IV IFSAM WORLD CONGRESS

Profesor Dr. Tomás Bañegil Palacios
Dpto. Economía Aplicada y Organización de Empresas
Universidad de Extremadura
Avda. Elvas, s/n
06071 BADAJOZ (Spain)
e-mail: tbanegil@unex.es

Pedro Rivero Nieto
Dpto. Economía Aplicada y Organización de Empresas
Universidad de Extremadura
Avda. Elvas, s/n
06071 BADAJOZ (Spain)
e-mail: privero@unex.es

Antonio Chamorro Mera
Dpto. Economía Aplicada y Organización de Empresas
Universidad de Extremadura
Avda. Elvas, s/n
06071 BADAJOZ (Spain)
e-mail: chamorro@unex.es

Profesor Dr. Jacinto González Pachón
Dpto. de Inteligencia Artificial
Universidad Politécnica de Madrid (Spain)
e-mail: jgpachon@fi.upa.es

AN ENVIRONMENTAL DECISIONS MODEL IN THE BUSINESS DECISION MAKING

1. INTRODUCTION.-

The civic concern on natural resources is getting a growing importance factor for the socio-economic activity; in fact, it is one of the last dimensions that internationalization is introducing into the economies of more countries every day. This way, the socio-economic model is changing into an economic sociological model that is why nowadays enterprise must properly mix quality, innovation and environment to be competitive.

In the business decision making process, economic rationality is usually a controversial point in front of environmental quality. This is the reason why the decision-maker needs to know how this natural environment has an influence on the results of the different choices he could make.

Along the following pages we will try to design a theoretical and general productive process, valid for nearly every product, and that helps to harmonize economical and environmental efficiency. We will start from a series of general environmental goals for all the process, the model is detached to quantify another specific goals of every stage of the productive and consumer process, trying to embrace the maximum possible number of variables. In this sense, we try to apply the operations research (particularly the multicriteria analysis) to help to a better performance on the managerial system. Its main limitation is the complexity that environmental problems stand when defining a quantifiable measure unity of what a "green product" is. In this sense, we seek to find a methodology which allows us to decide and compare how much ecological an enterprise is depending on the decisions it makes, we will use for that qualitative and quantitative items. Specifically, what we endeavour with this appliance is to arrange at the end the preferences on a set of inversions, taking in account a series of environmental factors.

2.- ENVIRONMENT AND MANAGERIAL DECISIONS.

It is evident that a new stage is being presented to the companies, and this is beginning to have an influence in all the politics developed by themselves, the new strategy consists on understanding the environment as a responsibility characteristic of the managerial duties. As Cairncross indicates (1993): "The world won't grow in a cleaner way without the cooperation of the industry, because only by means of this it could develop technologies that satisfy the human necessities reducing the imposed demands to the environment." That's why the decisions affecting the natural environment have to be adopted with the same suitability than those having more direct repercussions on the financial results. Companies are becoming aware that they will undergo a short term costs increase, but that they will be compensated and benefited in the long term basically due to the new business opportunities and the rise in competitiveness (Bañegil (c), 1996).

Every time more managers and workers are becoming aware that they themselves and their own companies are a part of that environment for what a minor rate of residuals, minor consumption of energy, or minor risk in the work is something positive for everyone. This way, it looks clear that environmental consumerism is not a fashion or tendency in the sort term but it is becoming part of our life style developing, and demanding new ideas in the way of traditional administration of the companies. Every time it is more complicated to decide resting on intuition, for what it is necessary the rational selection between several alternatives in order to achieve the attainment of their objectives. Therefore, it is necessary a new category of decisions in order to diminish the wasting and pollution flows in the industries.

To harmonize financial and environmental results, companies need tools to help them to decide. In addition to the implementation of an environmental management system and an adequate

ecological marketing campaign, it is necessary to develop a systematic decision approach, which will affect the organizational structure, responsibilities, processes, practices and resources; and which aim will be to minimise the environmental impact at an acceptable cost, establishing as basic preventive decisions of reduction, use, and elimination.

3. THE GENERAL MODEL

The complexity of environmental problems is also characterized by the typical difficulty to find a unique quantitative measure for “being green”. Environmental damage cannot easily be compared with parameters such a costs or time that are “hard” metrics. However, techniques like ‘life-cycle assessment’ should made it possible to compare products based on their environmental profile. Furthermore, environmental regulations are often stated in quantitative terms (e.g. emissions standards to air and water) (SETAC, 1993).

During each step in the business system, from the inputs to the consumption and waste treatment, emissions take place that can be a threat to people, plants, animals and ecosystems.

The life cycle of a product is integrated by four phases: inputs, production, distribution and sale and use. The tendency along the whole process will be getting a close system, not lineal, so that is generated the minimum amount of waste not valuable. The own managers will be the responsible for contributing valid solutions to the residuals generated by their activity, what could report them in many cases additional revenue through by-products, savings derived of the inputs minimization, etc. It is for this reason that we should dedicate a special attention to the waste in all the phases of the productive process, since their correct administration is directly related with the degree of environmental excellence of a company and could suppose an unexplored source of income in many cases.

At the moment a general consent exists that the principles of "cleaning at the end of the pipe" and "the one that contaminates pays” are not the real solution; the only thing they make is transferring the problems in time or place, but don't solving them. For what the design of green products, destined to substitute to those less green from the market, is causing important changes in the strategy of product.

The managerial problem would be based on the comparison among several alternatives that present different conditions of monetary and environmental benefits. Such and how figure nº1 indicates, this problem is a multiple aim one, where what is searched is knowing the group of efficient solutions, so that the decision maker selects in function of her objectives.

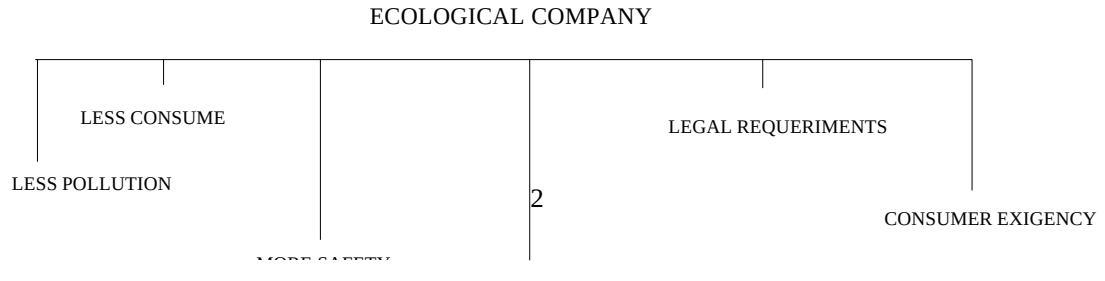


Figure nº1: Objectives that an ecological company should complete

3.1.- GLOBAL GOALS.

We in this paragraph comment three of the global goals that an ecological company should fulfil. The other three will be treated with more depth in the following paragraph.

a) Legal Requirements increasingly make suppliers and manufacturers responsible for their products, even beyond their sale and delivery. The frame of initial behaviour for any company comes after having considered the legal texts of the different competent administrations (international, community, national, autonomous and local), that it will be accurately defined and modernized by a group of specialists. An instrument of useful surveillance in this sense is the voluntary adhesion to the norm UNE 77801 of System of Environmental Administration, that has been elaborated by AENOR (Spain) and recognized for the CE for the development of the Regulation 1836/ 96 of Eco-management and Audit. But the maximum competitiveness is not achieved resigning in completing the law, but rather the company will constantly try to minimise the impact of its activity and be pioneer in the use of new technologies.

b) Demands of the consumers. The environmental progressive deterioration shown in the last decades begins to make a change of attitude in the consumption for many people, identifying more and more the quality of life with the enjoyment of an environment as less deteriorated as possible. In this way the tendency is that that ecological mentality comes to be a permanent part of our culture. In this sense, the eco-marketing should guide not only for the satisfaction of necessities, but also for the limitations of resources; putting under an obligation that the consumers are informed about the ecological consequences of their habits of purchase (Bañegil (b), 1996). As Ottman indicates (1994): "If your productive process is green, the products will also be it; if your products are green, your marketing will also be it."

c) Own company requirements for ethics and excellence. This point is essential if we keep in mind that systems like those of eco-audit are of voluntary implementation for the managers. The environmental policy should be understood like a global commitment and go beyond the productive process, so that a social solidarity is demonstrated that will rebound positively in the public image of the company, what will enlarge its market share and will be reflected in its Social Balance. Measures of this kind could include the promotion of a trail of local development in the

underprivileged places next to the factories, destining considerable budget departures to jointly shared actions and rewarding innovative environmental initiatives.

3.2.- CONSUMPTION, POLLUTION AND SAFETY OPTIMISATION.-

Starting from the general model (figure 1) and once three of the global goals have been commented; we have detached the objectives from the other three “to optimise consumption”, “to optimise pollution” and “to optimise safety”. These aims, at the same time, are divided in a series of subcriterion that are followed once another according to a hierarchical scale. Every variable has been established according to the product life cycle (from the cradle to the grave), so that on the figures the process phases can been noticed: input, transformation, output, consumption and wastes. Figure 2 describes the aims “less consumption” that we will explain in the decision model used in our example. Figures 3 and 4 describe summarily the other two main goals, whose development should be followed in the same way than the first one, to get the Global Goal, that is an “Ecological Company”.

Inside a minimisation general philosophy in the waste generation and in the raw materials use the recycling and the reuse have an essential role. When technically and economically possible, these strategies have to be an alternative to the natural raw material consume introducing them at the beginning of the manufacture process. The possibilities that are affected openned in this area are as wide and diverse as we want: for instance, packaging reuse if it is possible for what glass seeing to be the most favourable material, to the detriment of the tin and the plastic.

3.2.1.- Consumption in the inputs.

It is evident that we can not reach our product environmental efficiency if our suppliers are not as severe in their environmental policy as we are. In this way, any company can take steps like the following:

- Look for respectful with the environment suppliers. This requires an exhaustive initial investigation to determinate the number of suppliers that in fact carry out the legal demands of their sector. In this way we can establish a qualitative valuation of their activity in order to determinate the preference stage among them; it will be very useful to make position maps from factorial analysis to get it.

- Keep watches their methods and product quality do not turn aside from we prove in the previous analysis, and value the improvement they can insert.
- Protect the appearance of suppliers in our near environment inside general policy of help to the internal development of the zone where the industries are placed. When it is possible, it is given priority to the potentiality exploitation the zone we are placed offers. So, the suppliers nearer geographically will have more possibilities to introduce their material in the Addressee Company that, moreover, suppose the carriage minimisation.

Figure 2.- Consume optimisation.

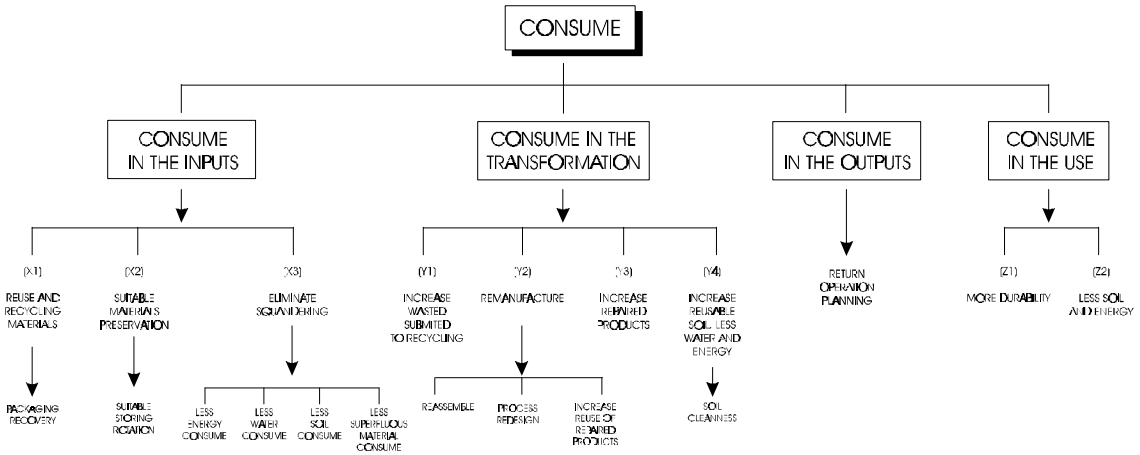


Figure 3.- Pollution optimisation.

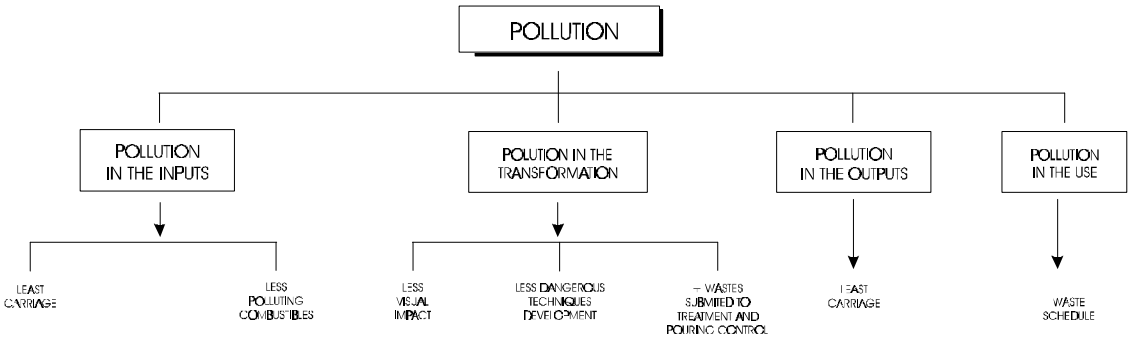
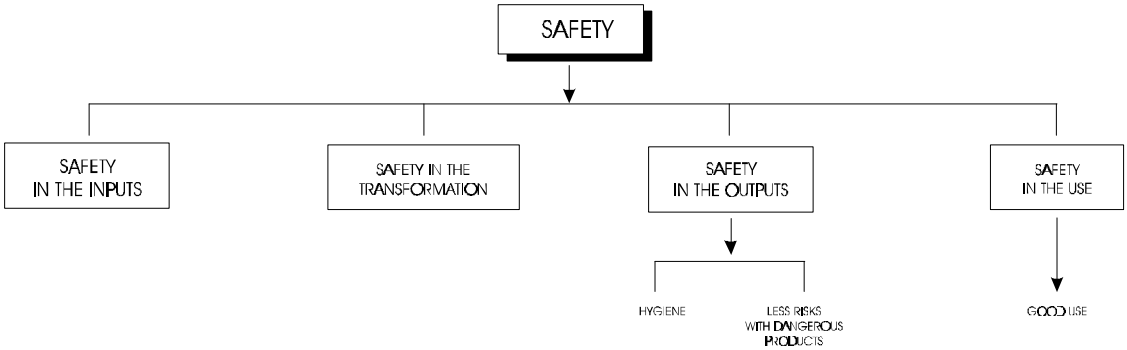


Figure 4.- Safety optimisation.



In this direction, our production place localization require a whole strategy, analysing elements like the factor before named to find the suitable placing, in which the costs derived for the input entry and the impact on the environment are minimum. It is important, so, the store and factory replacing. They must be placed in an environment near to the raw materials provision source and even if it is possible near the energy sources that we will use.

Technology and manufacture and storing plants design, especially when they are dangerous materials must be completely save, to avoid damaging social warning.

With regard to the environmental impact in the raw materials extraction, its study must propose the exploitation methods more compatible and, if it is suitable, the necessary restoration steps. The raw material consume must be reduced, that will induce a decrease in the material entry. To optimise the raw materials use we must study the possibilities to reinsert the wastes of this first phase of the manufacture or, even, to manufacture subproducts and less quality products line, with the aim of not squandering anything; replacing progressively the dangerous materials.

Energetic optimisation is other important aspect, more if we bear in mind that, Spain, for instance, is one of the European countries where its acquisition results more expensive. Besides this economic facet, energetic sources are polluting centres, so that the business strategy, in this case, should be directed towards these aspects:

- Alternative, renewable and with little incidence in the environment energies use, like solar, wind, tidal power,... However nowadays, because of its high economic cost there is not a total alternative to the traditional sources it should be very interesting to introduce experimental projects in small scale, like, for example, the electrical feed in the plants through solar panels.
- Using energy source according with the place and the economic moment we are. In this sense, it is worthy a special attention to the possible energy sources near to the plant. That in some cases can mean a cost decrease; but without loosing the environmental impact that they produce, so we must avoid or diminish it through necessary corrective means.

3.2.2.- Consumption in the transformation.

Innovation possibilities in a company begin in this point that can place it in privileged situation compare with their competitors. Basic aspects of this strategy are:

- Process redesign to, disassembly and recyclability cost diminish. Pieces compose our products must be easy to replace, that mind we manufacture them separately and provide consumers their buy from the usual channels.
- Less dangerous techniques development.
- Plants design that optimise the use of energy.

In the transformation phase it be generate an important part of the wastes, they are unavoidable manufacturer responsibility. The goal, again, is to decrease the wastes, find compatible methods to value and including make subproducts for the market. Performances are directed to:

- Smokes treatment, using filters.

- Diminish the noises.
- Reinsert the wastes employing whole valorisation methods (reuse, recycling, energetic valorisation and composting).
- Subproducts treatments. At first sight they are wastes but they can turn in raw material for other industries; and including, companies can take necessary technologies to manufacture new range of products that generate them economic profits.
- Internal disposal management, introducing selective collection methods for wastes produce by company performances.

In this case it is impossible to prevent some environmental troubles. We must to proceed to the damaged place rehabilitation. These damages monetary value and invests in restoration are an image of their important. So, it will be necessary make:

- Waters treatment. A little used possibility is the residual waters reuse treated in other company activities it is possible. It minds to close the water circuit in our company, consume the least possible and when we return it, the water had had different utilities.
- Ground cleanness and landscape rehabilitation.

3.2.3.- Consumption in the outputs.

The distances and the surface used for the stores will have to be taken in consideration, minimising the transport and optimising the design for a maximum use. The goal of this is, for example, to trying to use wholly the charge capacity of the transport mean that we use and that the delivery lorries do not come back empty; They could, for instance, transport to their origin used packaging to their valorisation.

It is important the fleet size and transport diversification, always looking for the most convenient environmental and economically exploiting the combination possibilities that they permit. There are cooperative means to maximise the transports in the regional environment. Little companies, without economic capacity to acquire a suitable transport fleet, have the economic and environmentally profitable possibility to cooperate with other companies, which have similar needs and be located near.

Dangerous materials re-collocation and distribution paths redesign. The places where the nocive wastes generate by our activity are laid aside have to have the best security means. In the dangerous goods transport the precaution means will also be amplified, looking for main roads paths and trying to avoid the population centre and especially dangerous points.

The process must be oriented toward the use of the least amount of containers and packagings. This mean go toward the only packaging, made with recyclable material; with a return (recover) schedule of our packaging. The retailer, imply in the selective collection, will be a relevant figure in this process phase.

Although the usual is that the selling stay outside our competence, we have to find the adequate channel, related with our product quality. To do that, we propose the following means:

- Distribution strategy design, that allow us to locate our ecological prestige companies, in which we are going to sell our products. Our product will be more credible to the consumer if we locate it in an adequate environment, with this goal we could use specialised commercial chains.
- Communication and publicity campaigns in which it is emphasised the ecological value of our products.

3.2.4.- Consumption in the use and the wastes.-

The variables must be oriented to increase the product life and, so, avoid overconsume. The products durability is a battleground in which are being reached important successes, the last goal must lead to eliminate the denominated “use and throw” philosophy. Reparation is a useful method to assure the product longevity. The easy accessibility of any component and the spare pieces selling is a basic point in this sense.

Avoid products that cause deep troubles in their use to demand big energetic consume and generate pollution. The size and weight diminish lead to a production rationalisation, looking for a less resources consumption and an important save. Multifunctionality is a great environmental relevant strategy because it allows reducing the total consumption. Likewise, it must be diminished the generation of auditive impact produced by the use.

Every view group agree that the environmental education is a fundamental point and the employer must not avoid his responsibility of create responsible consumers. A good marketing campaign is a good invest because it allows the consumer to know the profits that our green products offer to him and the society. A easy instruction manual for the knowledgments and the user cultural level must lead to an use and enjoyment of the acquire product in all its dimensions and allowing also a rational and ecological exploitation.

Related with the wastes after the use, it has been usual till the moment, that after products leave the plants, the manufactures forget them; but the trend is changing, not only by the environmental employer responsibility, as because this can contribute to increase the profits if it is perform correctly. In this sense, it must be take into account, that in the European Union, the different valorisation strategies are presented as a waste management methodology, that look for the maxima rationality and use, implying the manufactures in the environmental troubles information, in a selective collection system, through information that make easier their rating in the label. A third aspect would be the biodegradability.

4. A MULTICRITERIA DECISION MODEL FOR OPTIMIZING CONSUMPTION

A methodology is described below that quantifies the importance of each factor in achieving optimum consumption, according to our model. The above methodology can also be used to evaluate an action, such as an investment, depending on how near it comes to achieving the objective of optimising consumption in the setting of an environment-friendly company.

The multicriteria decision methodology used in this paper is known as the Analytical Hierarchy Process (AHP).

Saaty (1980) introduced AHP as a multicriteria method about twenty years ago. The reputation of this technique within the international scientific community has grown over the years, and it has been used in different decision making areas. AHP can be defined as a measurement theory that provides for aggregation, on a single scale, of both qualitative and quantitative criteria. It

is based on the principle that, in decision making, human expertise in and knowledge of the problem is as valuable as the data they have about it (Vargas, 1990).

The AHP is applied as a three-phase method to solve decision-making problems. These phases are summarized below.

Phase 1) *Hierarchy design*. This phase requires knowledge and expertise in the decision-making problem area. The AHP methodology starts by building a tree, referred to as an analytical hierarchy, the branches and levels of which represent important decision-making items (goals, criteria, scenarios or alternatives), as specified in the preceding section. In the case at hand at the top of the hierarchy is the end goal *Optimise Consumption in an Environment-friendly Company*. There are also three second level factors. These are defined by the criteria:

IC≡ Inputs Consumption

PC≡ Processing Consumption

OC≡ Outputs Consumption

UC≡ Usage Consumption

At the third level, there are three criteria that define Inputs Consumption, *IC*:

X_1≡ Reuse and recycled materials (% units/total used)

X_2≡ Proper materials storage (t rejected)

X_3≡ Waste elimination (million pesetas saved).

There are four criteria for defining Processing Consumption, *PC*:

Y_1≡ Increase of recycled waste (t)

Y_2≡ Remanufacturing

Y_3≡ Increase of repaired products (%)

Y_4≡ Increase of reusable lands, less waters and powers (%).

Only one criterion for defining Outputs Consumption:

W_1≡ Return operations planning (number of operations)

And two for Usage Consumption, *UC*:

Z_1≡ Longer product life (%)

Z_2≡ Less land and power (%)

Although it does not constitute a level in itself, the hierarchy will also include a finite set of alternatives. These are to be evaluated with regard to how far they manage to optimise consumption within the setting of an environment-friendly company.

For example, suppose that a furniture manufacturer intends to modify the components of its product range and has to evaluate three types of investment (A≡ Wood, B≡ Plastics, C≡ Metal), depending on how well they achieve the objective of *optimising consumption in an environment-friendly company*, and that these alternatives were to be described, as shown in the table below, according to the model subcriteria and the units of measurement specified above.

	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4	CO	Z_1	Z_2
A	20	0.2	2	3	2	7	10	10	6	6
B	30	0.1	2	5	3	5	5	10	8	4
C	60	0.5	2	7	8	9	6	10	4	4

Phase 2) *Measurement*. This phase seeks to weight how important each criterion is within its level (and/or branch, for levels under 2). This phase is based on the information supplied by the decision maker when comparing pairs of items. Accordingly, these items are compared pairwise depending on what they contribute to a higher level item. The result of this process is the quantification of the relative importance of the above items when there is a fixed criterion (or goal). The sum of all these relative weights must be equal to the unit. A square matrix is built for each level *k* item, the input cells of which are pairwise comparisons of level *k-1* subitems suspended from the item in the hierarchy. Comparisons are made on an integer scale from 1 to 9, where the value 1 is used to express equal importance between subitems and the value 9 to indicate that the subitem in the row is much more important than the subitem in the column. If the subitem in the column is more important than the subitem in the row, the reciprocal value, that is, 1/m, where m=2,..., 9, can be used. Saaty (1980) demonstrates that the best means of estimating the priorities

scale for the pairwise comparison matrix is to use the standardized autovector of the matrix corresponding to the highest autovalue.

Having established a subcriterion, the decision maker's subjective assessment of each alternative according to the above subcriterion is also added to the pairwise comparison matrix. This means that the standardized autovector of the above matrix now explicitly represents the above assessment.

Phase 3) *Aggregation*. Having determined the priorities of the items in the hierarchy, including the subjective assessments of the alternatives for each subcriterion, they are multiplied in ascending hierarchy order, where the alternatives are considered to constitute the lowest level. This will output a numerical assessment of each item and will be interpreted as the extent to which they manage to optimise consumption from an ecological viewpoint.

4.1.- THE MODEL APPLIED TO OUR CASE

The AHP method will be used in this case for two purposes. Firstly, it will quantify the importance of each criterion and subcriterion used to evaluate how optimum consumption is taking into account ecological factors. This will lead to a deeper understanding of the problem, according to the part played by its different components. Finally, it will be used to evaluate different actions or alternatives. Remember that the case at hand involves different investments: A| wood, B| plastic and C| metal.

For our problem, information was acquired at two levels: one for the first purpose, where a series of experts (thirteen to be precise) were asked to give their opinion; and another for the second purpose, where information was supplied by a potential investor.

QUESTIONNAIRES AND CONSISTENCY

In order to evaluate the relative importance of the subcriteria that describe a criterion, a questionnaire was designed that would extract the information required from a group of experts asked to compare pairs of items. A group of thirteen experts in the field of the Environment and Business Management were selected. Using the notion of response consistency implemented in the EXPERT CHOICE software, all the questionnaires were considered valid. A similar type of questionnaire was used to get the investor's matrix of comparison by pairs of alternatives, having fixed a criterion.

AGGREGATION OF EXPERT OPINIONS

A geometric mean was used to aggregate the opinions given by the experts as a result of pairwise comparison into a single value, because this is a measurement of central tendency that respects the formal conditions of Saaty's comparison matrix.

PAIRWISE COMPARISON MATRICES AND PRIORITIES FOR CRITERIA AND SUBCRITERIA

The aggregated pairwise comparison matrix, for the second level of the hierarchy, is shown in the table below. The far right-hand column specifies how important each criterion is in the evaluation of total consumption.

	CI	**CT**	**CO**	**CU**	**Priorities**
CI	1	1.34	3.92	2.55	0.412
CT	1/1.34	1	3.18	2.59	0.338
CO	1/3.92	1/3.18	1	1.36	0.125
CU	½.55	½.59	1/1.36	1	0.125

Represented in the same manner, the three aggregated pairwise comparison matrices at the third level are:

CI	**X_1**	**X_2**	**X_3**	**Priorities**
X_1	1	1.37	1/1.14	0.317
X_2	1/1.37	1	½.17	0.220
X_3	1.14	2.17	1	0.463

CT	Y1	Y2	Y3	Y4	Priorities
Y1	1	1/1.31	1.71	1/1.39	0.233
Y2	1.31	1	2.16	1/1.34	0.284
Y3	1/1.71	½.16	1	½.44	0.136
Y4	1.39	1.34	2.44	1	0.347

CU	Z_1	Z_2	Priorities
Z_1	1	2.31	0.698
Z_2	½.31	1	0.302

PAIRWISE COMPARISON MATRICES AND PRIORITIES FOR ALTERNATIVES

The pairwise comparison matrices for alternatives, fixed for each subcriterion, and their priorities are as follows:

X_1	A	B	C	Priorit.
A	1	6	1/3	0.323
B	1/6	1	1/4	0.090
C	3	4	1	0.589

X_2	A	B	C	Priorit.
A	1	1/5	1/3	0.105
B	5	1	3	0.637
C	3	1/3	1	0.258

λ_{max}= 3.25667 Ci= 0.125 λ_{max}= 3.03851 Ci= 0.02

X_3	A	B	C	Priorit.
A	1	3	2	0.541
B	1/3	1	½	0.161
C	½	2	1	0.298

Y_1	A	B	C	Priorit.
A	1	3	1/6	0.170
B	1/3	1	1/7	0.130
C	6	7	1	0.700

λ_{max}= 3.0092 Ci= 0.004 λ_{max}= 3.09993 Ci= 0.049

Y_2	A	B	C	Priorit.

A	1	1/3	1/5	0.105
B	3	1	1/3	0.258
C	5	3	1	0.637

Y_3	**A**	**B**	**C**	**Priorit.**
A	1	2	1/4	0.200
B	½	1	1/5	0.117
C	4	5	1	0.683

λ_{max}= 3.03851 Ci= 0.019 λ_{max}= 3.0246 Ci= 0.0123

Y^4	**A**	**B**	**C**	**Priorit.**
A	1	2	3	0.540
B	½	1	2	0.297
C	1/3	½	1	0.163

Z_1	**A**	**B**	**C**	**Priorit.**
A	1	2	1/7	0.144

B	½	1	1/6	0.10
C	7	6	1	0.756

λ_{max}= 3.0092 Ci= 0.0046 λ_{max}= 3.0803 Ci= 0.04

Z_2	**A**	**B**	**C**	**Priorit.**
A	1	1	2	0.4
B	1	1	2	0.4
C	½	½	1	0.2

W_1	**A**	**B**	**C**	**Priorit.**
A	1	1/5	1/5	0.091
B	1	1	2	0.4545
C	½	½	1	0.4545

λ_{max}= 3.0 Ci= 0 λ_{max}= 3.0 Ci= 0

The notation λ_{max} represents the highest autovalue of the pairwise comparison matrix, whereas the initials Ci represent the inconsistency coefficient of the above matrix. As Ci is under 0.2 in all matrices, all the expert responses can be considered consistent.

EVALUATION OF INVESTMENTS CONSIDERING THE END OBJECTIVE

The second purpose of our model is to be able to evaluate a series of potential investments considered by an investor, taking into account how well they achieve the objective of optimising consumption in an environment-friendly company. A general alternative α will be evaluated using our hierarchy, according to the linear aggregation formula described in Saaty (1980):

$$\textbf{Investment } \alpha \equiv 0.412\,(\,0.317\,\alpha_{11} + 0.220\,\alpha_{12} + 0.463\,\alpha_{13}) + 0.338\,(\,0.233\,\alpha_{21} + 0.284\,\alpha_{22} + 0.136\,\alpha_{23} + 0.447\,\alpha_{24}) + 0.125\,\alpha_{3} + 0.125\,(\,0.698\,\alpha_{41} + 0.302\,\alpha_{42})$$

Note that each pair of brackets represents a criterion in the order IC, PC, OC and UC. As OC has no subcriteria, no brackets are needed to calculate its value. The number by which each pair of brackets is multiplied is the priority of the above criterion, taking into account one of the above tables. So, α_{1j} represents the value of the above investment α (priority) in the subcriterion j of the first criterion (in this case IC) and so on. The result of the evaluation of our possible investments and their priority ranking is given in the table below.

Invests	Evaluation	Priority ranking
A	0.3076	2
B	0.2661	3
C	0.4542	1

4.2. RESULTS

As we have seen, *Input Consumption* (IC) is the highest weighted factor (0.412) for evaluating an investment depending how well it achieves the objective of optimising consumption. Within IC, *Elimination of Waste* (X3) is the most important subcriterion (0.463), closely followed by *Reuse and recycled materials* (X1, 0.317). On the other hand, *Output Consumption* (OC) and *Usage Consumption* (UC) are equally important for evaluating the end objective (0.125). This represents the aggregated personal opinion of thirteen experts.

With regard to the ordering of investments depending on how well they achieve the end objective, as inferred from the information supplied on pairwise comparisons, investors should consider that the best investment would be to develop the use of metal components in the product range, (0.4542) with a view to making the company more ecological. As stated at the beginning of the paper, this result refers to only one of the objectives of the model. Obviously, it would have to be checked against the other objectives set out in Figure 1, as they should all be developed according to the same methodology.

5. REFERENCES.

Azqueta Oyarzun, D. (1994): *Valoración Económica de la Calidad Ambiental*. McGraw- Hill.

Bañegil Palacios, Tomás M.(a); Rivero Nieto, P. (1996): *Efectos del medio ambiente sobre el entorno global de las empresas*. Ponencia presentada en el VI Congreso de la Asociación Científica de Economía y Dirección de la Empresa (ACEDE). La Coruña.

Bañegil Palacios,T.M. (b); Rivero Nieto, P.: "¿Cómo es de verde su marketing?". III Congreso Nacional de Medio Ambiente. Madrid, noviembre de 1996.

Bañegil Palacios, T.M.(c) (1997): Análisis del estado de la cuestión ecológica: la empresa como soución. Capítulo 6 del libro: Sociedad y Medio Ambiente. Editores: J. Ballesteros y J. Pérez Adán. Ed. Trotta.

Beghin, Roland-Horst Y Van Der Mensbrugghe (1994):"Los nexos entre el comercio y el medio ambiente:dimensiones globales".Economía Industrial, n1 298.

Bloembof-Ruwaard, J.; van Beek, P.; Hordijk, L.; Van Wassenhove, L. (1995): Interactions between operational research and environmental management. European Journal of Operational Research, n185.

Cabezudo, S. (1995): "La proteccion del medio ambiente: ¿Imperativo o Factor de competitividad clave en los mercados internacionales?": VIII Congreso AECA. Sevilla, Septiembre.

Coase,R.H. "The problem of social cost" (1961): Hacienda Pública Española, n168.

Coddington, W. (1993): *Environmental Marketing: Positive Strategies for Reaching the Green Consumer*. McGraw-Hill.

Conesa Fernandez-Vitora, Vicente (1995): *Auditorías Medioambientales. Guía Metodológica*. Mundi Prensa, Bilbao.

Davis, J. (1992): A*Ethics and Environmental Marketing*@. Journal of Business Ethics. Vol.11, n12.

Feldman, L.P. (1971): A*Social Adaptation: A New Challenge for Marketing*@. Journal of Marketing, July.

Field, B. "Economía Ecológia" (1995): Ed. Mc. Graw-Hill.

Gimenez Beltran (1994): "La Agencia Europea de Medio Ambiente:Objetivos y Estrategia". Economía Industrial n1298.

Gray, R.(1992): A*Accounting and Environmentalism: Am Exploration of de Challenge of Gently Accounting for Accountability, Transparency and Sustainability*@. Accounting, Organizations and Society, Vol.17, n15.

Halal,W. (1994): "La dirección estratégica en un orden mundial". Harvard Deusto Business Review.

Heraud,J.A. Y Llerena, D. (1992): "Enviroment el traditions nationales:comparaison el interpretation socio-economique des politiques publiques et des strategis industrielles en Europa du Nord", en Economique Appliqué.vol.XLV.n14.

Hopfenbeck (1993): "Direccion y Marketing Ecológicos" Ed.Deusto.

Kuri GaytumaA."Tecnología,comercio mudial e inversion extranjera en la era de la globalizacion". ICE. n1743, Julio 1995,

Leigh, J.H.; Murphy, P.E.; Enis, B.M. (1988): A*A New Approach to Measuring Socially Responsible Consumption Tendencies*@. Journal of Macromarketing, Spring.

Lucas, Wheler Y Hettinge, "Economic Development, Enviromental, regulation and the international migration of toxis industrial pollution: 1960 - 1988"" World Development, n1 21.

McDaniel, S.W.; Rylander,D.H. (1993): A*Strategic Green Marketing*@. Journal of Consumer Marketing. Vol 10, n13.

Montesinos Del Valle, M. y Rodriguez de Sancho,M.J. (1995): "Unión Europea y Medio Ambiente", Noticias de la Unión Europea, n1 131.

Opschoor Y Vos. (1989): "Instrumentos economiques pour la protection et l'environnement" OCDE, París.

Ottman, J.A. (1994): A*Green Marketing*@. NTC Business Books. Illinois.

Pearce,D. y KerrY Turner,R. "Economía de los recursos naturales y del medio ambiente" Ed.Celeste, Colegio de Economistas de Madrid, 1995.

Porter, Michael E.; Claass van der Linde. (1995): A*Green and Competitive*@. Harvard Business Review. September/October.

Ruesga,S.M. y Duran,G."Empresa y Medio ambiente", Ed.Pirámide,1995.

Ramirez, I. (1994): A*La Empresa y el Medio Ambiente en el Mercado Interior Comunitario*@. CERTIMAB, Madrid.

Saaty, T.L. (1980): A*The Analitical Hierarchy Process*@. McGraw-Hill. New York.

Sadgrove, K. (1993): A*La Ecología Aplicada a la Empresa*@. Deusto, Bilbao.

SETAC (1993): AGuidelines for Life-Cycle Assesment: A code for practice@. Edition 1. Workshop at Sesimbra (Portugal).

Vargas, L. (1990): A*An Overview of Analytical Hierarchy Process and its Applications*@. European Journal of Operational Research; n148.