresponding processing and final disposal costs, and the costs of investment in expanding existing facilities or constructing new ones.

The condition that in every period of the planning horizon all waste generated must be transported, either to intermediate facilities -for processing or transfer-, or directly to final disposal, is established in constraint (2). Correspondingly, constraint (3) establishes that all waste that is transported to any intermediate facility must be taken care off; there is no possibility of storage from one period to the next one. Constraint (4) states that the amount to be processed in any intermediate facility in a given year cannot exceed installed capacity, which is the sum of the initial capacity (zero in the case of new potential facilities), and the consecutive expansions to the facility built up to that year. In this constraint, capacities are expressed in rates -such as ton per year-. The condition that limits the possibility of final disposal in any given year to the capacity of the facilities in that year is established in constraint (5). The total accumulated waste up to a given year cannot be more than the cumulative capacity built up to that year; in this case, capacity is stated in terms of total ton. Constraint (6) states the condition that all residues from processing at intermediate facilities -all the waste in case of transfer stations, refuse in the case of treatment facilities- must be transported to a final disposal site. Factor "a_g" is in fact the percentage of waste arriving to a facility, to be processed, that has to be sent to final disposal. Finally, constraint (7) takes into account the fact that capacity expansion at certain sites may be limited to a fixed amount. The rest of the constraints express the non-negativity of decision variables.

Additional constraints might be introduced in the model to take into account particular situations that occur in real life instances, for example, limits to the total expansion capacity of the sites, limits to transportation distances, issues of equity regarding limitations to transhipment among different political entities, and others.

Among the relevant characteristics of this formulation are:

- Investments in the expansion of facilities for each period, that constitute the most important part of fixed costs, are introduced in the model as

separate elements.

- It introduces the concept of dynamic optimization over time within the same model.

In the specific case of the MAVM the utilization of mathematical programming to search for an efficient system of waste transfer, processing and disposal, would include the following steps:

- Select the area for the study. In this case, the generating districts are the 17 delegations of the Federal District, and the 27 municipalities within the State of Mexico that are considered to be part of the Metropolitan Area.
- Define the specific number "n" of waste generation areas to be included in the model. In order to diminish the time for the computer runs, it would be convenient to try to compact several delegations and municipalities in one waste generation area. However, so as to avoid unduly sacrifice of reality, care must be exerted so that the delegations and municipalities included in a single generation area, are of similar characteristics as regards population density, socio-economical level of the inhabitants land use, and urban infrastructure.
- Select the time periods over which the analysis will be carried out. Because of computational reasons, no more than 5 time periods should be utilized.
- Estimate expected waste generation for each of the selected time periods and waste generation areas. In the case of the MAVM there are several available, detailed demographic studies that utilize municipalities and delegations as basic census districts. As for per-capita waste generation, there does not exist detailed information for each district. More general information published by SEDESOL or the DDF must be utilized.
- Establish the capacity limits of existing waste management installations.
- Select sites for possible new solid waste facilities: transfer stations,

recycling and resource recovery installations, composting plants , waste to energy incineration plants, landfills. A judicious selection of the possible sites, trying for example to utilize locations already used for waste management purposes, for the development of additional integral waste management facilities, would increase the robustness of solutions. Sites should be looked for not only within the Federal District and the metropolitan territory of the State of Mexico, but also in adjacent states, such as Hidalgo, Queretaro and Morelos.

- Develop cost estimates, both for plant expansion and operations, for the incremental steps of all the different types of installations and competing technologies.
- Develop transportation costs: a) Between all waste generation areas, and all processing or final disposal facilities, existing or possible, and b) Between all existing and possible new sites, and existing or possible final disposal sites. Costs should be developed for the relevant cases where railroad transportation could be an alternative. In this latter case the possible need of additional transfer installations should be considered.
- Run the model for different strategies derived from basic alternatives such as: all installations within the Valley of Mexico; no restriction for site location; no incineration; no incineration within the Valley of Mexico; no restrictions for location or type of facilities.
- Conduct sensitivity analysis for the different strategies, examining dual solutions and shadow prices to examine the effect of modification of constraints. This is especially important in this case. Because of the characteristics of the model, there exists a high possibility of local optima.
- Try to improve upon the initial output solutions by introducing originally non-optimal variables in the solutions.
- Select the "best" solution for each of the strategies.
- Present in a clear manner the differences among the "best" solutions for

the different strategies.

The specialized literature abounds in examples of possible applications of mathematical programming for the search of solutions to the problem of the selection of the efficient combination of type, location and dimensions of waste management facilities, as well as of the corresponding transportation systems. Most of them utilize variations of the model that has been presented here, which shows the power of mathematical programming techniques in that respect[43].

However, the basic characteristics of mathematical programming, i.e. the search of an optimal solution within given constraints, makes it a tool less than complete for the analysis of problem involving variables of different natures, where diverse actors, with various utility functions must participate in the decision making process. It is clear that a typical mathematical programming lay-out of a problem, with the objective of minimizing the cost of a waste management system, would render a solution, that even if it took into account in a proper way technical, financial, economical and environmental constraints would still be lacking in the consideration of fundamental socio-political variables in whose interplay depends heavily the implementation of any solution. Mathematical programming cannot easily take into consideration the variable position of the population of a certain area, when faced to the siting of a final disposal facility in its neighborhood, or related equity issues, or the position of diverse influential non-governmental organizations regarding environmental matters -even if all regulations are complied with- , or the diverse interests of the various central and local governments involved in the decision, through what essentially is a process of negotiation, of a dynamic, uncertain nature.

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[43]For example, a model commonly utilized is the WRAP (Waste Resources Allocation Program), developed by the MITRE Corporation.

Still, mathematical programming must be considered, when adequately utilized, as a most useful tool for the strategic planning process. Its very characteristics make of mathematical programming an ideal instrument for a screening process, through which clearly inferior, unacceptable solutions in terms of variables that can be quantitatively expressed are weeded out, leaving a more manageable set of non-inferior solutions to be examined. Also, existing computing capacities, allow for the extensive examination of feasible solutions, through shadow pricing or opportunity costs, and permits the appraisal of the sensitivity of solutions to changing conditions, as well as the analysis of tradeoffs among diverse solutions. The characteristics of the tool do not make it especially suited for open discussion of alternatives among different participants. In this respect it can be classified as a "black box" tool as regards non-specialized actors.

7.4.2. Dynamic Programming.

One important aspect regarding the planning of a system of waste management facilities, is that of defining an optimum path for capacity expansion, as the demands on the system grow along the planing horizon. As it was shown in the previous section, one of the ways of solving the problem is through dynamic optimization over time, where the planning horizon is divided in periods and the total cost to be minimized is the sum of costs and benefits from these periods, discounted to their net present value. Of course, this leads to a very important increase, usually exponential, in the number of equations to be dealt with in the computational process. Up to recently it was considered that this formulation, given its nonlinearity and the nonconvexity of the objective function, would be limited to the analysis of a reduced number of periods, as well as of waste sources and sinks. Notwithstanding the growing availability of "out of the box" powerful algorithms, and of processing capabilities, this is an issue to be considered in the case of planning in the MAVM, where a realistic approach would require the consideration of many waste generation areas, of several different types of intermediate processes in various sites, and of a considerable number of final disposal facilities, given the diversity and extension of

the metropolitan area, and the amount of waste to be handled and disposed off. Even if dynamic optimization over time may produce the best solutions for the whole planning horizon, it is necessary to ponder its advantages against those of other options, based on static models.

Essentially, static models optimize the characteristics of a system for a given, static demand. A static model produces as its result a state of the waste management system. This type of model can be, of course, also be used to produce a series of successive partially optimal states of the system subject to different demands. One way of utilizing static models is then that of running the model for the conditions of different periods of the time horizon, using heuristics to find a satisfactory path for the expansion of facilities along the planning horizon. This approach has been utilized, for example, to select new disposal sites to replace old sites which must be closed when they have been filled to their total capacity. Another approach to the capacity expansion problem based on the utilization of static models is the dynamic step by step optimization, usually designed as dynamic programming, a systematic method of optimization which overcomes the three major drawbacks of linear programming, as it can be applied to problems that are non-linear, have concave feasible regions, and have discontinuous variables; however, it has relative limitations in the number of constraints it may effectively deal with

Dynamic programming is based in the concept of implicit enumeration; it systematically eliminates many sets of possible combinations because they can be shown to be inferior. In practice, implicit enumeration eliminates possible solutions in a series of stages, recurring to a repetitive process of optimization that eliminates whole sets of inferior solutions from the process of analysis. Assumptions of separability -the objective function can be broken up into a series of independent functions, designed as return functions-, and monotonicity -improvements in the value of the independent functions lead to improvements in the value of the objective function-, make it possible to decomposition of the objective function, essential to the dynamic programming approach.

The process of optimization of a system utilizing dynamic programming requires:

- Definition of the stages into which the problem is to be subdivided. In the case of sequential time processes, those are naturally successive time periods.
- Definition of the levels or states of the system at each stage, e.g. the demands on the system.
- Definition of the constraints for each of the stages.
- Carrying out partial optimization a each stage.
- Repetition of this process through all stages.

The optimal solution is provided by the cumulative return function over all the stages.

The above brief description of the method shows its suitability for the analysis of the optimal path of expansion for waste management facilities. For each of the successive time periods, embedded static optimization models of the type described in the first part of Section 7.4.1, or similar, must be formulated and solved to provide optimal waste transportation, processing and final disposal costs for different optional structures of waste management facilities. From this, optimal facility expansion and utilization schemes for each time period can be determined. After all expansion and utilization schemes are determined for the different stages, it is possible to trace back from the last stage to the first one to obtain the optimal route of facility expansion for the entire time horizon and the relevant system cost. Dynamic programming is then a powerful method that can be utilized in conduction with linear programming or similar techniques, to optimize the behavior of the waste management system in terms of one desired objective. Dynamic programming's capacity for sensitivity analysis is rather limited. It also may be considered as a "black box" tool.

The concept of dynamic programming can also be utilized to take into account the

uncertainties involved in the expansion of waste management facilities. Different approaches have been proposed in this respect, utilizing fuzzy dynamic programming, stochastic dynamic programming and grey dynamic programming.

7.4.3. Multiobjective Optimization.

As it was discussed above in relation with the characteristics of mathematical programming, planning for metropolitan waste management systems cannot be conceived as a process of optimizing for a single objective. In fact, the number of intervening, often conflicting, objectives may be large. A typical example is that maximum economic efficiency of the system, which might be a fundamental objective for an important group of stake-holders, including some areas of government and the general public, might be regarded as secondary by another important group of stake-holders, constituted by the neighbors of communities near the location of proposed facilities -the NIMBY syndrome- for whom local environmental considerations and land values may be more relevant. The example can be extended to many dimensions, including those of job creation, or generalized environmental risk. In essence, optimization is not possible so long as a problem deals with multiple objectives that are truly different. And the decision maker, even when he has the power to select a solution by himself, must take all those objectives into consideration. Of course, if all objectives can be somehow valued on a common basis, the optimization can be stated in terms of that single value. The multiobjective problem is then eliminated and it is possible to search for an optimum global solution utilizing one or several of the tools that have been described in preceding sections. However, such an approach is not ever easy to take. To clearly state the relative quantitative importance of the attainment of different objective in terms suited to the utilization of the tools of mathematical programming is usually a forlorn attempt.

The focus of multiobjective objective optimization in practice is then to define and eliminate the set of clearly inferior solutions, rather than to determine an optimal

alternative. The result is the identification of a manageable subset of feasible solutions that are worthy of further consideration. Formally, this result is known as the set of non-inferior solutions, a concept that also is referred to as the Pareto optimal or as the production feasibility frontier. The preferred solution for any system should be one of the non-inferior solutions. If all relevant objectives have been considered, no alternative that is not among the non-inferior solutions is worthwhile, as it is dominated by some solutions that are preferable as regards all objectives. This is the reason why multiobjective optimization focuses on the determination of the non-inferior solutions. All other solutions should be excluded from further consideration, due to the fact that they contribute so little to the attainment of one or more or the objectives that they are simply not acceptable. In order to make a choice, non-inferior solutions are then subject to additional examination, that is normally of a judgmental nature.

There are two major ways of defining the non-inferior solutions: the constraint and the weighting methods. By treating objectives alternatively as such, and as constraints, both of them transform the multidimensional problem, which cannot be solved explicitly, into a series of one-dimensional problems for which solutions can be obtained and examined. In general the constraint method is preferable because it gives a more reliable description of the non-inferior solutions. When the computational costs become an important issue, and such might be the case in a large scale problem such as waste management in the MAVM, the weighting method might be simpler to apply. This latter method may also be selected when a spread-sheet analysis is possible. The steps for a practical, easy to apply constraint method would be as follows:

- Optimize for each objective by itself, without any constraints on the objectives. These results define limits on the range of non-inferior solutions.
- Optimize on one objective, placing constraints on only one other objective. Iteratively change this constraint until the end of the maximum feasible value of this objective is reached.. This amounts to defining a trade-off

curve among the objective being optimized and the objective that is being treated as a variable constraint. Repeat for the rest of pairs of objectives.

- Optimize now with one objective, two other objectives being considered as variable constraints. This is equivalent to tracing out non-inferior solutions in three dimensions.
- Proceed as before for as many dimensions as desirable or necessary.

The constraint method works both when the solutions can be defined mathematically, or are only defined individually. The method implicitly assumes that mathematical programming will be used in the analysis, a it is the only method that can efficiently deal with multiple constraints.

The weighting method introduces a set of weights for each objective. Then the weighted sum of the objectives is optimized, so defining a non-inferior solution; the procedure follows in general terms the same steps as that recommended for the constraints method. The weighting method is particularly easy to apply when the alternative solutions are defined individually. Then, the characteristics of the different feasible solutions can be placed in a spread-sheet programs, and it is then easy to assign relative weights and define the corresponding non-inferior solutions.

Trade-off curves, that show graphically non-inferior solutions for pairs of objectives, are a convenient way or presenting the results of the multiobjective optimization process, as it allows the decision maker to visually determine the cost, in terms of the degree of attainment of one objective, of increasing the output in terms of the other. When trade-off curves present a "knee", the solution to be adopted almost surely lies within that region, where trade-offs among objectives may be achieved without significative losses in the degree of attainment of any of them. An also useful way of presenting the results of multiobjective optimization, are profile graphs that depict the performance of different solutions as regards diverse objectives (Figure 7.2).

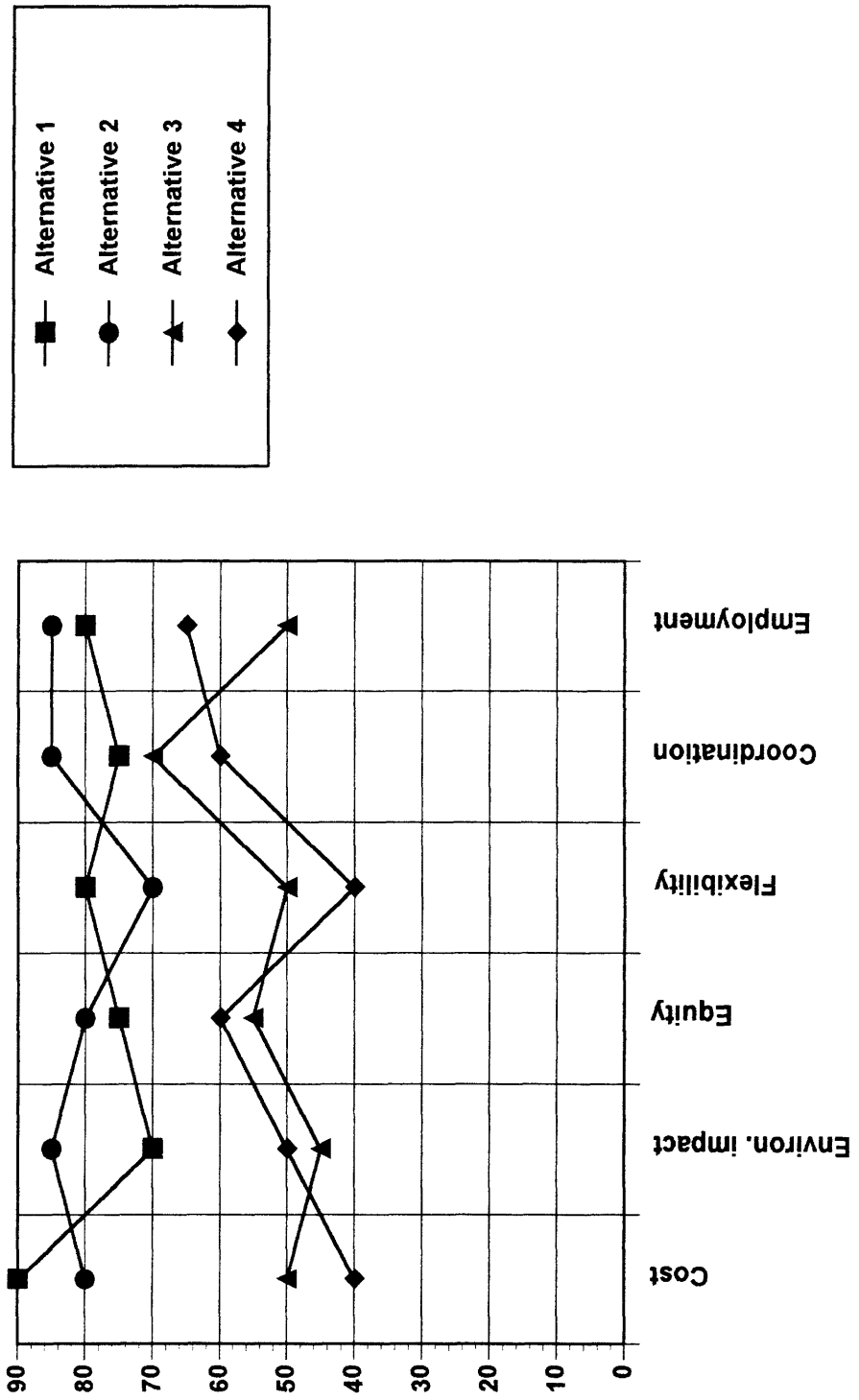

Figure 7.2 A profile graph for multiobjective analysis

Multiobjective optimization is an important method, in that it makes explicit the interrelationships between the different objectives that must be taken into consideration in metropolitan waste management systems. It allows the lone decision maker to exercise his or her judgment on a systematic, well-informed basis, taking into account the trade-offs that may exist among the attainment of different objectives. The method is also suited to a decision making process in which there are several parties involved, when those parties have similar interests and preferences, so that the trade-offs may be easily agreed upon. Multiobjective analysis can also be utilized as one of the tools to support decision making processes of a more complex nature, where the participants have different, often conflicting, interests, objectives and preferences.

When utilized as a support for more sophisticated methods, multiobjective optimization should be a most useful tool for waste management planning in the MAVM, due to the variety of objectives that exist in this case.

Some objectives to be considered in multiobjective analysis in the case at hand would be of a clearly quantitative nature, and could be included in the formal mathematical model. Some others, especially those of a socio-political nature, could not possibly be included in the model; therefore its degree of attainment would have to be estimated exogenously for each of the strategies under analysis, and be incorporated individually in the analysis. Some of the objectives that should be considered would relate for example to: a) Economic efficiency, b) Environmental impact, c) Flexibility, both as regards the system of installations, and the transportation system, d) Equity, e) Required institutional coordination. See the following section for a more detailed discussion of the different objectives.

7.4.4. Multiattribute Approaches: The Analytic Hierarchy Process (AHP).

As it was pointed out in the preceding section, multiobjective analysis is an useful

tool in those decision making situations where an explicit measure of preferences among the different objectives is not required, because the analysis leads to a clearly defined solution or set of solutions for the problem at hand. However, this is not always the case. The decision maker might have difficulties in selecting the preferred solution or strategy through the simple examination of trade-off curves or profile graphs, because the relative importance of the attainment of the diverse objectives has not been made explicit. In this cases, it is necessary to define the decision-maker's preference function for a set of distinct objectives or attributes, so that the selection of the preferred alternative can be made. One of the tools that has been utilized extensively in recent years for in this class of situations is the Analytic Hierarchy Process (AHP)[44]. This method also has characteristics that make it suitable for its utilization in certain decision processes belonging to the class that involves multiple actors with different conflicting objectives, although with certain limitations.

The underlying concept of AHP is that, for the study of causal relationships, a hierarchical structure is the single most powerful idea associated with systems, and that hierarchic organization is important to the synthesis and survival of large, complex systems. According to this concept, any system is a large matrix of interactions between its components in which most of the entries are close to zero. Ordering those entries according to their magnitude, a distinct hierarchic structure is discerned. Mathematically, structures are order-preserving structures that involve the study of order among partitions of a set. A hierarchical structure provides a method of partitioning the elements of a complex system into different set, known as the levels of the hierarchy; the elements of each level interact with elements in both the level above end the level below (Figure 7.3). The essential requirement for analysis by hierarchies is that it should be possible to decompose a problem int such levels, where each level has an impact on the levels above and below. The elements of each level may then be weighted according to their impact

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[44]See, for example: Thomas L Saaty, "The Analytic Hierarchy Process".

on the level above. This provides a quantitative connection between elements at one level and elements in the levels immediately above and immediately below. This then provides a measure for the elements at the lowest level with respect to those in upper levels and at the top. Given the elements of a certain level, for example level 3, of a hierarchy, and one element or the next higher level, the method compares the elements of level 3 pairwise in their strength of influence over the element of the higher next level. The agreed upon numbers that reflect the comparison are then inserted in a matrix, and the eigenvector with the highest eigenvalue is found. The eigenvector provides the priority ordering, and the eigenvalue is a measure of the consistency of the judgement.

In accordance with the above discussed concepts, the first major task in the AHP involves the estimation of the relative weights of a set of objects (criteria or alternatives), from a matrix of pairwise comparisons, $A = (a_{ij})$ which is positive and reciprocal. Given the matrix:

$$A = \begin{vmatrix} a_{11} & a_{12} & \dots & a_1 n \\ a_{21} & a_{22} & \dots & a_2 n \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{vmatrix}$$

Where:

$$a_{ij} = \frac{1}{a_{ji}} \qquad \text{for all} \quad i,j, = 1, 2, \dots\dots, n.$$

it is needed to compute a vector of weights or priorities:

$$w = (w_1, w_2, \dots, w_n)$$

By using ratio scales, the estimated weights are only unique up to a multiplication by a positive constant, i.e., w is equivalent to cw where c is greater than 0. Thus, w will be usually be normalized so that it sums 1 or 100, for convenience. If the judgments that were utilized to obtain the relative weights w, were perfectly consistent, i.e.,

$$a_{ik} \cdot a_{kj} = a_{ij} \text{ for all } i, j, k = 1, 2, \ldots, n.$$

then the entries of the matrix A would contain no errors and could be expressed as:

$$a_{ij} = \frac{w_i}{wj}$$

as:

$$a_{ik} \cdot a_{kj} = \frac{w_i \cdot w_k}{w_k \cdot w_j} = \frac{w_i}{w_j} = a_{ij} \quad \text{for all } i, j, k = 1, 2, \ldots, n.$$

In this case, any column j of A is normalized to yield the final weights to be utilized in the computations:

$$w_i = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad \text{for all} \quad i = 1, 2, \ldots n.$$

However, errors in judgement regarding the relative weights are usually made, that result in a certain degree of inconsistency of the matrix. The consistency index CI is defined as:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

For each size of matrix "n", random numbers have been generated and their mean CI value, called the random index, RI, has been computed. Using those values, the consistency ratio, CR is defined as the ratio of the CI to the RI; thus, CR is a measure of how a given matrix compares to a purely random matrix in terms of their CI's. A value of CR of less than 0.1 is typically considered acceptable; larger values require the

decision makers to reduce the inconsistencies by revising judgements.

One possible application of the AHP in the case of waste management in metropolitan regions would be in the ranking of possible strategies in an order of "implementability" or "global feasibility", taking into account the characteristics of the alternatives, the different objectives that are being sought by the diverse actors through the possible implementation of a strategy, the relative importance that each actor assigns to each objective, and the relative power and influence of the decision makers. Such a ranking would, in effect, be a ranking of the relative robustness of the strategies.

The problem would imply the definition of:

- The relative power of each of the parties to influence the outcome of the decision making process.
- The relative importance that each party assigns to each objective been taken into account.
- The extent to which each possible solution, would in the view of each stake-holder, satisfy each of the objectives.

A problem of this type may be organized in hierarchical terms by placing the actors at the highest level, since it is they who have the power to influence the final decision. In any conflict, each party will have a number of objectives that it wants to satisfy. Some of these objectives will be more important to them that others. The objectives form then the second level of the hierarchy. The different strategies that may be pursued for waste management will be viewed by each actor according to how well each structure might satisfy each of the objectives that are important to him or her. These strategies, or possible solutions form the third level of the hierarchy (Figure 7.3).

The actors may be weighted according to their power to influence the outcome. Questions regarding the relative power of the parties to influence the final decision must

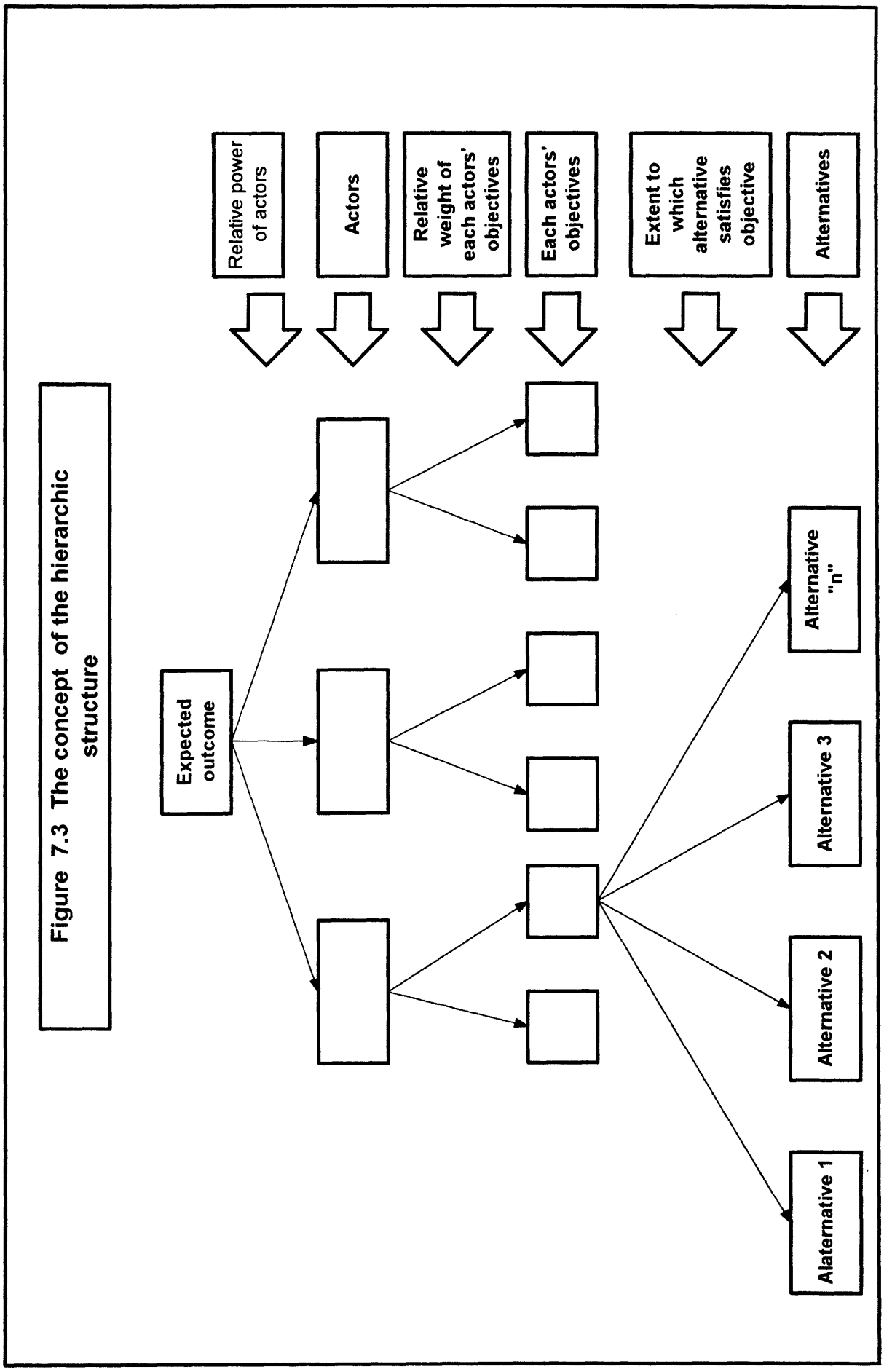

Figure 7.3 The concept of the hierarchic structure

have a definition; from this a pairwise comparison matrix for the relative power of the parties must be constructed. The objectives of each party are then weighted according to the relative importance to the party. This will produce, for each party, a pairwise comparison matrix, thus relating this level to the level above. The alternative strategies or solutions are then compared according to how well each of them satisfies each of the objectives being considered. For each objective, a pairwise comparison matrix will be produced, defining the comparative degree of incidence of each alternative strategy in the attainment of that objective. The weights of each of the strategies may now be obtained by composite weighting through the hierarchy. A path is followed from the decision at the apex to each final outcome at the lowest level, multiplying the weights along each segment of the path. The result is a vector of final weights that, for this case, would show the relative degree of "implementability" of each of the alternative strategies.

In the specific case of the MAVM, a somewhat more detailed description of the activities required for the application of this method to the selection of a robust strategy would be as follows:

Definition of a Hierarchic Structure. Similar to the one described in the preceding paragraphs: one level for global assessment of feasibility, and four additional levels: one for actors, two for criteria and subcriteria (that in the analysis can be collapsed into one), and one for alternative strategies. (Figure 7.4)[45].

Selection of actors. In this case the assumption is that the method is being utilized for prediction regarding the implementability or global feasibility of alternative solutions,

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[45]It is interesting to note here that different sub-hierarchies might be used in the analysis. For example, the relative importance ascribed to an objective by a decision maker, who represents the power of a governmental body, could be stated as a function of the relative power of the subagencies of that body and of the relative importance that those agencies assign to the objectives.

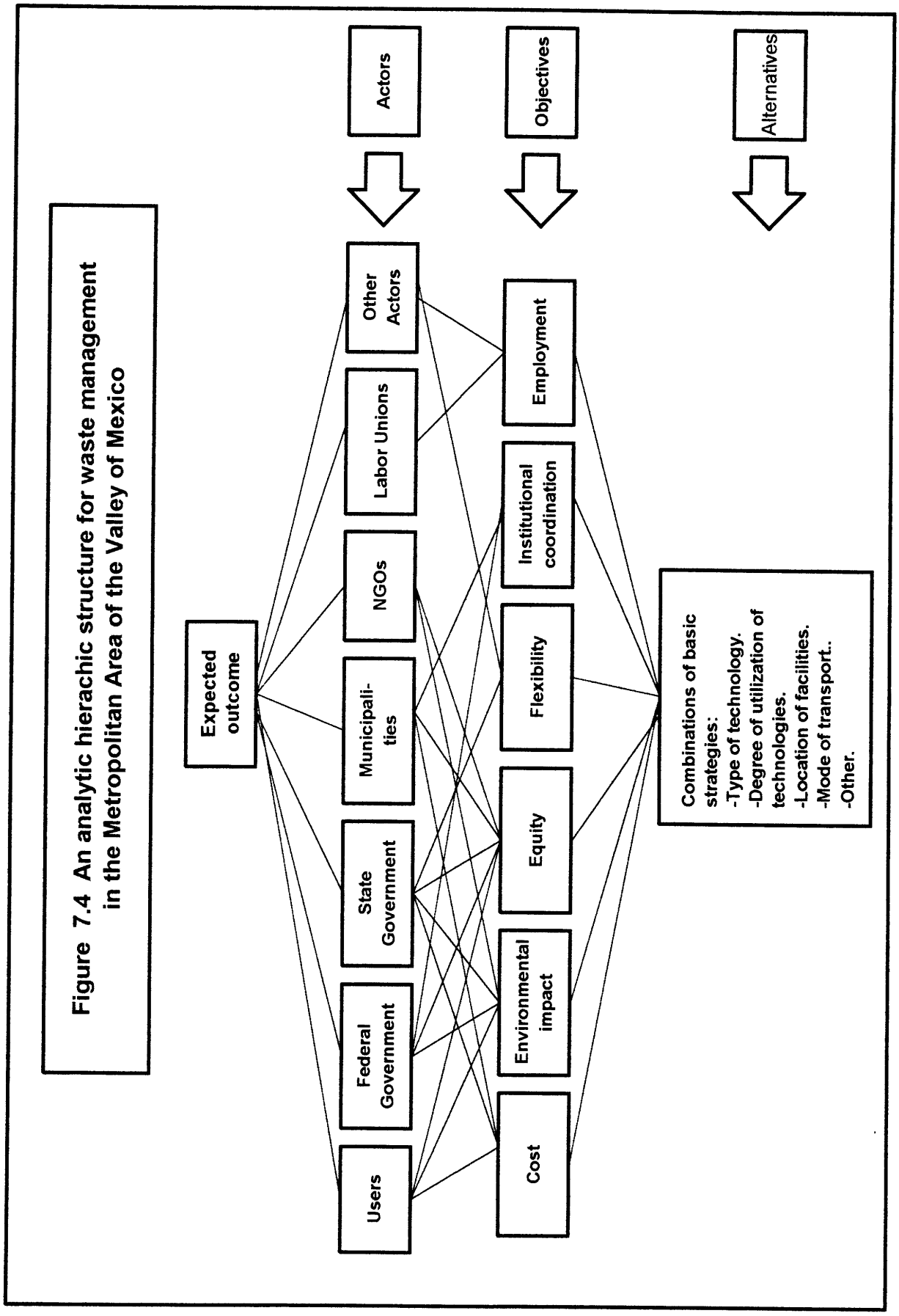
Figure 7.4 An analytic hierachic structure for waste management in the Metropolitan Area of the Valley of Mexico
Expected outcome
Actors
Objectives
Alternatives
Users
Federal Government
State Government
Municipali-ties
NGOs
Labor Unions
Other Actors
Cost
Environmental impact
Equity
Flexibility
Institutional coordination
Employment
Combinations of basic strategies:
-Type of technology.
-Degree of utilization of technologies.
-Location of facilities.
-Mode of transport..
-Other.

and not for a process of direct negotiation. This being the case, the actors to be considered might be not only those that -being direct stakeholders- would seat in a negotiations table, but also others, that although indirectly, may alter one way or the other the outcome of the process. The actors to be analyzed would then include:

- Federal Government.
- Government of the State of Mexico.
- Municipalities of the State of Mexico being considered for the siting of facilities (as a group, assuming that they would have similar interests and preferences).
- Other municipalities of the State of Mexico (as a group).
- Government of the State of Hidalgo (assuming that some of the out-of-Valley alternatives considered the siting of alternatives there).
- Municipalities of the State of Hidalgo being considered for the siting of alternatives.
- Associations of neighbors.
- NGO's.
- Labor Unions.
- Scavengers Unions.
- Scientific and academic community.
- Professional associations.
- Media.

Definition of Objectives and Subobjectives, and of the Criteria to be Utilized for Comparison. This involves the selection of the objectives that might be relevant to each or several of the actors, as well as of the criteria to be utilized in the ranking of the alternative strategies as for its degree of contribution to the attainment of the objectives. Objectives and subobjectives to be included could be:

- Minimum economic cost, for which the criteria of the global NPV of the total net cost of each strategy in the planning period could be utilized. This costs would be the output of , for example, a mathematical programming model utilized for the screening of the strategies from the economic point of view. Economic social costs should be utilized instead of the direct financial costs. Utility functions might have to be utilized here, as in other parts of the analysis, to take into account the relationships between the degree of preference and the level of cost involved in each alternative. Another, more sophisticated option to account for the economic components of the project would be to take into consideration the distribution of financial costs, for the different strategies, among the government and the users. Differences for the strategies might arise from the degree of participation of the private sector, for example, or from policies regarding direct charges for service to the users. Financial costs in this case should be expressed in total pesos per year for the governmental actors, and in pesos per family per month,or a similar indicator for the users.
- Minimum Environmental Impact. Notwithstanding that all strategies must comply with regulations, this is a subject that no doubt will be debated intensely. Three subobjectives might be considered:
    - Air pollution. A good option would be to utilize the IMP-Alamos model (see Section 2.6.1) to asses the impact of the different strategies in the level of atmospheric contamination of the Valley. An integral index, similar to IMECA, should have to be developed for this purpose.
    - Contamination of the aquifer. A more difficult issue, as there does not exist a global model (very probably it never will, due to the geologic conditions of the Valley). Direct expert opinion might be used here.
    - Soil pollution. Related mainly with the possibility of

contamination along the transportation system. Could be linked to an analysis of the relative probability of transportation accidents for the various strategies.

- Socio-Political Issues. Several subobjectives might be considered:
  - Maximum equity level. Could be measured as the number of municipalities that are expected to provide some kind of site for system's installations.
  - Minimum degree of local impact. Different from the regional environmental impacts mentioned above. It is related to the acceptability of the strategies for the neighbors of communities where facilities might be located.
  - Minimum degree of institutional coordination . Analysis of cases show a direct relationship between the failure of metropolitan management of waste and the degree of coordination required. This is then, an important element that must be considered to asses the different strategies. No doubt it will be important to governmental participants, that in addition, are not adept to squandering political capital. Could be measured as a function of the number of governmental authorities involved in the implementation of a strategy.
- Maximum flexibility. Again, different subobjectives might be taken into consideration here:
  - Maximum degree of transportation flexibility. Refers to the possibility of utilizing alternative means of transport in emergencies. Indicators could be developed taking into account, for example, the number of alternative routes of access to a facility, in the case of road transport. In the case of railroad transport flexibility is almost non-existent.
  - Maximum degree of infrastructure flexibility. Refers to the degree in which a strategy imposes constraints to future change of

directions.

Definition of Strategies. An important number of alternatives can be generated by the combination of elements, not necessarily defined by economic considerations. In fact, in an interactive process, additional strategies might be generated as a result of the low degree of satisfaction provided to the different objectives of the participants. Some of the elements that generate alternatives are:

- Type of installations: Incineration, no incineration.
- Degree of processing (recycling, composting).
- Location of facilities: Inside the Valley, outside the Valley.
- Road transport, railroad transport.

Assessment of the relative power of actors to influence the decision process. For a number of (a) actors, this would imply the generation of a (dxd) matrix and the corresponding priority vector.

Assessment of the importance that each stakeholder assigns to the different objectives. If (c) objectives are considered, a number of (d) matrices of dimension (cxc) and its corresponding priority vectors would have to be generated.

Assessment of the contribution of each of the alternatives to each of the objectives. For a number (s) of alternatives, it would be required to generate (c) matrices of a dimension (sxs) and the corresponding priority vectors.

Definition of the preferred alternative, for each actor. One priority vector for each actor, ranking the strategies.

Definition of the degree of global feasibility of the strategies. One final resulting priority vector, ranking the strategies.

From the computational point of view, the method does not present any difficulties. All computations can be carried out in a rather simple spread-sheet, and the process lends itself well to sensitivity analysis. In fact, the difficulties of its application arise from the need of a correct construction of the matrices that compare the relative importance of the different elements. Some of the comparisons undoubtedly require the support of experts; other must be made by the decision maker itself.

As a tool for planning, the AHP may be used both in a forward and a backward process. In the forward process, that was described in the preceding paragraphs, the aim is to identify the strategies that, in large measure, satisfy the objectives of each party. Such process may be regarded as a one-point boundary problem fixed at the present state. It is the forward process. The alternative approach tries to define the conditions that should exist to reach a predetermined future state. Working backwards it is possible to identify the problems and opportunities that affect that desired future state and to define the policies that would be more effective in producing that outcome.

It can be concluded that the Analytic Hierarchy Process is a useful tool for the support of decision making processes regarding complex systems. Its main characteristic is that it offers a well structured, logical procedure for the analysis of the relationships between the objectives of different natures, and the preferences and power structures of the actors that influence that process. AHP may be utilized -and it has been, widely- to define the course of action that a decision maker should take in the face of his or her multiple objectives, and to asses the possible outcome of decision processes in which the influence of different actors with conflicting interests is relevant. In this latter class of processes, AHP should be very useful as a screening tool, to eliminate strategies that are clearly inferior, as they have little probability of being accepted by consensus. Also, an actor may utilize AHP as a guide in a negotiation process to his or her advantage, because of the insights it provides regarding the interplay of the different variables. In this class of processes, the method's main weakness may be in the difficulty to realistically assess the position that a given actor will adopt regarding different objectives,

as well as the relative power of the actors[46].

Finally, AHP does not seem to have been a tool, jointly utilized by diverse actors with conflicting objectives, in open negotiation processes in which the actors sit around a table seeking for compromise consensual decisions. This might well be due to the fact that the very nature of AHP requires the explicit consensus on the relative power of the participants, which is not easy to be achieved in a table open to discussion by all of them. However, attention must be kept on AHP, as the tool and a host of applications are still developing that might widen its field of usefulness[47].

7.4.5. Simulation: Systems Dynamics

As it has been discussed above, because of the complexities involved , the available tools of analysis have to make many different simplifying assumptions. Even if those assumptions -such as linearity- are carefully made, special care must be exerted to avoid pitfalls in the decision making process related to complex systems, due to -among other reasons- the misuse of those assumptions. In addition, the fact remains that many of the commonly used -prescriptive- tools do not adequately take into account situations that are constantly present in complex systems, such as : a) This class of systems are highly interconnected and there is a high degree of feedback between elements. Ignoring feedback can result in the selection of strategies that are diluted, delayed or defeated by the system, or which generate unanticipated side effects. Even if feedback may, in theory be incorporated, for example, in optimization models, in practice

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[46]It also must be taken into account that real influence is a result not only of power, but also of the will to exercise it in specific circumstances.

[47]In a recent -July 1994- conference on AHP, of nearly 100 papers presented, more than 10% was on group decision making, with several papers dealing with issues of a conflicting nature, such as public housing, regional planning, and even global planning and sustainable development.

the resulting computational difficulties are very important., b) Complex systems are highly dynamic, and many modeling tools do not take appropriately into account this fact. Of course, as it was described above, ways exist to take into account the evolution of the demands on a system over time, and to find the most convenient path to respond to those demands. However, most tools are ill-suited to take into account the effect of delays. Delays occur in any system. It takes time for a social uneasiness to be converted into a demand, and for that demand to become a political issue. It takes time to obtain information and to get to consensus decisions. Delays in carrying out decisions or for the effect of those decisions to take effect, may cause overreaction, prevent intervention or cause oscillatory behavior of a system. Delays, that are crucial in determining the dynamic behavior of a system, are not easily incorporated in most analysis tools.

Complex systems are high order[48], multiple-loop, nonlinear feedback structures, with usually particular responses which cause many of the failures and frustrations experienced in trying to improve its behavior[49]. All social systems, among them waste management in metropolitan areas correspond to this description. In certain instances, the use of simulation tools, instead of prescriptive procedures might be preferred. A simulation model in this context has two main components. It must include a representation of the technical and economic characteristics relevant to the problem under study. The degree of the detail needed depends on the specific problem to be addressed by the model. In the case of strategic planning for waste management in the MAVM the model should include the characteristics of the waste generating subsystem, the technical and economic characteristics of the present or expected transporting, processing, and disposal facilities, as well as of the economics of the marketing input and output subsystems that are a part of the waste system, among others. In addition to the technical

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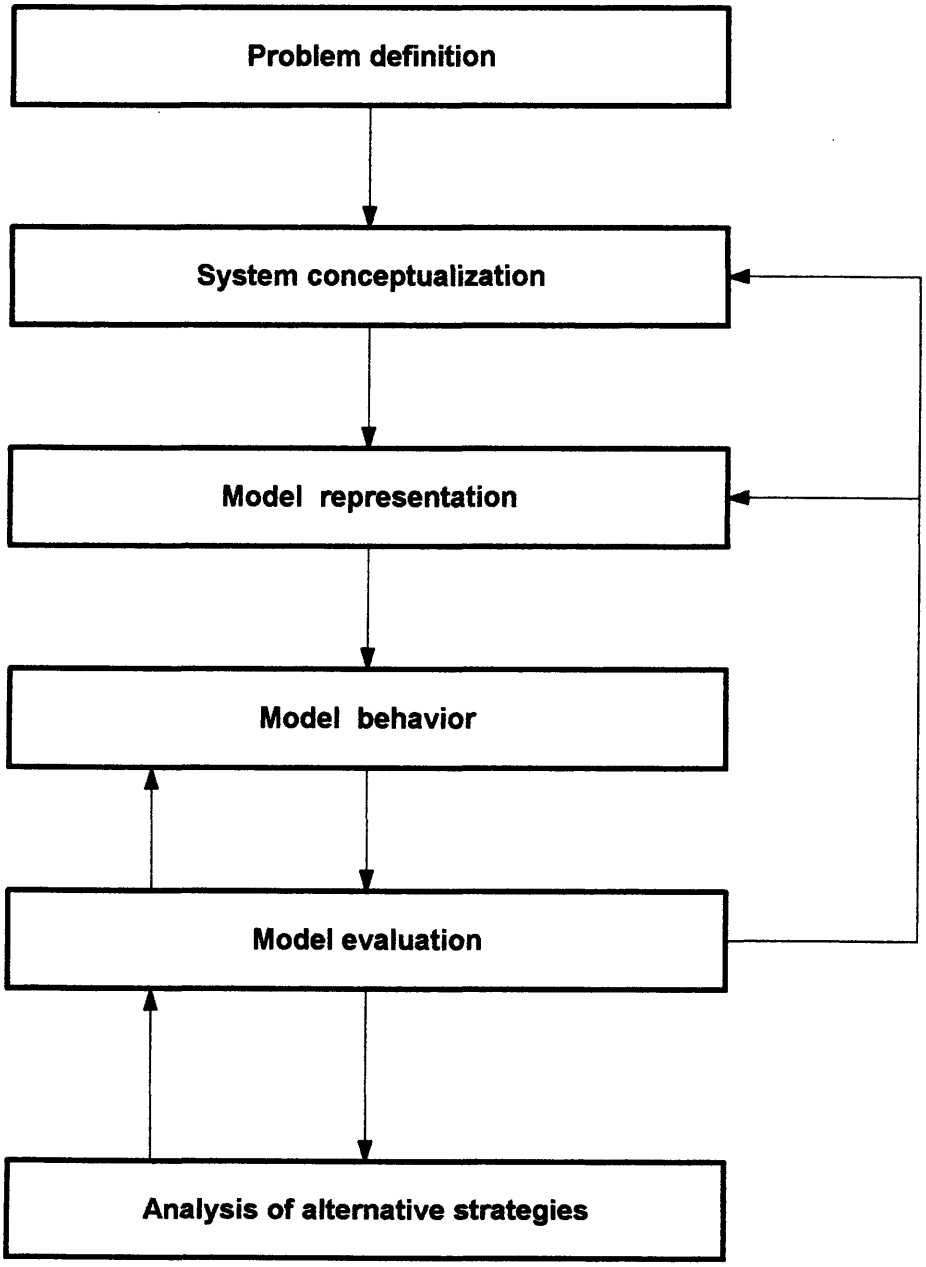
[48]The "order" of a system is determined by the number of states in the system's description. A typical company may be up to a 10th order. An adequate representation of a social system may well be of a 100th order.

[49]For a complete discussion on this subject, see Jay Forrester: "Urban Dynamics".

Figure 7.5 Steps for the construction of a Systems Dynamics model



and economic characteristics of the system, a simulation model must represent the behavior of the actors in the system. Behavior in this context means the way in which people respond to different situations. The behavioral assumptions of a simulation model describe the way in which decisions are made. In planning for waste management in the MAVM, the simulation should include, for example, the consideration of the relative power of the different actors to influence the behavior of the system.

Like any model, simulation models has limitations. They are of a descriptive nature. They are "what if" tools. The purpose of a simulation model is not to tell a decision maker what should be done, but what would happen in a given situation, given a structure of the system and some assumptions regarding its behavior. And, of course, simulation models are as good as the assumptions made for its construction and operation. However, unlike most prescriptive tools, they can easily incorporate feedback effects, nonlinearity, and dynamics. The structure of simulation models is not rigidly determined by mathematical limitations as those of optimization models often are. In fact, one of the main uses of simulation is to identify how nonlinearities, delays, and limited information available to decision makers interact to produce the troubling dynamics that so often has resisted solution in complex systems. One very interesting simulation tool that has been widely utilized in many different instances, and that has been proposed for some waste management applications is Systems Dynamics[50].

Six types of activities are usually involved in the process of constructing a computer simulation model using the system dynamics approach (Figure 7.5):

- Problem Definition: The first phase in the model building-process involves recognizing and defining a problem in order to define if a System

[50]See for example, Jorgen Randers and Dennis Meadows: "The Dynamics of Solid Waste Generation".

Dynamics approach is adequate for its study. Important properties of dynamic problems are that they contain quantities that vary over time, that the forces producing this variability can be described causally, and that important causal influences can be contained within a closed system of feedback loops.

- System conceptualization. The second phase of the model -building process involves defining the important influences believed to be operating within the system. Systems may be represented in several ways, the three most common being causal-loop diagrams, plots of variables against time, and computer flow diagrams. Variables have either the nature of a rate -a "flow"-, or of a state -a "level" or "stock"-.
- Model representation. In the third phase of the model-building process, models are represented in the form of a computer code that can be fed into the computer. Recent developments of System Dynamics include software that facilitates this step.
- Model Behavior. In this phase, computer simulation is used to determine how all of the variables within the system behave over time. Again, existing software permits to accomplish this task with relative ease.
- Model Evaluation. In this, the fifth phase of the process, numerous tests must be performed on the model to evaluate its quality and validity. These tests range from checking for logical consistency, to matching model output against observed data collected over time, to more formal statistical tests of the parameters used within the simulation.
- Analysis of Strategies and Model Use. In the last phase of the modeling process, the model is used to test the effect of alternative strategies in the behavior of the system under study.

Figure 7.6 depicts a very preliminary and simplified causal-loop diagram for the waste management system in the MAVM. It is stressed that it sole purpose is to show some of the variables involved, and the difficulties that might be met in quantitatively

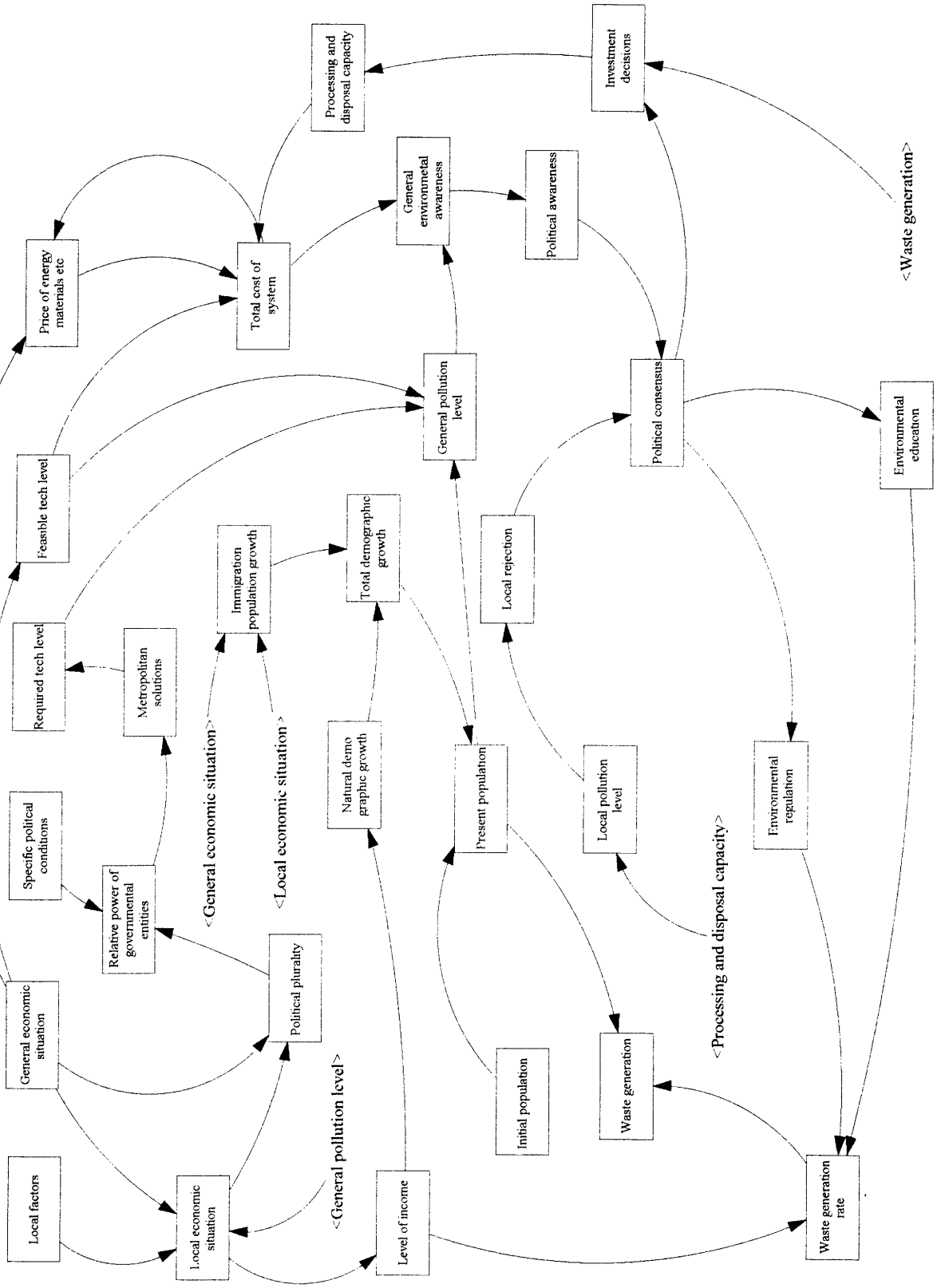


Figure 7.6 A preliminary causal-loop diagram for waste management.

defining the interrelationships among some of the variables. A brief definition of those variables is given in the following paragraphs.

General economic situation. A measure of the general economic situation of the country, utilizing standard parameters.

Local factors. Local economic factors that locally modify the general economic situation.

Local economic situation. A measure of the local economic situation. It is a function of the general economic situation an of the local factors.

Relative economic situation. A relationship between the local economic situation and that of the country.

Level of income. A measure of the level of household income. It is a function of the local economic situation. In a more detailed lay-out, distributional elements should be added.

Initial population. Total population of the MAVM at the beginning of the planning horizon.

Natural demographic growth. The rate of natural demographic growth, exclusive of net migration. Level of income is assumed here to be the most relevant causation.

Immigration demographic growth. The rate of demographic growth due to immigration into the MAVM. It is a function of the relative economic situation and of the general level of pollution.

Total demographic growth. A rate, resulting from the natural and immigration

rates of demographic growth.

Present population. A state resulting form initial population and the effect of consecutive growth increases.

Waste generation rate. The per-capita rate of waste generation. It is a function of the level of income, of environmental regulations, and of environmental education.

Waste generation. The total amount of waste generated in a planing period. A function of present population, and waste generation rate.

Processing and disposal capacity. The present capacity of installations for the diverse stages of waste management. It is a function of initial capacity and of consecutive investment decisions. A detailed lay-out must differentiate among the different types of facilities: transfer stations, recycling plants, composting, incineration and others, and final disposal.

Need of technological sophistication. The level of sophistication required for the management and disposal of waste. It includes transportation and processing technology. A function of waste generation, environmental regulations, and of the degree of metropolitazion that can be achieved.

Feasible technological sophistication. The possibilities of paying for technological solutions. A function of the local economic situation. Lack of congruence between needed and feasible technological sophistication -when this latter is of a lower level- increases environmental awareness.

Total cost . The total investment and operational costs of the waste management system. A function of processing capacity, and of waste generation.

Prices. The market prices of energy, recovered materials and other recoverables form the waste process. Prices are a function of the general and the local economic situations, and, on a lesser degree, of the production of recoverables.

General level of pollution. An indicator that expresses the level of pollution in the MAVM. It is a function of present population, of local economic activity, of environmental regulations, and of processing and disposal capacity.

Local level of pollution. An indicator that expresses the level of pollution in the areas where waste management facilities would be installed. A function of processing and disposal capacity.

Local level of rejection. An indicator that expresses the degree of rejection that population in the areas where waste management installations would be located, has regarding those actions.

General environmental awareness. An indicator that expresses the concern of the population of the MAVM as regards the level of pollution. It is a function of the general level of pollution, of total cost, of level of income, and of the relationship between needed and feasible technological sophistication.

Political awareness. An indicator that expresses the awareness that exists in the political body of social environmental concerns. It is a delayed function of general environmental awareness.

Political consensus. An indicator that expresses the level of consensus regarding waste management actions. A delayed function of political awareness, and of local level of rejection.

Level of investment. The amount of investments that according to political

consensus will be made. A function of political consensus, local economical situation, and needed level of technology.

Environmental regulations. Existing environmental regulations. A delayed function of political consensus.

Environmental education. Existing level of educational education. A delayed function of political consensus.

Political plurality. An indicator that expresses the general democratic atmosphere of the country as well as of the MAVM. It is a function of general and local economic development, and of diverse political conditions.

Diverse political conditions. An indicator expressing the level of diverse conditions that influence democratic processes.

Federal government power. An indicator that expresses the relative power of the federal government to influence decisions regarding waste management in the MAVM. A function of political plurality and of existing legal framework

Federal District power. An indicator that expresses the relative power of the Federal District Government to influence decisions regarding waste management in the MAVM. A function of political plurality and of the existing legal framework.

Local government power. An indicator that expresses the relative power of local governments to influence decisions regarding waste management in the MAVM. A function of political plurality and of the existing legal framework.

Metropolitan solutions. An indicator that expresses the degree to which metropolitan solutions can be adopted. A function of the general level of general

environmental awareness, and of the relative levels of power of intervening governments.

This preliminary lay-out of the conceptualization of a System Dynamics model regarding waste management planing for the MAVM, shows both the difficulties of the development of a complete, operational model, and the potential that it offers for the understanding of the behavior of such a complex system. Important efforts are currently being carried out to fulfill that potential[51].

7.4.6. Collective Decision Making: Multiattribute Trade-Off Analysis.

As it has been discussed above, decision making regarding waste management is often of a potential conflicting nature due to the different interests, objectives and positions of the diverse stake-holders . The need to define robust solutions that have a good probability of being implemented as well as of operating satisfactorily in the coming years, leads, as it was shown in Chapter 6, to a concept of planning that stresses the participation of the relevant actors in an open process, where potential conflicts can be identified, dealt with in a constructive, bounded environment. More and more this has proved to be a way to get to informed trade-offs and to agree on solutions which, at least, represent for some participants an improvement from their present circumstance, and for no participants a worsening of their actual situation. That process needs the support of systematic tools that have the capacity to: a) Deal with objectives of very different natures, that cannot be reduced to a single, all-encompassing objective, b) Present in a structured manner the causal relationships, the interplay of the interest and objectives of the different actors, c) Present the outcomes of each alternative course of action in terms of the objectives that are important to the actors, in order to facilitate trade-offs and, d)

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[51]One of the most interesting, is that of the team headed by Henry F. Taylor III, under the supervision of Professor David H. Marks, at the Energy Laboratory and the Department of Civil and Environmental Engineering, at MIT. See References.

Ideally, asses, the different courses of action, as regards its "feasibility", in terms of the different intervening variables, among them, the relative power and influence of the participants. This is the field of collective decision-making, for which there cannot be any universally acceptable analytic outcome in the sense of "the best" solution, because the way in which different individuals or groups value diverse objectives may vary in a very wide range. The approach recommended for this class of problems is collaborative negotiation. This is a process that permits the different groups or individuals to progress toward mutually beneficial improvements of alternative strategies. Because of the relevance of the subject, diverse efforts are being made to design and test specific procedures in this area[52]

The trade-off analysis approach assumes that a group rather than an individual will make the planning decision. It is an especially useful technique when there does not exist social consensus regarding strategic actions, so that controversy arises about different possibilities, and uncertainty affects the relative attractiveness of alternative strategies. Trade-off analysis recurs to the strengths of different tools of System Analysis along the different steps of the process. Those tools are utilized in an interactive manner so that the relevant stakeholders evaluate the impact of different alternatives in the objectives and attributes that are important to each stakeholder, in an open way that exposes the various trade-offs that exist in choices among options. The trade-offs are characterized using measures of both an attribute's absolute magnitude and its variability across alternatives.

In regards uncertainty, trade-off analysis addresses it through the examination of the robustness of the different alternatives in the context of possible futures. It is necessary to examine a large enough range of those futures to asses the possible behavior of optional strategies. In fact, this is an experiment where the emphasis is on controlled

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[52]See for example Clinton James Andrews: "Improving the Analytics of Open Planning Processes: Scenario-Based Multiattribute Tradeoff Analysis for Regional Electric Power Planning", on which the main lines of this discussion on multiattribute trade-off analysis are based.

experimental conditions, which requires that all conditions are held constant except for the one factor being studied. To study several different factors it is necessary to run a number of controlled experiments. However, there are an infinite number of factors to control, so that an infinite number of controlled experiments would be needed to be sure of the results. It is then necessary to bound the analytic task. The number and characteristics of the scenarios[53] to be analyzed should depend on the relevant actors of the planning process; their best and worst expectations of each participant must be taken into account. Within this context, the approach of controlled experimental conditions may be maintained by changing one factor at a time between scenarios. Combinations of specific uncertainties and alternatives that are of especial interest to the participants must be included in the analysis.

A possible future can be defined as the occurrence of a unique combination of independent uncertain events. In the case of waste management in the MAVM uncertainties may include economic growth, the relative price of energy, environmental regulations, governmental structures, political changes, technological changes, etc. For modeling purposes, a possible future can be defined by the vector or values assigned to those uncertainties. Thus one possible future would have high economic growth high fuel prices, existing environmental regulations, a planning structure suited for metropolitan action, a plural political atmosphere and stable technology. Another possible future might differ by only one uncertainty value, for example, fuel prices, assuming the same state for all other uncertainties. For the specific case of trade-off analysis, there are several reasons why it is better to model discrete possible futures rather than a probabilistic continuum: a) It is possible to learn about the behavior of the system for combinations

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[53]A semantic note: I have selected here to utilize the meaning of "scenario" as that of a combination of future events that, in general are exogenous to a certain action. Some technical papers utilize the word as to mean the combination of alternatives for action and a future combination of events, probably to account for the effect that the action has in the future events. This concept is considered here in the outcome of the alternatives in terms of the objectives.

of alternative strategies and uncertainties, when this are discretely defined. To constitute a learning process is one of the main attributes of the propose planning process, b) It is easier to understand specific possible futures constituted by independent uncertainties., c) Different actors can concentrate on those scenarios that are more relevant to them, and d) The relative probabilities of the scenarios can be easily changed during subsequent analysis.

In trade-off analysis individual members of the collective decision-making group may be assisted in sorting alternatives, according to their own preferences. Preferences may change as additional information is provided, and new options can be generated by the participants to be included in the next iteration of the process. In latter stages consensus building efforts may be assisted by graphical performance profiles and pairwise dominance comparisons, similar to those utilized in multiobjective analysis, that help the decision-makers to weed out alternatives that are identified by all of them as clearly inferior. Explicit analysis of the tradeoffs between alternatives could allow compensation packages to be developed addressing the concerns of those that stand to lose something from the implementation of some of the alternatives. Equity concerns can thus be made an integral part of the analysis and decision-making processes. This type of approach has the advantage of being "open" as opposed to "black box". All of the participants would know how the favored alternative was chosen, and of the trade-offs involved in that choice. Choices would be made directly by the actors, rather than by a mathematical programming technique that simulates their preferences. The decisions are thus more likely to be robust, based on its acceptance by all the participant actors.

Another interesting feature of multiattribute trade-off analysis is that, depending on the type of tools utilized it may avoid the difficult task of monetizing the intangible impacts of a strategy, by making impacts explicit in their original units, whether they may be pesos per ton of waste handled, or number of alternative access routes to a final disposal facility. This approach reduces the subjective content of the planning effort, and allows the intermediate results to remain useful to more of the stakeholders. Since

different parties care more about some attributes than others, this approach allows them to quickly rank options according to their own preferences based on performance along their favorite attributes. Multiattribute evaluation also assists parties in understanding the behavior of the system, and in identifying the characteristics of dominant strategies.

This type of analysis presents important programming and computing demands in order to integrate models of subsystems to allow for the rapid evaluation of a large number of alternatives. As for the demands on analytical capabilities, it is one of developing the efficient, effective means to utilize the data amassed during the multiattribute scenario simulations.

It must be realized, though, that for all its advantages in dealing with collective decision making processes, multiattribute trade-off analysis is an expensive, time consuming and difficult undertaking, that should be attempted only when a significant level of public participation will significantly improve the robustness of the selected strategies through the improvement of the efficiency, equity, stability and general wisdom of the decision. Multiattribute trade-off analysis could well be the best approach for the definition of strategies for waste management in the MAVM. Smaller, less encompassing projects, may not benefit form the utilization of this method.

As a summary, and in very general terms the recommended procedure for a collaborative negotiation process, as described above, involves the following steps:

- Identify the relevant actors and involve them in the planning process from its beginning.
- Model the physical system. This is essential to understand the interplay of the technical and economic variables involved in the process. For this purpose either an analytic or simulation model of the waste management system must be developed.
- Define the noninferior options. For this purpose multiobjective optimization is an useful tool.

- Determine the individual preferences of the actors. Multiattribute analysis is adequate for this purpose.
- Explore the possible trade-offs. This is an information gathering activity. In order to find opportunities for trade-offs it is necessary to understand which objectives or attributes are valued to what extent by the different actors, and therefore, where it lies the possibility of mutually beneficial exchanges.
- Conduct negotiations towards a collectively satisfactory solution. Obviously this is an activity that must be carried out by the actors themselves in an appropriate environment, often with the support of a neutral negotiator and the analyst that may provide additional information. The outcome of this step should be the selection of an effective, robust strategy that is acceptable for all the actors.

Because of the many complexities of the present and expected waste management system in the MAVM, it must be concluded that collective decision making utilizing multiattribute trade-off analysis, is the most adequate procedure for the search and selection of robust strategies regarding that system. Collective decision making, in the way it has been described here, stresses the open approach to the planning process that, as it was concluded in Chapter 6 is the most suitable for the case at hand, and makes it possible a balanced utilization of the available Systems Analysis tools along the different stages of the process.

Chapter 8 presents the proposal for a step-by-step procedure for waste management strategic planning in the MAVM, based on a collective decision making approach.

8. A Procedure for Waste Management Planning in the Metropolitan Area of the Valley of Mexico.

Along the present work, a definite proposal for a methodology has been developed for the search and selection of robust solutions for waste management and disposal in the MAVM. The proposal is based in the specific characteristics of the -complex- waste management system in the MAVM, and includes: a) A concept of planning appropriate for the present state and expected general evolution of that system, b) A decision-making structure adequate to the characteristics of the proposed concept of planning, and c) The use of the tools of Systems Analysis, as an essential support for the decision making process.

The concrete application of the methodology should take into account the following considerations, derived from the characteristics of the system:

- An open-planning approach, utilizing collective decision making, and multiattribute trade-off analysis, is the most adequate in the case of planning for waste management in the MAVM.

- It is necessary to include in the search for robust alternatives, those derived from a metropolitan integrated approach, that seems to offer clear advantages in some respects, when compared with an independent approach by each of the political entities involved.

- A wide range of technological options must be taken into consideration in the analysis, as different technologies might be preferred in different scenarios.

- Possible strategies must include the possibility of siting facilities not only within the Federal District and the metropolitan territory of the State of Mexico, but also in neighboring area, both inside and outside the Valley of Mexico. Appropriate locations exist there (for an example, see Figure 8.1), and in the near future, their utilization might become essential for satisfactory waste management.

The present chapter presents a step-by-step procedure for the application of a collective decision making approach in the case of planing for a system constituted by transfer stations, processing facilities of different technologies, and final disposal facilities.. It is assumed that a governmental body of the characteristics discussed in Section 6.6, hence forth designed as the "Organism", is already in operation, and is in charge of the coordination of the planning effort, with the support of an analyst (the "Analyst") that can be part of the internal structure of the organism, or preferably, an independent, neutral party.

The general steps proposed for the process (See Section 6.4) are as follows:

- Identify the relevant actors or stakeholders that directly influence the decision making process.

- Formally incorporate the relevant actors to the process.

- Define the issues and specific objectives on which the analysis should concentrate. Define the attributes that will be used to compare the performance of alternative strategies.

- Gather or develop the information that will be required for the process.

- Generate alternative strategies for waste management in the Area.

- Develop scenarios to take into account uncertain future events.

- Define the performance of the alternative strategies when faced with the different scenarios.

- Select non-inferior strategies in terms of the different objectives.

- Explore the behavior of the system by observing the possible tradeoffs between attributes for the different non-inferior strategies for the diverse scenarios. Try to develop better strategies based on this information.

- Asses the preferences of the participants by observing which strategies are acceptable to each party, and how they ponder the various attributes relative to one another.

- Repeat the above steps as necessary.

- Seek consensus for one strategy.

In the following paragraphs the above listed steps are described in some detail as regards its contents, the participants, and the analytic tools utilized in each of them.

1. Identify the relevant actors or stakeholders that directly influence the decision making process. For the case of the MAVM, the participants are numerous. They should include representatives for each of the following organisms:

- Federal Government.
- Government of the State of Mexico.
- Municipalities of the State of Mexico that a preliminary evaluation has

defined as possible locations for the siting of metropolitan facilities. This municipalities should be considered in general as a group, with, for example, two representatives in all the discussions. In certain discussions, all the representatives from those municipalities should be present.

- Other municipalities of the State of Mexico, which will be users of the system of facilities. Also represented in the form described immediately above.
- Government of other states being considered (for example Hidalgo, Queretaro, and Morelos), either as users of the metropolitan facilities, and/or as possible locations for those.
- Municipalities of the above mentioned states, represented as discussed for the case of the municipalities of the State of Mexico.
- Associations of neighbors of the areas that could be affected by the facilities.
- Environmental NGOs, or preferably, federations of those, known by its balanced, responsible approach to this type of issues.
- Business guilds.
- Labor Unions directly related to waste handling activities.
- Relevant scavenger's associations.

The number and diversity of the participants, reveals the magnitude of the coordination effort required, as well as the characteristics that must be fulfilled by the Project Manager and his or her team, that would be in direct charge of the success of the process.

The organism would also be responsible, in this stage, of selecting the analyst, as well as an advisory body, that should be constituted by members of respected professional associations, such as the CICM or the SMISA, and reputable members of the scientific and academic communities. Participant organizations could also have their own particular advisors, but not as official participants in the process.

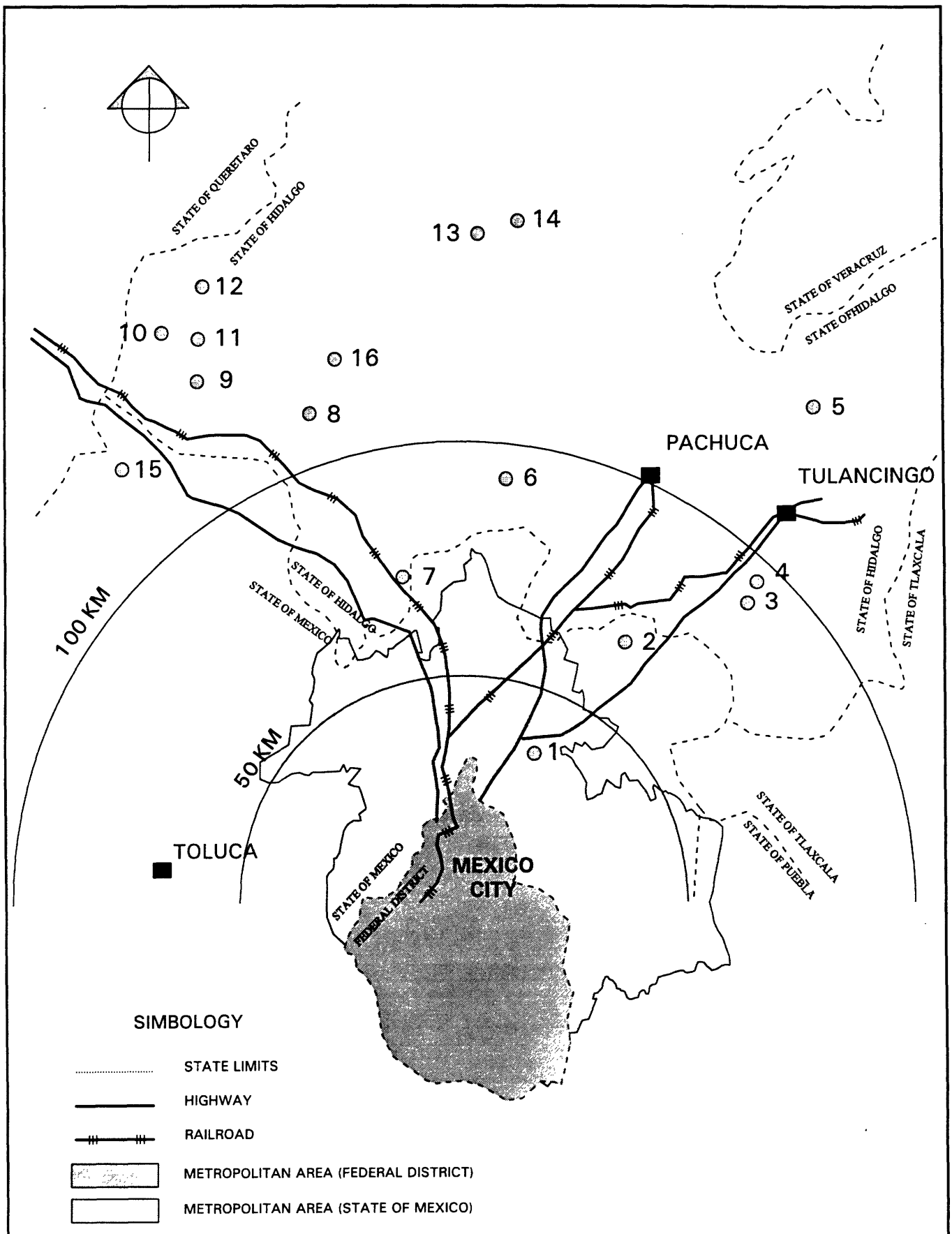

FIGURE 8.1.- SOME POSIBLE SITES FOR FUTURE WASTE MANAGEMENT INSTALLATIONS

2. Formally incorporate the relevant actors to the process. Parties of the planning process would be incorporated by strict invitation from the organism, even if membership should be maintained flexible, according to the evolving needs of the process. A formal meeting should be used for the constitution of the planning body. This meeting could also be utilized for introduction of the analyst, and of the advisory body, as well as a preliminary assessment of the position of the participants regarding broad strategic alternatives.

3. Define issues and specific objectives on which analysis should concentrate. Define the attributes that will be used to compare the performance of alternative strategies. In this step, the role of the analyst is to support the direct stakeholders so that they can articulate their objectives regarding the waste management system. It is also the analyst's responsibility to understand the positions of the participants. For this purpose the analyst should provide examples of issues and attributes -economic, environmental, equity, flexibility, etc- to facilitate discussions on the formal meetings, coordinated by the project manager, of the group of participants. Questionnaires sent by the analyst to the participants may allow them to consult issues with their constituents, and to express in their answers additional issues, or views that a particular participant might consider as too controversial to be openly discussed in the collective meetings.

The final result of this step is a set of primary issues, each of them paired to a concrete attribute, that will be utilized to asses the performance of the strategies. A first effort should be made in this step to priorities the set of objectives that have been selected by the participants. This would shed light on the "best alternatives to a negotiated agreement" ("Badness", in the jargon of negotiation), of each of the stakeholders.

4. Gather or develop the information that will required for the process. So as to ensure the efficient support of all participants in the task of information gathering, and avoid subsequent doubts on the validity of the information, open meetings should be held

to discuss the kind of information that will be utilized for planning, the relevant sources, and the needs to develop additional information. The actual gathering and development of information would be a direct responsibility of the analyst.

Typical information to be utilized in the process is described in section 7.4.1. A considerable amount of available information for the case of the MAVM has been summarized in chapters 2 to 4 of the present work. Another kind of information that would be independently developed by the analyst in a closed manner might be that related to the assessment of the particular objectives of the participants, by some systematic method; this might later be used to give the analyst a general guide as to the possible outcome of the process; in addition, the ex-post comparison could result interesting, both form the theoretical and practical points of view.

5. Generate alternative strategies for waste management in the Area. In this stage, the analyst would support the group in a joint effort to identify alternative strategies that would comply with the objectives of the different participants. It is essential that the set of alternative strategies take into account the objectives of all participants, even if that leads to some strategies that are mutually exclusive. It is the work of the analyst to identify, as much as it is possible in this stage, intermediate strategies that could be later used for negotiation purposes.

6. Develop scenarios to take into account uncertain future events. This step must be developed collectively. Scenarios are defined here as the combination of possible future events[54]. A certain strategy when confronted with a scenario will produce certain outcomes in terms of the attributes being analyzed. This permits the evaluation of the performance of different strategies across a variety of uncertain futures. Because scenario analysis will involve considerable computational effort, it is important in this step that the participants, with the support of the analyst, define collectively the scenarios most

[54]See comment relative to semantics in the immediately previous note.

important for each of the stakeholders, that should be included in the analysis. Scenarios that might be relevant in the case of the MAVM are presented in section 7.4.6.

7. Define the performance of the alternative strategies when faced with the different scenarios. Mathematical programming such as that discussed in Section 7.4.1, must be intensively utilized in this step, with analysis being carried out in parallel, of the effect of the alternatives on attributes that cannot be included in mathematical models. As it was discussed in section 7.4.6, the aim of this step is to supply a well balanced experimental sample of all the options, so that within reasonable limits, no effort should be spared here. Extreme strategies, such as "no incineration", "minimum landiflling", "no intermediate processing", should be considered here because they serve as points in the space of solutions to which the participants may later relate the more realistic intermediate strategies. This step is a responsibility of the analyst. However, as it may happen that additional information will be required, collective participation of the group will be essential to validate the information utilized in the analysis.

8. Select non-inferior strategies in terms of the different objectives. For this purpose, multiobjective optimization, such as is described in detail in Section 7.4.3, must be carried out by the analyst, with the information generated in the previous step. Multiobjective optimization allows to make explicit the interrelationships that exist between the different objectives being considered in the analysis. The aim of this step is to eliminate clearly inferior strategies, that do not perform well in terms of any of the objectives, in order to center the open discussion that take place in the following step. Even if the task is carried out by the analyst, the results must be validated by the group.

9. Explore the behavior of the system by observing the possible tradeoffs between attributes, for the different non-inferior strategies for the diverse scenarios. Try to develop better strategies based in this information. This is an intermediate step, developed collectively, whose main aim is to develop a shared understanding of the tradeoffs involved in different choices, and to invent better strategies than those that have

been developed up to this point. This step is particularly useful as a collective learning experience for the participants, as they become more familiarized with the detailed implications of the strategies that have been collectively developed. An useful tools in this step is AHP, that, properly used, might support each of the participants in better understanding the effect of his relative preference for his objectives on the ranking of his preferred strategies, and prepare the way for negotiation..

10. Asses the preferences of the participants by observing which strategies are acceptable to each party, and how they ponder the various attributes relative to one another. This is a negotiation step, carried out collectively. By this time, participants will be bargaining on a smaller set of strategies on which they can concentrate, and with full knowledge of the outcome of each those strategies, in the face of the uncertainties addressed through scenario analysis, regarding the different objectives of the various stakeholders.

The above steps may be repeated as necessary, seeking for new strategies, until consensus is reached in a collectively selected strategy.

A few words on Decision Support Systems (DSS) might be appropriate here. DDS have been defined[55] as interactive computer programs that utilize analytical methods, such as decision analysis, optimization algorithms, program scheduling routines, an so on, for developing models t help decision makers formulate alternatives, analyze their impacts, and interpret and select appropriate options for implementation. DSS are the type of integrated tool that would be very useful in collective decision making of the kind being discussed here. However, the very definition of DSS suggests the difficulties and costs involved in their development and utilization. In this case, as in many matters related to Systems Analysis, the decreasing cost of hardware and the increasing power of software

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[55]See for example, Adelman, Leonard: "Evaluating Decision Support and Expert Systems", in References.

are making it possible for decision makers to use sophisticated problem-solving techniques. that are today more affordable than they were a few years ago. Many are now available on personal computers, thereby decreasing the implementation costs. Still, Decision Support Systems are not fulfilling most of the expectations created about them. Some of the reasons cited for this, are that, as in other areas of decision making, development is currently technology driven instead of requirements driven. Efforts must then be made to develop applications where practical problem-solving is the fundamental driving force.

9. Conclusions

The present work consists of three, interrelated parts. The first part is an introduction that sets the basic concepts in which the work is based. The second part, that includes from Chapter 2 to Chapter 5, of a descriptive and prospective nature, describes the present and expected characteristics of the different elements that make up the waste management system in the Metropolitan Area of the Valley of Mexico. Part three is constituted by Chapters 6 to 8, that develop in detail a proposal for a planning process for waste management in the area. The main conclusions of the work can be briefly stated as follows:

- Because of diverse demographic, institutional, economic, environmental social and political factors, waste management in the Metropolitan Area of the Valley of Mexico constitutes a complex system. Its complexity is a result, not only of the magnitude of waste generation, or of the number of the relevant subsystems, or of the number of the intervening variables, but also of the heterogeneity of those variables, and of the multiple interactions that exist among the different subsystems.

- A metropolitan approach to waste management decisions and actions in the area is essential. The present situation, based on institutional boundaries that are not congruent with the physical, demographic and economic boundaries of the system, is inefficient from the economic point of view, and unsatisfactory from the environmental perspective. Economic and environmental restrictions, as well as social pressures make of the

metropolitan approach a need. Particular objectives of the two more important direct institutional actors, the Federal District and the State of Mexico may soon coincide in a metropolitan approach: the territory of the Federal District will soon no longer be apt for additional waste processing and disposal installations, and the State of Mexico would benefit from the increased efficiency of a regional approach, as well as of the more important economic and technical resources of the Federal District.

- Due to diverse uncertainties, of an economic, regulatory, social and political nature, alternative strategies for waste management in the Area must include the consideration of a wide range of technologies. Different scenarios point to the selection of diverse combinations of competing technologies, and this must be accounted for in the planning process.

- Given the expected demographic and economic evolution, as well as the present and expected environmental constraints, in the medium and long range metropolitan waste management in the Area must consider solutions that, for the treatment and final disposal subsystems include not only the territory of the Federal District and the State of Mexico within the Valley of Mexico, but also other areas as well, some of them located in the neighboring states of Hidalgo, Queretaro, and Morelos. Favorable sites exist there, and railroad transportation might become economically feasible in certain scenarios.

- Even if diverse economic, political and regulatory circumstances have hampered an extensive participation of the private sector in waste management activities in the Area, it is foreseen that the dynamics of the system will soon favor a more active role for private companies in this field. In the Federal District, private participation is expected to grow

rapidly mainly in downstream activities, such as waste processing and disposal, with a more gradual growth in the collection activities. A more politically open atmosphere might be found in the State of Mexico for the participation of private companies in integral waste management activities, although with important economic constraints.

- As a result of the many diverse actors, of their many different objectives and interests, and because of the dynamic evolution that the political system is expected to undergo in the near and medium terms, conflict will be present in all attempts to change the present characteristics and behavior of the waste management system in the Area.

- A planning system for waste management in the Area must include three main components, all of them suited for the expected characteristics of the system and congruent among them: a) A planning process, b) An organizational structure to house and implement the process, and c) Adequate tools and procedures for decision making.

- The main characteristics for an appropriate planning system are: a) A wide institutional and geographic approach, searching for solutions of a metropolitan nature, b) An open nature, providing for the participation of all relevant, real stakeholding actors, during the different stages of the process, c) To constitute a framework for bounded disputing among the diverse actors with conflicting interests, in the search for consensus in decision making, e) To be intimately linked to a strong organism, responsible for the implementation of plans, and f) Adequate, active utilization of the existing tools of Systems Analysis.

- The organizational structure should have the nature of a decentralized public corporation, that responds to a permanent metropolitan commission

constituted by the main governmental actors, but that has wide operational independence, as well as the grounds for financial self-sufficiency. Its corporate philosophy is based in the requirements of financial stability, in the need of an open, participative and balanced approach to decision making and actions, and in the support of strong technical capabilities.

- Collective decision making, utilizing multiattribute trade-off analysis, is the most adequate procedure for the search and section of robust strategies in planning for waste management in the Area. Collective decision making in the manner it is proposed in the present work, stresses the open approach to strategic planning that is the most suitable for the case at hand, an makes a balanced utilization of the available tools of Systems Analysis along the different stages of the process. Interesting developments in this area are taking place at this moment. These include practical applications of simulation approaches, such as Systems Dynamics, and they must be watched closely, as they may represent a breakthrough in decision making in the field of waste management strategies. Another interesting tool that might facilitate decision making is Decision Support Systems (DSS), that, as technological development makes it easier and less costly, might also become useful for practical, real life applications in planning for waste management in the MAVM.

A final reflection on the subject is that, notwithstanding the increasing sophistication of administrative science, and the diversity of tools available for the analysis of systems, a widespread concern is felt in diverse instances, both for the lack of a more extended utilization of systematic approaches to decision making, and for the lack of implementation of the solutions that result form systematic analysis, whenever it is carried out. Diverse causes have been cited for this situation. However, it cannot be rationally denied that a systematic, well informed approach to decision making, that takes into account the relevant outcomes of proposed actions, and its effects on the

different actors, is the best way for the search and selection of robust actions in any field, that of waste management included. It is to be expected that a closer collaboration between the scientific and academic community, practicing professionals, and decision makers, as well as the utilization of permanent, adequate channels of communication with the general public, will lead to a better common understanding of the issues involved in systematic decision making, so that this approach becomes increasingly more problem oriented, and widely utilized in real life situations in the Metropolitan Area of the Valley of Mexico and elsewhere.

Acronyms (In order of appearance)

MAVM Area Metropolitana del Valle de México.
Metropolitan Area of The Valley of México.

SEDESOL Secretaría de Desarrollo Social.
Ministry of Social Development.

INE Instituto Nacional de Ecología.
National Institute of Ecology.

PROFEPA Procuraduría Federal de Protección al Ambiente.
Federal Agency for Environmental Action.

DDF Departamento del Distrito Federal.
Departament of the Federal District.

ARDF Asamblea de Representantes del Distrito Federal.
Federal District´s Assemnbly of Representatives.

LSPEE Ley del Servicio Público de Energia Eléctrica.
Law for the Public Service of Electrical Power.

LGEEPA Ley General del Equilibrio Ecólogico y Protección Ambiental.
General Law of Ecological balance and Environmental Protection.

NTE Normas Técnicas Ecológicas.
Technical Ecological Norms.

NOM Normas Oficiales Mexicanas.
Official Mexican Norms.

SECOFI Secretaria de Comercio y Fomento Industrial.
Ministry of Commerce and Industrial Promotion.

CFE Comisión Federal de Electricidad.
Federal Electric Power Commission.

DGS Dirección General de Servicios Urbanos.
General Directorate for Urban services.

SGO Secretaria General de Obras.
General Secretariat for Public Works.

SGPE Secretaría General de Planeación y Evaluación.
General Secretariat for Planning and Evaluation.

DGPP Dirección General de Programación y Presupuesto
General Directorate for Programming and Budget.

SGB Secretaría General de Gobierno.
General Secretariat for Internal Affairs.

SGACM Secretaría General Adjunta de Coordinación Metropolitana
General Adjunct Secretariat for Public Works.

STDDF Sindicato de Trabajadores del Departamento del Distrito Federal.
Union Workers of the Department of the Federal District.

UPTBDDF Union de Pepenadores de los Tiraderos de Basura del Distrito Federal.
Union of Scavengers of the Federal District Dumps.

SMISA Sociedad Mexicana de Ingenieria Sanitaria y Ambiental.
Mexican Sanitary and Environmental Engineering Society.

CANACO Camara Nacional de Comercio.
National Chamber of Commerce.

CANACINTRA Camara Nacional de Industrias de la Transformación.
National Chamber of Manufactuting Industries.

CONCAMIN Confederación de Camaras Industriales.
Confederation of Industrial Chambers.

COPARMEX Confederación Patronal de la República Mexicana.
Confederation of Business of the Mexican Republic.

PRI Partido Revolucionario Institucional.
Revolutionary Institutional Party.

PAN Partido Acción Nacional
National Action Party.

PRD Partido de la Revolución Demcrática.
Democratic Revolution Party.

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