Ecological Costs of Small Islands Development

Matías González & Carmelo J. León

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Abstract Small Islands tend to contain fragile and diverse ecosystems. In addition, transportation costs, distance from the main economic centres, and low economies of scale are responsible for economic costs differentials in production and consumption activities. The purpose of this paper is to link the economic costs of insularity and the ecological costs associated with small islands development. Insular ecological costs are defined as the extra costs resulting from island development processes interacting with fragile ecosystems. We try to identify the factors that would make monetized ecological costs in islands higher than in mainland regions. The empirical part of the paper focuses on the case of managing urban solid waste in the Canary Islands. The comparison of a set of environmental indicators gives some support to the idea of ecological cost differences between islands and other geographical regions.

1. Introduction

Economic development involves costs in any society. Some of these costs are in the form of external costs due to the deterioration of environmental quality. The ecosystems provide essential functions for human life and welfare. Thus the reduction of environmental quality due to economic growth implies costs which can be expressed in terms of diminished welfare and quality of life. Accounting for these costs is relevant in order to have a fair figure of the increase in welfare and living standards that society is accomplishing on a long term basis. By definition, the concept of sustainable national product discounts the environmental costs implied by economic growth. These costs represent the amount of damage caused to human and natural societies because of the increase in consumption and production activities.

Integration of environmental concerns into national accounting is a growing area of social research with an extense and controversial background. One can find that there are

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*. Instructors, Department of Applied Economics, University of Las palmas de Gran Canaria, Saulo Torón 4, Las Palmas de Gran Canaria, Spain 35017. Paper presented at the International Conference on ***Integrating Economic and Environmental Planning in Islands and Small States***, Malta, 14-16 March, 1996

several approaches to be followed for measuring the environmental deterioration from development: i) Satellite accounting, ii) Estimation of defensive expenditure, iii) Non-market monetary valuation (Peskin (1991), iv) Depreciation costs (Repetto et al. (1989)), and v) Costs of achieving sustainable standards (Hueting et al. (1992)). All these approaches look at related aspects of the environmental and resource costs imposed by economic development. In most cases, data availability dictates the methodology to be used in empirical work.

The present paper is empirical in its purpose. Our aim is to show how the costs incurred to achieve a sustainable development path may be higher in small islands than in the mainlands or big islands. The principal implication of this hypothesis is that small islands development processes could be experiencing differential ecological and environmental costs. There is a large amount of work, such as Coccosis (1987) and Brookfield (1990), which have stressed that small islands may share differential characteristics from other geographical contexts. Some of these specific factors are:

i) Small islands tend to have diverse and vulnerable ecosystems, with high proportions of endemic species relative to their size.

ii) Smallness and fragmentation impose constraints on economic efficiency and diversification, thereby depending on external supply sources of essential resources.

iii) The short size of the internal markets limits the advantages resulting from economies of scale and the proliferation of competitors.

iv) The limitation of space implies that population growth derives in growing density and pressure on scarce resources.

v) Locational advantages, as well as progress in transportation and communication facilities are vital to economic activity.

Empirical evidence is drawn from the case of the Canary Islands, an archipelagic region traditionally endowed with a rich and diverse natural environment. The economy has experienced strong growth in the last three decades, resulting in the convergence of living standards with the Spanish average. As in some other archipelagic regions, economic growth has been especially guided by the expansion of the tourism industry over the world economic cycles. The development of society has involved substantial ecological and environmental costs, noticeably in the reduction of the number of species and the destruction of ecosystems, the depletion and pollution of groundwater, and the deterioration of the landscape.

The functioning of the economy involves emission of pollutants by tourism, industrial, and agricultural activities, as well as the generation of waste from human consumption. There are relevant monetary costs from targeting sustainable standards in some areas of the environment. An interesting question is whether these costs turn out to be higher than in the context of mainland regions. A great deal of extra costs are due to the distance from the main economic centres and to the difficulty for reaching economies of scale in reprocessing and recycling. As an empirical example, we focus on the problem of managing waste disposal. Insularity and isolation lead to important difficulties for efficient management. This paper estimates the differential costs of managing waste disposal in the Canary Islands. Results reveal that these costs could be significant, and may increase with the standards of sustainability established by international regulations and agreements.

2. The Concept of Ecological Costs Differential

Environmental problems are the result of the interaction of the resource and natural endowments with the economic and social systems. Acute problems emerge when the assimilative capacity of the environment is overcome because of excessive stress from human activities. In order to evaluate and identify the extent of the problems it is necessary to have a system of specific quality indicators. These indicators should reflect the state and the stress of the natural and physical systems in any moment of time. They may also be useful for defining the goals or standards towards which policy decisions should aim.

Policy measures are needed for achieving a predefined set of quality goals, but they generally involve costly actions. Among the costs incurred in environmental management there are investments in necessary facilities and running costs (labour, materials, and energy). In the context of small islands, the costs of targeting a given set of quality standards may be higher than in other geographical contexts because of two basic reasons: i) Smallness and fragmentation reduce the extent of economies of scale in investment facilities, and ii) Total costs are increased by transportation and communication costs. The result is that total abatement costs could rise faster than in other regions where these characteristics are not present. Therefore, ecological costs of small islands can be defined as the differential costs of managing a given level of quality in all areas of the environment.

This concept is represented by the following expression,

$$ECSI = \sum_{i=1}^{n} Q_{p_i}(C_{I_i} - C_{c_i})$$

where n is the number of indicators of environmental quality for which there are differential costs, Q is the environmental quality indicator expressed in relative terms, (i.e. residuals or emissions per Km^2, per capita, etc); p_i represents the environmental problem for which indicator i is appropriate; C_I is the average cost of managing quality aspect i in small islands; and C_C are the equivalent costs in a mainland region. Thus, difference C_I-C_C is the per unit of quality level cost differential.

Graphically, Figure 1 shows total abatement costs curves for a small island economy and for a mainland integrated region. The horizontal axe represents the level of abatement s and the vertical axe the total costs for each level. It can be seen that the cost curve for the small island economy is above and more stepper than the cost curve for the mainland region. Given a level of environmental quality implied by abatement level s_0, the differential cost is represented by distance ab. Moreover, the diagram represents the hypothesis that the higher the level of environmental quality the larger the cost differential.

3. The Causes of Differential Ecological Costs in the Canary Islands

The interactions between the environmental and economic systems in small islands have specific and differentiating characteristics. Some of these factors may be contributing to high management costs in achieving a given level of environmental quality. In the case of the Canary Islands archipelago, it is clear that isolation and distance from the main

economic centres come together with fragmentation and high population density, high production of goods and services, and specialization on tourism.

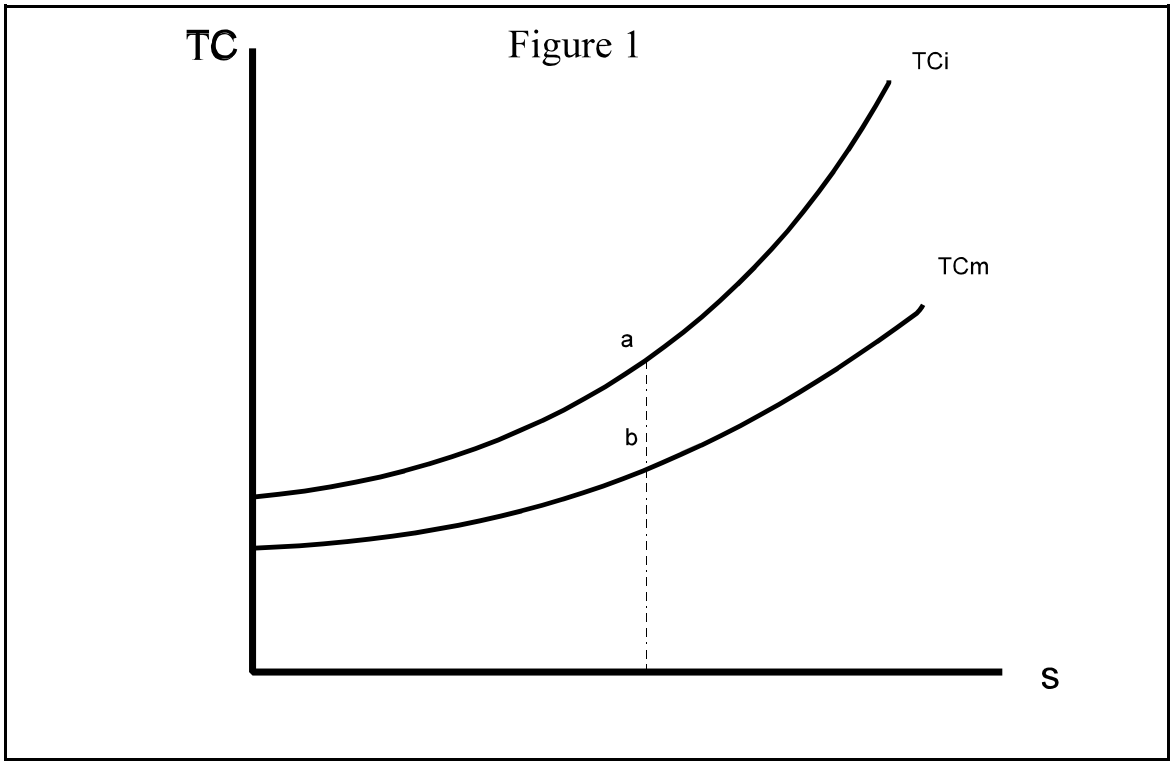

Figure 1

All these geographical, socioeconomic, and demographic factors eject strong pressure on the fragile and vulnerable ecosystems. It is well known that the Canary Islands are among the highest levels of biodiversity of the world. Moreover, high biodiversity is principally represented by a large number of endemic species. Many of these species are under threat of extinction because of the evolution of society. Taking this into account, the possible causes of differential costs in the Canary Islands are the following:

i) Productive specialization in tourism services and the general absence of essential natural resources mean that the economic system depends strongly on external sources of supply and external markets. The large distance from these economic centres and the archipelagic fragmentation conduce to distribution systems intensive in packaged products, augmenting the problem of managing solid waste.

ii) The scarce land and water resources are under strong pressure because of the high population density and tourism development. The need to utilize land for the human environment makes difficult the preservation of biological diversity and the ecosystems.

iii) The scarcity of land and its abrupt geomorpholophy have determine the use of agricultural techniques intensive in fertilizers, pesticides, and water, contributing to the depletion of the aquifers and soil degradation.

iv) Archipelagic fragmentation has led to an energy system based on the use of fossil fuels and small scale plants for each of the islands, which run high average costs and low efficiency in consumption.

v) Rapid economic growth and the concentration of population in the coastal areas in a process of abandoning traditional agriculture have resulted in soil erosion and desertification.

vi) The valuable landscape has suffered important transformations because of unplanned use of the land for residential and tourism, and the impact of infrastructures such as roads and highways.

Hence, the combination of the latter factors may explain the differential ecological costs in the Canary Islands and the difficulty of a sustainable development path. Both the relative intensity of the problems and the higher abatement costs determine the extent of the differential costs. The result is that environmental policy may be more costly in this particular setting. In addition, following Hueting's (1991, 1992) methodology for deriving sustainable national product, the proportion of the reduction in conventional income may become higher than in other regions.

4. Application to Solid Waste Management

Solid waste is an area of environmental management where there are expected differential costs. The increase of solid waste is the result of the growth in urban areas and tourism. Waste disposal is based principally on landfills. This system has relevant costs in the case of small islands because i) the scarcity of land, and ii) the risk of groundwater contamination. In the case of the Canary Islands, it is expected that current landfills will be depleted by the year 2000, and there are no prospects to find new areas. Using land for waste disposal implies important opportunity costs because land resources are very valuable and scarce. In addition, uncontrolled landfills in the past have been the source of contamination of some aquifers, and have had an impact on the landscape. Table 1 shows some indicators

of solid waste. In this section, we look at the differential costs of managing solid waste disposal, considering three management alternatives: a) recycling, b) composting, and c) incineration.

Table 1 Production of solid waste 1992.

	Population	Tm/year	Tm/day	kgs/inh/day	Tm/has
Fuerteventura	49542	40220	110.2	2.2	0.24
Gran Canaria	715611	347696	952.6	1.33	2.22
Lanzarote	88475	45594	155	1.75	0.53
La Gomera	15858	4131	11.3	0.71	0.11
Hierro	69995	4160	11.4	1.63	0.15
La Palma	75577	20986	57.5	0.76	1.29
Tenerife	685583	283904	777.8	1.13	1.39
Canary Islands	1637641	757691	2075.8	1.27	1.01
Spain	38885850	12821450	35127.2	0.91	0.25

Source: Elaborated from Department of Economics and Finance (1994a).

4.1 *Assumptions*

In order to simplify the analysis we make the following assumptions:

1. Geographical comparison is concentrated in the differences between the Canary Islands and the Spanish mainland.

2. We consider two scenarios, one baseline (BASE) define by the current situation and an alternative scenario (ALT) resulting from an integrated management of waste disposal. The latter scenario gives priority to several ways of dealing with waste, the order being reduction of waste, recycling and reusing, energy transformation, and minimization of the environmental impact of those residuals which are left to be discarded.

3. Scenario ALT of integrated management of solid waste is characterized by 64% recycling of paper waste and incineration of 25% of all waste.

4. Costs comparisons are referred to three aspects of solid waste management: i), collecting and recycling organic residuals, ii) collecting and recycling paper, and iii) incinerating.

Organic residuals can be considered as an example of the type which can be recycled in the islands, while wasted paper is an example of the type for which recycling is not economically viable, and has to be exported.

5. In respect of managing wasted paper, we assume similar costs of collecting, cleaning, and packaging. This means that costs differential are going to be observed in the transportation costs incurred in taking the collected material to the minimum scale recycling plants.

6. Regarding organic residuals, we assume that the costs of collecting materials and their transportation to the treatment plant are similar in the mainland. Thus cost differential may be observed because possible scale economies in treatment plants.

7. Incineration plants operate with similar fixed and variable costs, but cost differences may be observed because the economies of scale effect.

4.2 *The Costs of Paper Recycling*

Recycling paper in the Canary Island has not proved to be profitable because of the relatively small amount of material collected. The solution is to export collected paper to the Spanish mainland. The total amount collected and exported in all the islands was 43000 tons in 1995.

Let us assume that the infrastructure for collection is available and has the same costs in both geographical contexts. There is an ongoing national programme to provide one container per 2000 inhabitants. Nevertheless, this infrastructure adds little to the collecting process. It is expected that the total facilities available once the programme is implemented will be responsible for the collection of only 5% of all materials.

Table 2 shows the structure of the costs attributed to collection and oceanic transportation. It can be seen that the latter are 5.5 pts per kg. of collected paper, representing a 50% of the total variable costs incurred in collection and transportation. The current ecological cost difference due to managing paper waste in the Canary Island is obtained by multiplying the unitary transportation costs by the total amount exported, giving 239 millions of pts. This cost exceeds the subsidy received by the central government for exporting collected paper (21,5 millions, or 0,5 pts per kg.). Further, the costs of exporting materials are being paid by consumers, since these are charged by the collecting company. This situation may be due not only to the extra costs of transportation, but also to the fact that there is only one collecting company, which therefore could be imposing monopoly power on consumers. Nevertheless, the short size of the market may prevent the introduction of more competitors.

Table 2. Recycling costs of paper waste per kg.

Concept	Ptas	%
Transportation from the collecting points to the packaging plant	2,02	18,0
Classification, processing and packaging	1,54	13,7
Land transportation from the packaging/recycling plants to the ports in origin and destination respectively	2,08	18,6
Maritime transport and port handling costs	5,50	49,1
Other port costs	0,06	0,6
Total costs	11,20	100,0

Source: the authors.

Simulating what would be the costs in an integrated management framework, this assumes that 80% of the paper waste is collected and classified, while 64% is recycled. Thus

there is a material loss of 20% in the classification process. The total amount of paper waste in the Canary Islands was 160000 tons in 1995. Thus, while the percentage of collected paper was 34%, the percentage of exported paper ready for recycling is 26% of the total. Considering the objective of recycling 60% of the total paper waste, this would amount to exporting 96000 tons, after collecting 115200 tons from the total paper waste. Therefore, total differential costs would rise to 533 millions pesetas.

4.3 *The Costs of Recycling Organic Residuals*

Organic residuals may be recycled by composting. There was only one plant in the Canary Islands, which produced 23000 tons in 1989, but is now closed since 1993. In the Spanish mainland there are 17 plants, all together producing 370000 tons per year. This is on average 22000 tons, varying between 8000 and 50960. A problem of comparing the costs of composting plants is that the quality of the product is not homogeneous. Higher quality levels present higher costs, depending on the input residuals and their selection, production conditions (temperature, humidity, etc.), and the removal of inert residuals.

Observing current technology, it seems that economies of scale are not relevant in this area of environmental management. That is, average cost does not vary significantly with the scale of production of compost. Even if average and marginal costs decrease with the levels of production, the scale of the current plant in the Canary Islands is in the range of the average of the Spanish mainland. Assuming that the latter plants reach efficiency levels, this could reveal that the optimal scale involves a small production level which is appropriate for the context of the island economy considered. Thus, assuming that investment costs and

variable costs are similar between both geographical contexts, there are no costs differential because of the scale effect in managing organic waste. However, in practice the plant of the Canary Islands could be working under lower costs because the quality of the product is much lower than the Spanish average. This is implicit by a composting rate of 41% of all material processed, against a 25,5% for the Spanish mainland.

4.4 *The Costs of Incinerating*

Incineration is an alternative disposal method, although it is well down in the hierarchy list for the preferred methods of waste management. It is commonly preferred to the use of landfills, but only after the alternatives of reusing, waste reduction, recycling, and resource recovery have been exhausted. Thus, incineration might be considered in an integrated management strategy of solid waste in small island economies.

However, incineration presents the problems that it is only economically viable after a certain amount of waste is available. This means that there is need for large scale of processing which may give incentives to waste generation. Further, although groundwater resources are not directly affected by contamination, it may create problems of air pollution and ash disposal. However, incineration produces energy which may help to cover the investment costs, and the pollution problem could be minimized with strict control measures.

It can be shown that incineration is an activity subject to relevant scale economies which are the cause of potential differential costs in an integrated management strategy. Looking at the current situation, there is only one small scale incineration plant in the Canary Islands (La Palma) which serves a population of 75000. This plant has a maximum capacity

of 2 tons per hour, but it is now processing 10000 tons per year. In the Spanish mainland, the projection for 1996 is the implementation of a total of 21 plants with a capacity of 3,43 millions tons, that is, average capacity of 165000 tms. Table 3 shows the current average costs structure for the plant in La Palma, and its comparison with the average plant of the Spanish mainland. It can be seen how the small capacity of the former plant leads to average costs which are 130 per cent higher. Both variable and fixed costs are similarly affected by the capacity constraint.

Table 3. Comparison of actual varible costs (total costs/tons) of incineration (pesetas).

Concept	La Palma´s plant		Spanish mainland average plant	
Fuel	1.000	11,5 %	19	0,5 %
Electric energy	30	0,3 %	400	10,6 %
Calcium	100	1,15 %	31	0,8 %
Water			49	1,3 %
Ash control	150	1,7 %	125	3,3 %
Maintenence	1.400	16,1 %	959	25,5 %
Labour	2.200	25,3 %	431	11,4 %
General costs	590	6,8 %	141	3,7 %
TOTAL VARIABLE COSTS	5.470	63,1 %	2.155	57,4 %
CAPITAL COSTS	3.200	36,9 %	1.600	42,6 %
TOTAL COSTS	8.670	100 %	3.755	100,0 %

Source: Elaborated from Marzábal Martínez, J. 1995.

Simulating what would be the results under an integrated management approach, we assume that this strategy implies incinerating 25% of solid waste. This would lead to the following dimensions for the plants across the isles: Tenerife and Gran Canaria with

respective plants of 80000 tms optimal capacity, Fuerteventura a plant of 12500 tms, and Lanzarote and La Palma each with plants of 20000 tms. The same incineration rate in the Spanish mainland would involve an average plant of 200000 tons. This processing level would be feasible because the high scale economies in incineration.

Table 4 compares the average costs assuming the ALT scenario for the different isles of the Canary Islands and the Spanish mainland. It can be seen that scale economies have an impact on differential costs, especially in maintenance, labour, and the capital costs. The cost differential for each isle is detailed in Table 5. Thus, the extra costs involved in managing incineration in the Canary Islands following an integrated management approach would be 320 millions pts. These costs are due to the strong scale effects in the production process of incineration.

Table 4. Comparative average costs (total costs/tons) of integrated management incineration plants between the Canary Islands and the Spanish mainland.

Concept	La Palma	Tenerife	G.Canaria	Fuertev.	Lanzarote	Spain
Fuel	18	18	18	19	18	19
Electry energy	240	400	400	25O	240	400
Calcium	24	31	31	25	24	31
Water	42	48	48	45	42	48
Ash control	120	125	125	125	120	125
Maintanence	1500	1288	1288	1560	1500	917
Labour	1260	675	675	1310	1260	375
General costs	300	201	201	312	300	132
TOTAL VARIABLE COSTS	3504	2786	2786	3646	3504	2047
CAPITAL COSTS	2306	2061	2061	2310	2306	1525
TOTAL COSTS	5810	4847	4847	5956	5810	3572

Source: the authors.

Table 5. Differential costs of integrated management of incineration plants (pts).

Isle	Differential/Tm.	Total difference
La Palma	2.242	44.840.000
Tenerife	1.275	102.000.000
Gran Canaria	1.275	102.000.000
Lanzarote	2.242	44.840.000
Fuerteventura	2.384	29.800.000
Canarias	1.524	323.480.000

Source: the authors.

5. Conclusions

Managing environmental problems in small island economies may incur higher costs than in other geographical contexts. The basic reasons for these extra costs are the need for transportation of inputs and outputs, and the economies of scale effect in processing residuals and emissions. Further reasons for extra costs may be found in the higher relative biodiversity and unique environment of small islands. The implication is that there are differential ecological and environmental costs resulting from economic development. These differential costs rise with the standards of sustainability. Evidence drawn from the Canary Islands shows that costs differential are significant in recycling paper waste and incineration, and would increase substantially under an integrated strategy of waste management.

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