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The Lanzarote Society and Tourism's Metabolism

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Chapter 1 - Introduction

Since the first national park was created in the world, the Yellowstone National Park (created in 1872 in the Northeast region of the Wyoming state, USA, according to preservationist ideas), protected areas have been matter of broad debates concerning the function of natural areas and the objectives and purposes of protecting them.

At the end of the nineteen century there were two main views of "natural world" conservation, which have been synthesized by Gifford Pinchot and John Muir proposals. Pinchot created the resources conservation movement, suggesting the rational use of nature. In his conception, natural processes are frequently slow and consequently, management actions should be implemented by men with the purpose of turning it efficient. According to Pinchot's idea, conservation should be based in 3 principles: the use of natural resources by present generation; waste prevention; use of natural resources for benefits of most citizens (Diegues, 1998, p.29). "The idea was to control nature and serve the material interests of humankind but with an eye to long term needs" (Nash, 1989, p.9). On the other hand, John Muir's ideas would form the called preservationism movement. Challenging anthropocentrism and defending passionately nature rights, Muir believed man should not value himself more than a small part of one great unit of creation. According to Muir, nature has many values besides those perceived by men, and hence, nature has a right to be cared for, regardless of any man's judgment. Muir was a strong protector of wilderness and a precursor of the current deep ecology movement (see also Guha, 2000).

Nowadays, the presence or not of humans within protected areas is still causing controversy. On the on hand, there are the deep ecology defenders, who argue for the preservation of nature as wilderness, i.e. nature conservation in total absence of people[1]. On the other hand, there are people who believe that the value of nature is to serve the human purpose. That is, in absence of people, nature would have no value. Between these two extremes, there are many people who believe in a intermediate solution between preservation and exploitation.

Indeed, the diversity of schools of thought and the different opinions about the role of protected areas in the process of social and economic development were clear

[1] According to the 1964 US Wilderness Act, wilderness is a place where man himself is a visitor who does not remain.

at both World Congresses on National Park, at Bali in 1982 and at Caracas in 1992 (see respectively McNeely, 1982, p.1 and Kemf, 1993, p.6). No single answer about such role appeared sufficiently convincing, making clear that the only certainty is the necessity of a diversity of approaches to protected areas (McNeely, 1982, p.1).

Recently it has becoming more and more accepted the idea that even when a natural area is left untouched, with no humans in there, it is suffering effects from the human way of life. For obvious reasons, this point of view is raised when environmental impacts attain a global scale due to "modern development", principally in the western and northern countries of the globe. Climate change, acid rain and air pollution are impacts affecting protected areas with no direct human contact. Areas where there are people living inside or close to show even more and different impacts. Actually, the natural environment, characterized by protected/preserved areas, and humans are linked by a series of variables working in different time and space scales. In this context, neither of the two extremes of the debate involving protected areas seems to provide a framework to guide a management plan in such a way that all the relevant values and perspectives are contemplated.

Since there is a great number of variables and diffuse interests, there is not a single optimum management strategy which will optimize all of them and maximize satisfaction of everybody. Management has to achieve a good compromise among variables in such a way that an equilibrium among parts are attained. The central point for the debate concerns the interaction of humans with nature. On the one hand, protected areas must be regulated to avoid impacts and to preserve the reasons why they have been protected, and on the other hand, the isolation of the area causes a broad range of conflicts, going from international and intergovernmental conflicts to local subsistence problems.

Clearly, the diversity of values cannot be indicated only by monetary valuation. Indeed, natural areas have been protected with the purpose of maintaining the ecological, cultural and/or aesthetic values of such areas, avoiding the negative effects which the market driving forces may cause on them. Nevertheless, monetary values, expressed through income generation, are a necessary, however not sufficient, condition to attain development. Thus, keeping a natural area isolated from the market forces, as nature reservoir, will block the possibilities to development. Since most protected areas around the world have people living within their boundaries or close to, maintaining them away from the development stream implies to condemn such people to ostracism.

Furthermore, an area is kept away from the market forces by the uses of market forces itself. Thus, governments who have to protect areas within their territories are confronting monetary costs like opportunity costs, supervision costs, social costs and so on. These features involving protected areas are not desirable. They are neither ethical from the population point of view nor convenient from the government point of view.

Nowadays, many protected areas are presenting problems to deal effectively with their initial objectives. Demographic pressure increases the government's costs which moreover has problems to supply population with the adequate living conditions. Opportunity costs play an important feature in this pattern. In this situation, the necessity for finding economic alternatives to protected areas management is increasing. This economic alternative has to promote not only economic growth, but has also to assure the maintenance of environmental and socio-cultural values. That is, economic activities in protected areas have to promote development in a broad ecological-economic sense. According to this view, economic growth and development are clearly different things. While economic growth is a function of produced capital only, development depends of environmental, social and cultural values. Thus, whereas the increasing produced capital stock implies economic growth, it does not assure development. As a result, economic growth will not always enhance environmental quality. It will depend on the composition of inputs (including environmental resources) and outputs (including waste products) (Arrow et. al., 1995) of the economic system and on trade-off between produced and natural capital.

Tourism, particularly ecotourism, has been suggested to be an activity which can deal effectively with such conflicts (see for examples Myers, 1988; Terborgh, 1992; Pearce and Brown, 1994; Lindberg et. al. 1997 and Gössling, 1999). Since the main input to ecotourism is conserved nature, and it does not require great transformations of natural capital into produced capital in the productive process, ecotourism is believed to create the conditions for ecological-economic development. Nevertheless, affluence of people to conserved areas is always followed by many interactions. By the simple contact with local population, tourism is changing local behavior and providing different perspectives of living standards. This situation may change local patterns and cause a cultural degradation in the long term. Moreover, tourism usually is generating more money than any other activity in the area, and consequently, it is common to see a shift on the economic relations in protected areas which have been exposed to tourism. Traditional activities are abandoned in favor of

activities related to tourism, usually services. This may carry an important change on the local land use patterns. Local environment is suddenly exposed to a intense visitation which will cause perturbation to some degree, depending on the quantity and the quality of the tourists. And obviously, tourism signifies an important income source to protected areas.

Thus, ecotourism is a potential activity to promote economic growth on protected areas. Ecological-economic development, however, is definitely not assured by the simple implementation of the activity. It will depend on the number of visitants, the type of interaction they perform with local society, their consumption patterns, and the local ecosystem fragility.

These factors are represented by many variables, which may be combined in very diverse ways, producing different results. For example, quantity and quality (which determines the type of interaction people have with the environment) of tourists may be combined in different levels with similar or different results. A higher number of tourists combined with a less harmful behavior towards the environment may be more satisfactory than a strict restriction to visitation. Or a few people with a given behavior may be equivalent, in terms of environmental pressure, to many people with a different behavior.

Nowadays, in the island of Lanzarote tourism is the main economic activity while there are high environmental and cultural values, many of them "protected" by law. Therefore, it will be taken as an example to carry a field study. Lanzarote is one of the Canary Islands, which are located in the Atlantic ocean, close to the Morocco coast, and it is Spanish territory. In the last decades, and mostly in the last 10-15 years, tourism has increased in Lanzarote to such an extent that it is currently the activity which totally dominates the island's economy. It is illustrative that in 1999 the average number of tourists in the island daily was half of the residents – 49,997 and 90,375[2] respectively. Consequently, environment pressure and cultural impacts due to tourism may be very high. Furthermore, tourism is a strong driving force to shift local land use patterns. Great part of its territory has some kind of legal protection, and the island as a whole is a Biosphere Reserve within the UNESCO's Man and the Biosphere (MAB) program.

[2] Number given by the Canary Data Institute, ISTAC.

There is a broad debate within the local society concerning tourism. Some undesirable impacts have been felt by local population as consequence of tourism, impelling the discussion on its limits. In 1998, the local government approved the "tourism moratorium", which established a maximum limit to the number of tourists and accommodations for the following 10 years. To some degree, imposing a limit to the increase of tourists is to recognize that economic growth alone will not certainly assure development, i.e. that the quality of both tourists and residents may indeed decrease.

If it is true that the main concern under the political decision is local development, the relevant manageable variable is not necessarily the number of tourists or accommodations allowed. The relevant information in this case is how the different values recognized are changing or being affected. Or in other words, the important information is to know if values are maintained. Since many of these values are not substitutable – for instance, loss of welfare due to landscape degradation is not totally replaced by income generation – their changes have to be assessed separately. That is to say, the issue is not to assess changes in the aggregated capital (the produced capital – k_p – and the different forms of natural capital – k_n), but to analyze changes in the different values separately in such a way as to understand substitution among them. In the end, the level and the characteristics of substitution accepted are political decisions, and should assure a good compromise among values which will conduce to development.

The mentioned different values cannot be measured in the same unit. For example, while economic growth may be measured in monetary terms, the impact on landscape is better assessed by descriptions like good, bad, or high and low (impacts). In other cases, like agriculture for example, there are many scales of analysis implied. Income changes in the agriculture sector is easily measured in monetary terms. Land occupied is easily measured in extension. But biodiversity loss or erosion increases are assessed in other unit of measurement.

Therefore, decisions have to be based in a multidimensional description of the system. Thus, a first necessity is to design an information system able to describe different perspectives of the area assessed. Further, different information, in different scales, will have to be linked in such a way that allows decisions to be taken.

While economics carries out the task of measuring economic flows, a comprehensive set of physical measures is necessary to provide information on other

perspectives of the same system. One method to systematize physical accounts is the Material and Energy Flow Analysis (MEFA). Flows of material and energy from the environment into the human system and vice-versa may be quantifiable in terms of their size and composition. Analyzing how these flows pass through the system within the framework of Society's Metabolism (how they enter into the system, how they are "metabolized" within the system, and how they are "excreted" back to the environment) may provide valuable information about consumption and production patterns and about type and change in land use. Furthermore, it allows a comparison among the System's local productivity and the local requirements (in both sides, inflows and outflows), allowing an analysis at a global scale, i.e. verifying if the local system internalizes global impacts or externalizes the local ones.

The Society's Metabolism approach will be applied to Lanzarote, intending to systematize information of flows throughout the system and to provide stakeholders with plausible arguments and variables to guide management actions. That is to say, to provide stakeholders with information which allows them to manage other variables more relevant than number of people. Moreover, flows will be separated into residents and tourists' flows. Thus, the usefulness of MEFA to assess tourists impacts on tourism sites in general and in protected areas in particular will be verified .

Chapter 2 – An Introduction to The Field Study: Lanzarote

2.1 The Local Context

2.1.1 Physical Description

Lanzarote[3] is the most north-eastern island of the Canary archipelago, located 140 km distant from the nearest African coast, Cape Juby on the Morocco coast. The island is found between the parallels 29º25' (Punta Mosegos, Alegranza) and 28º50' (Punta del Papagayo) latitude north, and between the meridians 13º20' (Roque del Este) and 14º 57' (Punta Ginés) longitude west. In referring to Lanzarote, both the main island, named Lanzarote itself, and the nearby small archipelago named Chinijo – constituted by La Graciosa, Montaña Clara and Alegranza islands and by the Roques del Oeste (west) and Este (east) – are implied. Lanzarote, the island, is 862 km² – 58 km at its largest point and 34,5 km in its widest point – which added to the 43 km² of the archipelago Chinijo makes 905 km². Its mountains are modest, Peñas del Chache being the highest point at 670 meters.

Map 1 – Canary Islands

Source of the map: http://www.cistia.es/cabildo-lanzarote/mapa.html

The island is completely volcanic and has been created through many eruptions. Although the oldest sediments, dating from 60 million years ago, indicate there was movement deep in the ocean which permitted Canaries to arise, it was eruptions starting 15 million years ago which started to form Lanzarote as it is known today. The last eruptions on the island date from the XIX century – the eruption of 1824.

Map 2 – Lanzarote

Lanzarote is within a zone of hot and dry climate, where rain is very rare, with less than 200 mm/m² annually. This gives a semi-desert climate to the island. The low altitudes found in Lanzarote are a geographical feature which makes the climate different to the other Canary islands. Unlike in Lanzarote and Fuerteventura, the high mountains of the other islands form a barrier to the clouds which in turn form what is

[3] The description of Lanzarote is based mainly in the book "Lanzarote: Reserva de Biosfera" coordinated by Cipriano Marín and Alberto Luengo.

called a ‘sea of clouds’, favorable for rain. Furthermore ‘seas of clouds’ create conditions of lower evaporation rates and a humidity level which gives opportunity for vegetation growth. Lanzarote, on the contrary, has not such natural barriers and the ‘seas of clouds’ are not seen. Moreover, the trade winds do not meet any obstacles in their way, and hence, despite high relative humidity due to the humid and fresh air**,** rain does not occur.

Temperatures are very stable through the year, varying between an average of 17ºC in January-February to 23ºC in the summer time. The sun shines an average of 290.6 hours in July, the sunniest month, and 200.8 hours in December, the least sunny month. The monthly average is 244.4 hours of sun.

Water availability is obviously low, a consequence of rain absence. Few water sources exist in the *Risco de Famara* (Famara Massif) region and in the center of the island. The supply, however, is insignificant in the face of the needs of the island’s population. There is a small usage of underground water, with most wells located in the Haría zone. The majority of the underground water comes from 4 of 7 galleries in the Famara massif, where the exploitation exceeds the replenishment with a consequent decrease in stock. The highest rates of exploitation are 10 l/s. Undoubtedly the most important source of potable water is desalinization of sea water. According to the “Insular de Aguas de Lanzarote” (water company of Lanzarote) desalinization has increased on the island from 1.76 hm^3 in 1977 to 10.2 hm^3 in 1996 (an increase of 580%), with an average daily consumption increasing from 7,808 m^3 in 1985 to 12,188 m^3 in 1991 and 20,876 m^3 in 1996 (an increase of 156% and 267% respectively, far higher than the population growth).

2.1.2 Human Settlement

From the first settlements until recent history, human occupies have had to interact and deal very strictly with the natural conditions and scarcity of resources. It has been done well by the natives and colonists on Lanzarote, who developed very interesting adaptive systems of agriculture.

There is not much knowledge about aboriginal occupation in Lanzarote – the *Majos*. Their origin is agreed by most historians to be the north of Africa. The date these people arrived in the Canary Islands, however, is not certain. Aborigines in Lanzarote had sedentary settlements, where they could control agriculture and pasturing, their main economic activity. Gathering plants and the exploitation of

coastal/marine resources complemented island economy before European conquest (Marín and Luengo, n.d.; Rodríguez, 1999; Pérez, Betancor and Gaspar, 1999). Until recently, in more or less the same way and subject to natural accidents, Lanzarote people have followed the same general patterns.

The first European settlements occurred in the first years of the XV century, around the year of 1402, but only by 1479, with the signature of the Alcazovar treaty by Portugal and Castilla, were the Canary island finally under the domain of the Castilian crown.

2.1.3 Economy

Before European settlement, the aboriginal economy was based on the agriculture and the pasturing, complemented with the gathering of wild plants and shellfishes, the fishery and the capturing of small animals – lizards, birds and even small insects. The main agriculture product cultivated by the *Majos* was the barley. Although there is mentions about wheat and broad bean cultivation (Rodriguez, 1999), it seems these products were not cultivated before the European arriving. There is reference on the literature that wheat was brought to Lanzarote from the Iberian peninsula by the first conquers, specifically by Juan de Bethencourt in a trip he made to Seville in 1404 (Pérez, Betancor and Gaspar, 1999). Additionally to the gathering and the agriculture production, the native people of Lanzarote completed their economy by the pasturing, mainly goats, sheep and pigs. Possibly, the pasturing was the main economic activity of the society, a result of a combination of difficult conditions to agriculture and the high adaptability of goats to the arid conditions (Pérez, Betancor and Gaspar, 1999).

After the conquest, island inhabitants dedicated themselves to cultivating a dominant product which could be commercialized outside of the island boundaries. Thus, they could concentrate efforts of attracting capital, technical labor force and transportation around a main product according to European interests.

The first main export product was, by the XVI century, the *orchilla* (*Rocella* ssp.), a lichen which is found in the cliffs, in the massifs' rocks and between the volcanic lava exposed to the ocean salt humidity. From this lichen a pigment is extracted to prepare paint which was appreciated in the European continent. By the XVII century the grape destined to wine production began to be cultivated in Lanzarote. At this time, *wine* and *orchilla* shared the exportation list from the island. Was after the

Timanfaya's eruption, in the XVIII century, that wine became the main exportation product. By the end of the XVIII century and beginning of the XIX, the combination of two factors, the conflict between Spain and England and the boom of textile sector in Europe, cause the *barrilla* to be the main export product, a plant used mainly to soap and paint production. Around 1810, *barrila* cultivation starts to decline. At this time, emigrants regressing from Mexico, brought the news that a small snail living in a cactus leaf had a great value due to the color pigment which is obtained from them and used to produce lipsticks and to dye fabrics. Thus, by the XIX century (between 1830 and 1880), this specific cactus was brought from Mexico and massively planted in Lanzarote. The *cochinilla* (*Dactylopius coccus*) became the island's exportation product. The fast expansion of their production associated to the discovering of the aniline in 1862 caused the prices to decline and the necessity for find a new exportation product to the island. This product was the onion, which until today, together with the grape, are the main agriculture products of Lanzarote.

2.1.4 The Agriculture Without Water

Since water is extremely rare in Lanzarote, the agriculture techniques as well as the seeds had to adapt to the arid environment and to the dry soil. There are in the island basically two types of agricultural soil which determine the techniques: the *jable* and the *enarenados.*

The *jable* is a calcareous sand from marine origin. It is composed by rests of shells and mollusks brought to the island by the wind and covers a clayey soil. The agricultural technique of cultivation on *jable* consists of opening holes in the sand until reach the clay layer. Then, dung and guano are putted with the seeds to be covered again by the same sand. The *jable* conserves and condense the humidity and works as a thermally isolation. Nowadays potato and watermelon are cultivated in this soil.

The *enarenado* technique is done in soil covered with volcanic ashes, which keep and conserve the subsoil's humidity. There are two types of *enarenados*, the naturals ones and the artificial.

The natural *enarenados* are located close to the recent volcanoes, where the ashes cover the preexistent vegetal soil. The high variability of the volcanic ashes' thickness makes difficult the cultivation in these areas, being necessary a layer varying between 0.2 and 2 meters. The species which can be cultivated in this soil type must have a deep root system which is able to cross the volcanic soil. The dominant

cultivation is the grape. The soil is prepared to the plantation through the opening of holes of 1 to 1.25 meters deep and the grape is planted in the organic soil. Thus, it is possible to have agricultural production in the most arid part of the island.

The artificial *enarenados* have the same function as the natural ones. The difference is that they are located in areas where there is no natural volcanic ashes. Thus, the seed are planted in the soil after it has been cleaned from stones and then covered by a 10 to 15 cm layer of volcanic ash. The dominant cultivation on artificial *enarenados* is onion, but there are also some melon, watermelon, leguminous, potato, corn and others cereals.

Grape Plantation on Natural *Enarenados* – La Geria Region

2.1.5 Demography

There is not many information about population in Lanzarote before the XX century. Despite that fact, it is well known that in the frequent crises, consequence of natural disasters, the local population used to emigrate. Initially, emigrations were to Gran Canaria and to Tenerife. Later, the inhabitants of Lanzarote looked for refugees on

the American continent. Argentina, Paraguay, Venezuela, Cuba and Mexico were the principal destinations of those people.

By the arriving of the Europeans in Lanzarote, the aboriginal population was of between 1,000 and 3,000 people (Val, 2001). In 1730, there was 4,967 persons inhabiting the island (Rodríguez, 1999). Data indicating precisely the population growth after that time was not found. Nevertheless, the population probably did not increase to a great extent. Deaths and emigrations caused by natural disasters were responsible for maintaining the population in a low growth pattern. In 1730, a strong eruption started at the Timanfaya volcano and continued until 1736, obligating the people to run to Gran Canaria. Later, in the dry season between 1766 and 1771, a third part of the population died (Rodríguez, 1999). Again, between 1831 and 1836, and between 1838 and 1840, another drought was felt in the island.

Thus, by the 1900 the population inhabiting Lanzarote was of 17,566 inhabitants. Along the XX century the emigration did not stop. Although there are no data about late emigration, the table 2.1 shows the census population of Lanzarote in this century. Table 2.2 shows the population recently.

Table 2.1 – Census of Lanzarote's Population on the XX century.

	1900	1910	1920	1930	1940	1950	1960	1970	1981	1991
Arrecife	3,082	3,764	4,758	5,118	7,733	9,178	12,886	21,906	29,502	33,398
Haria	3,101	3,196	3,763	3,533	4,772	4,491	4,150	2,968	2,555	3,199
San Bartolomé	1,860	2,067	2,153	2,234	2,651	2,923	3,305	3,462	4,753	6,798
Teguise	3,786	4,228	4,394	5,457	5,547	5,854	6,521	5,809	6,074	8,189
Tias	2,365	2,715	2,792	2,543	2,567	2,923	3,174	3,339	5,672	7,556
Tinajo	1,688	1,660	1,739	1,806	2,212	2,546	2,563	2,768	2,983	3,517
Yaiza	1,302	1,347	1,466	1,241	1,439	1,471	2,219	1,660	1,913	2,675
Lanzarote	17,184	18,977	21,065	21,932	26,921	29,386	34,818	41,912	53,452	65,332

Source: Spanish National Statistics Institute (Insitituto Nacional de Estadística – INE)

Table 2.2 – Population of Lanzarote (1996-1999)

	1991	**1996**	**1997**	Var. 96-97 (%)	**1998**	Var. 97-98 (%)	**1999**	Var. 98-99 (%)
Local Population	64,911	77,379	85,560	10.6%	84,849	-0.8%	90,375	6.5%
Tourist Average		44,018	45,544	3.5%	49,678	9.1%	49,997	0.6%
Total Population		121,397	131,104	8.0%	134,527	2.6%	140,372	4.3%

Source: ISTAC
Anuário Estadístico de Lanzarote, 1999.

By 1960 tourism appeared very slightly in Lanzarote, introducing the activity which would eventually totally dominate the island economy and put it onto the

international scene. After 1983[4] tourism assumed great proportions in Lanzarote, reverting the demographic tendency. This new demographic pattern is reflected in the tables 2.1 and 2.2 above. Since this population census account for the people who is leaving in the island and not only for the people who was born there, the accentuated increase in population after the 70s is reflecting not only the emigration decrease but also the immigration which began to arrive in Lanzarote associated to the tourism increase.

Such a tourism increase was quickly felt not only in the island's economy (income, employment, construction, etc.) but also in environmental and social features. The fragile local ecosystem, as well as the local culture, was suddenly exposed to a high external component which could not be dissociated of a strong impact. However this impact did not come without its associated problems. The negative impacts of tourism in Lanzarote on ecology and society raised concern in the local population led by the artist César Manrique. Since the 70s until 1992, César Manrique developed some 20 projects which are good examples of harmony between the constructed and natural environments. Expressed through his art and architecture, César Manrique impelled a broader debate concerning tourism and the development patterns of Lanzarote. Thus, when Lanzarote hoped to be declared a Biosphere Reserve, it had only to adapt the proposals which were already discussed in the island context to fit within the UNESCO's MAB program.

2.1.6 The Tourism Era – Lanzarote on the Biosphere

The inclusion of Lanzarote in the World Network of Biosphere Reserves, however, did not occur without an intensive debate about how it should be done. Lanzarote differs from other Biosphere Reserves due to both the strong interaction of its inhabitants with the physical environment and an economy strongly dependent on tourism. Thus, Lanzarote appeared as a place with conflicts of interests, with great beauty and nature richness (Enrique Pérez Parrilla, Lanzarote Cabildo President, In Marín and Luengo, p.7). For that reason Lanzarote is an experimental territory regarding sustainable tourism to the MAB program.

The increase in tourism of recent decades has reinforced the preoccupation in the society of Lanzarote regarding the limitations of the ecosystem in receiving such

[4] Between 1983 and 1990 tourists visiting Lanzarote pass from 200,000/year to more than 1 million/year (Marín and Luengo, n.d., p. 141).

amounts of people. Following current thoughts on tourism management, the idea took force in Lanzarote that the island and the touristic activity would be well balanced, and thus conveniently conserved, if the appropriate carrying capacity, determining the 'optimum' number of tourists, was determined. In 1997 the first political demonstration was put in evidence assuming that an uncontrolled increase in tourism may be not good. Inserted in the strategy for the Biosphere Reserve, the island's government – the Cabildo from Lanzarote – made public the idea known as the tourism moratorium. Thus, in march of 1998 was publicized the document for the debate of the Biosphere Reserve (Cabildo de Lanzarote, 1998e, p.56) stating:

> *"The limitation of touritic growth in Lanzarote is a key factor in avoiding a situation where the floating population increases surpassing the limits of the island's system, in being able to reestablish a demographic evolution assimilable, and to give time enough to the island's society to define, put itself in accordance and to orient at the future of the island.*
>
> *For these reasons, the Lanzarote on the Biosphere strategy proposal is to establish a moratorium in relation to tourism growth during the next 10 years according to the following reference criteria:*

- *The increase in the number of tourists who stay in Lanzarote daily will not be greater than 6,700 during the next ten years, and that the total number of tourists daily in the island is not higher than 51,000 visitors.*
- *As a consequence, during these ten years, the supply of tourist accommodation does not increase by more than 8,000 new places and does not surpass a total number of 61,300, encouraging, however, the substitution of old accommodation places, especially in puerto del Carmen."*

Later the limit of total accommodation places was increased to 66,589 with no explicit technical explanation.

The moratorium is controversial territory. Not all the whole population accepts it as the solution to the "problem" of touristic growth. On one hand there are the landowners who want to build tourist accommodations on their property. Indeed, since the moratorium was publicly known until the publication date – approximately 2 months later – some 6,200 projects for tourist accommodation were presented to the Cabildo de Lanzarote (El Guincho-Ecologistas en Acción, 1998). On the other hand there are ecologists who argue that the amount of tourist accommodation officially allowed to be built plus the 17,943 new accommodation places which have been

reclassified as residential[5] signify a possibility of maintaining the same growth pattern observed between 1988 and 1997. During this period 28,491 accommodation places were built in Lanzarote, while the moratorium allowed 10,707 more tourist accommodation places and 17,943 residential accommodation places, which adds up as 28,650 places (El Guincho-Ecologistas en Acción, 1998; Aguilera, 2001).

Nevertheless, the moratorium brought to light the debate about limits for tourism. Moreover, it established an "acceptable[6]" number of tourists for the next ten years in Lanzarote. The moratorium, as published by the strategy for the Biosphere Reserve, stating the island system's limit, could be interpreted as a first approximation for carrying capacity. The methodology and the foundations which were behind such a number, however, are not clear; in the same way it is not clear how the system's limit will be assured with this amount of tourists.

2.1.7 Ecological System

Because the desert ecosystem, the ecological system is not as rich as other places situated at similar latitudes, i.e. tropical zones. At the global level, the ecosystem does not perform any important environmental service.

5 main topics were selected to identify the ecological system as follow:

- Biodiversity
- Atmosphere
- Soil
- Hydrographic system
- Landscape

These topics coincide with the analysis done by Cabildo de Lanzarote (1998b) and they were chosen because they have been considered to give a complete overview of such ecological system.

2.1.7.1 Biodiversity

Most part of flora and fauna from the Canary Islands come from Europe and Africa. While in the mainland they were adapting to changes in the climate and in the land uses due to human actions, in the islands of the archipelago they could evolved

[5] Together with the moratorium there was a reclassification of accommodation changing from tourist accommodation to residential. These named residential places are not considered tourist accommodation places but they will be, however, used to accommodate tourists.

without the human component and subjected to less variability on climate due to a buffer effect performed by the ocean. In this condition, flora and fauna which were disappearing in the rest of the world, had the conditions to survive in the Canaries. Moreover, new species could appear from the evolution of the first colonizers. In Lanzarote, particularly, the geographical features, originated from different periods of formation, gives to the island a variety of ecosystems and natural habitats disposed in a mosaic way. This characteristic generate a high edge effect within the island and a particular internal ecological succession (García, 1999, p.60).

The geographical localization of Lanzarote gives two more particular aspects to the island. The first is a fauna and flora crossover which limits of distribution are in Lanzarote. That is, Lanzarote is the northern limit where some species can be found (e.g. the pardela chica – *puffinus assimilis* and the petrel de Bulwer – *Bulweria bulwerii*) and the southern limit to others (e.g. the paiño común – *Hydrobates pelagicus* and the halcón de eleonora – *Falco eleonorae*) (García, op. cit.). The second aspect is to be a pioneer island. That is, to be the nearest island to the African continent, Lanzarote works as a bridge to the reception, settlement and further dispersion of the Canarian biodiversity. At the same time, this proximity to Africa tend to reduces the level of endemism in Lanzarote. Notwithstanding, there are many endemic species in Lanzarote, most of them located in the Famara region.

Plants on the island are conditioned by climate, soil and by human action manifested through agriculture and over grazing. According to Marín and Luengo (n.d., p.43) because of this human action, areas with vegetation in Lanzarote are reduced to sites with some kind of legal protection. The endemic flora in Lanzarote is not as extensive as on the other Canary islands. Even so, there are approximately 600 vascular plants species of which 20 are endemic.

Lanzarote displays the following vegetation units:

- Beach vegetation
- Sand-dune littoral
- Salting – predominance of plants adapted to high salinity (mud). It is an ideal habitat for migratory birds, who find food in this place;

[6] Despite not being accepted by the whole population, the moratorium at least refers to a limit according to the decision makers.

- Coastal Cliff – exhibit all distinct vegetation types existing on the island, forming its most complete site of referred to vegetation. Of 291 current counted taxa, 10 are endemic to Macaronésia[7], 24 endemic to the Canaries, 21 endemic to Lanzarote and Fuerteventura, 19 endemic to Lanzarote and the small islands surrounding and 14 exclusive to this referred to zone.
- Palms in Harías
- Scrubland
- Specific Vegetation on the Malpaís de La Corona and Volcanoes Natural Park areas
- Specific vegetation on Recent Malpaís
- Mountainous massif vegetation
- Ravine vegetation

Furthermore, Lanzarote is surprisingly rich in lichens. Despite a semi-desert climate, lichens fix in small holes in the volcanic soil and are exposed to the humidity of the trade winds (in the higher altitudes, where they are felt) and the ocean breeze, which means they can prosper. According to Marín and Luengo (n.d., p.55), at present, 150 lichens species have been counted on the island, despite the fact that this number in reality may be around 200.

The invertebrates animals are the group of fauna most populous in the island, and among them the insects. Vertebrates are not very numerous, being best represented by birds. There are also few reptiles, amphibious and 2 terrestrial mammals species.

The number of species does not call for special attention in Lanzarote, since it is not very high. In addition to the 600 mentioned species of vascular flora, there vertebrate fauna appears with 3 reptiles species, 2 mammals, 1 amphibious and 39 nest birds species (García, 1999, p.60). Indeed, other ecosystems and even other islands of the Canary archipelago present a higher number of species. Notwithstanding, Lanzarote shows a high endemism rate, with an average of 20-23%. Based on secondary data, García (op. cit., p.69) points out that the endemism rates vary from 13,4% and 18% at

[7] Group of island which include the Canary islands, Cabo Verde, Azores and Madeiras islands.

Janubio and Timanfaya respectively to 24,4% in Tenenguime and 37,7% in Famarra and Islotes.

Biodiversity has been seriously affected by the tourism increase. In addition to the lost of habitat areas directly attributed to hotels, houses and infrastructure construction, there is an important impact in natural flows. Roads construction – Lanzarote has 425 linear kilometers of road, that is, 0,5 linear km/km^2, one of world's highest rates according to García (1999, p.77) – affects recent volcanic areas trough the introduction of aggressive vegetal species. Moreover roads break biological paths fragmenting habitats and causing traffic accidents (García, 1999). New recreational activities introduced by tourists are not regulated and thus are also the cause of biodiversity loss. That is the case with off-road driving and glider on Famarra.

Additionally the aforementioned decrease of cultivated land in preference for tourism activities is responsible for a loss of a food source where populations of wild animals used to feed. The decrease of pasturing, on the contrary, permitted the recovery, or at least a cease of endemic flora destruction.

2.1.7.2 Atmosphere

Lanzarote's localization and topography characteristics – as an oceanic island with low average altitude – make it propitious to pollutants dispersion. In addition, the fact that the main urban centers are close to the coast contribute to such dispersion and assure that no negative impacts are felt at the local level.

In reference to the structure of the economic system described earlier, the main emissions sources are vehicles (number of vehicles are given further on table 4.3) and the electricity generation process.

The vegetation coverage is extremely low in Lanzarote due to the arid characteristic of its desert ecosystem. In such instance, the emissions resulting from the burning of fossil fuels are almost externalized in its totality to the global atmosphere. Only some carbon sink task is performed by the adjacent ocean environment.

Additionally to the mentioned emissions source, it is important to notice that the main access to the island is by airplane, which is responsible for great CO_2 emissions.

2.1.7.3 Soil

Traditionally, people have adapted to the severe nature conditions of Lanzarote. Soil characteristics have had an active function in the adaptation process. For instance, use of volcanic soil to compensate the aridity as well as the building of stone walls to avoid winds into the fields, are common practice among local people. The demand for land and soil resources had been low and had not been a problem until the 1960's, when the cultivation on sand (see photo on page 18) was introduced. But it was in the 1980's, with the increase of tourism and the associated constructions, that soil resources were severely exploited. In the last 20 years the volume of soil extracted reached an average of 336,000 m^3/year (Cabildo de Lanzarote, 1998b, p.18). Around 120 spots in the island have been affected by some sort of soil extraction.

Only 23,000 ha. of Lanzarote soil are cultivable land, and from these only 10,000 ha. are really suitable to agriculture uses. In addition to such cultivable soil scarcity, the human action has threaten their conservation. There is an important erosive process caused by both, natural and human factors. Among the first is rain absence, which does not permit an adequate vegetal coverage, and among the human factors are the decline in agricultural land use, overpasturing and uncontrolled vegetation cutting. The tourist urban centers, at least, are situated in poor agricultural land areas, and hence, do not contribute directly to the cultivable soil loss (Cabildo de Lanzarote, 1998b).

Impacts on soil and underground due to waste final disposal are unknown and not documented. Anyway this impact, if exists and under any circumstance, is still restricted to the Zonzonas sink area.

2.1.7.4 Hydrographic system

Water is obviously a restricted resource in Lanzarote and has historically conditioned the development in the island. In dry times the emigration used to increase. Water originated by rain is calculated to be around 111 hm^3/year, from which 89% is lost by vapour-transpiration, 2% are lost in superficial flowing, and about 9% is infiltrated into the soil. It means that rain water is infiltrated on underground in similar amount to the actual consumption needs. Notwithstanding, the irregularity of rain and the great depth of the wells make it difficult to get this water. The overexploitation of such water wells has caused salinization with high mineral components in the past. Hence the current possibility to potable use is restricted. The water wells supply today around 10% of Lanzarote's water demand (Inalsa, 1993).

In this way, the main water source is the desalinization process (table 4.5 gives the total amount of water which is desalinated in Lanzarote). Desalinization brought to Lanzarote the idea that water is no longer a problem, and that it is an endless resource. Since it depends from oil to be generated, it is clear that water undergoes the same problems found to the energy sector (discussed further). Furthermore, this water sufficiency broke a traditional relation which local people had with water as a scarce good. Tourists do not see water as a seldom resource, and local people are giving away their traditional water-saving patterns.

2.1.7.5 Landscape

Last, but extremely important, is the insular landscape. Together with climate and beaches, the unique landscape forms a major attraction to tourists and hence, is very important to the island economy as well as to the local people well-being.

Three main divisions about Lanzarote's landscape may be identified. The first one regards to the landscape dominated by recent volcanism, with many volcanoes peaks and some massifs. The second one is related to traditional agriculture and the last one are coastal and urban landscapes. Volcanic landscape is affected by the numerous roads and cars of Lanzarote, and by the extraction of material to construction. The last is very grave and it is estimated that 56 volcanoes peaks show serious impacts, while other 64 present impacts to some important degree (Cabildo de Lanzarote, 1998b). The agricultural dominated landscape varies in function of the agricultural activity itself. Consequently, it is a landscape which has been recently degraded due to progressive abandon of this activity in preference of tourism as mentioned before. Coastal landscape is by far the most affected of Lanzarote. Since most urban centers and hotel resorts were built on this area, the lost of landscape and the degradation of ecological values and parameters are extremely high.

Most discussions about the future of the island and the development patterns take in account the landscape values, chiefly the coastal and urban ones. With reason, this is the most perceptible and impacting impression in a first and superficial looking at the island.

2.1.8 Protected Areas

Lanzarote has 13 areas under some kind of legal protection, accounting for 41.3% of its territory. These 13 natural areas may be classified in 3 groups accordingly

to the purpose they are subjected. That is, accordingly to the relation among conservation and development performed by them (García, n.d.) as follows[8]:

Strict conservation, where scientific and ecological values are dominant:

Los Islotes – Strict Nature Reserve

Los Jameos – Area of Scientific Interest

Janubio – Area of Scientific Interest

Compatibility among public use and conservation:

Teneguime – Protected Landscape

La Geria – Protected Landscape

La Corona – Natural Monument

Los Ajaches – Natural Monument

Cueva de los Naturalistas – Natural Monument

Islote Halcones – Natural Monument

Montañas del Fuego – Natural Monument

Strict equilibrium among conservation and public use:

Timanfaya – National Park

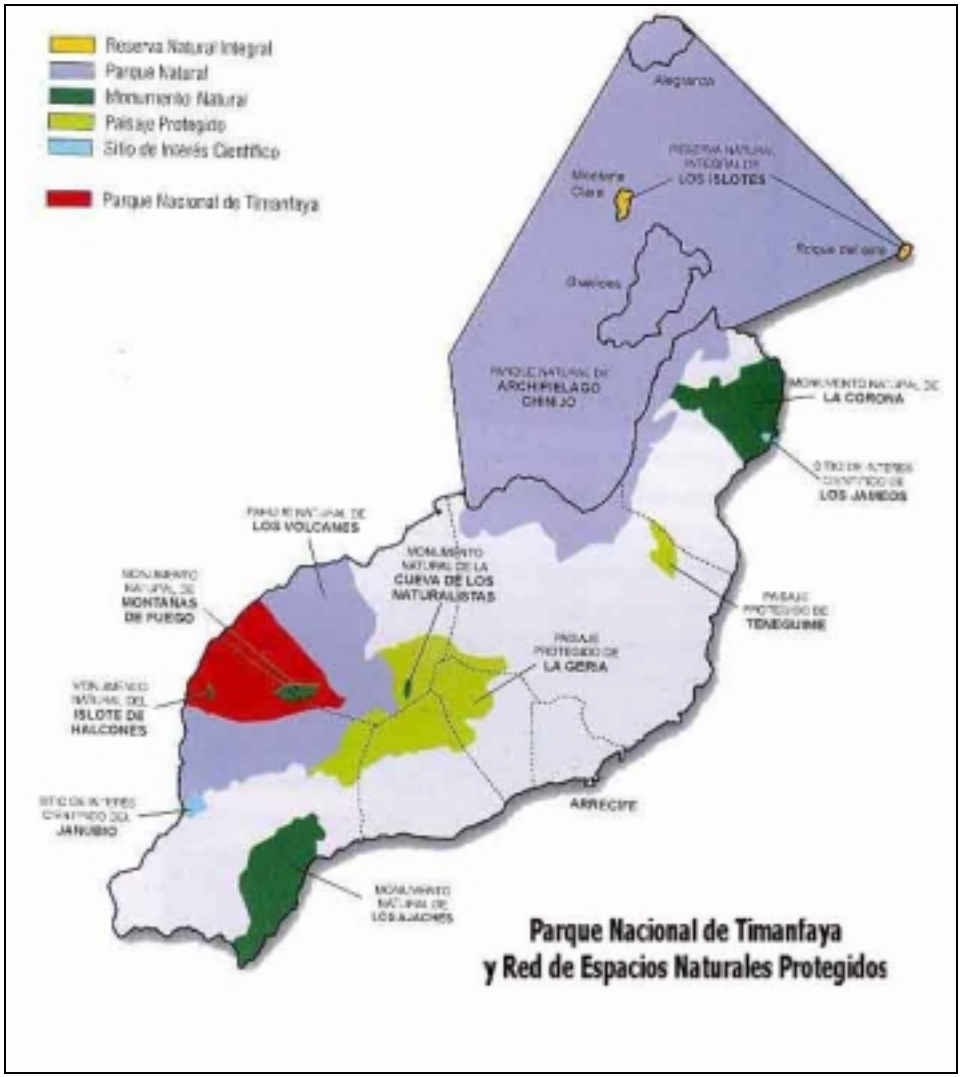
Chinijo Archipelago – Natural Park

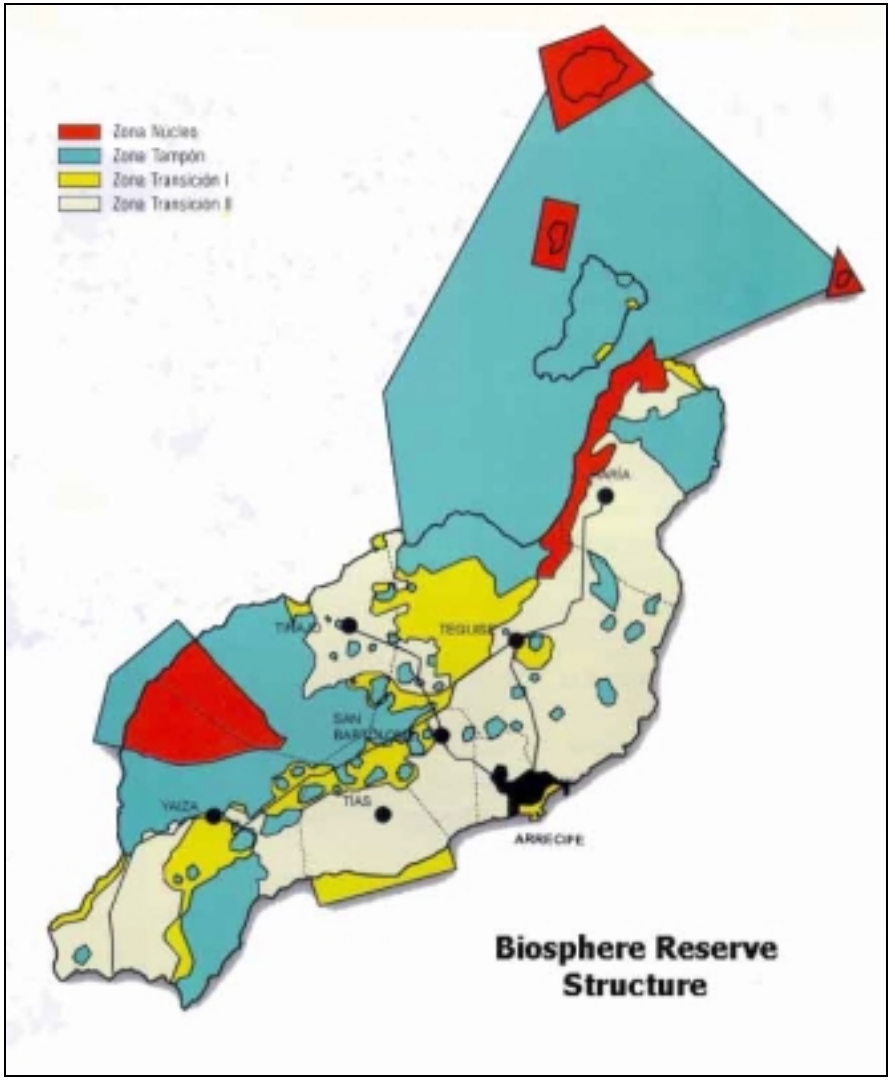
Los Volcanes – Natural Park

Protected areas written with red types make part of Biosphere Reserve core zones. The other natural protected areas form the buffer zone. It seems strange that within the National Park there are two other areas protected under a less restricted classification – Islote de los Halcones and Montañas del Fuego which are classified as Natural Monument. Nevertheless those two areas are subjected to management actions that apply to the National Park.

Lanzarote's protected areas designation appeared clearly as a demand of tourism. Thus, the motivation which guided the selection of areas were much more aesthetic than ecological. Recent volcanism areas, with high valued landscape, makes most of the protected areas net.

[8] It is attached a table with the UICN correspondent to the protected areas figure existing in Lanzarote.


Reserva Natural Integral
Parque Natural
Monumento Natural
Paisaje Protegido
Sitio de Interés Científico
Parque Nacional de Timanfaya
Alegranza
Montaña Clara
RESERVA NATURAL INTEGRAL DE LOS ISLOTES
Roque del este
Graciosa
PARQUE NATURAL DE ARCHIPIELAGO CHINIJO
MONUMENTO NATURAL DE LA CORONA
LOS JAMEOS
PARQUE NATURAL DE LOS VOLCANES
MONUMENTO NATURAL DE LA CUEVA DE LOS NATURALISTAS
MONUMENTO NATURAL DE MONTAÑAS DE FUEGO
PAISAJE PROTEGIDO DE TENEGUIME
PAISAJE PROTEGIDO DE LA GERIA
MONUMENTO NATURAL DEL ISLOTE DE HALCONES
ARRECIFE
SITIO DE INTERES CIENTIFICO DEL JANUBIO
MONUMENTO NATURAL DE LOS AJACHES
Parque Nacional de Timanfaya
y Red de Espacios Naturales Protegidos


Zona Nucleo
Zona Tampón
Zona Transición I
Zona Transicion II
TIAS
YAIZA
ARRECIFE
Biosphere Reserve
Structure

2.2 The General Context of the Research

2.1.1 Desert Ecosystem

Dry climates areas cover around 30% of the land surface of the Earth, including areas within seventy countries, nearly half the nations of the world. Life conditions in deserts are severe and the flora and fauna have to be very well adapted to survive in the hard deserts' environment conditions. Consequently, human life has also to be adapted to the environmental conditions. On one hand, lack of water determines the possibilities for human populations settlements. On the other hand, transformation of k_n into k_p is very limited by the low ecosystem's productivity, limiting the economic growth.

The extreme specializations and adaptations required by life forms to survive in arid conditions make them very sensitive to disturbances. Small changes in the physical environment may result in great changes in plant life and consequently in the animals who depends on them for food. Furthermore, the "fragility of desert ecosystems and their slow recovery from damage renders them especially vulnerable to heavy use" (Sutton, 1981, p. 495).

In such a situation, human populations inhabiting desert areas have to deal with two features of the same problem. On the one hand, people have to find economic alternatives to generate income and increase the k_p. On the other hand, they have to avoid the k_n depletion, which could cause important changes on the environment. Indeed, deserts ecosystems seem to be quite stable, but they are not resilient. That is to say, changes in deserts ecosystems are difficult to recover.

With the intention of conserving desert ecosystems and developing an economic alternative (in addition to enhancing education and research), many protected areas have been created within arid areas. Among these legally protected areas are found some of the Biosphere Reserves.

2.1.2 Protected Areas and Biosphere Reserves

Historically protected areas have been seen dialectically, opposing a diverse range of possible uses to the area with the nature "untouched", in a confrontation among exploitation and preservation. Recently it has become more and more accepted the idea that even when a natural area is left untouched, with no humans inhabiting it, this area is under effects of the human way of life. The increment of environmental impacts which

are felt at the global level, makes visible that wilderness areas are also under the effect of activities which are performed abroad. In this sense, problems like climate change, acid rain and air pollution, among others, changed the perception that natural areas could be away from the development stream and be saved as humanity gardens. Moreover it began to be accepted that these areas have an active role to take in the development process.

Nowadays, many people working with protected area agree that the traditional Yellowstone National Park approach of wilderness reserves does not seems appropriate to cope with the diversity of environmental and social realities. The reality of a wide range of protected areas, which have people within its boundaries, took the UNESCO to raise the Biosphere Reserve idea, which focuses on natural areas where the relation between humans and nature was not bad in principle. The Biosphere Reserve is a central component of the MaB program, intending to achieve biodiversity conservation at the same time it promotes economic and social development while cultural values are not lost (UNESCO-MaB, 2000a).

Each Biosphere Reserve is intended to fulfill three basic functions, which are complementary and mutually reinforcing:

- A conservation function: to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
- A development function: to foster economic and human development which is socio-culturally and ecologically sustainable;
- A logistic function: to provide support for research, monitoring education and information exchange related to local , national and global issues of conservation and development (UNESCO-MaB, 2000).

The Biosphere Reserve conception shifts the traditional perspective of protected areas as wilderness - breaking the "wilderness myth"[9] – to an integrated perspective where human and nature coexist as part of the same system, precisely an ecosystem. Consequently, it creates the possibility to protect areas when they are no

[9] "Wilderness myth" according to Gómez-Pompa and Kaus (1992) or "the modern myth of untouched nature " in Diegues' (1998) definition.
"When it is talked about *modern myth*, it is referred to a group of existent representations among important sectors of the environment conservationism of our days, who carry a biocentric conception of the relation men/nature, by which the natural world has identical rights to humans. As corollary of this conception, man would have no right to dominate nature. It is revealed on the conception of North American 'national parks' , on the second half of XIX century, according to which parts of the territory considered 'untouchables' had been transformed in protected natural areas, in which residents were not allowed" (Diegues, 1998, p.53).

more islands of preserved nature. They are seen as integrated ecosystems where people and nature co-evolve.

The fact that an area gets the status of a Biosphere Reserves, however, does not mean that such area is working in a fully sustainable way, respecting ecosystems in all levels of interaction. What it does mean is that the area (region) deserves some special attention due to particular characteristics (landscapes, ecosystems or animal and plant species or varieties which need to be conserved) at the same time taking in account the human populations inhabiting the area. The concept is interesting because of the mentioned reality of integrating people and nature. But how this relation will take effect is not precisely specified by the MaB guidance. Of course it will be different according to different local requirements.

The Biosphere Reserve is not a legal figure which strictly control management actions. On the contrary, it recognizes different realities and give some guidelines and recommendations as indicated in the 'Seville Strategy for Biosphere Reserves'[10]. In these circumstances there is a wide variety of Biosphere Reserves representing the most different ecosystem types.

The difficult task of harmonizing conservation goals with development, associated to the wide range of realities found in the world network of Biosphere Reserve, makes very difficult to assure that a particular Biosphere Reserve works in the framework of sustainability. The contextual features of the term sustainable development highlighted by Svedin (1991) and Noorgard (1994), with questions like important to whom, in which circumstance, from which point of view, etc., appears markedly in this type of system.

2.1.3 The Tourism Alternative

The "Yellowstone model" of national parks, as "islands of non-development", has demonstrated itself to be not efficient to conservation goals. The protected area itself is inserted in a marketplace, which has been shaped by the global economy and has dominated trends in modern societies. In this situation protected areas have to deal with a clear contradiction. On the one hand they are under pressure from market forces which see the area as an opportunity for exploitation, and on the other hand there are non-market values which must be preserved.

[10] The Seville Strategy is available at http://www.unesco.org/mab/wnbr.htm.

The problem is that these non-market values are not always perceived by the general public. If they are, they are not – and indeed many times they cannot – be translated into money value. The consequence is that a protected area, which has been protected due to non-market values, appears to have a foregone local market opportunity cost. Furthermore demographic pressure does not respect the limits imposed by protected areas. This is aggravated by the fact that frequently their boundaries are not established by biogeographical limits. Such situations gave force to the Biosphere Reserve concept.

The Biosphere Reserve figure accepts that people and nature may cohabit the same space where they both benefit from this relation. The development pattern, however, has to be different from that of urban centers and developed countries. It strives for a development model where humans and nature have values which must be respected[11]. The trade-offs between them have to be carefully analyzed in order to better guide management actions. Tourism, specially the ecotourism, has been a widely suggested activity that could fit this new development model (see for examples Myers, 1988; Terborgh, 1992; Pearce and Brown, 1994; Lindberg et. al. 1997 and Gössling, 1999).

The current state of the global environment (submitted to increased human pressure and degradation), the increased availability of information, and transportation improvements have dramatically increased the number of people who search for conserved areas as a tourism destination. It is believed that (eco)tourism may be an important revenue source to tourist destinations and an important activity to help shape the development pattern required in protected areas. Apparently tourism may reduce the economic opportunity costs of protection.

If the profitability of tourism is thought exclusively in market terms, it would not be different, in principle, to other economic activities. The advantage of ecotourism is that it has the possibility to generate income while maintaining healthy ecological values. Nevertheless, if the ecological values are not taken into account, that is, if its viability is based strictly on economic terms and compared to alternative economic activities, the ecological economic system as a whole will be under dimensioned and tourism will lose its attractiveness. In brief, tourism is suggested a good activity for protected areas because not only has revenue generation potential, but

[11] Coevolutionary Development according to Noorgard (1994) or Ecodevelopment according to Sachs (1986).

it can work under strong sustainability principles[12], in terms of non-decreasing natural capital.

Natural areas have been declared protected to assure that the stock of natural capital is maintained. Nevertheless, avoiding the trade-offs which occur when human and nature are in contact is a political decision with monetary costs as consequence. Opportunity costs as well as maintenance costs are incurred to avoid trade-offs. In a situation of complete absence of trade-offs there is no economic growth nor development as agent of modernization.

It is obvious that trade-offs are present and are important when tourism activity attains a significant size. The term ecotourism itself puts in evidence the existence of a link between the tourism activity and nature. In such situation the more connected the ecological and the economic aspects of a system, the more pronounced the feedback effects will be, and the more the system will co-evolve as stated by Norgaard (1994). This evolution could be good or bad. If tourism occurs at a large scale it may have a negative impact and become a strong driving force against the whole system, damaging the protected area particularly. As a feedback reaction tourism itself may be affected if the asset base, nature, is negatively impacted by the activity. In this situation k_n is being converted into k_p in such way that the aggregate capital ($k_n + k_p$) decreases.

Many indicators have been suggested to assess ecological and economic interactions and to find limits and 'optimal' trade-offs between k_n and k_p. All of them differ in the variables' aggregation process, what implies different perspectives in assessing the same system. A complex system with very diversified forces different in nature and scales, runs the risk of misinterpretation (or loss of information) when viewed under a single indicator. It has to be carefully interpreted to get the essential information which a single indicator may provide.

The existing interactions between people and nature and among people themselves are very complex in the development of the tourism activity. Very different judgment of values are implied by the diverse stakeholders, including native people, tourists, foreign residents and foreign people who do not visit the touristic site but have an opinion about that. Among them, there are people who are more concerned with

[12] The strong sustainability principle states for a development where the natural capital is maintained, regardless the status of the aggregate capital stock. Substitution of one form of natural capital for another,

economic growth, people who are equal concerned for human and nature (co)development, and there are also people who are more concerned with nature.

In such a situation, the limit which determines the adequate amount of people which will assure the development of the area will vary according to the perspective the decision makers are adopting, starting by the development definition itself. Definitely there is not a methodology which can indicate through a single measure the ideal amount of tourists to a given area. First, because tourist behaviors vary to such an extent that it is difficult to generalize and define common tourists patterns. Second, because there is no agreement in what is the ideal relationship between humans and nature to the area. Therefore, management will be more effective if it focuses environmental pressures.

subject to various minimum and maximum ecological constraints, may be allowed (strong sustainability) or substitution of natural resources may not be allowed (very strong sustainability).

Chapter 3 – Justification of the Chosen Approach – The Society's Metabolism

The task of identifying tourists and residents' environmental pressure in Lanzarote, as well as how Lanzarote is positioned in the global ecosystem, requires a variety of measures indicating economic, social and environmental conditions. In such a situation, the traditional Carrying Capacity (CC) concept does not provide valuable information, which have to be provided by a multidimensional indicator. "Although the equilibrium-centered view is analytically more tractable, it does not always provide a realistic understanding of the system's behavior. Moreover, if this perspective is used as the exclusive guide to the management activities of man, exactly the reverse behavior and result can be produced than is expected" (Holling, 1973, p.15) .

3.1 Carrying Capacity

When dealing with tourism management and the human impacts on touristic sites, it is common to find references to the carrying capacity (CC) concept. Many bibliography related to tourism and natural areas (see for example Marchena Gómez et. al., 1993; Ceballos-Lascuráin, 1996; Gössling, 1999; Cifuentes et. al., 1999) refers to carrying capacity as an upper limit to the activity such that if tourism is kept within this boundary, the site's quality as well as the tourists and residents' satisfaction will not be reduced. According to this perspective, if the amount of tourists is maintained close to the carrying capacity, environmental conditions (k_n) would be maintained and income generation (k_p) would be maximized.

The applicability of the CC concept has two related main problems. The first is that if it is possible to determine a maximum number of tourists, this limit does not reflect the system's conditions. It is a fixed number, which may be calculated in different ways (see for example Hawkins and Roberts, 1997; Hawkins et. al., 1999; Cifuentes, 1992), and management is conducted to maintain the maximum amount of tourists within this limit. Nevertheless, ecological process and human interaction with ecosystems are dynamic. Consequently, conditions are always changing even when management is fixed by the CC. Moreover, fixing rules to dynamic relations may break the unstable equilibrium of the system. "Policies and management that apply fixed rules for achieving constant yields (e.g., constant carrying capacity of cattle or wildlife, or constant sustainable yield of fish, wood, or water), independent of scale, lead to systems

that gradually lose resilience, i.e., to ones that suddenly break down in the face of disturbance that previously could be absorbed" (Holling, 1996, p.733).

The second, but equal serious, problem of the CC application is that the determination of a single number is questionable itself. One fixed number can not indicate different perspectives of a system, and consequently, many system's features are lost and management can not be effective.

Get for instance an hypothetical system composed of a small area of forest and a small primitive human community. Carrying capacity may be calculated in so many different ways that it is impossible to state which is the optimum one that will assure the maintenance of both the forest and the community. The optimum one under a perspective of the system will be not efficient under a different perspective.

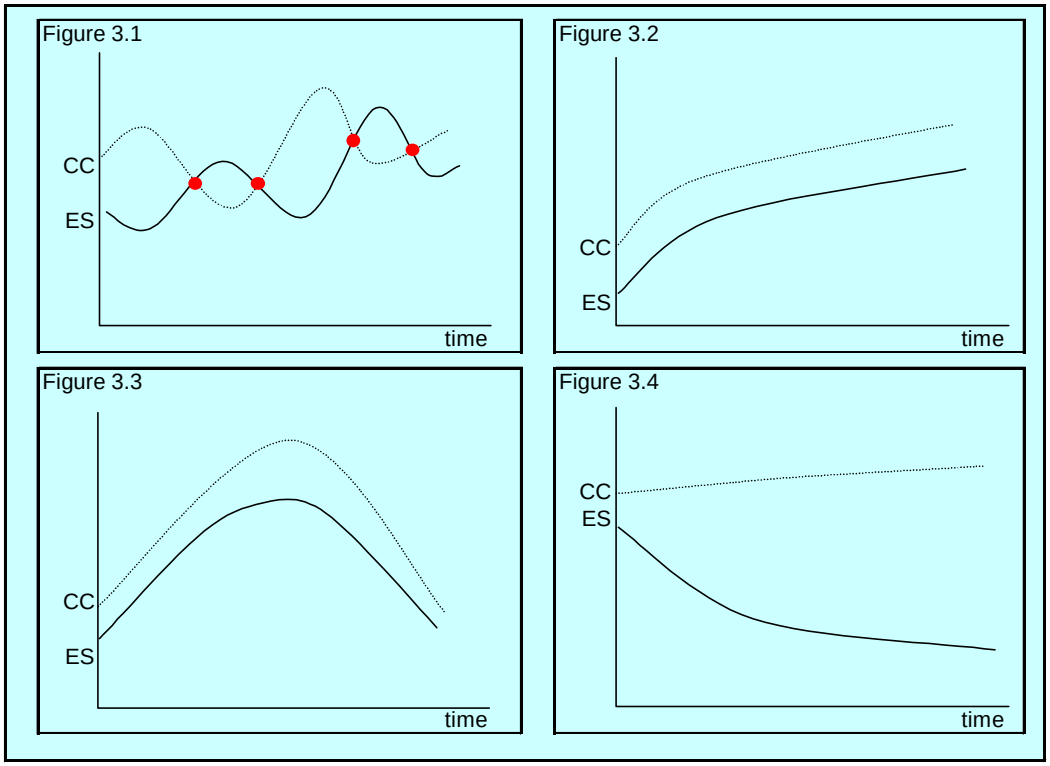
One interpretation to such system is represented on figure 3.1. The community settles in the area and people start to feed themselves from local fruit-trees. After some time, the local CC decreases due to less fruit availability and would force the population to move to another place. Seeds left in the soil by the human activity will sprout and, as consequence of the human migration, the forest area has time to regenerate and further increase the fruit production capability. Hence, local CC will increase. The red points on the graphic mark the total requirements of the community and the limit where their needs surpass the forest's supplies. Surpassing this point forces the community to migrate and contributes to the maintenance of system's resilience, allowing ecosystem's regeneration.

If the same system includes an expectation of technological improvement – let say, improvement of forestry management actions and some agriculture development – which allows the trees to produce fruits during the entire year, the pattern indicated on figure 3.2 may be more adequate.

Suppose now that the settlement of this human community on the area has a primer effect positive to the fruits tree. Humans frighten predators and in the first moments trees' productivity increase as well as the CC. But considering that the original predators have a key function in the maintenance of system's resilience, after some time the system will collapse and will not return to the previous state due to loss of resilience. The CC will decrease and consequently the population will have to move away (figure 3.3). Moreover, if the same system includes other scale of analysis, it may be concluded that the area lacks of other requirements to the human diet and that even while eating as many fruits as one wants, no one will survive on eating fruits alone.

Hence, this community would not be able to inhabit the mentioned area. The population there will decreases or disappear; figure 3.4 may be a more genuine representation. So, which is the local CC in this hypothetical case? It depends on the population behavior as well as on the variables assessed. That is, there is not a single number which can represent the local CC effectively. The initial definition of the system will determine its representation.

Figures 3.1, 3.2, 3.3 and 3.4 – Representation of interactions that ecology and economy may present.



Personal Elaboration

A concrete and simple example may be given to Lanzarote:

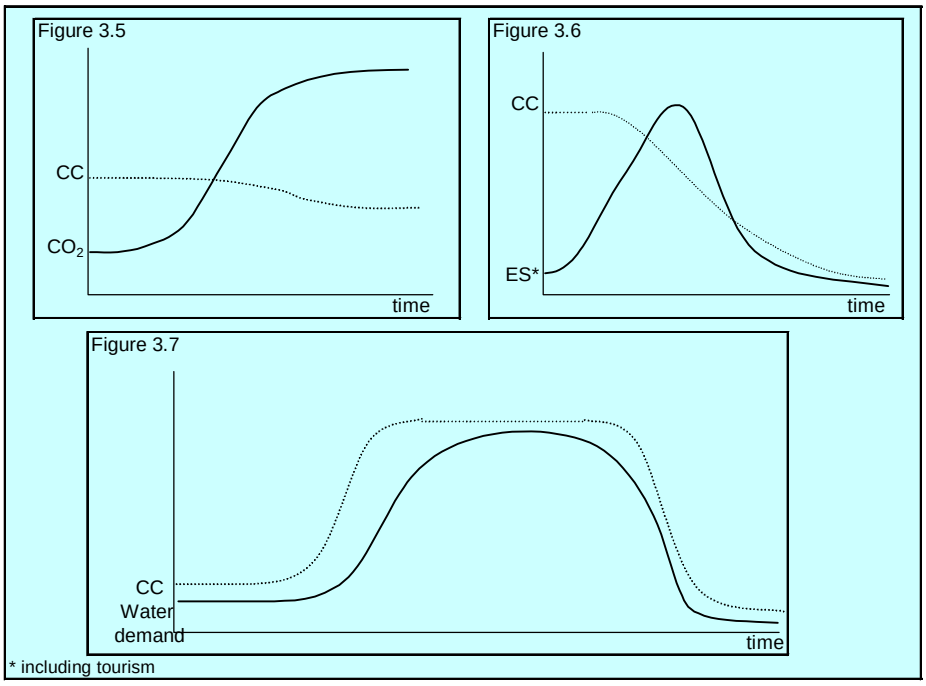
Looking from the global perspective, one might argue that any place in the world have to respect an ecological balance. That is to say, a nation, or an Island in the case, can not externalize residues produced in the local economy to the global environment. Everything produced and consumed locally has to be disposed locally. In this case, the carrying capacity of Lanzarote would be very low regarding CO_2 emissions. Due to the desert ecosystem, there is not many carbon sinks in the island, and the CC would be fixed, since carbon sinks are not increasing (see figure 3.5). CO_2 emissions in Lanzarote follows the curve indicated in the figure 3.5. Initially there was not many CO2 emissions, but they got increased as the desalinization process (oil

consumer) and the tourism increased (flights to and from Lanzarote, electricity and water consumers). At some time, the carrying capacity would be surpassed, fact which probably is happening nowadays, with the consequence, in this case, that the impact is at the global scale.

Another representation of the same system may be given by the figure 3.6. In this case, it is considered that landscape is the main attractive of Lanzarote, and hence, it is a constraining factor to be taken in account. In the beginning, the economic system (ES – which include tourism) increase is not so great to affect the landscape. Consequently, the CC is not affected. As the ES increase, it starts to affect the landscape and the CC declines. Once landscape is affected it does not regenerate (is not resilient) and the ES itself will be affected.

Figure 3.7 represents water as limiting factor. When there was no desalinization in Lanzarote, water availability was very low, and the population which could inhabit there was also low. With the desalinization process, the water availability increased to such a extent that allowed the island to be inhabited by many people. Considering that oil is a no-renewable resource, it will finish some day, and the desalinization process will have to change technology or it will break down as indicated in the figure. As a consequence, the capacity of Lanzarote to maintain a large population will decline.

Figures 3.5, 3.6 and 3.7 – Three different representation of CC to Lanzarote.



Personal Elaboration

These 3 examples represent the same system – Lanzarote. They differ in the time scale used and in the perspective by which the system is focused. Nevertheless, all of them could be a truly representation of reality, in such a way that is not possible to determine which one better represent the system. It is clear that the initial definition of the system is what determine its representation.

3.2 Society's Metabolism – Energy and Material Flow Accounts

Since variable and trade-offs in Lanzarote occur in different time and space scales, a decomposed type of approach is needed to analyze the island. If it is analyzed by the traditional economics point of view, a given result is found. If the approach considers the economy as an open system (to matter and energy), the result would be very different. It is not possible to find a single unit of comparison, indicating if the system is more or less healthy. Indeed, a system is more or less healthy according to the judgment of people who have their ideas already formed by previous experiences and values.

A multidimensional approach does not give a single number which allows comparison between different things or the judgment of the state of a system (a sustainability index). But a multidimensional approach does provide people who make such judgments with information about different aspects of the system, allowing a better understand of the same and hence (possibly) better decisions.

The origins of the societal metabolism paradigm goes back to the XIX century when the concept "metabolism", applied to both organisms and to human social systems, was born. Moleschott (1857, mentioned by Fischer-Kowalski, 1997 and Schandl and Schulz, 2000) linked the idea of metabolism with the concept of conservation of matter, which means that the available matter remains always the same. Thus, the metabolism was seen as an exchange of substances between organisms and environment. By the contributions of different disciplines of both the social and the natural sciences, the idea of society's metabolism grew to reach the current approach putted in practice, known as Material and Energy Flow Account (MEFA). Thus, the society's metabolism approach has the basis to connect the natural and the social sciences in such a way that makes it a truly interdisciplinary tool (Fischer-Kowalski, 1997).

According to the Society's Metabolism idea, economies are seen metaphorically as living organisms, ingesting raw materials, which are "metabolized" to

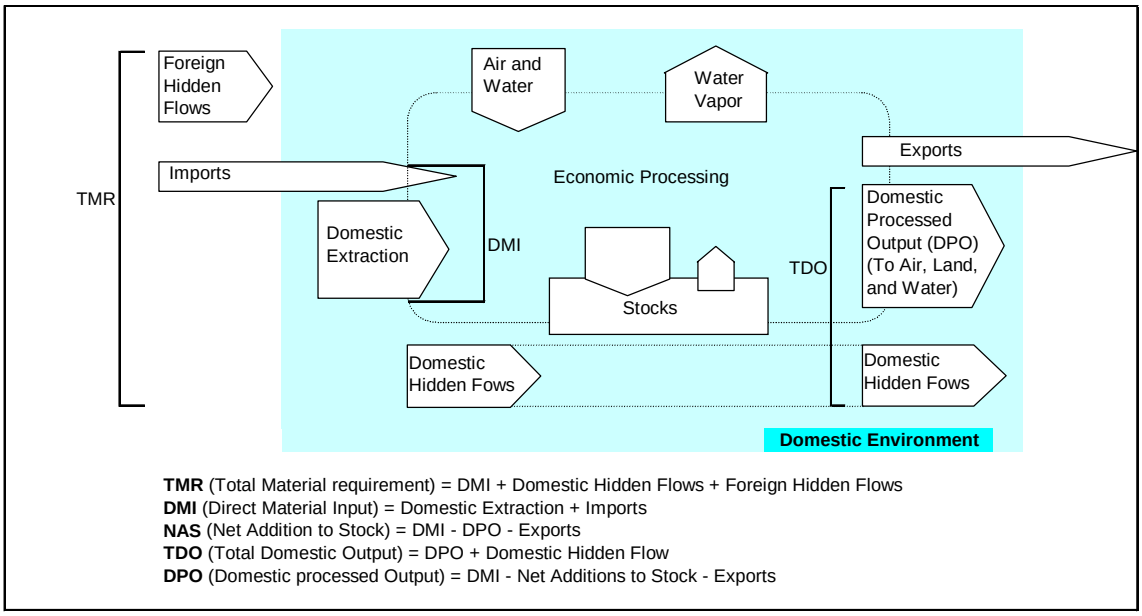
produce goods and services, and they "excrete" material waste and pollution (Matthews et. al., 2000; Schandl and Schulz, 2000).

Under this perspective material and energy flows are two different aspects of the same process. They are components which feed a society's metabolism. In this manner, material and energy flows accountability clarify the consumption requirement (inflows) and the waste generation (outflows) of a given society. This information associated to the origins of materials and energetic resources and the technology applied in their extraction/exploitation will help to understand trade-offs between k_n and k_p and understand human – or societal – load on the environment. Furthermore, the analysis of the society's metabolism provides information to discuss sustainability at the global and the local level.

Both aspects – energy and materials – are relevant since energy is responsible for the transformation of materials, and materials are the base for k_p production. Indeed there is much interdependence between material and energy flows. For instance energy can be used to increase the availability of materials, materials can be used to reduce energy flows and conversely energy can be used to increase the efficiency of material use (Haberl, 2000a).

A schematic representation of the material flow through the modern industrial economy is given in the figure 3.8.

Figure 3.8 – The material cycle.



Source: Matthews et. al., 2000.

According to Matthews et. al (2000) as represented in the figure above, the total material requirement of an economy (TMR) is given by the direct material input (DMI) plus both the domestic and the foreign hidden flows. Hidden flows represent the total weight of materials moved or mobilized in the environment (domestic or foreign) in the course of providing commodities to economy but do not enter the economy themselves. Hidden flows are externalities caused by the economic activity. Land moved in the mining sector or erosion caused by agriculture are examples of hidden flows. The materials which enter the economy, crosses the boundary into the economy (purchased or produced) and then crosses the boundary back to the environment. The hidden flows do not cross such boundaries and consequently they do not enter directly in the economy. Nevertheless hidden flows shall be included in a material account since they produce environmental changes. Thus, Matthews et. al. (2000) chose to include the domestic hidden flows as simultaneous inputs and outputs of the system in such way that it enables these flows to be measured and accounted. The foreign hidden flows do not enter in the calculation of the total domestic output (TDO) to avoid double accounting. Foreign hidden flows are accounted for as domestic hidden flows in their countries of origin.

The TDO is composed by the domestic processed output (DPO) plus the domestic hidden flows. The difference between the inputs (DMI) and the outputs (TDO) stay in system as stock. That is to say, this difference is called of net addition to stock (NAS).

The usefulness of material and energy flow account (MEFA) is to provide an environmental information system which can be linked to many other criteria with the purpose of facilitating decision making, international comparison of ecological performance of societies and scenarios analysis (Schandl and Schulz, 2000). Without applying an aggregation procedure, the MEFA is like a net of flows which can be assessed whether as a whole or in parts. It means that the MEFA may identify the metabolic work, and thus the “sustainability”, of a whole society or of particular economic sectors.

The choice of indicating all material and energy flows in a same measure unit, namely weight, is not different, in principle, to reduce everything to money, to land area, to energy or whatever that single unit may be. The strength of the MEFA is that there is not an intention of summing up all weights found in the different flows to get a total number and declare if given economy is more or less sustainable or rich. Indeed

weights alone do not mean many things. Big flows are not automatically bad and small flows good. For instance, a ton of mercury is not equivalent to a ton of iron. Furthermore, materials flows will be good or bad depending from their source and where they end up. For example, nitrogen absorbed on agricultural plants tissue is good while nitrogen dissolved in groundwater may be bad (Matthews, et. al., 2000).

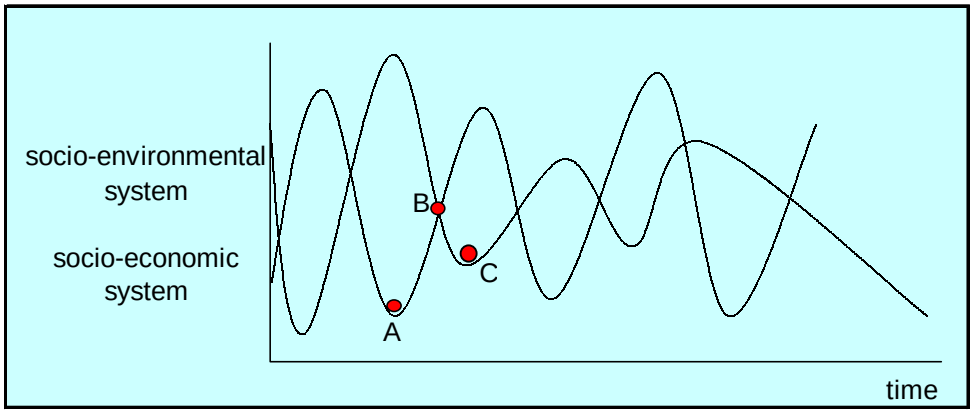
Thus, the main function played by a MEFA is to clarify how material and energy flow through a society or by mean of a specific economic activity. It is thus possible to link these information with information about ecosystem characteristics, land use type, social behavior, available technology and so on, in such a way that possibly support better decision and definitely more transparent processes.

3.3 Resilience

Resilience is a property of the system which has to be considered whatever is the approach adopted. It has been defined in the literature in two different ways. One of them, by Pimm (1984), refers to the system's resistance to disturbance and to the speed to return to a local stable equilibrium. The other definition, by Holling (1973), defines resilience as a magnitude of the disturbance that can be absorbed by the system before it flips from a base of attraction to another (Holling, 1973; Gunderson et. al., 1997; Perrings, 1996**;** Perrings, 1998**;** Perrings et. al., 1995; Berkes & Folke, 1998).

The main difference among the two resilience definitions resides in the supposition of the existence of multiple stable states or not (Gunderson et. al., 1997, p.4). Holling (1973) suggests that natural undisturbed systems are characterized to be continuously in a transient state. As far as men interact with nature, population growth and resources exploitation shift equilibrium states. That means the whole system – ecological economic system – is moved away from equilibrium. Notwithstanding this non-equilibrium system shows many local equilibrium, or better said, multiple stable states.

Figure 3.9 – Multiple stable states system and Resilience according to Holling's definition.



According to Holling (1973), resilience is the measure of the ability of the system in the stable state "A" to absorb changes of state variables, driving variables, and parameters without reach the point B where the system flips to the stable state "C". Stability is the ability of a system to return to an equilibrium state "A" after a temporary disturbance which moved system closer to "B".

Take for instance the example of the Amazon rainforest. It is well known that once forest areas are cleaned for their agricultural and/or cattle use, they do not return to their previous stable state, characterized by dense forest. After abandoned, these areas shift to other stability domain, characterized by grasslands areas. Or the example mentioned by Levin et. al. (1998, p.227) to the case of forest fires:

> *"Classical management regimes endeavored to suppress fires entirely, apparently preserving the status quo in terms of the most evident variables. Yet total fire suppression increases both the stock of timber, and thus the stock of combustible litter, creating accidents waiting to happen. Trough simplistic management regimes, robustness and resilience are lost, and the predisposition to catastrophic fires is increased. Such fires would spread farther and burn longer and at higher temperature than otherwise, leading not just to the destruction of trees and seeds, but also to soil erosion and a deterioration in the capability of the system to recover. It was for example the myopic success of earlier fire control that made the recent fires in Yellowstone National Park so devastating. Enlightened forest management now recognizes the value of letting small fires burn in order to maintain the resilience of systems."*

The recognition that ecological economic systems present multiple stables states led Holling's definition of resilience to be more accepted and discussed on the literature (see for example Holling, 1973; Perrings, 1996; Perrings, 1998; Perrings et

al., 1995; Gunderson et. al. 1997; Levin et. al, 1998). However, in some cases, Pimm's definition may be more relevant[13] (see Batabyal, 1998).

It would be interesting to use the resilience concept as an indicator to the tourism management. In this situation, if it is possible to identify species which carry key functions to the maintenance of the system's resilience, tourism can be managed with a focus on this specific species, which means, environmental conditions. Thus, the central issue to management is to monitor the state of the keystone species and their ecosystem's links which perform key processes for the maintenance of ecological resilience. Thus, should it be impacted by an external factor – it might be due to tourists affluence –, the ecosystem will be able to regenerate some time after the stress. This view rises the possibility for an adaptive management (see Walters and Holling, 1990; Holling, 1996), which consists of changeable practices according to necessities imposed by a system's state. Under this framework management can deal with different variables in very distinct situations and may induces shifts in their relationship.

In practice the task is not so simple. Species which are important to the ecosystem's resilience under a determined state of the system, may be not important under a different state. On the contrary, species which do not carry relevant system's function under one state may be important when the system is taken away from equilibrium. Furthermore, there is controversy about how specie diversity and their connectivity affect a system's resilience. Some people argue that resilience is an increasing function of complexity and interconnectedness within ecosystems. That is, resilience is directly related to the number of populations within an ecosystem. As the population number increases, the greater the number of species capable of supporting the critical structuring processes of systems under different environmental conditions (Holling, 1973, p.18). Others argue that more complex systems (e.g. tropical forest and coral reefs) are less resilient due to their high level of connectance. In this case, the loss of one species may imply the loss of many other species (Common and Perrings, 1992, p.17; Perrings, 1998, p.514).

Apparently the higher level of connectance – which implies that the loss of one specie will causes the loss of many others – signify a lower stability. On the contrary it seems to implies higher resilience due to the first argument – more species to assume key process. Indeed it is possible that "instability in numbers can result in more

[13] That is the case where an area shall be managed to return to a previous stable state after some external disruption like fire or hurricane.

diversity of species and in spatial patchiness, and hence in increased resilience" (Holling, 1973, p.19). If one proceeds a comparison among a desert and a tropical forest, for instance, it seems that desert ecosystems are less diverse and more stable than tropical forest ecosystems. The desert ecosystem, however, is more susceptible to break downs, and thus is less resilient. In other words, loss of one specie in a desert does not imply loss of many other species like in a tropical forest, but the consequences to the equilibrium of the whole ecosystem may be greater.

Since it is not possible to measure resilience and identify all keystone species (or potential keystone species), it is not possible to guide tourism management using resilience as indicator. Nevertheless, trade-offs between k_n and k_p, change in land uses and environmental impacts due to tourism or other activities have to be carefully understood and analyzed to avoid the system to lose resilience. Loss of species in the Lanzarote's desert ecosystem, in addition to the direct biodiversity loss[14], may cause the system to loose resilience and to break down face to disturbances.

3.4 Conclusion

Theoretically there is an agreement that a carrying capacity exists which must be respect in tourism management, in the sense that there are limits within ecological economic systems. There is a recognition that tourism implies trade-offs between k_n and k_p and that there are limits to such ecological economic trade-offs. This situation, however, is characterized by incommensurability and incomparability of values and thus a multidimensional analysis has to be applied.

Carrying capacity is an important concept because it is the basis of thinking of the relation between people and the ecosystem in the specific case of tourism management. It is important to keep in mind the agreed figurative idea of CC to find applicable solutions to guide the management plan. Nevertheless, the CC calculation is a controversial issue. Thus, carrying capacity is more valuable when understood as a metaphorical concept than an empirical tool.

I strongly believe that resilience is a concept to be taken in account in the tourism management case. If tourism is not managed within the limits of resilience, the system may break down and tourism itself may be affected. Nowadays, there is no available knowledge that may provide the necessary information to use resilience as a single indicator to manage tourism. However, the identification and comprehension of

[14] Which is a relevant issue due to the high endemism rate in Lanzarote.

this property is important to the success of the management plan. If resilience is used in conjunction with other methodology, both will be reinforced as well as the management plan itself.

The need for a multidimensional approach has led the MEFA of the Society's Metabolism to be chosen as the methodology to guide the study case in Lanzarote. Again, this approach does not provide direct answers about sustainability and the limits of humans and nature interactions. However, it does provide information which allows people and decision makers to formulate new questions and provides guidance for the focus and application of different frameworks. Through a MEFA it is possible to identify consumption and production patterns as well as land use type, allowing a further link with the concept of resilience of ecosystem and with ecological performance. These information may be of great value to understand Lanzarote's system in both local and global level, and consequently it may provide important insights to guide management.

Chapter 4 - The Lanzarote's Energy Flow Account, 1999

To understand the Lanzarote's Metabolism, the two components which characterize the system have to be identified: the energy and the material flows. These flows will be traced based on data collected in the two field visits as well as data from secondary sources. Moreover, flows will be separated into residents and tourists flows, in an attempt to identify not only the society's metabolism but also the whole society's environmental pressure and the particular environmental pressure of the tourism activity. Further, a short analysis of monetary indicators will be performed to provide different information of the same system. Linking the different information allows a better comprehension of the system and hence better decisions making.

The figure 4.1 has been designed to help the understanding of Lanzarote's system – consumption and production patterns, and the natural endowment which is in the process of being converted to produced capital – and to facilitate the data collection.

Virtually all of the energy – which performs the desalinization process, moves the locomotion means and generates electricity for the commercial and industrial sector as well as illuminating houses and streets – comes from oil, which is imported to the island. A very small fraction of the electricity production is provided by wind source. As a result, oil is the main input which turns the economy of Lanzarote. Figure 4.2 and 4.3 shows the energy sector flows (energy and electricity balance respectively) in detail.

The oil imported to the island has three main destinations. A small fraction is destined to GLP and other thermal uses. Most part is destined to electric transformation, which generate electricity to be used in different sector as indicated in figure 4.3. The remaining oil imported (around 30%) is used on the transportation sector (see table 4.1).

The energy which enters in Lanzarote's system is thus mostly proceeded from foreign economies (see table 4.2 with the amount of imported energy, oil, and local produced energy, wind energy). Therefore, impacts from its production (input) do not occur in Lanzarote, but instead in the origin countries. On the system's output side, the main residue coming from this energy consumption pattern is CO_2 emissions, which enters the atmosphere, i.e. the global environment.

Figure 4.1

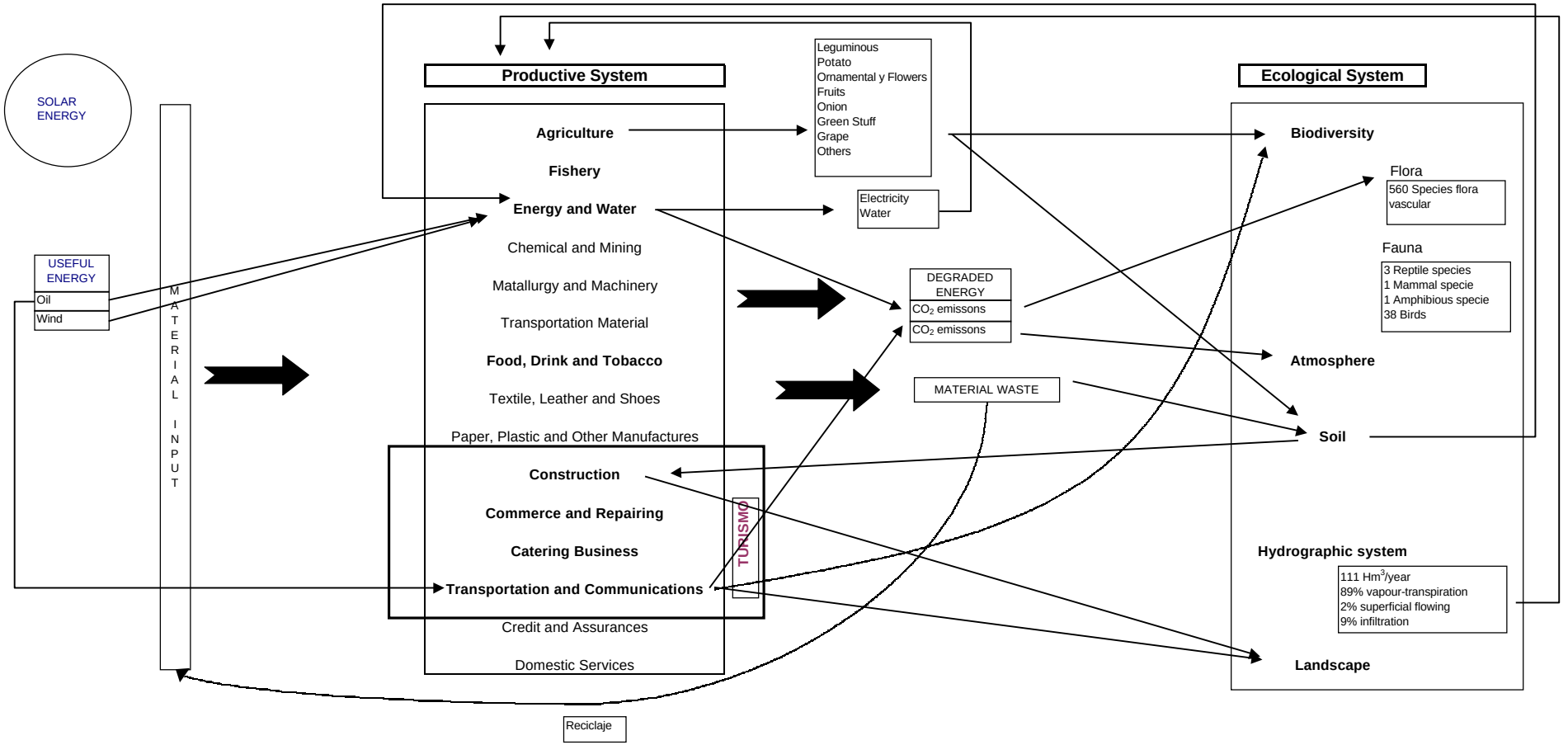

SOLAR ENERGY
USEFUL ENERGY
Oil
Wind
MATERIAL INPUT
Productive System
Agriculture
Fishery
Energy and Water
Chemical and Mining
Matallurgy and Machinery
Transportation Material
Food, Drink and Tobacco
Textile, Leather and Shoes
Paper, Plastic and Other Manufactures
Construction
Commerce and Repairing
Catering Business
Transportation and Communications
Credit and Assurances
Domestic Services
TURISMØ
Leguminous
Potato
Ornamental y Flowers
Fruits
Onion
Green Stuff
Grape
Others
Electricity
Water
DEGRADED ENERGY
CO2 emissons
CO2 emissons
MATERIAL WASTE
Reciclaje
Ecological System
Biodiversity
Flora
560 Species flora vascular
Fauna
3 Reptile species
1 Mammal specie
1 Amphibious specie
38 Birds
Atmosphere
Soil
Hydrographic system
111 Hm3/year
89% vapour-transpiration
2% superficial flowing
9% infiltration
Landscape

Figure 4.2 – Energy Balance

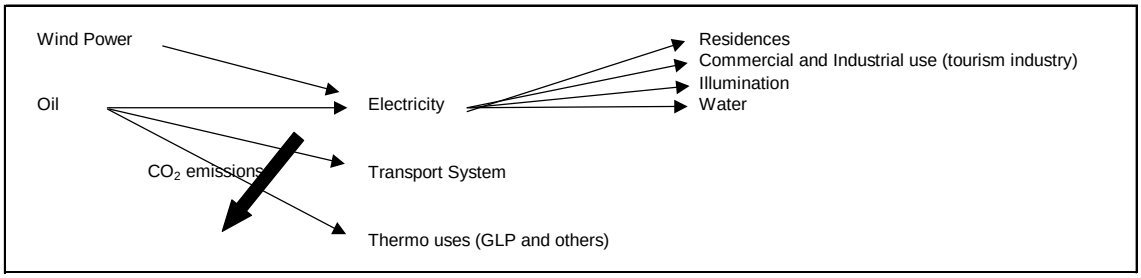
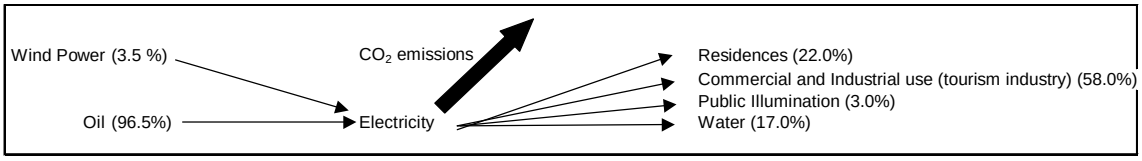


Figure 4.3 – Electricity Balance[15]



Source: Anuário Estadístico de Lanzarote, 1999 and Cabildo de Lanzarote, 1998c.

Table 4.1 – Oil Input

Oil Consumption (metric ton - m.t.)											
		Inland Transportation				Non Transportation Uses					
				Total of Transp. (a)		Electric Transformation (b)		GLP and Others (a)		Total Non Transp.	
	TOTAL	Gasoline	Diesel (a)	m.t.	%/total	m.t.	%/total	m.t.	%/total	m.t.	%/total
1996	158,276	36,231	21,329	57,560	36.4%	81,349	51.4%	19,367	12.2%	100,716	63.6%
1997	173,490	39,441	23,219	62,660	36.1%	93,708	54.0%	17,122	9.9%	110,830	63.9%
1998	189,067	40,130	23,624	63,754	33.7%	107,242	56.7%	18,071	9.6%	125,313	66.3%
1999	212,968	40,191	23,660	63,851	30.0%	126,270	59.3%	22,847	10.7%	149,117	70.0%

Source: Anuario Estadístico de Lanzarote, 1999.

(a) Black numbers are given by "Cabildo de Lanzarote, 1998c". Red numbers are extrapolations done by the author based on these numbers.

(b) Electric transformation data from "Gobierno de Canarias, 1999a".

Table 4.2 – Electricity Production by Source

	Oil (MWH)	%/Total	Wind (MWH)	%/Total	Total (MWH)
1996	407,828	95.60%	18,755	4.40%	426,583
1997	456,439	97.28%	12,758	2.72%	469,197
1998	489,637	96.48%	17,846	3.52%	507,483
1999	548,182	96.82%	17,997	3.18%	566,179

Source: Anuário Estadístico de Lanzarote, 1999 and Cabildo de Lanzarote, 1998c.

According to the Cabildo de Lanzarote (1998e, p.40) and El Guincho (1998, p.134), the electricity and the transportation sectors emitted respectively in 1996 440,767 MT./year and 192,000 m.t.. of CO_2. In addition, the way of access to Lanzarote, mainly by plane, accounted for 1,230,000 m.t. of CO_2 emitted in the same year.

[15] The percentages of the inputs in this figure are an average from the years 1996 to 1999. The output percentages refers to 1996.

To complete the energy flow account and to be able to understand the Lanzarote's metabolism as proposed, data hereby presented have to be adjusted to the reference year of 1999. Moreover, it has to be identified which proportion of this oil consumption and of the CO_2 emitted are proceeded from residents and from tourists uses.

4.1 Transportation Sector

Table 4.1 indicates that the inland transportation is responsible for roughly 30% of total oil consumption (63,851 m.t.). At the same time, almost 30% of vehicles are destined for tourist use (including cars for rent and taxis as tourists' transport, excluding public and private buses; see table 4.3). Due to the intensive use of vehicles by tourists, it is assumed that cars for rent and taxis, as well as the public service vehicles, spend twice as much oil as private cars do (see table Annex 1.2 with multiplier factor of oil consumption in the annex 1). Thus, the relative percentage of oil consumption, by type of vehicle and utilization, is given on table 4.4.

Table 4.3 – Number of Vehicles.

	Trucks and Vans			Buses			Cars			Motorcycle			Others		
Service	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Private	11,343	12,427	13,911	25	26	31	34,061	37,216	39,879	2,293	2,332	2,409	295	335	382
Public Service	344	371	415	216	272	326	50	49	53	1	1	1	372	378	431
Auto Taxi	1	2	2	0	0	0	340	335	359	0	0	0	0	0	0
Rent Cars	749	735	823	0	0	0	19,637	21,650	23,199	95	96	99	1	1	1
Driving School	4	4	4	4	4	5	67	61	65	19	22	23	5	5	6
TOTAL	**12,441**	**13,539**	**15,156**	**245**	**302**	**362**	**54,155**	**59,311**	**63,555**	**2,408**	**2,451**	**2,532**	**673**	**719**	**820**

Source: Dirección General de Tráfico. Ministerio del Interior
Anuário Estadístico de Lanzarote, 1999.

Table 4.3 – Number of Vehicles - Continuation.

	Total			% Total		
Service	1997	1998	1999	1997	1998	1999
Private	**48,017**	**52,336**	**56,612**	**68.7%**	**68.6%**	**68.7%**
Public Service	**983**	**1,071**	**1,226**	**1.4%**	**1.4%**	**1.5%**
Auto Taxi	**341**	**337**	**361**	**0.5%**	**0.4%**	**0.4%**
Rent Cars	**20,482**	**22,482**	**24,122**	**29.3%**	**29.5%**	**29.3%**
Driving School	**99**	**96**	**103**	**0.1%**	**0.1%**	**0.1%**
TOTAL	**69,922**	**76,322**	**82,425**	**100.0%**	**100.0%**	**100.0%**

Source: Dirección General de Tráfico. Ministerio del Interior
Anuário Estadístico de Lanzarote, 1999.

According to table 4.4, tourists spent approximately 40,6% (25,935 m.t.) of the oil consumed in the transportation sector, which is equivalent to 12.2% of the total oil consumed on the island in 1999.

Table 4.4 – Percentage of oil used by type of vehicle and utilization, 1999.

	Trucks and Vans	Buses	Cars	Motorcycle	Others	Total
Private	23.1%	0.1%	33.1%	1.0%	0.3%	**57.6%**
Public Service	0.7%	0.5%	0.1%	0.0%	0.4%	**1.7%**
Auto taxi	0.0%	0.0%	0.6%	0.0%	0.0%	**0.6%**
Rent cars	1.4%	0.0%	38.6%	0.1%	0.0%	**40.0%**
Driving school	0.0%	0.0%	0.1%	0.0%	0.0%	**0.1%**
Total	**25.2%**	**0.6%**	**72.4%**	**1.1%**	**0.7%**	**100.0%**

Personal Elaboration

The number of cars on the island increased approximately 30% from 1996 to 1999. Thus, the application of this percentages to the CO_2 emitted in 1996 by the transportation sector, gives a total of 249,600 m.t. of CO_2 emitted by the transportation sector in 1999. Since tourists are responsible for 40.6% of the oil consumed on the inland transportation, the amount of CO_2 emitted in this specific sector is of 101,338 m.t., or 10.8% of the total CO_2 emitted in Lanzarote in 1999.

4.2 Electricity

The desalinization process is the largest individual consumer, responsible for some 17% of the total demand. Commercial and industrial uses, which include the tourism industry, spend 58% of the total electricity. The other 25% is from residential use (22%) and public illumination (3%).

Of all of electricity generation, 96%-97% is provided by electrical transformation from oil and between 3 and 4% has its source in wind power. The Lanzarote water company – Inalsa – has its own wind electricity generation plant. Therefore part of the wind-generated energy on the island – 75% – powers the desalinization process exclusively. Notwithstanding, it accounts for just 20% of the energy demanded by the desalinization process while the remaining 80% is supplied by the energy company (Unelco) from an electrical transformation source.

4.2.1 Desalinization Process – Water

The total water produced and consumed in Lanzarote, as well as the amount of electricity used in the desalinization process (from both oil and wind sources) are given on table 4.5.

Table 4.5 – Water Production, Consumption and Respective Energy Used.

	Water Production (m^3)	Water Consumption (m^3)	Electricity Consumed in the Desalinization Process (MWH)	%/total Lanzarote's Electricity Consumption	Electricity Generated with Imported Energy (Petrol) (MWH)	%/total Electricity Consumed in the Desalinization Process	Electricity Generated with Renewable Energy (Wind Power) (MWH)	%/total Electricity Consumed in the Desalinization Process
1996	10,269,800	7,620,603	68,000	17.3%	54,316	79.9%	13,684	20.1%
1997	11,028,818	7,972,665	75,400	17.6%	66,196	87.8%	9,204	12.2%
1998	12,415,815	9,065,922	81,890	17.6%	68,411	83.5%	13,479	16.5%
1999	13,165,519	9,890,951	79,724	16.0%	66,076	82.9%	13,648	17.1%

Source: Inalsa, verbal communication.
Anuário Estadístico de Lanzarote.1999.

It is estimated that tourists use 1.67 times more water than residents do – 230 l/person.day and 138 l/person.day respectively (Cabildo de Lanzarote, 1998c). Thus, supposing that all of the available desalinized water is used by households, and that the loss before the final consumption is equal to everybody (0.33 m^3 lost per each m^3 of water consumed), it concluded that 6,322,281 m^3 of water produced in 1999 (1,572,497 m^3 lost on the distribution process and 4,749,784 m^3 consumed) – 48.0% of the total – was destined for tourists. It implies an use of 9,137 m.t. of oil on the desalinization process, or 4.29% of all the oil consumed on the island (see table 4.6).

Table 4.6 – Water consumed and energetic expenditure on the desalinization process - 1999.

	Population	Water consumed	Loss	Total Water Produced (m^3)	Electricity Produced to be Used in the Desalinization Process (MWH)	Electric Transformation Efficiency (m.t./MWH)	Total Oil Spent (m.t.)	% Total Oil Consumed in Lanzarote
Tourists	49,997	4,749,784	1,572,497	6,322,281	39,667	0.230343207	9,137	4.29%
Residents	90,375	5,141,167	1,702,071	6,843,238	42,935		9,890	4.64%
Total	140,372	9,890,951	3,274,568	13,165,519	82,602		19,027	8.93%

Personal Elaboration

4.2.2 Commercial and Industrial Sectors

The majority of the electricity used on Lanzarote is spent on the "commercial and industrial" sectors (58%). It is difficult to estimate exactly the proportion which is generated for tourism and which is for local people uses. It will be assumed that the fraction of electricity spent on the commercial sector which is for tourism is proportional to tourism participation in this sector in terms of money. It may appears redundant to use the same percentage, but they mean different readings of the same process. For instance, a high number is desirable to money generated and undesirable to energy use. Further in this work, it will be shown that tourists are responsible for 37% of expenditures in the commercial sector, and hence, by analogy, it is adopted that 37% of electricity of the commercial sector is used to satisfy tourists

demand. Since most goods sold in Lanzarote come from outside economies, consumption in this sector does not multiply electricity consumption nor money generation to a great extent.

Commercial and industrial sectors use 58% of the total electricity produced in Lanzarote and 59.6% of the total oil destined to electric transformation[16], which means 326,934 MWH and 75,307 m.t. of oil to generate such electricity. In this situation, tourism consumes 120,966 MWH and consequently 27,864 m.t. of oil, equivalent to 13.1% of the total oil imported to the island.

4.2.3 Residences and Public Illumination

Residences spend 22.5% of the oil destined to electricity production, which means 124,559 MWH. This electricity is assumed to be used by the resident population in its totality. The electricity used to public illumination is considered to be a political decision which provide welfare to all. Thus, the 2,8% of oil electricity used in this sector, 16,985 MWH, enter in the whole Lanzarote's Metabolism, but do not enter as tourist or residents uses.

Thus, not including GLP and other uses, which account for 10% of total oil consumption, tourists spent in Lanzarote 12.2% of the total oil on locomotion, 4.3% on water production and 13.1% on the commercial and industrial sectors. This accounts for the total use by tourists of approximately 29.6% of the total oil imported to the island as indicated on table 4.7.

Table 4.7 – Tourists oil consumption (m.t.).

Oil Consumption (metric ton - m.t.)														
		Inland Transportation			Non Transportation Uses							Total tourists		
		Total of Transp. [a]			Electric Transformation [b]									
1999	TOTAL	m.t.	%/total transp.	%/total oil onsumed	water	%/total water	%/total oil consumed	Commercial and industrial use	%/total commerce	%/total oil onsumed	%/total electricity	m.t.	%/total oil onsumed
	212,968	25,935	40.6%	12.2%	9,137	48.0%	4.3%	27,864	38.0%	13.1%	29.3%	62,936	29.6%

Personal Elaboration

In 1996, 441,000 m.t. of CO_2 were emitted in the electric transformation process (Cabildo de Lanzarote, 1998e, p.40). Since the oil spent on electric transformation increased 55.6% from 1996 to 1999, the CO_2 emissions is assumed to have increased in the same proportion. It means that in 1999, 684,432 m.t. of CO_2 were

emitted to the atmosphere in Lanzarote as a result of electric transformation. According to the table 4.7 tourists use 29,6% of the oil spent to generate electricity. Applying this percentage to the output side, gives that 200,539 m.t. of CO_2 emitted in the electric transformation process in 1999 were due to tourists electricity use.

Therefore, in 1999, 934,032 m.t. of CO_2 were emitted in Lanzarote – 249,600 m.t. on the transportation sector and 684,432 on the electric transformation process. 32.3% of the total, or 301,876 m.t., were produced due to tourism activities. In addition, it was estimated that in 1996 the access to the island was responsible by an emission of 1,230,000 m.t. of CO_2.

[16] The difference in percentages here is due to the fact that the wind generated energy is not distributed equally between sectors. The desalinization process consume, proportionally, more energy from wind source.

Chapter 5 – The Lanzarote's Material Flow Account, 1999

The agricultural land area has decreased as tourism increases, a consequence of change on land use patterns and on population's occupation. In 1982 there was 8,268 ha. of agricultural land (Extramedia Consultores, 2000). In 1999 this area was of only 3,171 ha. (Gobierno de Canarias, 1999). Furthermore, the local ecosystem does not supply natural resources in abundance to be transformed in a productive process. In this situation, most materials consumed on Lanzarote are imported from other countries or regions.

5.1 Total Material Requirement (TMR)

The total material requirement (TMR) of a society is composed by the direct material input (DMI = domestic extraction + imports) plus the domestic and the foreign hidden flows. Thus, to analyze the material flow, the local production and the imports will be separated.

5.2.1 Domestic extraction

The domestic extraction in Lanzarote is mainly composed of agriculture and cattle. The agricultural land area and the type of culture cultivated is given on table 5.1.

Table 5.1 – Cultivated land area and type of culture (ha.) – 1999.

	1999	%
Potato	247	7.79%
Other tubercle plant	121	3.82%
Industrial cultivations	225	7.10%
Onion	101	3.19%
Tomato	30	0.95%
Melon	21	0.66%
Green Stuff	96	3.03%
Grape	2,277	71.81%
Others	53	1.67%
TOTAL	**3,171**	**100.00%**

Source: Servicio de Estadística. Consejería de Agricultura, Ganaderia, Pesca y Alimentación.

It was not found information regarding the correspondent weight of such a production. The total weight of the grape production, however, culture responsible by almost 72% of the total cultivated area, is available and is of 2,691 ton (Anuario Estadistico de Lanzarote). The weight of the remaining 28% of production has been estimated based on data available of cultivated land area and weight production to the

aggregate of the Las Palmas province. That is to say, it is assumed that the productivity in Lanzarote is similar to that of the Las Palmas province. In this situation the weight of the remaining local production is given on table 5.2.

Table 5.2 – Agricultural production in 1999, excluding "green stuff", "others" and grape (m.t.).

	1999
Potato	2,887
Other tubercle plant	139
Industrial cultivations	813
Onion	1,768
Tomato	2,574
Melon	172
TOTAL	**8,353**

Personal Elaboration.

The total weight of the agricultural production[17] in Lanzarote is thus, approximately, 11,044 ton.

There is not many information regarding the weight of cattle. The only estimation available regarding weight of animals is given by the Cabildo de Lanzarote (1998d). Multiplying the weights given by this document by the animals' census given by the Cabildo de Lanzarote (2000) show that the total animal population weights roughly 1,115 ton.. That is to say, approximately 10% of the agricultural production.

Furthermore, there is a big requirement of materials to the construction sector. Most part has imported sources, but there is important extraction of land and rock to supply these necessities. Part of these extraction enter direct as material to the construction sector, but part are hidden flows, i.e. they are removed, causing impact, but do not enter directly in the economic system. Despite an important flow of construction materials, they have not be accounted due to lack of data.

5.1.2 Imports

Almost all of Lanzarote's imports arrive through the Arrecife port (99,4%), being the airport used mostly for passenger traffic (extramedia consultores, 2000). According to the Las Palmas Port Authority (Autoridad Portuaria de Las Palmas, 1999), 1,157,523 ton. of products entered the island in 1999 as specified in table 5.3.

[17] Excluding "green stuff" and "others" because they are composed by products with different productivity and thus not possible to sum up. They account for less than 4% of the total productive area.

Table 5.3 – Goods unloaded in Arrecife's Port (importation) according to the economic activity of destination (1999).

Destination of the good	Tons.	%
Power Products	212.968	28,3%
Agriculture and Cattle Breeding	8.992	1,2%
Industry	20.043	2,7%
Building Materials	322.611	42,9%
Commerce	188.253	25,0%
Total	**752.867**	**100,0%**
Combustible to navigation	149.590	
Container tare	41.029	
Containerized goods in transit [(a)]	214.033	
TOTAL	**1.157.519**	

Source: Autoridad Portuaria de Las Palmas.
Personal elaboration.

Of this total, 752,967 ton. are destined to the local market, while other 404,652 ton. are destined to navigation or are further sent to other island. Therefore, they do not enter the Lanzarote's system. Furthermore, 212,968 ton. imported are power products, and it will be discounted to avoid double account with the energy flow account. Consequently, the direct material input (DMI) is 11,044 ton. (local agricultural production), plus the cattle weight (around 1,115 ton.), plus the local extraction of land to the construction sector and plus 539,899 ton. (imports). That is to say, the DMI is 550,943 ton. plus the cattle weight and the local land extraction.

5.1.3 Domestic and foreign hidden flows

Domestic and foreign hidden flows have not been estimated on this work. Since this work focuses strictly on what happens within Lanzarote's boundaries, other economies have not been object of study and the foreign hidden flows could not be estimated. Domestic hidden flows lacks of data to be analyzed deeply. These flows are probably not very big, since the local production is extremely low. Nevertheless, in addition to some hidden flows resulting from agriculture production, which certainly exist, there is the mentioned hidden flow of land extraction to the construction sector, which affect landscape.

5.2 Total Domestic Output (TDO)

The TDO is formed by the domestic processed output (DPO) plus the domestic hidden flows. Due to the reasons already mentioned, domestic hidden flows

have not been accounted. The domestic hidden flow appears in both the input and the output side because it does not enter the economy.

The DPO is composed by the residues which flow out of the system. It is estimated that in 1996, 159,807 ton. of solid residue has been generated (Cabildo de Lanzarote, 1998d). The physical composition of this solid residue is given on table 5.4.

Table 5.4 – Composition of solid residues generated in Lanzarote, 1996.

Type	Quantity		Type of collection
	m^3	Ton	
Solid domestic urban waste	187.629	48.784	Public
Carton paper and glass waste	---	1.305	Private
Vegetal waste (gardening)	26.520	3.978	Mixed
Automobiles and tires waste	1.250 (1)	1.282	Private
Rubble and land from excavation	97.200	97.200	Private
Dirt	2.900 (2)	2.900	Private
Cattle dung	14.100	4.230	Private
Farms and slaughterhouse waste	---	128	Public
Total	329.599	159.807	---

Source: Cabildo de Lanzarote, 1998d.
(1) 22% of dry mass equal to 638 ton.

The same source shows that from these 159,807 ton of solid waste, less than 7,000 ton. have been recycled. Furthermore, from these 7,000 ton, cattle dung accounted for most of the recycles, and carton, paper and glass was second, each sector representing 4,230 and 1,305 ton. respectively. Automobiles waste recycles followed (Cabildo de Lanzarote, 1998d, p.68).

The analysis of the TMR and of DPO gives the Lanzarote's material balance as indicated on figure 5.1 below.

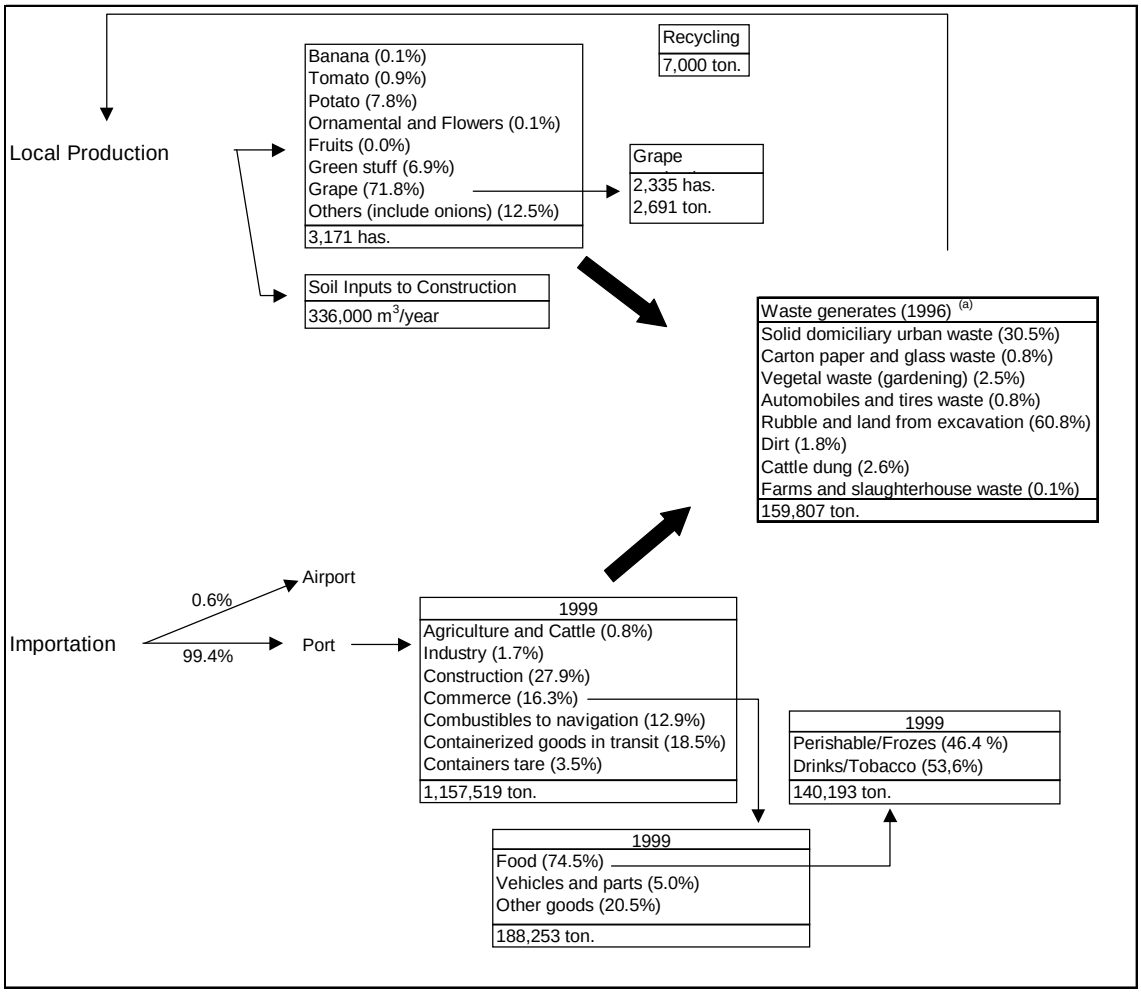
5.3 Exports

Since the productivity in Lanzarote is very low, the exportation is also very low. Indeed, the importation exceeds the exportation to a great extent. According to the Las Palmas Port Authority (Autoridad Portuaria de Las Palmas, 1999), the total amount of goods exported from Lanzarote in 1999 was of 177,605 ton., most composed by rests of vehicles.

5.4 Net Addition to Stock (NAS)

The difference between the DMI and the DPO added with the exports, gives the net addition to stock (NAS). That is to say, the NAS = DMI – (DPO + exports). Thus, the NAS in Lanzarote in 1999 was of 213,531 ton.

Figure 5.1 – Material Balance.



(a) Percentage of the total volume

5.5 Tourists' Material Flow

5.5.1 Input

It has been shown that the material balance of Lanzarote is fed, basically, by imported products. Internal production is chiefly concentrated in the primary sector – agriculture and cattle (mainly goats and birds). Moreover, internal production is not enough to supply the whole population which inhabits the island daily. The total weight of agricultural production is roughly 10% of the total weight of food imported to the island (140,193 ton. according to Autoridad portuaria de Las Palmas, 1999). The incorporation of the weight of cattle production diminish this difference, but it is still high and the external dependence is very strong. Going beyond the primary sector, weights of importation become extremely high compared with internal production. Thus, the tourists' material balance will be focused, basically, on the imported products.

To calculate the importance of tourism to the material balance of Lanzarote it is necessary to have information about both tourist and resident consumption patterns and expenditure. With this information it is possible to estimate the relative participation of tourism in the total consumption of the island. However, such information is not available in the required format. Consequently, data necessary to provide the mentioned information was estimated based on secondary data available by the Canary Institute of Statistics (ISTAC). Data relative to tourists expenditure are available in the *Inquire about Tourist Expenditure* (ISTAC, 2000) and refers to Lanzarote in the year 1999. Local population expenditure was found in the *Annually Statistic Book of Canary* (ISTAC, 2000a) and refers to the aggregate of the Canary population in 1991. Since the categories for which expenditures are given are not the same in both publications available from the ISTAC, as well as the year of reference being not the same, an aggregation procedure was made freely by the author to allow comparison of information. Data referring to 1991 was corrected by the IPC given by the Spanish National Statistic Institute (INE) and by the GNP growth in the Canary island, assuming that local population expenditure increases proportionally to the economic growth. Moreover, it was accepted that expenditure patterns of local population in Lanzarote are similar to the expenditure average on the entire Canary archipelago. After all these adjustments made, the information resultant is displayed on table 5.5 as follows. Notice that expenditure of tourists refers only to expenditures made in Lanzarote. Nevertheless, approximately 64% of tourists' expenditures on travel to Lanzarote are made in their home city (ISTAC, 2000, p.35).

Table 5.5 – Total expenditure of tourists and residents in Lanzarote, 1999 (million of pesetas).

	Tourists total expenditure (a)	%/total	Residents total expenditure (b)	%/total	Total
Food, Drink and Tobacco	17,705	42.0%	24,424	58.0%	42,129
Commerce	12,693	35.9%	22,655	64.1%	35,348
Sub-Total Commerce	30,397	39.2%	47,079	60.8%	77,476
Transport and Communication	8,847	39.9%	13,349	60.1%	22,196
Restaurants and Hotels	43,100	82.5%	9,170	17.5%	52,270
Others	22,727 (c)	43.8%	29,147 (d)	56.2%	51,874
Total	105,071	51.6%	98,745	48.4%	203,816

Source: (a) ISTAC, 2000.
(b) ISTAC, 2000a.
(c) Include organized tours, leisure and discos.
(d) Include house rent or mortgage, health, education and tax.
Personal elaboration.

The categories displayed in the table 5.5 above, excluding 'others', represent approximately 50% of the gross added value of Lanzarote (compare with table 6.1 on the next chapter). The construction sector have to be added to these categories. Materials mobilized in the construction sector are heavy, and all the material used in this sector sums up an important weight to Lanzarote's economy (indeed, according to table 5.3, building materials are responsible by 42.9% of Lanzarote's importation). Thus, the construction sector will have an important influence in the final material balance.

It was not found reliant data related to the construction sector. Information regarding the total amount of cement as well as the total constructed area is available. Nevertheless, the class of buildings which exist or are going to be constructed is not clear. Thus, the tourism influence in the construction sector is not possible to be determined accurately

Face to this obstacle, 3 scenarios were made, with different distribution of construction sector, in terms of weights, between tourists and residents. The activity in the construction sector due to tourism is not only a result of accommodation construction, but is also felt by all the other buildings (bureaucratic offices, commerce, cinemas, hospital, etc.) and infra-structure which are built to supply tourists demand. Thus, for instance, a percentage of the commercial area built in Lanzarote is to satisfy tourism demand. It can be supposed that the percentage of commercial area built to satisfy tourism is proportional to the amount of money spent by tourists in this sector (39,2% of the total).

The Cabildo de Lanzarote (2001), based on data provided by the Canary official school of architects (Colegio Oficial de Arquitetos de Canarias – COAC), points out that in 1999, 21.2% of all executive projects approved by such institution (COAC) had touristic ends. Nevertheless, the meaning of each category in the document presented is not clear and thus is not possible to know exactly the proportion of constructions which are destined to tourism purposes. For example, it is not possible to know if the projects approved to commerce and shows houses' construction are going to supply tourists or residents demands. Probably, they will serve to both. But the biggest problem regards the category private houses, which is shown to be more than 3 times superior to the category tourism in terms of construction area approved. First, not certainly all the projects approved are going to be done. Second, possibly part of the projects approved to be private house are going to work as accommodations for tourists.

These information should be checked with the COAC and the Cabildo de Lanzarote. Nevertheless, there is not better information to date.

Therefore, the 3 scenarios which will be used are: (1) accordingly to the mentioned document, with 20% of construction sector moved by tourism and 80% due to residents; (2) Equal shared between tourism and residents, that is, 50% and 50%; and (3) 80% due to tourism and 20% due to residents. Indeed, the population growth between 1996 and 1999 was of 15.6%, from which 68.5% refers to the local population and 31.5% is due to tourist growth. Locally, in the field visit, it called more the attention the quantity of hotels which were being building that the private houses constructions. But it may be a merely unreal impression.

Applying the percentages found to tourism expenditure of power products (oil given on table 4.7 – 29.6%), construction (adopted to be 20%, 50% and 80% in the three different scenarios) and commerce (39.2% adding the category ‘food, drink and tobacco’ to the category ‘commerce’ on table 5.5) to the importation weights showed in the table 5.3, the percentage of importation destined to tourism and the one destined to local population is given. It can be visualized on tables 5.6, 5.7 and 5.8 according to the three different scenarios of construction sector.

Agriculture is practiced in a small scale. This practice has been decreasing with the increase of tourism. Consequently it is estimated that all of the imported inputs to agriculture are destined to local population. Despite the fact tourists consume agricultural products, these inputs would occur in Lanzarote even with the absence of tourists. It could even be larger. Cattle follow the same patterns. Participation of the industrial sector in importation is also relatively small. Furthermore, there is not an important industrial activity destined for tourists’ consumption. In this way, the industrial sector was assumed to attend exclusively the local population. As well as in the agriculture, a decrease in tourism probably would not affect directly the small industrial sector. Three different scenarios were built to the construction sector. In any case, with the absence of tourism, population growth would be very small on the island, in the same way it was in the past, and consequently the construction sector would be much smaller than it is today. Part of the imported goods given on table 5.3 are not included in this analysis of material balance because they do not enter directly in the system. Part of the power products is excluded because they have the navigation sector as a final destination, which has not been considered in this study. Containerized goods

in transit arrive in Lanzarote and are further transported to another destination and thus they also do not enter directly in Lanzarote's system.

Table 5.6 – Weights of importation to Lanzarote according to destination activity and population, Ton., 1999. Construction sector – scenario 1.

Destination of the good	Tourists	%	Residents	%	Total	%/total weight
Power Products	62,936	29.6%	150,032	70.4%	212,968	28.3%
Commerce	73,795	39.2%	114,458	60.8%	188,253	25.0%
Agriculture and Cattle Breeding	0	0.0%	8,992	100.0%	8,992	1.2%
Industry	0	0.0%	20,043	100.0%	20,043	2.7%
Building Materials	64,522	20.0%	258,089	80.0%	322,611	42.9%
Total	**201,253**	**26.7%**	**551,614**	**73.3%**	**752,867**	**100.0%**
Combustible to Navigation					149,590	
Container tare	--	--	--	--	41,029	
Containerized goods in transit	--	--	--	--	214,033	
TOTAL					**1,157,519**	

Personal Elaboration

Table 5.7 – Weights of importation to Lanzarote according to destination activity and population, Ton., 1999. Construction sector – scenario 2.

Destination of the good	Tourists	%	Residents	%	Total	%/total weight
Power Products	62,936	29.6%	150,032	70.4%	212,968	28.3%
Commerce	73,795	39.2%	114,458	60.8%	188,253	25.0%
Agriculture and Cattle Breeding	0	0.0%	8,992	100.0%	8,992	1.2%
Industry	0	0.0%	20,043	100.0%	20,043	2.7%
Building Materials	161,306	50.0%	161,306	50.0%	322,611	42.9%
Total	**298,037**	**39.6%**	**454,830**	**60.4%**	**752,867**	**100.0%**
Combustible to Navigation					149,590	
Container tare	--	--	--	--	41,029	
Containerized goods in transit	--	--	--	--	214,033	
TOTAL					**1,157,519**	

Personal Elaboration

Table 5.8 – Weights of importation to Lanzarote according to destination activity and population, Ton., 1999. Construction sector – scenario 3.

Destination of the good	Tourists	%	Residents	%	Total	%/total weight
Power Products	62,936	29.6%	150,032	70.4%	212,968	28.3%
Commerce	73,795	39.2%	114,458	60.8%	188,253	25.0%
Agriculture and Cattle Breeding	0	0.0%	8,992	100.0%	8,992	1.2%
Industry	0	0.0%	20,043	100.0%	20,043	2.7%
Building Materials	258,089	80.0%	64,522	20.0%	322,611	42.9%
Total	**394,820**	**52.4%**	**358,047**	**47.6%**	**752,867**	**100.0%**
Combustible to Navigation					149,590	
Container tare	--	--	--	--	41,029	
Containerized goods in transit	--	--	--	--	214,033	
TOTAL					**1,157,519**	

Personal Elaboration
Notice that red number are adopted with no data foundation.

In the scenarios described, tourists and residents have a material consumption pattern per capita of 4.03 kg/person and 6.10 kg/person respectively in the scenario 1, 5.96 kg/person and 5.03 kg/person in the scenario 2 and 7.90 kg/person and 3.96 kg/person in the scenario 3. Excluding power products to avoid double accounting

with the energy sector, the per capita material consumption is 2.77 kg/person and 4.44 kg/person in scenario 1, 4.70 kg/person and 3.37 kg/person in scenario 2 and 6.64 kg/person and 2.30 kg/person in scenario 3, to tourists and residents respectively. The construction sector is still uncertain and may change according to more precise data.

5.5.2 Output

The total DPO of Lanzarote in 1996 accounted for 159,807 tons, from which 91.3% correspond to "solid domestic urban waste" (30.5%) and "rubble and land from excavation"(60.8%) (see table 5.4). The determination of tourists' participation on the Lanzarote's DPO will be based on the percentages found on the input side of the system. That is to say, the percentages of tourists' requirements in the different sector will be applied to the residues generated by each of these sectors.

Materials used on building sector usually are durable goods, i.e. they are of long duration and take many years to be disposed as residue. These materials, which appear in the island as hotels, houses and infrastructure, are the main contributor to Lanzarote's "NAS". Thus, wastes generated by the building sector are not a function of the amount of inputs. Rather, they are a function of the quantity of demolition and excavations. However, these materials eventually become waste outflows, too.

As a result, the biggest outflow of the Lanzarote's system, "rubber and land from excavation", is not directly related to the number of tourists or the size of the population. Of course, the amount of constructions are related to the population, and in the end the final disposition of waste is also related to population. But this relation is not direct, and it is not possible to link this specific class of waste to the size or the change in size of population. Moreover, part of this flow may be hidden flows of other economic process.

Due to the uncertainty on this outflow, the 30.5% of domestic solid urban waste (DSUW) will be focused here. Agriculture, commerce and industry are sectors which contribute directly to the amount of output generated as DSUW. These sectors were accounted for a total input of 217,288 ton. in 1999 from imported source.

Food alone accounts for 140,193 ton. of imported products (Autoridad Portuaria de Las Palmas, 1999) plus the 11,044 ton of local agricultural production and the animals production. The category "food" can be divided in two groups. One is composed by perishable and frozen products (64,980 ton.) and the other is constituted by drinks and tobacco (72,213 ton.). The first group generates organic matter as waste,

and the latter generates mainly glass from bottles and aluminum from tin cans. This means that the imported food which will increase the waste generated is composed by 64,980 ton. of perishable and frozen products plus the weight of bottles and tin cans.

According to Cabildo de Lanzarote (1998d, p.56), 44% of Lanzarote's domestic solid urban waste in 1996 was organic matter, corresponding to 21,465 ton. Applying the rate by which the importation increased from 1996 to 1999 (and consequently the amount of food which entered the system), 49.6%, to the domestic organic matter generated in 1996 gives an estimation of 32,112 ton. of organic matter generated in 1999 (see table 5.9).

Table 5.9 – Composition estimated of domestic solid urban waste (DSUW), 1999.

	Ton.	%
Organic Matter	32.112	44,0%
Paper and Card	17.515	24,0%
Plastic	8.028	11,0%
Glass	7.297	10,0%
Metal	3.649	5,0%
Aluminum		
Textile	730	1,0%
Wood	730	1,0%
Battery	730	1,0%
Rubber		
Land	2.190	3,0%
Other		
TOTAL	**72.981**	**100,0%**

Source: Cabildo de Lanzarote. 1998d
Personal elaboration

Different percentages of tourists' participation on the DPO were assigned to different categories. Assumptions made here are in accordance with other assumption made along this work. Nevertheless, lack of detailed information on the waste generation and final disposal in Lanzarote may conduce to some disagreement. The percentages were assigned according to the follow rationality:

- Organic matter, generated basically by food waste, is considered to be proportional to the population, considering tourists as well as residents.
- Textile, wood, battery and land are not significant in the final result and there is no information about their consumption. Thus, these categories were also considered as proportional to the population.

- Glass and metal are residues associated to drink consumption. Therefore, it was estimated that 48.4% of the waste generated within these categories is due to tourists consumption[18].
- Paper, card and plastic are residues of processed material. That is to say, they are residues of materials which are imported to Lanzarote and are not specifically destined to basic consumption. Therefore, these categories follow the same percentage of goods imported to commerce.

The table 5.10 show the percentages assumed to each sector and the respective waste generated by tourists and residents to each of these sectors.

Table 5.10 – Composition estimated of domestic solid urban waste (DSUW) accordingly to population, 1999.

	Tourists		Residents	
Organic Matter	35.6%	11,432	64.4%	20,680
Paper and Card	35.9%	6,288	64.1%	11,227
Plastic	35.9%	2,882	64.1%	5,146
Glass	48.4%	3,532	51.6%	3,766
Metal	48.4%	1,766	51.6%	1,883
Textile	35.6%	260	64.4%	470
Wood	35.6%	260	64.4%	470
Battery	35.6%	260	64.4%	470
Land	35.6%	780	64.4%	1,410
TOTAL	37.6%	27,459	62.4%	45,522

According to the assumptions hereby presented, tourists are responsible by 37.6% of the DSUW of Lanzarote, equivalent to 27,459 ton, while residents generate 45,522 ton. of DSUW, or 62.4%.

[18] 42.0% of money expenditures on "food, drink and tobacco" are made by tourists. Since it is considered the food consumption as proportional to the population distribution between tourists and residents, the percentages spent on drinks and tobacco have to be higher than the relative population distribution (and even higher than 42.0%) to get the final result of 42% of expenditures on "food drink and tobacco" made by tourists.

Chapter 6 – Lanzarote's Metabolism

It is now possible to design the Lanzarote's Metabolism, based on the MEFA previously presented. The identification of such a metabolism will be divided into tourists and residents' flows. To this representation, the scenario 2 of construction sector – construction sector divided equally among tourists and residents – will be adopted. Notice, however, that it may change accordingly to the scenario accepted as more close to reality. The Lanzarote's metabolism is represented in the **figure 6.1**.

6.1 Gateways

According to Matthews et. al. (2000, p.7) gateways are the first point of entry of a material flow into the environment. The total domestic output can be disaggregated to show the quantity and major constituents of flows to environment. The environment gateways are air, land and water.

The analysis of the environment gateways is important because it is possible to identify potential impacts generated by the outflows. Moreover, the joint analysis of MEFA and environment gateways supports decision making.

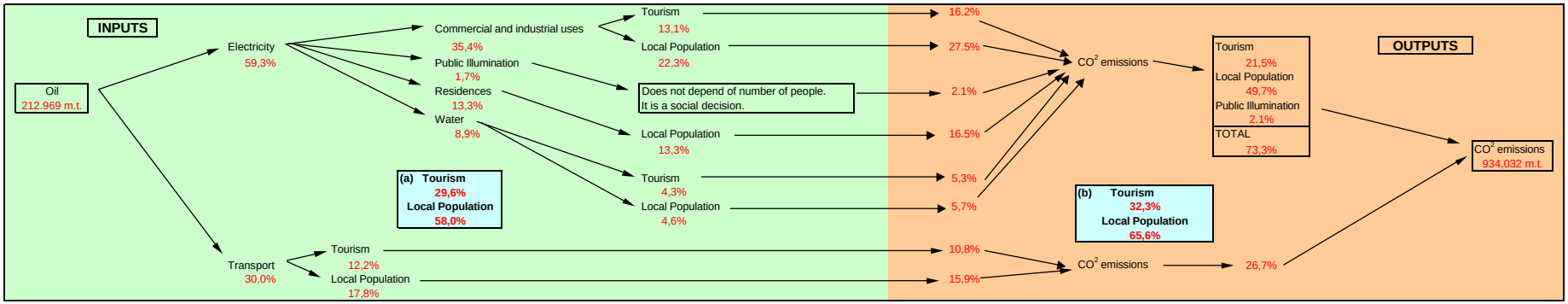
In this work, two main environment gateways were identified in Lanzarote, namely air and land. In the material consulted along this work, it was not found references of outflows to water environment (Cabildo de Lanzarote, 1998d), despite the fact that in the field visit some people argued that these flows do exist[19]. The lack of information about residues management in Lanzarote implies a complete ignorance regarding chemical composition of it. There are only estimations available about physical composition, and even those are precarious. Thus, the analysis of gateways flows are very simplified.

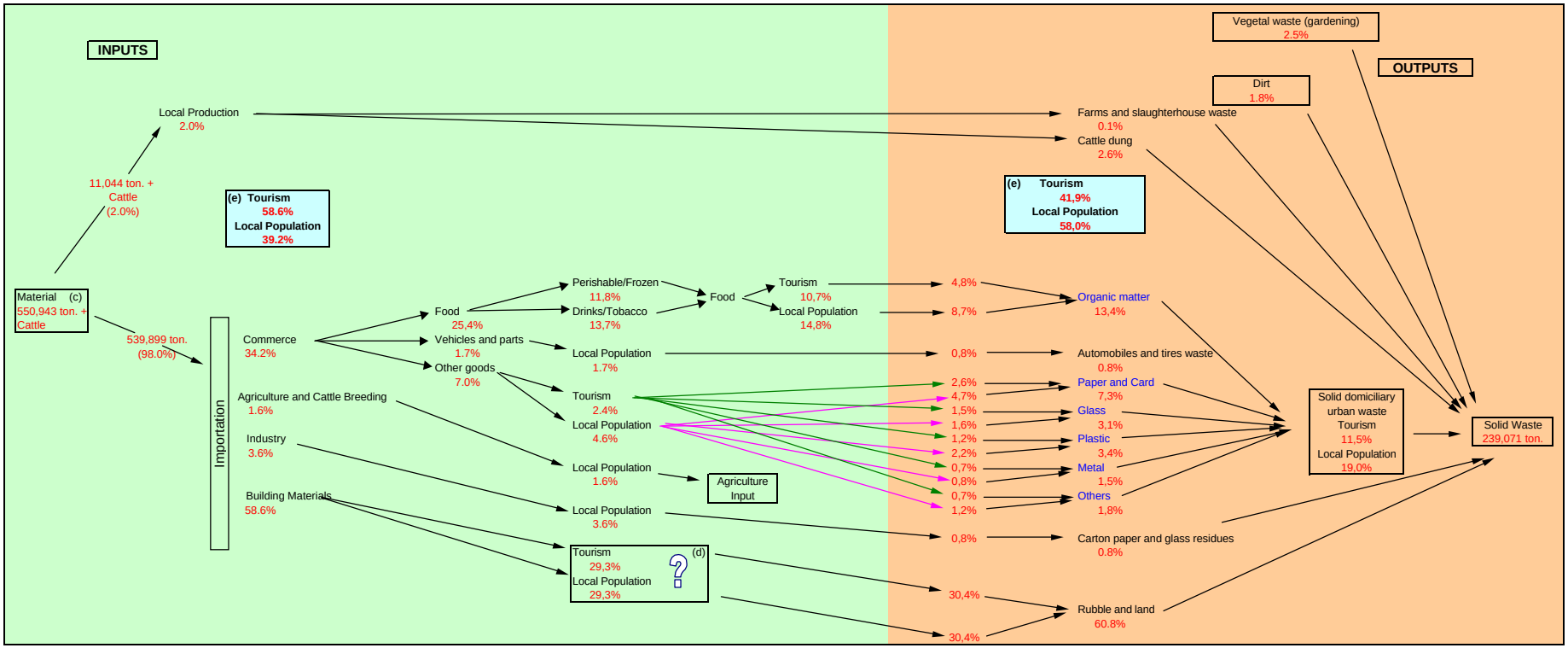
CO_2 was identified as one of the main outflows of Lanzarote's system. This flow enter the environment clearly through the air gateway.

[19] Indeed, Lanzarote's underground water is already contaminated. Moreover, the main touristic areas are located near to the coast, and possibly there are outflows to the ocean environment.

Figure 6.1

LANZAROTE'S METABOLISM





(a) Percentage of total oil consumed in Lanzarote, excluding Public Illumination and "GLP and other uses".
(b) Percentage of total CO2 emitted in Lanzarote, excluding Public Illumination and "GLP and other uses".
(c) Excluding weights unload in Arrecife's port related to the categories "combustible to navigation", "container tare"and "containerized goods in transit", which does not enter the system and does not depend from population.
(d) Assuming that the construction sector is 50% moved by tourists.
(e) Including building materials

Solid residues enter mostly by the land gateway. There is clearly some flows to air and water environment resulting from solid residues waste. At the Zonzoma's sink there are some chimneys of gases evacuation, but the quantity and composition of them are totally unknown (Cabildo de Lanzarote, 1998d). In the same way, the impacts on the sink's subsoil are ignored. The estimation of the physical composition of final waste deposition is given in the table 5.4 and is shown in the metabolism figure. Despite the lack of information regarding outflows of Lanzarote's system, the Cabildo de Lanzarote (op. cit.) points out that the situation of waste disposal and handling are not bad. That is because there are some circumstances in Lanzarote that allow further actions to palliate the pressure over the environment. Some of the mentioned circumstances are:

- Nonexistence of dangerous residues in a great or uncontrolled extent;
- The existence of a unique and well located waste treatment center;
- High demand of organic fertilizers to agriculture, external dependence of fertilizers and high deficit of organic matter in Lanzarote's soil;
- High concerns about waste management in large part of the society, ranging from island government to private sector and population.

6.2 A Non-Equivalent Description

The society's metabolism indicates physical flows through the system. In this way, environmental pressure of different flows and sectors may be visualized. A non-equivalent description of the system provides different information and allows the comprehension of different perspective of the same processes. The analysis of tourists' participation on the Gross Added Value (GAV) will describe the system differently of the physical indicators' description, and the joint analysis provide much better information to decisions makers.

Table 6.1 gives the GAV of Lanzarote, in the year 1991[20], separated by sectors. Applying the percentages found along this work of tourists' participation on each sector to the correspondent sectors of table 6.1, gives the tourism participation on the GAV.

[20] This data is available by ISTAC every 10 years. 1991 is thus the last data available. Notwithstanding GAV's values were found in the literature for 1996 (Cabildo de Lanzarote, 1998a) and 1999 (Extramedia Consultores, 2000) (158 and 188 billion of pesetas respectively). While it is not clear how the first has been calculated, the last is simply the 91 data corrected by the IPC. It is not significant information for the purpose of this task since it is known that different sectors developed differently recently, with the service

Table 6.1 – Gross Added Value (GAV), Lanzarote 1991 (million of pesetas).

Productive System	1991	Participation (%)		1996	1998
Agriculture	1.455	**1,32%**			
Fishery	2.182	**1,98%**			
Energy and Water	2.626	**2,38%**			
Chemical and Mining	891	0,81%			
Matallurgy and Machinery	610	0,55%			
Transportation Material	216	0,20%			
Food, Drink and Tobacco	2.262	**2,05%**			
Textile, Leather and Shoes	123	0,11%			
Paper, Paper Articles and Printing	496	0,45%			
Wood, Cork and Furniture	221	0,20%			
Rubber, Plastic and Other Manufactures	130	0,12%			
Construction	12.547	**11,36%**	**59,6%**		
Commerce and Repairing	18.038	**16,33%**			
Catering Business	26.928	**24,38%**			
Transportation and Communications	8.348	**7,56%**			
Credit and Assurances	3.699	**3,35%**			
Domestic Services	604	0,55%			
Others [(a)]	29.074	**26,32%**			
Gross Aggregated Value	**110.450**	**100,00%**		**158.000** [(b)]	**188.000** [(c)]

Source: Instituto Canário de Estadística (ISTAC), 1991.
(a) Education, health, public administration, services to firms, etc.
(b) Cabildo de Lanzarote, 1998a.
(c) Extramedia Consultores, 2000.

The construction sector is adopted to be equally divided into tourists and residents (scenario 2), coherently to assumptions made in the material flow analysis. Nevertheless, because of the weak reliability of such a decision, criteria involving construction sector are indicated twice, one including this sector and another not (table 6.2).

Table 6.2 – GAV and expenditure divided by tourists and residents (million of pesetas)

	Tourists	%	per capita	Residents	%	per capita	Total	per capita
Daily population	49,997	35.6%		90,375	64.4%		140,372	
Monetary indicators								
GAV (million of ptas)	47,534	48.6%	0.95	50,369	51.4%	0.56	97,903	0.70
GAV including building materials	53,808	48.7%	1.08	56,642	51.3%	0.63	110,450	0.79
Total expenditure (million of ptas.)	105,071	51.6%	2.10	98,745	48.4%	1.09	203,816	1.45

Source: Instituto Canário de Estadística (ISTAC), 1991.
ISTAC, 2000
ISTAC, 2000[a]
Personal Elaboration

Tourism is directly responsible by something less than 50% of GAV, whether including the construction sector (assumed to be 50% related to tourism) or not. If the alternative scenarios of the construction sector are adopted, tourism's participation on the GAV are of 45.3% and 52.1% respectively to scenario 1 and scenario 3. In any

sector showing a larger increase. The numbers show, however, the magnitude that these values may be currently.

case, the relative percentage of tourism participation in the GAV is clearly superior to the participation tourists have in the total daily population in Lanzarote, implying a GAV generation per capita greater to tourists than to residents. These results are coherent and very similar to that one showed on table 5.5, which indicates tourist and residents expenditures.

6.3 Impacts

Since most materials consumed in Lanzarote, as well as the oil used there, are imported, outflows' impacts are much greater than inflow's impacts. Some of them are felt at the local level, others affect the global environment.

CO_2 and gases emitted from the waste sink go directly to the atmosphere, despite only the first is well detailed and accounted. Consequently, this source of emission has a global impact. Geographical and topographical characteristics of Lanzarote are propitious to gas dispersion, and hence gases emissions is not a problem felt locally. On the other hand, carbon sinks practically does not exist in the island, being the ocean environment the only resource which can perform such function. Thus, this particular pollutant of Lanzarote's metabolism, despite affecting global environment, does not affect local environment. It is a local negative impact which is in process of being externilized to the global environment and society.

From the material point of view, outflows impacts are felt more in the local level than in the global level. Despite some global impacts like gases emitted from the Zonzoma's sink and possible residual waters running to the ocean, most absorption occur locally, basically at the Zonzoma's sink. Since most material consumed in this society comes from outside economies, impacts on the production process occur in their origin countries. That is, the foreign hidden flows caused by Lanzarote's economy are certainly high. Since this research focused specifically in the field study of Lanzarote, foreign hidden flows were not included in the analysis[21]. However, it is clear that to understand the complete society's metabolism this component shall be incorporated. But always as a separated component in such a way that it is possible to differentiate local and global impacts.

It was already mentioned that local production is relative small and concentrated in the primary sector. Moreover, it has been said that both agriculture and

[21] In the same way that oil and CO_2 emission from navigation and from access to the island were not included.

cattle are decreasing as tourism activity increases. Thus, tourism has almost no impact over the local environment regarding the productivity sector. It is even possible that tourism is contributing to environment improvement through the decrease of animals pressure on the environment, fact that allows some vegetal coverage to restore (García, 1999, p.72).

Concerning agriculture, the change of land use has two main consequences. On the one hand, the decrease of agricultural production keeps land and landscape intact of modifications imposed by human activity. On the other hand, the traditional agriculture loss[22] has signified an important decrease of food to wildlife, mainly in the summer season when food availability is more scarce. This trend, associated to the soil lost due to human occupation and fragmentation, implies an important impact to Lanzarote's fauna. The decrease of vegetation coverage, due to agricultural lost and the vegetation which develop in the surround area, has another consequence which is the lost of soil by erosion.

The pattern of soil occupation destined to satisfy tourism demand is one of the most important impacts in the island. Construction of hotels horizontally in the coast signify a large extension of built area, with a consequent landscape impact and an important soil fragmentation. Nowadays, the touristic infrastructure is basically concentrated in the ocean coast, what is favorable to keep impacts within some limits. Nevertheless, the pressure to the inland Lanzarote occupation is increasing. More serious is the extended net of roads which causes soil and landscape fragmentation and breaks biological pathways.

Some leisure activities strictly related to tourism are directly responsible by some negative impacts on natural environment. Among them García (op. cit., p.79) mentions the off-road practice, common in historic volcanic area, which causes soil loss and dust emissions. The last affects vegetation, preventing their respiration. Trekking, speleology and climbing are other mentioned activities which cause some negative impact on natural environment.

[22] For instance the cultivated area of cereals and leguminous decreased from 3,450 to 70 hectares in 30 years – from 1970 to 2000 (García, 1999, p.73).

Chapter 7 – Conclusion

The Society's Metabolism approach gives important information of material and energy flows of a given area, and constitutes an important part of a broad information system. Again, it does not give direct answers about specific complex issues, but provides information for people to ask the right questions and take better decisions. Information provided by the material and energy flow account has to be linked to other class of information, i.e. other readings of the system. For instance, economic performance and behavioral changes will add relevant perceptions of the system in a way to take better decisions. To the effective analysis of material and energy flows, the system's boundaries have to be very well defined. The point where the material or the energy leave the environment and enter into the system, and vice versa, is an important issue. The fact that the field study has been performed in an island allowed the MEFA to be done with relative precision regarding this topic.

A single number resulted from the sum of all flows' weights does not mean many things, i.e. does not indicates the system's state. The direct material input (DMI) of Lanzarote sum 550,943 ton., while the domestic processed output (DPO) 239,071 ton.. Nevertheless, 239,071 ton. of organic matter and 239,071 of heavy metals will have totally different consequences to the environment. Furthermore, not only the type of material will have different consequences, but also the way these material enter the environment, i.e. the environment gateway, is determinant. However, analyzing the components (stocks and flows) which forms the DMI and the DPO separately provides important information to the understand of production and consumption patterns. In addition to the quantification of flows individually, the identification of how they are produced, how they enter the environment and to what extent they are cause or consequence of changes on population's behavior, allows a good perspective of the system. Linking it with others non-equivalent system's descriptions will provide different perspectives and enable better decisions to be taken.

Tourism participation in Lanzarote's metabolism has been expressed in physical indicators according to figure 6.1. Tourism participation on the GAV and on the population's total expenditure was indicated in monetary terms as illustrated on table 6.2. Table 7.1 shows a summary of the results founded to both physical and monetary indicators.

Due to the uncertainty regarding the final utilization of the constructed buildings, and consequently to allocation of the construction materials, criteria involving construction sector were indicated twice, one including this sector and another not. When included, the construction sector was supposed to be equally distributed, in terms of materials weights, between tourists and residents, that is, 50% of constructions to supply tourism demand and 50% due to residents demand.

Table 7.1 – Summary of tourism participation on Lanzarote's system.

	Tourists	%	per capita	Residents	%	per capita	Total	per capita
Daily population	49,997	35.6%		90,375	64.4%		140,372	
Monetary indicators								
GAV (million of ptas)	47,534	48.6%	0.95	50,369	51.4%	0.56	97,903	0.70
GAV including building materials	53,808	48.7%	1.08	56,642	51.3%	0.63	110,450	0.79
Total expenditure (million of ptas.)	105,071	51.6%	2.10	98,745	48.4%	1.09	203,816	1.45
Physical indicators								
Inputs								
Oil consumption (m.t.)	62,936	29.6%	1.26	150,032	70.4%	1.66	212,968	1.52
Material consumption (ton.)	136,731	31.8%	2.73	293,525	68.2%	3.25	430,256	3.07
Material consumption including building materials (ton.)	298,037	39.6%	5.96	454,830	60.4%	5.03	752,867	5.36
Outputs								
CO_2 emissions (m.t.)	303,929	32.5%	6.08	630,103	67.5%	6.97	934,032	6.65
DSUW (ton.)	27,459	37.6%	0.55	45,522	62.4%	0.50	72,981	0.52

Personal Elaboration

As indicated in the table 7.1, tourism is directly responsible by something less than 50% of GAV, whether including the construction sector (assumed to be 50% related to tourism) or not. In the alternative scenarios described in chapter 5, tourism's participation are 45.3% and 52.1% respectively to scenario 1 (20% tourism and 80% residents) and scenario 3 (80% tourism and 20% residents). In any case, the relative percentage of tourism participation in the GAV is clearly superior to the participation tourists have in the total daily population in Lanzarote (35.6%), implying a GAV generation per capita greater to tourists than to residents. An interpretation to these results is that tourism is providing to Lanzarote an income generation and an economic growth would not be possible to maintain without tourists. It may be or may not be translated into a higher quality of life level, depending on how this surplus is being applied. It makes possible, for instance, an extended public illumination net, which has not been included on the analysis since it was considered a social decision which generates welfare to all.

Regarding physical flows, the relative percentage found to tourists requirement are slightly lower than the participation tourists have in the total population, if not included the construction sector. Once this sector is included (always considering the scenario 2 – 50% of construction material to tourists), the percentage increases and is higher than the percentage of tourists on the total population. It means that the physical requirements of one tourist are lower than the requirements of a resident if not included the construction sector, and similar if it is included.

On the output side, one resident contributes to CO_2 emission in a higher degree than one tourist does. Domestic solid urban waste (DSUW) generation, on the contrary, is higher in the tourist per capita pattern than in the local resident pattern. The fact residents contribute more in the material input side and less in the output side, drives to the conclusion that residents consume more durable goods than tourists. In a general way, materials consumed by residents spend more time in the society's metabolism before its final disposal.

The relative percentages found to tourism participation on the physical flows, whether in the inflows or in the outflows, are lower than the ones found to money indicators – expenditures or generation (GAV)[23]. Generally speaking, the direct impact of tourism in Lanzarote is much higher from the economic point of view (positively) than it is from the material and energetic perspectives. In absolute terms, tourism increases the island consumption and residues generation. Nevertheless, there is a surplus of money which has to be analyzed to see if it compensates damages or simple damages should be avoided.

Regarding the natural environment, it was already mentioned that the productive system does not impact Lanzarote's ecosystem in a high degree. Since economy is totally dependent on imported goods, impacts on local ecosystem occur basically due to tourists behavior on the island instead of trade-offs with economic system. That is, trade-offs among k_n and k_p resulting from goods production do not occur at the local level. They occur mainly at foreign economies. At the local level, environmental quality threaten, like landscape values or biodiversity loss, occurs due to tourists behavior towards the island environment, which constitute the tourism land use pattern. Environmental impacts mentioned on literature or identified in the field visit

[23] In the scenario 3 of construction sector, the percentage of tourists participation in the material input increases to 52.4%. In this case, however, the tourism relative participation is very close to its participation on the GAV when applied the same scenario, 52.1%.

and through personal communications are caused by tourists' occupation. Thus, building constructions, roads, off-roads vehicles, mountain climbing and tourists walking outside pathways are the origin of the majority of impacts detected at the local level. In a smaller extent, impacts occur due to changes in land used by agriculture motivated by the tourism growth in recent years.

In this scenario, environmental impacts on Lanzarote occur due to tourism activity but they are not directly related to the number of tourists. Number of tourists determines directly the amount of material and energy consumed in the island. Since neither goods nor energy are produced in the island, this topic directly affects Lanzarote only by the outflows. It has been shown that part of the output goes directly to the global environment, and thus, it is only part of the consumed goods which are permanently disposed on Lanzarote territory; and it is not a serious problem nowadays (Cabildo de Lanzarote, 1998d). Tourism impacts Lanzarote basically trough infrastructure construction and tourists visitation to sensible areas. Once the infrastructure is constructed, it can serve a great number of people. A possible increase in the number of tourists in Lanzarote is translated into a need for more accommodation places, but does not mean necessarily other additional infrastructure construction.

In this reality, the "problem" of tourist visitation should be solved by the protected areas regulation. The 13 designated protected areas of Lanzarote - holding 41.3% of the island's territory – should be enough to protect the sensible ecosystem, including species and landscape. Indeed, in places where there is an adequate management plan with qualified staff – case of Timanfaya National Park – tourists visitation has not signified important environmental and ecological impacts. Nevertheless, this is not the rule to most protected areas in Lanzarote, where human interference has produced serious local ecological changes.

Guidelines to protected areas designation in Lanzarote were more focused on landscape protection than in the conservation of biodiversity values. Nevertheless, most part of autochthonal vegetation which presents particular interests, as well as singular landscapes and agricultural fields with particular landscape interests (case of La Geria), are within protected areas (see maps p.29). Thus, protection of important fauna and flora as well as landscape depends on adequate regulation and monitoring. The basis for the appropriate management of tourism already exists in Lanzarote due to the extended protected areas net, the existing infrastructure and the structure of the economic system. Consequently, impacts on Lanzarote's ecosystem are much more

related to an inadequate management rather than to the number of tourists who visit these places.

It became clear that nowadays tourism contributes to Lanzarote's system aggregating money in a higher degree than it requires natural resources, i.e. tourism impacts the islands' monetary system in a higher degree than the local environment. Local population is living in better conditions than in the past, and at the same time, ecological conditions at the local level are relatively healthy and showing favorable conditions to improve. At the global level, however, Lanzarote presents a deficit related to ecological flows (produces more residues which have global environment as gateway than absorbs). It is not necessarily bad, but has to be analyzed in detail in the future. That is because trade and global flows exist and may improve local populations quality of life[24]. In the context of comparative advantages of countries and regions, natural endowments and ecological resources may have an important role in determining economic activities and land use pattern. Nevertheless, it seems strange that an island enrolled in a program called "Man and the Biosphere" is negatively contributing to the global environment as a whole.

[24] It may indeed be good or bad. Trade may increase local carrying capacity but it may also harm it when apparently is improving (Van den Bergh and Verbruggen, 1999).

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Annex 1

ANNEX 2

Table Annex 1.1 - Number of Vehicles 1999

	Trucks and Vans	Buses	Tourisms	Motorcycle	Others	Total
Servicio	1999	1999	1999	1999	1999	1999
Private	13,911	31	39,879	2,409	382	**56,612**
Public Service	415	326	53	1	431	**1,226**
Auto taxi	2	0	359	0	0	**361**
Rent cars	823	0	23,199	99	1	**24,122**
Auto escuela	4	5	65	23	6	**103**
TOTAL	**15,156**	**362**	**63,555**	**2,532**	**820**	**82,425**

Source: see **Table 4.3**

Table Annex 1.2 -Oil expenditure multiplier factor

	Trucks and Vans	Buses	Tourisms	Motorcycle	Others
Servicio	1999	1999	1999	1999	1999
Private	2.0	2.0	1.0	0.5	1.0
Public Service	2.0	2.0	1.5	0.5	1.0
Auto taxi	2.0	2.0	2.0	0.0	0.0
Rent cars	2.0	2.0	2.0	1.0	1.0
Auto escuela	1.5	2.0	1.0	0.5	1.0

Table Annex 1.3 - Oil expenditure factor (= table annex 1.1 X table annex 1.2)

Servicio	Trucks and Vans	Buses	Tourisms	Motorcycle	Others	
Private	27,822	62	39,879	1,205	382	
Public Service	831	652	79	1	431	
Auto taxi	4	0	718	0	0	
Rent cars	1,646	0	46,398	99	1	
Auto escuela	7	10	65	11	6	
	30,309	**724**	**87,140**	**1,316**	**820**	**120,308**

Table Annex 1.4 - Oil expenditure by categories (mt)

Servicio	Trucks and Vans	Buses	Tourisms	Motorcycle	Others
Private	14,765.8	33.1	21,165.0	639.3	202.8
Public Service	440.8	346.1	41.8	0.3	228.8
Auto taxi	2.4	0.0	381.0	0.0	0.0
Rent cars	873.3	0.0	24,625.0	52.6	0.6
Auto escuela	3.6	5.1	34.7	6.0	3.0

Table Annex 1.5 - Percentage of oil used by type of vehicle and utilization, 1999

	Trucks and Vans	Buses	Cars	Motorcycle	Others	Total
Private	23.1%	0.1%	33.1%	1.0%	0.3%	**57.6%**
Public Service	0.7%	0.5%	0.1%	0.0%	0.4%	**1.7%**
Auto taxi	0.0%	0.0%	0.6%	0.0%	0.0%	**0.6%**
Rent cars	1.4%	0.0%	38.6%	0.1%	0.0%	**40.0%**
Driving school	0.0%	0.0%	0.1%	0.0%	0.0%	**0.1%**
Total	**25.2%**	**0.6%**	**72.4%**	**1.1%**	**0.7%**	**100.0%**