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**Fifth Joint Conference on  
Agriculture, Food and the Environment**

Proceedings of a Conference Sponsored by  
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**SESSION II: AGRICULTURAL POLICY AND SUSTAINABLE  
DEVELOPMENT - I**

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**PAPER 3: PUBLIC PROJECTS EVALUATION, ENVIRONMENT,  
AND SEN'S THEORY**

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# **PUBLIC PROJECTS EVALUATION, ENVIRONMENT, AND SEN'S THEORY**

**I. Bernetti (University of Florence) - L. Casini (University of Naples)**

## **1. INTRODUCTION**

The purpose of this paper is to present a methodology for analyzing public investment plans based on Sen's theory of capabilities. Specifically, we will review the methodological and application problems involved in the use of Sen's theoretical framework for assessing the environmental and intergenerational impact of long-term public investments.

In recent years subjects such as environmental impact analysis of land planning have been playing an increasingly important role in public decisions. However, often there is a lack of methodological-theoretical tools that can guarantee the correctness of the decision-making process. The problem of improving information and assessment of ecosystems values for public decision making has been recognized for decades. From a 1958 report of the US Subcommittee on Standards and evaluation: "The problem of evaluating, from a public viewpoint, the extent to which a project (policy) accomplishes the aim of satisfying human needs and desires presents a major difficulty at the outset, because there are no common terms in which all effects of a project (policy) are normally expressed". In 1990 the U.S. EPA Science Advisory Board report recommends to improve "... methods to value natural resources and to account for long-term environmental effects in economic analysis".

In most concrete cases the procedure to face these problems is to apply Cost Benefit Analysis (CBA) or Environmental Impact Assessment techniques, which only describe the effects generated by the plans in physical terms. In both cases, as we shall explain below, the assessment issues are either excessively arbitrary or not suitable for application to environmental goods (CBA), or there is no rule for making decisions when faced with several, equally Pareto-efficient alternatives.

In this paper we shall try, even without wanting to propose an autonomous theoretical corpus, to analyze the problems brought to light in the context of some methods of public decision making in environmental issues. These methods have great application

potential and at the same time much in common with Sen's viewpoints; furthermore, they can also be improved by some of his theoretical ideas.

In the first part we will describe the theoretical framework and will present the analysis of the environmental aspects of public evaluation using Sen's instruments of functionings and capabilities. In this section we propose a taxonomy of environmental values and a hypothesis for classifying those that we can define as environmental functionings.

Finally, we will analyze some public decision making methods with respect to three categories of fundamental issues in this context: assessment and trade-off for individual items (utility, functionings); assessment and trade-off for individuals of the same generation (interpersonal equity); assessment and trade-off among different generations (intergenerational equity).

## 2. THE THEORETICAL FRAMEWORK

With rare exceptions, in the assessment of public projects and hence in social decision making, environmental issues are evaluated either by specific procedures for environmental impact or by attempts at internalizing environmental effects by CBA methods.

Both of these approaches are unsatisfactory. In the first case the environmental component is generally analyzed in-depth by a multidisciplinary staff that draws up a descriptive picture of the project's environmental impact. This exhaustive descriptive analysis does not, per se, provide any indications for the decision making process unless there are other alternatives of irrelevant environmental impact, or there exists a dominant Paretian alternative. Unfortunately, however, neither of these conditions are hardly ever fulfilled, and this leads to significant environmental alterations with major trade-off among the effects of the various alternatives.

The only widely used method that completely formalizes the decision process is the CBA. The theoretical bases of CBA are entirely derived from the neoclassical utilitarian theory which dictates operational solutions in terms of evaluation space, interpersonal equity and intergenerational equity.

The utilitarian theory identifies objects of value in the individuals utilities and the Function of Social Choice is hence represented by a function of social well being of the type:

$$W(u) \equiv F(u^1, u^2, \dots, u^n) \quad [2.1]$$

Where  $W$  is social well being and  $u^1, \dots, u^n$  individual utility. In the Bentham version, the most widely used,  $W$  assumes the forms:

$$W(u) = \sum_{i=1}^n u^i \text{ or } W(u) = \sum_{i=1}^n \alpha_i u^i \quad [2.2]$$

with  $\alpha_i$  being the weight attributed to the individual's utility.

For a critique of the use of utility as a valuation function on which to base the concept of social well being and in particular as related to the ambiguity and subjectivity of the term, we refer to Sen's many contributions (Sen 1985, among others). Here we will only analyze its inadequacy in order to achieve an understanding of environmental aspects in a decision making process.

By breaking down the problem of the evaluation space into the definition of the value objects and the definition of a value system, the neoclassical approach is incapable of satisfactorily assessing the environment in either case.

With reference to value objects, identified as individual utility, the environment can contribute to a process of welfare-type decisions if, and only if, it affects the individuals' levels of utility, considered mainly as levels of consumption. The various neoclassical treatises on public goods thus identify in the marginal utility the main element on which to establish, for example, the optimum offer of public goods or their price (Samuelson's condition, Wicksell-Lindahl equilibrium). The first criticism to this approach, in addition to the aforementioned theoretical limitations of the concept of utility, comes from the context of information failures, which leads to the failure of the neoclassical theory of public intervention in its traditional enunciation, even without specifically considering environmental issues. If we explicitly consider the environment, and the environmental impact of certain social decisions, we find ourselves facing a nearly total lack of information and of certainties on how the studied effects can be translated into terms of "utility" for individuals, especially because of the long term horizon of this issue and the indeterminate nature of ecological processes. Rationally, the matter of effects in terms of well-being of environmental changes cannot be analyzed in a deterministic context and in terms of utility (consumption) for the current generation.

What is the neoclassical answer of the CBA to these problems? The information problem is very vague as it regards objects of value, while it is exalted regarding the definition of the system of values. The prevalently short term view and essentially deterministic approach of CBA tends to render the effects of projects easily verifiable, while problems arise when it comes to utilitarian quantification which implies the cardinalization of all the variations of well being (utility).

However, the main problem is the theoretically correct translation of environmental effects in terms of social well being, something which utilitarian tools do not allow, as we will try to prove in the next paragraph. Going back to the system of values, CBA uses the so called first or second best shadow prices. The environmental applications of the shadow prices is based on the principle of internalizing the effects which remain outside the market due to its incomplete and/or imperfect nature, through taxation or compensation mechanisms or by appropriate contractual or legal organization of rights. With reference to this last approach the Greenwald and Stiglitz "theorem of non decentralization", among the many criticisms of Coase's theorem, seems to definitively close the issue of efficiency (even constrained) that can be reached by the market mechanism alone in the presence of imperfect information.

Pigou's taxes and the various polluter payer, compensating beneficiary, user-payer principles, are the fundamental application instruments of CBA for projects involving externalities, and certainly provide an improvement in the information framework on which to develop the decision making process. However, these tools seem inadequate to face the main environmental issues in theoretically correct terms, that, especially, because of the inherent difficulties in the estimation procedures, and also because of the invalidity of the assumptions on which they are based. With regard to the first point, the CBA approach generally uses "prices" for environmental goods estimated through the concept of willingness to pay, that is, it attributes a value that corresponds to utility derived directly or indirectly (option, existence and bequest value) by the current generation. Now, whereas the WTP assessment is generally satisfactory for direct use values, when it comes to other elements comprising the total economic value of resources, the limitations of assessment made by the various approaches of contingent valuation

become evident. And unfortunately, this latter component of the value of natural resources is usually the most important.

Using the CBA we can define a price as "sustainable for a resource" in the following manner:

**sustainable price** = Marginal production cost + Marginal cost for restoring damaged ecosystems + Marginal cost of the pollution produced + Marginal cost of offsetting lost future options + Marginal cost of offsetting losses of existing value and of bequest value - Compensation for any additional costs associated with the provision of non-market benefits (and introducing the concept of resource development and conservation + Unit cost of resource research and development).

However, the following problems remain:

- is the pricing system, influenced by the current distribution of wealth, the optimum?
- is the present generation assessment of environmental impact socially correct?
- are current consumers really the best judges when it comes to defining the value of natural resources?

The answer to these questions from an ecological standpoint is certainly negative. However, even the economic answer cannot be considered satisfactory except from a short term viewpoint.

Now, let us take a look at the issues of interpersonal and intergenerational equity as raised by these questions. The CBA tends to resolve the first problem without facing it directly. Without going into the debate on social equity generated around the second fundamental theory of economic well-being, and thereby limiting our discussion to the application of the CBA, we can see how its applications generally work in a supra decision maker context. Therefore, the entire system of values derives from estimates of the "mean utilities" generated by the project under review. Recourse to this type of measurement of well-being and to sum ranking, considering the utility of several individuals leads to a total lack of conditions of interpersonal equity in the decision making process. The use of fully compensatory tools of aggregation of preferences and the use of evaluation criteria based on the WTP, do not permit the evaluation of poverty conditions, etc. In some cases, there is recourse to a diversification of the effects for different social groups and the introduction of weight structures for different objectives and/or different groups. However, we still have the problem of the inadequacy of the space of the evaluation adopted as the indicator of well-being and hence of sustainable well-being, without speaking about the uncertain and hence arbitrary nature of decisions based on the weight structures that cannot be deduced from a rigorous basic theory.

Criticism of the CBA becomes even more significant when it comes to intergenerational equity, the basic issue in an analysis of well-being and development in a framework that includes environmental issues. Coherently with utilitarian approach the CBA carries the issue of future well being back to the problem of defining an adequate social discount rate. Without going into a comprehensive review of the literature we should, however, note how the neoclassical approach would have it, under conditions of first best, equal to the rate of profit generated by the market, excluding any reference to the sustainability of current productive decisions or the well-being of future generations. In essence, the "sovereignty of the present consumer" is the only significant principle in defining a system of values on which to base an Social Choice Function (SCF). On the contrary, it is easy to verify that also working in a context of "thoughtful parents" (Rawls, 1972) the issue is "how generation might be expected to save, not about how they ought to save" (Dasgupta, 1995, p. 379). Even without considering other important criticisms of the utilitarian approach, such as the role of information in determining preferences, it is sufficient to show how uncertainties regarding the future effects of environment-

impacting decisions are such that they do not give members of the current generation any satisfactory capability of evaluating such impact, and therefore of deciding effectively for future generations. The approach to these problems cannot be a procedure that optimizes present "utility".

### 3. EVALUATION OF ENVIRONMENTAL GOODS

#### 3.1 Sen's Theory

In the search for an alternative theoretical paradigm to the CBA, capable of overcoming the limits of the neoclassical approach, on which to base methods for deciding on public investments involving environmental goods, Sen's theory of well-being seems particularly interesting, especially because of its ties with specific disciplines, such as Applied Ecology, that study the relationships between individuals and the environment.

In this section we will deal with the matter of using the theory of functionings and capabilities as the basis for the definition of an area for evaluating social well-being that can better integrate environmental problems and principles than the theory based on utility for current individuals.

By taking the formal structure of Sen's theory of capabilities according to the opulence approach, well being can be represented by the vector of goods and services. If, however, we consider those commodities as only means (or rather, also as means), which, on the basis of their characteristics can determine states of making or being, or in other words be translated into the real life of an individual, formalization of well being requires the identification of a function  $c(x_i)$ , which transforms the commodities vector into a vector of characteristics, and a function  $f_i(c(x_i))$  which represents the individual's personal use of his basket of goods given their characteristics, that is, it represents *real functionings*. As a first approximation the evaluation of the individual's well being can thus be identified with the definition of an evaluation function  $v_i(.)$  of the level of well being attained by individual  $i^{th}$  concerning the  $f_i$  functioning of vector  $b_i = f_i(c(x_i))$ , representing the "person's being", the functionings achieved by the individual (from the most material such as level of nutrition, education, morbidity, to the most social such as levels of relationships, expressive capabilities, etc.). From this point of view, the evaluation of well being becomes a problem of ranking the various  $b_i$  vectors to make a comparison.

The definition of well being in terms of capabilities, involves the need to integrate the results obtained in terms of  $v(b_i) = v(f_i(c(x_i)))$ , with the level of freedom of choice underlying the achievement of the well being. When evaluating well being it is essential to consider the potentiality of choice among the various possible functionings of a given basket of commodities with given characteristics, and the choice of the same goods and services. If we define  $F_i$ , the whole of "utilization functions",  $f_i(c(X))$ , available to the  $i^{th}$  individual given the whole basket of  $X$  goods on the market, and  $x_i$ , as the total of goods and services from which he can actually choose, the basic elements of well being can be expressed by:

$$Q_i(X_i) = [b_i | b_i = f_i(c(x_i)), \text{ for some } f_i(.) \in F_i \text{ for some } x_i \in X_i], \quad [2.3]$$

which represents the so called capabilities  $Q_i(X_i)$  of the  $i^{th}$  individual, that is the whole of functionings that the individual can achieve given the specific conversion structure  $F_i$  of



the characteristics of the goods in functionings and hence in relation to the accessible resources and his socio-cultural level.

### 3.2 The environment, its characteristics, functionings and capabilities

According to a relatively accepted general concept (Malcevski, 1991; Westman, 1985), the term "environment" expresses the system of relationships that bind living beings and their development to the chemical and physical resources through which they live and develop. Therefore, the procedure which seems most correct for conducting an analysis of environmental quality is the sequence of a first analytical phase (analysis of the various components of the environmental system) and a summary phase concerning the recognition of the relationships between the components and the system's specific properties.

This procedure, which is typical of applied ecology, can be easily integrated into the approach of Sen's theory of freedom. This integration also permits an effective analysis of the influence of environmental quality on social well being. The basic idea of this proposal is that the correct way of considering environmental impact for purposes of social choice is that of using well being associated with each hypothesized environmental condition, and hence the respective available functionings as the space of evaluation.

#### 3.2.1 Environmental Goods

To transfer Sen's approach to the evaluation of environmental goods we must first define environmental goods and the relationships between them and the individual's functionings.

The definition of the various categories of environmental goods is complex. One of the most complete classifications, as regards systematic identification of environmental goods is the French system of environmental accounting. It is based on three types of accounts. The accounts of the elements, divided into.

- a) underground resources
- b) sea water
- c) atmosphere
- d) continental water
- e) soil
- f) fauna
- g) flora

The accounts of the elements are divided by region to show how the resources are distributed in the territory. Thus, we have an account of ecozones classified as:

- a) urban areas
- b) agricultural land
- c) forests
- d) wetlands
- e) wilderness zones.

On the basis of this structure an environmental good  $x$  is given by an element found in given *ecozone* (e.g.: the air in a city, water in agricultural areas, etc.).

There remains, however, the problem of the relationships between environmental goods and the individual's well-being. Environment goods, by their nature, are public goods

(pure or mixed). Therefore, their individual entities derive not so much from possession of the good as from its use or exploitation. In addition to good's existence, the value of such use depends on its quality. In fact it is on this basis that we determine the value of existence of given functionings. The quality of an environmental goods can be viewed as a vector of characteristics of  $x$ ,  $c(x)$ , which, according to Sen's definition, "...are the various desirable properties of the commodities in question" (Sen, 1995, p.9). It is clear, therefore, that the desirable properties of a commodity derive from its quality. Identifying vector  $c(x)$  means evaluating the quality of the environmental goods in a given ecozone. It will be on the basis of this vector and the characteristics of the  $i^{\text{th}}$  individual that we will be able to define the whole of capabilities  $Q_i$ , determined by the functionings  $f_i(c(x))$ . And finally, we must consider that the whole of capabilities  $Q_i$  which can be achieved by the individual depend on the quantity and quality of the available resources and the characteristics of the individual himself, and this is particularly important with reference to environmental functionings.

In the first case it is a matter of evaluating functionings relative to environmental goods  $x$ , classified as above, with respect to the territory where the individual lives and/or works. It is evident how an individual's "quality of life" is strongly tied to the "quality of the environment in which he lives".

In the second case, it is necessary to consider many factors that fall into the following main categories.

1. The individual's physical characteristics, as regards his sensitivity (or vulnerability) to the quality of the environment: age, health, pregnancy, hazardous/harmful working environments, etc.
2. The individual's possibilities of defending himself from the negative influences related to the deterioration of the quality of the environment, e. g. spending part of his time (vacations, holidays) in areas of high environmental quality, buying biologically raised foods, defending himself against noise by technical means<sup>1</sup>

On the basis of these considerations, it becomes extremely important to be able to use public choice methods capable of working in an space of evaluation differentiated by groups of individuals, since a different structure of well-being is highly probably for different categories of individuals, even if supporters of CBA insist on stating differences of utility between groups of individuals are almost always irrelevant.

The vector of the characteristics of an environmental good is typical of the good itself. In applied ecology there are specific disciplines which, on the basis of functionings related to each commodity, study the characteristics and construct the respective indices of evaluation. A preliminary approximation of functionings related to environment quality can be obtained by starting with this type of analysis which makes it possible to connect each environmental good to one or more functionings and the respective valuation. The following table presents environmental goods, their characteristics, the activated functionings and some possible valuation indices.

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<sup>1</sup>These factors are closely tied to defensive spending that are evaluated in many attempts at environmental accounting.

### A static analysis: characteristics and functionings of environmental goods

Environmental goods	Characteristics	Functionings	Influences of the characteristics on other functionings	Valuation
A) Air	a) Air quality, pollutants	1. Preventing morbidity: damage to eyes, respiratory function.	I. Preventing damage to other environmental goods (flora and fauna) which in turn give rise to other functionings for future generations.	Ecotoxicological models
B) Water resources	a) Quantity of available water and regime b) Water quality	Availability: Element necessary for life Pollution 1. Preventing impediments or limitations to the use of directly potable water and possible health risk due to the use of polluted water 2. Preventing damage to health due to the accumulation of pollutants in animal and vegetable products.	I. Preventing damage to other environmental goods (flora and fauna) deriving from lack of water and /or pollution.	Models for evaluating water needs for the human Ecotoxicological models
C. Soil and mineral resources	a. Geological characteristics  b. Fertility  c. Regulation of water flow  d. Landscape  e. Soil pollution	1. Preventing damage to man and his property due to catastrophic geological events. 2. Permitting agricultural activities and life in the area 3. Preventing damage to man and his properties 4. Amusements, esthetics pleasure, personal satisfaction through sports. 5. Permitting agricultural activities and life in the area	I. Preventing damage to other goods that involve or affect future functionings.   II. Water availability (B.a.). III. Ground loss (C.b.)  IV. Water quality (B.b.)	Models of geological risk  Index of the ground's agricultural potential.  Models of hydrologic risk  Models of landscape value  Pollution diffusion model
E. Biological environment, flora and fauna	Ecological feature, number of species, relationships between species, risk	1. Productive functions: permit the performance of economic activities and hence employment and added value in the area. 2. Genetic reservoir for improvements in agriculture, biotechnology, etc.	I. Oxygen production and water quality (A.a.) II. Water retention (C.b.) III. Genetic reservoir to improve the quality of human life (medicines) agricultural production (genetic improvement of plants) etc..	Ecological index, biodiversity models

### 3.2.2 An integrated analysis - Components of Environmental Quality

As we said, this representation of the relationship between environmental goods and functionings is only a preliminary approximation of the relationships that link the environment to social well being. The effects of environmental quality on man's well being cannot be efficiently analyzed using only environmental components as the sum of functionings derived from the single elements. The concept of environmental quality derives not only from the characteristics of the single components, but also from an overall valuation that takes into account the static and mainly dynamic interrelationships between the components (Margules and Usher, 1981; Smith and Theberger, 1986). The global and territorial validity of the concept of environmental quality is also recognized by the French environmental accounting method's subdivisions into ecozones. The aspects considered within the context of territorial planning are the following (Malcevski, 1991): a) pollution and degradation; b) hazards/danger; c) stability and vulnerability; d) cultural and recreational value; e) value as a resource; f) rarity and diversity. We will attempt an analysis of these components within the theoretical context used for this study.

#### *Pollution and Degradation<sup>2</sup>*

Pollution means, the direct or indirect introduction, by man, of substances that are harmful to living resources and/or to human health. The effects on the capabilities may be direct or indirect. The direct effects are the possible diseases and pathologies that develop mainly in the weaker strata of society (children, the elderly, the ill). The indirect effects concern impact on natural biotic or abiotic resources.

By using the proposed approach, vector  $x$  of environmental goods comprises the whole of the environmental components in the territory in which an individual lives and works, function  $c(x)$  represents the qualitative characteristics of those components in terms of levels of pollution from various sources and the consequent toxicological and epidemiological effects, functionings  $f_i(c(x))$  concern health and quality of life in relation to the individual's state (age, constitution, general and current health, pregnancy, etc.), and finally capabilities  $Q_i(X_i)$ , accessible for the  $i^{\text{th}}$  individual are related to the availability of territory with such environmental characteristics as to permit an acceptable level of health and quality of life.

The hazard, stability and vulnerability components are closely interrelated and comprise various aspects of environmental risk in relation to life in an area or territory.

#### *Hazards/Danger*

This aspect is related to the concept of risk due to pollution and degradation. It expresses the intrinsic possibility of producing pollution and serious degradation. Environmentally hazardous manufacturing is highly relevant here. This concept is covered in the European Union directive 501/82 that identifies industrial activities which may be related to "an event such as a significant explosion, fire or emission, connected to uncontrolled industrial development that gives rise to a serious, immediate or deferred hazard for man or for the environment".

#### *Stability and Vulnerability<sup>3</sup>*

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<sup>2</sup>Also defined as "anthropic pressure"

The concept of stability applied to ecosystems and environmental systems starts with the identification of the main transformation factors, and indirectly defines environmental equilibrium as the total of conditions for which processes of rapid and profound change cannot be hypothesized (Meadows, 1972). The concept of vulnerability is closely tied to that of stability and expresses the risk that an environmental system may not succeed in resisting external impacts. The concept of "anthropic vulnerability", that is the risk of environmental impact leading to serious effects for the lives of persons living in the area is particularly important in our working context. The most widely applied examples in the field of territorial planning are the models of hydrogeological stability and vulnerability and the aquifers' vulnerability to pollution.

For this component the vector  $\mathbf{x}$  represents the environments in which the individual lives and works, function  $c_i(\mathbf{x})$  represents the characteristics of the territory that influence the risk of natural calamities or environmental disasters evaluated in terms of risk, danger, stability and vulnerability charts and indices, the involved functionings  $f_i(c_i(\mathbf{x}))$  are related to the individual's moral right to live in an area where there are no risks to himself, his family, his property and his work<sup>4</sup>. Finally, capabilities  $Q_i(\mathbf{X})$  represent the availability of territory with an acceptable risk level for the  $i^{\text{th}}$  individual's social and economic activities.

#### *Cultural, Esthetic and Recreational Value<sup>5</sup>*

The environmental quality of an area also depends on its cultural importance and the recreational facilities it offers. In fact, the development of modern society has led to a marked increase in psychological stress, at least in the industrialized countries, with a concomitant separation from the natural environment, and the social, cultural and anthropological traditions related to it. At the same time, there has been an increase in the demand for relaxation. Outdoor recreation, in natural settings characterized by natural, historical and cultural attractions, plays a primary role. In this case, vector  $\mathbf{x}$  of goods and services represents natural resources and cultural highlights, function  $c(\mathbf{x})$ , the qualitative and quantitative characteristics that determine the resource's potential as a recreational and/or cultural enrichment object (indices of recreational potential, landscape valuation, map of territorial highlights, etc.). Functionings  $f_i(c(\mathbf{x}))$  represent man's need for outdoor recreation in its various forms of cultural enrichment related to the understanding of the area (knowledge of nature, anthropology, etc.). And finally, capability  $Q_i(\mathbf{X}_i)$  represents availability of recreation and cultural enrichment in relation to his accessible resources ( $\mathbf{X}_i \in \mathbf{X}$ ), his income, cultural level and sensitivity towards those values ( $f_i \in F_i$ ).

#### *Value as a Resource*

This aspect expresses the environment's capability of being a site of productive activities, and of producing wealth, work, and in the broadest sense, economic growth. In more general terms it represents the capability of hosting human communities in the territory, complete with the necessary productive and social service infrastructures. With regard to this component, vector  $\mathbf{x}$  of environmental services and goods, represents the settled territory as a living and working environment and the natural resources therein. Function  $c(\mathbf{x})$  comprises the characteristics of the environmental resources that provide opportunities for (sustainable) economic growth in terms of direct or indirect

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<sup>3</sup>This term has also been defined by other authors as "sensitivity", "fragility", "environmental criticality" or "resilience" (cfr. Holling, 1973; Whittaker, 1975; Westman, 1985)

<sup>4</sup>It is obvious how these risks seriously affect functionings that are essential to the individual's life

<sup>5</sup>Defined by other authors as "natural" or "wilderness" areas

employment, added value of service efficiency, etc. Functioning's  $f_i(c(x))$  related to this use can concern both current and future generations. For the current generation, the individual has a moral right to live, and hence find work in the area where he was born and decided to live, and indirectly as a result of economic growth, find the services necessary for an acceptable quality of life. Looking towards future generations, the functionings are related to the moral right of future generations to enjoy the same opportunities (same level of capability) as the current one. Finally, capability  $Q_i(X)$  is the opportunity of working and accessing services for the  $i^{\text{th}}$  individual in relation to his individual characteristics (age, education, social aspirations linked to his occupation, etc.) It is interesting to note that the environmental quality component becomes particularly important in the context of territorial management of areas, such as mountain zones, that are marginal to the economy.

#### *Rarity and Diversity*

Some motivations at the basis of the "rarity" component have been well described in *World Conservation Strategy* (IUCN, 1980), which says that conservation of genetic material is insurance and an investment as well as a moral principle. The moral principle concerns the extinction of the species, and we have a moral obligation to our descendants and other living beings to act prudently. We cannot predict which species will become useful for us. For ethical reasons and in our own interest we cannot, therefore, knowingly cause the extinction of a species.

The fact that diversity is a fundamental component of environmental quality to be protected has been fully accepted as a concept on the international level. According to UNESCO's *Man and Biosphere Program*, 1974, it is desirable that representative reserves of the biosphere contain the maximum possible variety of ecosystems, communities and organizations typical of the biome. The concept of biodiversity is closely tied to that of rarity. In fact, high specific biodiversity also implies high genetic diversity. The genetic material of natural species is a theoretically immense and non-duplicable wealth of potential in terms of biologically active organic substances. The activable functionings and capabilities are clearly intergenerational and derive from possible innovations in biochemistry, medicine and manufacturing<sup>6</sup> and are therefore directly related to health and quality of life. Conservation of biodiversity, therefore represents an investment on behalf of future generations.

In more analytical terms, vector  $x$  of goods and services is the availability of ecosystems, function  $c(x)$  describes the biological diversity characteristics of the ecosystems, e.g. in terms of biodiversity<sup>7</sup>, functionings  $f_i(c(x))$  are purely intergenerational and connected with the concept of sustainable growth (see section 1). In fact, according to this principle, the current generation has the moral duty to conserve existing biodiversities as a condition of well being and hence of capabilities available to future generations. Finally, capabilities  $Q_i(X_i)$  are given by the number of biologically diverse ecosystems that are conserved as reserves of genetic material<sup>8</sup>.

The chart contains a summary of the various components of environmental quality and the respective functionings that represent the area of evaluation on which to base comparisons of the individual's and society's well being.

<sup>6</sup>E.g. genetic improvements in agriculture, biotechnology, etc.

<sup>7</sup>For a review of the biodiversity indices most widely used in applied ecology, see Westman, 1985.

<sup>8</sup>Since rarity and biodiversity are an environmental component that can be valued on the global level, vector  $X_i = X_i$  for each individual  $i$ , at least from the ethical standpoint, the benefits deriving from the use of genetic material for the good of humanity should be available to all individuals.

Components of the Environmental Quality	Vector $x_i$	$c(x_i)$	$f_i(c(x_i))$	$Q(X_i)$
Rarity and diversity	Biological environment, flora and fauna	Features that express specific and ecosystem biodiversity. Indices of biodiversity.	Conservation of genetic wealth to improve the quality of life for future generations.	Number of biologically diverse ecosystems accessible by future generations
Pollution, degradation and anthropic pressure	Air, water and soil	Qualitative features of the area in terms of pollution levels.	Individual's health and quality of life in relation to his specific conditions (age, general an current health, pregnancy, etc.;).	Availability of area with environmental characteristics such as to permit an acceptable quality of life.
Danger, hazards, stability, vulnerability, and environmental resilience	Ground and underground, biological environment, flora and fauna.	Features of the area that influence the risk of natural calamities or environmental disasters.	Moral right of an individual to live in an environment where there is no risk to himself, his family, his property and his work.	Availability of area with acceptable risk levels.
Cultural, esthetic and recreational value, wilderness.	Soil, landscape, flora and fauna	Qualitative and quantitative characteristics that determine a resource's capacity of being a source of amusement, or cultural and spiritual enrichment.	Man's need for outdoor recreation, amusement and cultural enrichment.	Accessible opportunities given available environmental resources and highlights, income, education, etc.;
Value as resource	Environment al resource usable as production factors.	Characteristics of environmental resources in terms of economic growth, production of wealth and work.	For the current generation, the opportunity of finding work where the individual was born or where he plans on living, with necessary services. For future generations, the right to enjoy the same opportunities as the current generation.	Opportunities for work and accessibility of social services in relation to the individual's characteristics (age, education, expectations related to type of work, etc.).

It is important to note how many desirable characteristics and hence many functionings of environmental goods derive from interconnections and complex ecosystems which are not yet fully known. Another feature of environmental goods is that some functionings can be noted only when they are limiting in nature. For this reason, the analysis of links between environmental goods, functionings, capabilities and therefore, well being is certainly incomplete to a great extent, and in the current state of knowledge, still unknown. Therefore, a Social Choice Function coherent with environmental issues should explicitly take into account the limits of uncertainty inherent in a decision making process that involves natural resources.

### 3.2.3 An attempt at classifying environmental functionings

On the basis of the analysis conducted separately for each environmental resource and of the integrated analysis for environmental quality components, it is possible to propose a classification of functionings related to the environment and which we shall define as "environmental functionings". To make this classification more effective, it is worthwhile to distinguish functionings in relation to their relevance and of the affected subjects.

The functionings, that can be extracted from the environment, range from the most elementary and essential such as preventing diseases connected to air quality, preventing catastrophes related to hydrogeological imbalances, to the more complex and specific functionings deriving from the individual's cultural background and personal sensitivity, such as obtaining enjoyment from an excursion, "feeling" something when looking at the landscape, etc.

Another feature of the effects of environmental goods on functionings is that of affecting the well being of future generations in terms of freedom and ability to choose. From the analysis in the foregoing paragraphs it is evident that choices made by the current generation will influence functionings that can be **truly** or **potentially obtained** by future generations.

The classification proposed in the following table was done by taking single environmental goods and interactions among them in order to define a given qualitative component, differentiating the functionings in relation to the their "social value" and the generation primarily involved.



Components of Environmental Quality	Environmental goods			
	Air	Water	Soil	Biological Environment
Pollution and degradation	<i>Health</i> Essential functioning	<i>Health</i> Essential functioning	<i>Health</i> Essential functioning	<i>Conservation of the Environment</i> Functionings of future generations
Danger/Hazards	<i>Security</i> Essential functioning	<i>Security</i> Essential functioning	<i>Security</i> Essential functioning	<i>Conservation of the Environment</i> Functionings of future generations
Stability	<i>Security</i> Essential functioning	<i>Security</i> Essential functioning	<i>Security</i> Essential functioning	<i>Conservation of the Environment</i> Functionings of future generations
Cultural, esthetic, recreational value			<i>Cultural Enrichment</i>	<i>Cultural Enrichment</i>
Value as an economic resource, sustainability of economic growth	<i>Conservation of productive capabilities</i> Functionings of current and future generations	<i>Conservation of productive capabilities</i> Functionings of current and future generations	<i>Conservation of productive capabilities</i> Functionings of current and future generations	<i>Conservation of productive capabilities</i> Functionings of current and future generations
Rarity and biodiversity				<i>Conservation of the Environment</i> Potential functionings of future generations

### 3.2.4 Evaluation - Indices and Treatment of Uncertainties

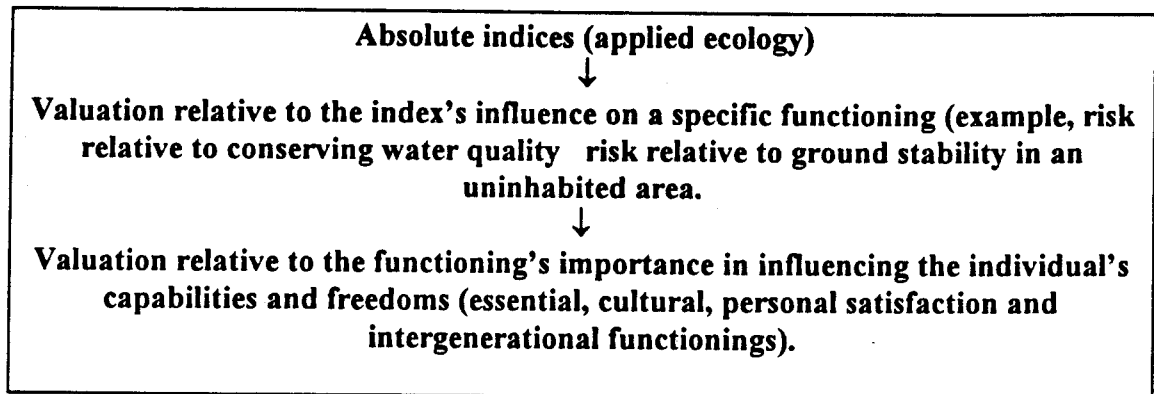
The valuation of functionings  $v_i(x)$  is related to the level of individual satisfaction attained by the functioning.

There are many problems to analyze concerning the form and the scale (unit of measure) of function  $v_i(.)$ . The main merit of the use of indicators deriving from Applied Ecology is the fact that they directly link the index of environmental quality to the effect it has on the individual's life on the basis of his characteristics. The valuations are based on experts' judgments and this feature resolves many issues of individual information regarding contingent evaluation (individual and subjective) that are always present when dealing with the environment. Nor, with this valuation is lost the possibility of making reference to the individual's personal condition or state. For example, the toxicological models of environmental quality can be related to the elderly or to pregnant women.

Not all environmental functionings, however, can give rise to objective valuations, especially those related to obtaining purely personal satisfaction such as the pleasure of

an excursion, admiring an animal roaming the woods, etc.. For this category of functionings there is the problem of defining suitable indices to represent their value with respect to existing environmental quality. There are many potential solutions. It is important to note the need for adopting a single numerarie for all the value objects, which as in the case of CBA would lead to considerable estimation problems, while overcoming this obstacle in the definition of the SCF there are considerable operational margins for determining the functions of value,  $v(.)$ .

One possible general valuation method could consist of the following phases.



#### **4. A PROPOSED SOCIAL CHOICE FUNCTION**

##### **4.1 The Features of the Social Choice Function**

The properties of a SCF consistent with the proposed approach and capable of being operationally efficient can be summarized as follows:

- a) considering value indicators that cannot be related to a single numerarie or that are exclusively ordinal;
- b) managing functionings in hierarchical form;
- c) internalizing explicitly uncertainty in values (c1) and in future effects (c2), that is, without to use forms of social discount;
- d) making explicit the impact on the well being of each group;
- e) making explicit the impact on various generations;
- f) the possibility of showing the tools of interpersonal (f1) and intergenerational (f2) equity used.

The first problem to face defining this SCF is the Arrow's Impossibility Theorem. Two ways have been proposed to overcome this theorem: to modify the Arrow's conditions; to use a richer informational base. Working in the second context Sen proposed /Sen 1977) the decomposition of the original problem in sub-problems. For problems of aggregation of individual interests or into social welfare judgements either for social decisions, the Arrow's framework "... seems to be quite inappropriate ...". The n-tuples of individual orderings are informationally inadequate for representing conflict of interests" (Sen 1977, p.80). According to this approach, for decision problems concerning interests aggregation it is possible to improve Arrow's information scheme by interpersonal comparison, even with cardinal valuations, and by explicitly considering

extra-utility information. In this way the impossibility theorem vanishes for most public decision problems. On the contrary, in this context, the difficulty is to choose the best methodology of aggregation and of evaluation of alternative projects (or policies) effects in terms of economy, environment and intra and intergenerational equity.

In our opinion the properties above are substantially verified within the context of the Multiple Criteria Decision Making (MCDM) method based on the theory of the ideal point and the use of fuzzy indicators (Marinelli, Casini, Bernetti, 1995). Here we will try to determine how the foregoing properties can be applied to those methods by first analyzing the properties relative to the valuation and aggregation of functionings (a, b, c1) and then those relative to interpersonal (d, f1) and intergenerational (e, f2) equity.

A strong point of the MCDM method is the possibility of considering several objectives separately without having to use a single numerarie. In the case of SCF it is possible to examine several functionings evaluated with completely different indicators as requested by the foregoing examples of environmental functionings. The problem of aggregating functions  $v(.)$  can be tackled in several ways.

As a first approximation of SCF can even be defined without the explicit definition of an evaluation function, through a relative valuation of well being based on the comparison of elements in the capability sets. So, the central point is the correct determination of the physical or qualitative quantification of the functionings. The intrinsic features of the entities being compared (levels or variations of well being) lead to broad elements of uncertainty and inaccuracy in the valuation process. Trying to ignore this by using inflexible analytical tools seem too unrealistic. Therefore the characteristics of the methodological tools used in the evaluation should allow a representation of the approximation and any incompleteness of the comparisons that exist in reality even in analytical terms. For the comparison of the elements of the capability sets Sen proposes (Sen, 1985) the approach defined as "elementary capability evaluation", based on the two logical relationships "*better than*",  $P$ , and "*at least as good as*",  $R$  at the single element level and which are translated into relationships of complete or partial ranking of *capability sets*  $P^*$  and  $R^*$ . Hence given two capability sets  $Q_1$  and  $Q_2$  with  $n$  potential functionings,  $f^n(c(.))$  ( $n=1, \dots, N$ )<sup>9</sup>, deriving respectively from the actually available commodities sets,  $X_i$  and  $Y_i$ , we have.

$$\begin{aligned}
 & Q_1 R^* Q_2 && [4.1] \\
 & \text{if and only if} \\
 & \exists f^n(c(X_i)) \in Q_1, \forall f^n(c(Y_i)) \in Q_2 : f^n(c(X_i)) R f^n(c(Y_i)) \\
 & \text{and} \\
 & Q_1 P^* Q_2 \\
 & \text{if and only if} \\
 & Q_1 R^* Q_2 \\
 & \text{and not} \\
 & Q_2 R^* Q_1
 \end{aligned}$$

This "elementary" criterion, as Sen defines it, makes it difficult to create complete ranking. Frequently, in most real situations, it leaves broad areas where comparisons

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<sup>9</sup>For purposes of simplicity we omit index  $i$  indicating the subjectivity of the transformation of commodities into functions by the  $n$ th individual or group of individuals,

cannot be made. Even the lack of one element in either of the two sets, or the non-comparability of even one capability can cause [4.1] not to be fulfilled.

The search for methods capable of improving information on various capability sets with respect to the “elementary capability evaluation”<sup>10</sup>, seems to find fertile ground within the context of the theory of decisions. For example there are the multi-attribute methods that are widely applied in agriculture economics (Bernetti Casini, 1995). These methods use logic propositions that are very close to those proposed by Sen for pair comparisons, and they offer the advantage of being based on evolved decisional processes that tend to reduce markedly the level of incompleteness of the rankings obtained. The multi-attribute methods based on fuzzy logic seem to offer greater opportunities for improving the information picture. The relations P and R that we showed above, are, in fact typical of those used in *crisp* decisional logic, that is the traditional approach in which relationships can be expressed in dichotomic terms, true-false, 0-1, greater or lesser. Actually, the relations that exist between the diverse “values” assumed by the capabilities or between levels of well being are rarely expressible in such definite terms. Most frequently value judgments in this field respond to propositions such as “quite better”, “probably worse”, etc., that imply levels of uncertainty in the judgment. Using the fuzzy approach we can internalize such uncertainty within the model by the relations “Indifference”, “Strict preference”, “Broad preference”, etc. (Zimmermann, 1987).

After the pairwise comparison of the functionings the next step is the comparison between states of well being, that is the approach proposed by the capability sets  $Q(X)$ . At this level the methods available in the field of the theory of decisions are based mainly on the use of concordance and/or discordance matrices. However, the economic implications of these methods are anything but explicit and resolved within the context of a complete theoretical arrangement of the matter (Bernetti, Casini, 1995).

The use of SCF based only on the comparison of the elements of the capabilities sets may not obtain a complete ranking of alternatives. In order to overcome the limits of incomplete orderings which are particularly serious in the context of decisions regarding public investments, it is important to introduce an aggregation function of the indicators of the various functionings.

One of the most effective approaches to attain this new SCF seems to be the one based on the theory of the “displaced ideal”. The theory of the displaced ideal (Zeleny, 1982) or of Utopia (Yu, 1973) is based on the concept of the ideal point. The ideal point corresponds to Arrow’s (1967) bliss point in the traditional theory of utility. It is defined as an alternative which, in reality cannot be achieved given the available resources and the decision maker’s objectives; it can be represented by a vector, the elements of which are the maximum values that each criterion can attain among the various alternatives. The basic hypothesis of theory of the ideal is the so-called “axiom of choice”, according to which the closest alternatives to the ideal point are preferable to those which are farthest. On the basis of this axiom we can construct the following families of functions of distance from the ideal point

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<sup>10</sup>See Kreps (1979) and Sen (1985) for a summary of the main proposals within the context of economic theory.

$$L_{i,t}(p) = \left[ \sum_{k=1}^K (w_{k,i,t})^p (1 - d_{i,k}^{s_j})^p \right]^{\frac{1}{p}}$$

for

$$d_{i,k}^{s_j} = \frac{c_k(x_{i,t}^*) - c_k(x_{i,t}^{s_j})}{c_k(x_{i,t}^*) - c_k(x_{i,t}^0)}$$
[4.2]

leaving aside notations relative to interpersonal and intergenerational equity we have

$$L(p) = \left[ \sum_{k=1}^K (w_k)^p (1 - d_k^{s_j})^p \right]^{\frac{1}{p}}$$

for

$$d_k^{s_j} = \frac{c_k(x^*) - c_k(x^{s_j})}{c_k(x^*) - c_k(x^0)}$$
[4.3]

Where  $c_k(x_{i,t}^*)$  can be interpreted as the optimum endowment of environmental goods with diverse desirable characteristics  $k$ , for each  $i^{\text{th}}$  individual and for each  $t^{\text{th}}$  generation,  $c_k(x_{i,t}^{s_j})$ , endowment of environmental goods with the realization of the subset of the project  $s_j$  feasible with the available resources, where  $j \in J$  set of all the relevant projects,  $c_k(x_{i,t}^0)$  endowment of environmental goods of the  $i^{\text{th}}$  individual before the fulfilment of any project (initial endowment),  $d_k^{s_j}$ , distance relative to the  $k^{\text{th}}$  feature,  $L_p$  distance calculated according to metrics  $p$  which represents the typical parameter of the distance function family for  $1 \leq p \leq \infty$ . Each value of  $p$  identifies a particular way of calculating the distance between the alternative under consideration and the alternative considered: with  $p=1$  it is given by the weighted sum of the distances from the ideal value; with  $p=2$  we obtain the classic Euclidean distance in a multidimensional context, while with  $p=\infty$  we obtain the maximum distance with respect to the ideal endowment ( $L_\infty = \max_i \{\lambda_i (1 - d_i^j)\}$ ). The choice of a given metrics is therefore fundamental for purposes of identifying the final decision. Through Yager (1978) we can see that for  $p=1$  the minimization of  $L_p$  reflects the decision maker's interest regarding the total sum of the deviations of attributes with respect to the ideal point. Similarly to the CBA this corresponds to the case of an absolute compensation between the various criteria<sup>11</sup>. On the other hand, for  $p=\infty$  we try to minimize the maximum among the individual deviations, that is, all the objectives are considered separately in terms of utility, which corresponds to the case of the total lack of compensation<sup>12</sup>. The intermediate cases for  $1 < p < \infty$  correspond to partial trade off among the various criteria<sup>13</sup>. There is no solid theory capable of justifying the use of intermediate metrics which therefore seems to be of little value if not in very specific cases. The possibility of considering different distance measures for different groups of functionings within the same aggregate procedure seems much more positive. In the case of essential functionings (health, security, etc.) the apparently most

<sup>11</sup>In other words, there is a marginal substitution sample between the various criteria.

<sup>12</sup>There is no marginal substitution sample since the indifference curves are of the I/O type.

<sup>13</sup>In this family of functions the marginal substitution sample decreases progressively

appropriate metrics is  $L_{\infty}$ , while in the case of cultural functionings deriving from personal sensitivity (landscape, recreation, cultural enrichment, etc., usually not essential for an individual's life) partial or total trade off could be allowed.

A critical point in this approach is the identification of the ideal endowment. In general, this is interpreted as an achievable ideal, that is the maximum result that can be obtained for each  $k$  functioning if all the resources (financial, physical, etc.) were allocated to it. In the case of the environment, the definition of the ideal can be made to coincide with values of functionings that can be found in an intact environment, so that for many cases the ideal value could be easily determined. In those cases where this does not occur, recourse to fuzzy indicators capable of approximating the ideal in a more or less broad range, could solve many of the problems or at least allow a more faithful representation of the real decision making context and hence even more efficient choices (Bernetti Casini, 1995). We must point out that the concept of the ideal, as proposed in applications to specific socio-economic functionings, must be interpreted not as the maximum value achievable by an individual, but as the ideal pursuable by the majority of individuals or by the least privileged (Rawls minmax).

Finally, the use of the distance from the ideal as the unifying measure of values of functionings seems to permit a good correlation of the mathematical approach to a decision making process with the goal of reaching given growth objectives, in pursuit of specific quality-quantity standards for the majority of the population.

## 4.2 Interpersonal Equity

The first step on the theoretical and applied level in solving problems that involve changes in interpersonal well being and hence comparisons of well being consists of identifying Pareto-optimum or unanimously approved choices. Often, however, this cannot be considered satisfactory given the difficulty in identifying this kind of solution for public investments. On the other hand, recourse to various compensating criteria (Hicks, Kaldor, Scitowsky) was been proved to be useless or redundant. Therefore, we once again are faced with the question of how correct is it to use interpersonal comparisons of well being and even aggregate criteria according to Sen's theoretical context.

Accepting the possibility of aggregating interests for well being (Sen 1993, Bernetti and Casini 1995), the problem is how to formalize the aggregation of the various capability sets of all individuals. Limiting our analysis to the standard interpretations of interpersonal comparisons in relation to the subject of the contribution, the various methods proposed in the literature range from the total utilitarian ranking to the weighted sums, to Rawls's lex-min and max-min, to Hammond's axiom of equity, to the methods of maximizing agreement.

The transposition of these theoretical approaches in the field of applied methods to aggregate individual interests is often immediate. Take for example the method of additive valuation of preferences, that coincides with the utilitarian approach, or the minmax method which is used in many mathematical models.

The definition of an aggregating function finds extreme conditions of comparison in the two above methods. The additive valuation requires total independence of the decision from the initial and final levels of well being, and from the distribution of the changes in well being assuming the total compensatory nature of interests. The valuation using the minmax approach, like the multiplier type is based on the maximization of lower levels of well being and hence requires total non-compensatory nature of interests.

Among the theoretical-operational problems raised by the additive valuation model, those related to distributive equity are particularly important. The same structure of the aggregation function, as we have already shown, implies a total compensation of interests of the several groups, and leaves aside initial and final and even potential levels of well being of the various groups. However, even the methods of evaluating changes in well being, typical of the CBA context, imply significant consequences for the social equity of the final decisions. The use of willingness to pay, for example, tends to over estimate the interests of higher income groups in relation to their generally lower marginal utility of money. On the other hand, the definition of a WTP function of income presents many operational difficulties. Incorporating into the classic additive function extra-utilitarian value judgments on various social groups involved in the decision making process is a possible solution to the problem of distributive equity in the CBA context. Evidently the reliability of the system of weights is the essential requisite for achieving maximum mitigation of the distribution of distortions, and there are many difficulties in assessing a system of weights. Then, we must point out that even with recourse to weighting, the problems of levels of well being remain unresolved. Therefore, in those cases in which the final or potential levels are determining elements in the evaluation of post-project social conditions (poverty, etc.), we see that not even this method allows us to obtain results that are acceptable in the CBA context.

It seems worthwhile examining the definition of the aggregate function on the basis of displaced ideal theory. This approach has the advantage of extending to the interpersonal case the trade off versatility that exists among the various objectives. In the interpersonal context the problem is the minimization of the distance from the ideal conditions for each individual, as follows:

$$L_t(p) = \left[ \sum_{i=1}^I (w_{i,t})^p (1 - D_i^{s_j})^p \right]^{\frac{1}{p}}$$

[4.4]

for

$$D_i^{s_j} = \frac{Q_{i,t}^*(X_{i,t}^*) - Q_{i,t}^{s_j}(X_{i,t}^{s_j})}{Q_{i,t}^*(X_{i,t}^*) - Q_{i,t}^0(X_{i,t}^0)}$$

with  $Q_{i,t}^{s_j}(X_{i,t}^{s_j})$  is the set of capabilities of the  $i^{th}$  individual (in the generation  $t^{th}$ ) with the subset of project  $s_j$  feasible with the available resources,  $Q_{i,t}^0(X_{i,t}^0)$  the initial capabilities for individual  $i$ ,  $Q_{i,t}^*(X_{i,t}^*)$  the set of ideal capabilities, and  $w_{i,t}$ , if necessary, the weight attributed to the social groups of the  $i^{th}$  individual in the  $t^{th}$  generation. Naturally, this is true under the assumption that the individuals' capability sets can be measured in cardinal terms and that it is possible to identify the ideal capability set for each individual.

Recourse to a flexible valuation instrument such as distance, that can be adapted to various types of trade off among the various decision elements through the use of appropriate metrics, makes it possible to achieve good adherence to the reality of the relationships between the diverse interests. In this interpersonal context the problems of defining the most correct metrics also seems attenuated since the nature of the interests in question would seem to permit an easier definition of the compensating relationships between the individuals. In essence, the advantage of this method over the attribution of weights by CBA consists of the possibility of explicitly considering the level of well being achieved by each group as the deciding criterion.

It is evident that the choice of one or more possible metrics for evaluating the level of goal attainment must be made on the basis of the specific problem analyzed, in relation to the characteristics of the interests involved and also the extra-utilitarian information. Problems that involve basic rights or that have significant moral or social implications cannot be dealt with under completely neutral conditions, just as sharply conflicting interests are hard to reconcile with strongly compensating criteria.

#### 4.3 Intergenerational Equity

Environmental economics deals with intergenerational equity using the concept of sustainable economic growth in economic, environmental and social terms (intra and intergenerational equity). According to the Brundtland commission's analysis of the concept of sustainable growth the well being of individuals of the current generations should not be increased if it compromises the well being of future generations. Therefore, the criterion of Paretian efficiency is also extended to individuals of future generations. With regard to these issues, the liberalistic and utilitarian view which in practice is translated in the "classic" CBA approach affirms that current generations have no indebtedness towards future generations. In fact, future generations are only "potential individuals" who might never even exist. These concepts are translated into the following formulations of the function of intergenerational well being (van den Bergh and Nijkamp, 1991; Dasgupta and Heal, 1979):

$$W = \int_0^T \int_0^T \exp\left\{-\int_0^s \delta_s ds\right\} \sum_{i=1}^L u_i[x(t)] p(t) dt ds \quad [4.5]$$

where it is important to point out both the presence of a discount rate ( $\delta_s$ ) which favors the benefits of the current generations with respect to future ones, as well as the existence of a distribution of the probability  $p(t)$  of their existence.

Aside from this context that essentially rejects the issue, CBA has attempted to take aspects of intergenerational equity into account mainly via the Total Economic Value. This approach concerns the identification of bequest values and existence values, which in different contexts attempt to measure the value that the current generation attributes to the well being of future generations. Leaving the major practical difficulties in identifying that value, the resulting attribution is not an ethical imperative but basically a concession, a totally voluntary acknowledgment of value by the current generation with respect to future generations.

If we consider future generations within the context of Sen's theory of freedoms, it is easy to see how we cannot know either the characteristics or the functionings of future generations as regards natural resources. In fact, we have but a limited knowledge of ecosystem mechanisms, and many characteristics and functionings of the environment become limiting and become desirable only when they are lacking or scarce. This leads to the fact that we cannot directly consider the functionings of future generations in the choice function, and thus it becomes necessary to preserve the vector of environmental goods as the guarantee of the characteristics and functionings (unknown) of the individuals who will come after us.

The problem of intergenerational equity and the related uncertainty cannot therefore be dealt with in the context proposed by the CBA approach, but rather with a choice model in which environmental problems and principles act and are explicitly represented. These elements can be implemented in the MCDM context by introducing a set of constraints



on the critical levels of: natural resource, ecosystem alterations, available functionings. The implementation can be achieved also by the explicit consideration in the model of the social group of future generations, with specific potential functionings to pursue and with diverse risk levels regarding their attainability.

Finally, it is important to point out the links between intra and intergenerational equity through environmental functionings. There is a relationship between poverty and high utilization of natural resources, and between poverty and low levels of essential environmental functionings. Both elements prejudice overall social well being affecting the quality of life of both current and future generations.

## 5. CONCLUSIONS

Due to its theoretical basis, CBA does not allow correct implementation of the process of public investments decisions and evaluation of its environmental impact. In our opinion, this inadequacy derives mainly from the principle of the current consumer's sovereignty that permeates all CBA methodology. In fact, this principle that leads to the use of present individual utility as the value element in the decision process, and thus involves various conceptual and practical problems highlighted (par. 2), particularly defining optimum development routes with obvious underestimates of the problems of the use of natural resources from an intergenerational viewpoint.

In proposing an alternative method for selecting public investments we have found in Sen's theory of well being an interesting basis for the definition of criteria that better responds to a correct evaluation of the environment in social decision processes. In fact, functionings and capabilities allow the transposition of many principles of applied ecology into terms of social well being. They greatly reduce the imperfections caused by the use of the neoclassical concept of utility on evaluation of the effects of public projects on the territory and environment.

The definition of the choice function was made within the context of the MCDM methods which permit a multidimensional representation of the decision process with regard to the selection criteria and the decision makers. In this context it is thus possible to deal with each functioning of group of functionings with the most suitable *numerarie* and even to attribute different evaluations on the basis of the various social groups involved.

Other significant aspects of the proposal concern: the use of fuzzy of indicators that permit the presentation of the uncertainty components that exist during evaluation of functionings as well as relations of preference between alternative social conditions; recourse to the theory of the ideal point as an instrument for unifying the selected indicators of well being if dominant solutions in the Paretian sense cannot be identified.

The matter of intergenerational equity and related problems of uncertainty was dealt with by introducing both restricting structure aimed at highlighting the projects' environmental sustainability, and setting for the effects in terms of functionings and capabilities for future generation that, in this context, become a well defined social group.

The proposed method is mainly a starting point for the definition of a real, theoretical-methodological corpus that is a valid alternative to CBA. Many subjects, starting from intergenerational problems need further study and must be resolved in all their theoretical aspects and implications. In addition we must point out the problems inherent in the choice of intermediate metrics between non-compensatory and total compensatory, along with the hierarchical structure in the pursuit of different types of functionings.

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