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An assessment model for the environmental damage simulation through scenarios predicted with a Geographic information system*

This essay describes the most relevant steps of a method for the environmental damage assessment that was edited in 1989 and that could be easily adapted to the actual context, using a scenario approach built thanks to Gis tools and procedures. Once the scenarios have been identified, the turning point is a prospective comparison referred to the decreased capability of the environment to support the activities of its three components and to the evaluation of "value parameters", depending on the importance given to each element, in order to identify the damage costs. At this point, the damage value could be quantified considering the actual reclamation costs and outlining the uniqueness of each area and ecosystem and the actual inability of exactly restoring the previous configuration.

1. Background and purpose

The problem of assessing an environmental damage action is increasingly challenging, to the extent that it has recently influenced several facts, brought to the attention of the so-called "general public". Although the Italian law and jurisprudence have significantly changed, producing an important case history, the methods used to calculate the reparations amount have never evolved in a valuable way (as already remarked from an earlier work, published for a Ce.S.E.T. meeting in 1989) and they cannot certainly be suitable, because in most cases they only consider the reclamation costs for the damaged areas. From the perspective of the authors, this approach cannot be regarded as acceptable, as it considerably downplays the factors that add to the damage caused to the environment several negative side-effects, related to the real inability of restoring the situation to the configuration that it used to have before the harmful events. As a matter of fact, this is an "old" topic in the estimation debate, if we consider that the Environmental Economy and, above all, the Regional and Environmental Appraisal have been developed just from the need to measure, on one side, the value of use for environmental goods (and the positive or negative externalities they are exposed to) and, on the other side, to take into account these elements in the development strategies. Actually, the regional Estimate is responsible for estimating the value of

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assets comprising the natural resources in terms of value of use in a social meaning (and not of exchange value), whereas the Environmental Appraisal deals with the impact of human activities on the environment, in order to provide the competent agencies with the knowledge elements, by which they can decide whether to approve, suspend, or modify a project, a plan, or a program. In this sense, the actual legislative framework highlights the increasing need of the society for a more effective economic justice in those conditions, in which illegal actions had a detrimental effect for the environmental assets, as it is necessary to determine the appropriate and unique criteria to assess in monetary terms, to the fullest possible extent, the compensation of environmental damages (Mattia, Miccoli, 1989)[1], especially after the sustainability concept became one of the main goals to be reached in all the principal activities[2].

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[1] The objectification is one of the principles at the base of the Estimate logic and theory for the definition of an interpretative model of immediate applicability, both in a legislative and judicial meaning. It is clear, then, the complete practical utility of considering this way the environmental damages, especially when it is not possible to determine an accurate quantification of destructions, as described in the chapter VI of article 18 of law n. 349/1986. Through the approach described by Mattia and Miccoli (1989) it is possible to formulate a value judgment that could be defined as ordinary, objective, fair, and of general validity, as the Estimate principles state.

[2] What kind of development could we reach? There are at least three main problems to be solved in this sense (Musu, 1998). Is it possible to reach a kind of economic development that ensures that the environment quality through time is at least preserved and that its damage is prevented? What level of environment quality should be ensured? Is it possible to reach an economic development that is matching to the environment preservation? The answer to the first question is "yes", by respecting the natural cycles and the environment regeneration capability, preserving the environmental resources stock and its capacity of providing a service stream (production, consumption). The answer to the second matter could be split in two different approaches: the economic method and the social attitude toward the problem. For the economic approach, preserving or improving the environmental quality is expensive and it needs the use of economical resources (e.g. specific technologies), that needs the calculation of the balance between costs/benefits of the environmental preservation and costs/incomes for the economical systems to be evaluated in terms of trade off. The social approach, instead, is based on the importance of the social balance of development and of the social surplus of interventions. The answer to the third question, finally, considers if the environment is a whole of limited resources: is it possible to reach an infinite and continuous development? For sure, this is a contradiction for many of the environmental economists, as a matter of facts the environmental sustainable economic development is considered as a puzzling concept, because the economic development is usually growing through time, whereas the resources on which it is based are fixed. There are two different positions about solving this problem: pessimists state that it is impossible that the human development will continue forever; optimists, in opposition, think that we should try to make the development compatible to the environment preservation, thanks to the technological improvement that minimizes more and more the use of resources exploited to produce a unit of product, generating less impacts and pollution. The question is then if the natural evolution of economical systems goes towards this objective spontaneously and the reply to this question is that unfortunately, it usually doesn't go in that direction, especially in the market trends, but why? It happens because the market is an institution invented by the human kind in order to exchange goods and services through their property rights (depending also on its specific roles): this convention works properly only if

Therefore the environmental and regional Estimate contributes to specify in a clearer way the new features of the value and the techniques to express them in monetary terms, in order to help the local communities in seeking for the economic justice they need, even in a simple action of use of natural resources made by different subjects (individual or collective). For their insightful nature, the environmental goods are to be considered as public assets and they cannot be consequently meant as completely private (even in cases of breach of any person), but they must be placed in the category of mixed goods[3], at least for the indirect effects that their use may lead to other assets[4].

To solve this problematic node, the authors propose to reconsider the approach described in 1988[5] and to combine it with a damage analysis developed

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the property rights are clear and definite, but the environmental resources are difficultly definable referring to the relative property rights, as they are public goods (as assets involved in an economic system and that can be used simultaneously and in a non-exclusive way by all the economical operators). In this situation, it is impossible (or simply not possible) to exchange the property rights of public goods in order to guarantee their production/reproduction: from these matters come the considerations on the social role of markets and ethics in the economical systems. Another significant problem about this topic is the egoistic use of public goods: these assets are produced and paid by citizens, but not all the of them pay for their production and preservation, as there are two egoistic attitudes that are widespread between individuals ("If I am the only one that pays for it, why should I do it?" and "If all the others pay for it, why do I have to do it?"). Of course, the market is not efficient in ensuring the production and preservation of public goods (that represent one of the main market failures) and the State intervention through policies that limit the market (e.g. ecological taxes, payment of environmental damages, and so on) is fundamental in this sense: it is necessary to have an economic policy to ensure the sustainable development after the circulation of a new common sensitivity on the environmental preservation between developed countries and, recently, also the so called "third world" nations. At this stage a new question arises: which government level is more appropriate to decide on environmental and economical issues to determine integrated policies? This is a matter still to be solved.

[3] The models of the so-called classical and neoclassical economics are based on strategies about production and market, elements that have recently shown their own inefficiency, especially in the management of public and mixed goods. It is necessary and recognized, then, to pass to the sustainability economy, for some simple reasons: *a)* the scarcity of resources, a very old topic in the economics theories, already stated by the "founding fathers" of Economics (e.g. see Smith, Ricardo, Malthus and Mill); *b)* the understandable problems in the efficient managing (by the market) of the so-called collective property and public/mixed goods; *c)* the obvious efficiency issues related to emergency situations, in particular, due to natural phenomena and environmental damages.

[4] This concept underlines the effects produced by a specific illegal behavior: the special conditions of the agent subject (degree of guilt, character of the productive activity, and so on) usually push the involved evaluators to underestimate the important position recognized to the guilty individual by the point of view of the society. This is why Mattia and Miccoli (1989) suggested to try to understand first of all the effects of an environmental damaging action in an objective way, and not only from the point of view of behaviors and of their reasons, purpose, meaning, and so on.

[5] The starting position of this model is an attempt to make the same concept of environment as clear as possible in an estimation meaning, as it has not always been clarified in the same

through the scenarios appraisal (splitting the evaluation, therefore, into the consideration of hazard, vulnerability and exposure factors, in the typical triple conception of the harmful phenomena), updating the results both in the light of the changes introduced by the sustainability concept, and thanks to the use of Gis tools, that could enable the researchers to draw the frameworks to be analyzed in a simple and user-friendly way. In the definition of that model (Mattia, Miccoli, 1989), with a close reference to the sources of law and for the purpose of the definition of a social value of the environment of straight estimate meaning, it is possible to define three distinct and fundamental components, to which any variation in the levels of utility can be traced back. This division is based on the distinction between those elements in the environment that are immediately perceptible, and other factors that are inappreciable or, however, too costly (in the meaning of the calculation of their own value): the main components of the model are, then, *a)* the social system, *b)* the esthetic and cultural elements, and *c)* the natural environment. The same primary elements constitute them, factors whose physical, chemical, or biological characters are fully discoverable in every state they can take and that can be grouped into the following classes: *1)* atmosphere, 2*)* water, *3)* soil and subsoil, *4)* flora and vegetation, *5)* fauna, and *6)* human beings. The effects related to every single element that constitute the main components of the model have influence on: *A)* the socio-economic activities and the public health, *B)* the landscape, and *C)* the local and general ecosystems in a proper sense. Definitively, starting from this point of view, the model will describe respectively these sectors as variables, called *H*, *K*, *Y*, and the referring total utility function. This concise and simple representation explains the characters of the environment, which must be viewed separately[6] from the con-

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way by the legislative tools: e.g. on one hand, in reference to the environmental protection, it has been often seen as a restriction to the use of some of its components (in this conception, it is significantly rare to find a coincidence in the identification of a set of resources that are considered worthy of protection under such designation); on the other hand, it should not be excluded from this definition anything from those conditions that depend on the different configurations that a given ecosystem can take (it is always necessary to identify the total utility provided by them to the human society that populates it; in this sense, the D.P.C.M. 22nd December 1988, published in the Official Journal (7-1-1989) introduced the first and most significant contributions for its unique definition to that effect).

[6] The reason of this separation between the characters of the environment and the construction of an interpretative model is that utility, as economic concept referring to the total satisfaction received from consuming a good or service, is a character that each person gives to things for every single specific purpose. In this sense, it is the measure of the relationship between an object and a subject that has the purpose of maximizing its utility in using that same good, therefore, it has been measured in different ways during the Economics history, mainly referring, on one side, to production costs of goods (classical Economics), or, on the other side, to market prices of goods (neoclassical Economics). Even some of the principles that regulate the Utility functions have a significant meaning for this model: *a)* the satiety principle (as, for every individual, the utility of goods decreases when the available quantity of assets increases); *b)* the hedonistic principle (that states that every individual gets an amount of goods that is able to maximize his/her own advantage, rationally spending his/her available resources for

struction of an interpretative model in any configuration, to determine for each of them its social value of use, that cannot only be considered as the utility of the environment as good from the point of view of the State, meant as owner subject that has the right of pretending the compensation for those actions of the environment modification that should not be allowed under the local and international in force laws.

2. The environmental damage model

The element of the value or the estimation criterion, that the Estimate must seize, becomes, then, the social value of each configuration of the environment, from the collective point of view. The assessment activities should subsequently consider the environment modification, passing from a valid configuration to another arrangement, modified for an illegal or detrimental action, in order to calculate the amount of damages[7], but, as the extent of the destruction must be made as objective and ordinary as possible, it implies a model for the monetization of the amount of damaging actions in terms that should be acceptable in general, as indicator of the correct price to pay for those people who do not respect (in their actions of use and modification of the environment) the constraints already determined at a certain time. The problem is then to define an indicator of monetization of the damage in estimation terms that is the most appropriate to the criteria, whilst always estimative, described in the Law n. 349/1986 for the equitative evaluation of damages. Therefore, the first step of the model considers the main components of the environment, that could be related to the elements that determine the concept of sustainability[8]. Actually, the model is designed to test the ef-

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buying goods, maximizing the amount of bought goods and at the same time minimizing expenses); *c)* the indifference concept (for which all the possible kinds of mix of goods that have the same utility level for an individual are indifferent).

[7] It is important to associate each environmental situation to a specific monetary quantity, which can be considered of general validity for a better efficiency in the administration of the economic justice.

[8] The relationship between economical development and environment is a central part of the sustainable development (in facts, the social issues were introduced only later) and it is recognized by most of the people as the Environmentally Friendly Development in two principal different ways (Musu, 1998): *1.* the environment as limit to the economical development; *2.* the development in terms of life quality. The first topic started being discussed before the Bruntland Report in 1987 (see classical Economics, Malthus) and it has been shared to most of the people starting from the 70s (see Energy crises started in 1973, but efficiently predicted by the essay "Limits to the development" edited by the MIT Press in 1971): the focus of these theories, instead, was on the economical development, while the environment was only considered as a support/base to the development itself. Actually, the reaction to the crises of the economists of that period was about replacing the limited/non-renewable resources (as coal, oil, and so on) with unrestricted/renewable sources (e.g. nuclear energy): it was a partial way of perceiving the problem, as the environment protection is only functional to the economical

fects that a potential environmental damage might have *a)* on the set of socio-economic activities and on public health (*H*), *b)* on the aesthetic-cultural variables and on the landscape (*K*), and *c)* on the natural and ecological elements of ecosystems (*Y*). The total utility function, that comes from these elements, will be identified as a summation of the differentials existing between the reference scenario and the measurable situation caused by the harmful event:

$$D = \Delta H + \Delta K + \Delta Y \quad (1)$$

The reference scenario could be drawn thanks to different methods (depending on the availability of reliable data and the capability of processing their information content), referring, on one hand, to the situation before the harmful event, and, on the other hand, to the greatest bearable damage that each one of the environmental components could withstand. The damage scenario, instead, describes the situation after the harmful event, highlighting, thanks to specific alphanumeric parameters, the elements to be used to assess the social value of the environment. As a matter of fact, the highest acceptable natural damage in a certain area is calculated as a function of the greatest differential between all the natural elements ($D = \Delta H + \Delta K + \Delta Y$), that could not determine any well-being variation on other environmental components (Mattia, Miccoli, 1989). The cultural aesthetic damage, instead, depends on the divergence between the social and aesthetic-cultural reference configuration and the harmful scenario, but also on any differential from the initial framework, on the situation after the restoration activities, and on the value of the discounted reclamation costs. The social damage, at last, is to be understood as a function of *a)* any change in ordinary income flows that a certain good suffers after the action that determines the changeover from the initial scenario to the damage framework[9], *b)* of the reproduction costs for damaged assets that do not have a market value[10] in relation to their loss of flow, *c)* of the variations in the ordinary income flows that the subjects suffered because of the

development. In reference to the second matter, the Bruntland Report changed the perception of the problem, as the sustainability definition it provides is wider: the needs of future generations are meant both quantitatively and qualitatively, then, the environmental quality becomes a central part of the life quality of society and of its economical system. In this sense, the perception of the environment problem in Economics has radically changed from a passive support to an active element, to which the economical development should be compatible. From this point of view, the environment protection becomes the principal goal of the economical development, that has been meant from that disclosure to maintain or reduce the environmental decay or to improve the environmental quality, trying to increase the resources stock (even if limited) embodied by the environment as economical source.

[9] The change in ordinary income flows should also include the related loss of flow in relation to the capitalization rate connected to the reference market.

[10] The reproduction costs for damaged assets that do not have a market value should consider the components that are not that harmed to affect the income streams of goods traded on the market, though they are evidently compromised.

environmental damage[11], and *d)* of the recovery costs for the involved elements to be restored to the initial configuration.

The model, as shown by now, is built on three main factors to be considered: the social damage (*H*), the esthetic and cultural damage (*K*), and the natural damage (*Y*). The following parts of this essay will describe how these variables are built and practically calculated throughout the model (Mattia, Miccoli, 1989).

How should we calculate the social damage (*H*)? It depends from the effects (referring to the socio-economical sectors and to the public health) set from a certain environmental configuration that changes its state because of some illegal actions: for a specific quantification of that component, we should primarily consider the variations of the income streams of tasks routinely performed in two different conditions of environmental quality. To make these evaluations more correct, the flows of utility can only be determined in reference with the same market and with the referring values that are most frequently attributed to the various goods: among many different utility rates that each of the constituent parts of the ecological system can provide to the various possible operators, it should be chosen the one that is objectively suitable to represent the collective needs, in order to let them meet the expectations of many individuals both in terms of quality and quantity. For the practical application of the evaluation model, it is necessary to proceed with the identification of the various components of the ecosystem concerned by the propositions of transformation, to which all the actions undertaken in the past by men continuously attributed a sort of economic utility function: this first kind of analysis only considers, then, those kinds of assets for which an income can be determined. In the second step of this analysis, we could consider all the eventual modifications of income (creation, maintenance or change) to which all the other parts of the system[12] obviously contribute. As a matter of facts, each ecosystem can be considered as a set of elements that become direct producers of income flows, according to their specific use, that is usually decided from time to time: these streams, however, depend not only on the intrinsic characteristics of individual parts, for which it is necessary to form a market[13], but also (and in

[11] The variations in the ordinary income flows that the subjects suffered because of the environmental damage should also include the referring loss of flow compared to the relating cap-rate.

[12] The model should only consider that parts that have a relationship of complementarity with those elements that can be directly evaluated in monetary terms and economic benefits, as they have determined the formation of a market.

[13] The purpose of Economics itself is to understand the reasons of the behavior of subjects acting on the market and the regarding relationship with the available resources, defined, generally, as "economic goods": *1)* they are defined referring to their use value; *2)* in the classic economics, they are the principal object of estimates; *3)* they are material goods defined by some specific features (they should not be rare, or better the regarding accessibility and use availability should not be limited, and there should be a definable right of use on them by a certain subject, that could be an individual or a group). The classification of economical goods depends on different categories, some which are particularly significant for this model: *1)* the materiality of goods: direct or consumers goods (used to satisfy a direct need), instrumental or capital goods (used to produce other goods), immaterial goods; *2)* the immovability of goods:

a measure that is often fundamental) on the more or less consistent presence of other natural or man-made assets, whose utility cannot be directly assessed in monetary terms, because they are not exchanged in any market. Moreover, every environmental transformation intervention can give the result of slight variations in the utility of this second category of goods (or better, the ones that do not have a direct market price): these are the only ones that could be assessed in monetary terms for the social component of the damage, through the variations that the income series related to them have suffered for, as the deteriorating or the complete downfall of goods out of markets are not always likely to be affected by the negative immediate effects on some system components that produce incomes. The relationship of complementarity that exists between these two categories of goods still exists and, on the contrary, it ensures the maintenance of the pre-existing income streams in most of the damage cases and up to certain levels of modification: in these situations, the goods complementary value (that does not give rise to the production of incomes, but often reduces the cost of the goods themselves) is still essentially unchanged. Finally, for the purpose of the assessment in monetary terms of the actual size of the damage, it is necessary to introduce a second component in the economic calculation, given by the summation of all costs to be borne to take these goods back at the same characteristics that they had before the damaging actions.

In this sense, the main steps to calculate the social costs of environmental damages are:

- individuating the complementarity relationships existing between each component of the system that is practically able to create an income flow and the other components that are not usually exchanged in a specific reference market;
- determining up to which deterioration level the complementary assets and the goods that create income do not determine negative effects on the different income flows;
- evaluating the extent and nature of the works necessary to cancel the effects of the physical degradation that the goods out of the market may undergo, without adversely affect changes in the income of other assets;
- assessing the cost of cancelling this type of degradation;
- determining the changes in the income flows that could be determined for these assets that have a reference market and assessing their capital value reductions.

The definition of every single element of this part of the model that could come into play is now fully possible: this is why this procedure have a significant operational effectiveness that could be arisen thanks to a continuous and comput-

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movable and non-movable goods (e.g. real estate properties); *3)* property rights on goods: private, free or market goods (individuals pay a certain amount of money to get them and they are subject to the principle of exclusivity), or public and common goods; *4)* form of goods: identical (they have all the same features), similar (they have only some different features), dissimilar (they have only some features in common).

erized detection system that could be implemented to investigate the observed characteristics of the goods and their status changes, right thanks to the standardized use of Gis procedures.

Moreover, the 1989 model of monetary evaluation of social damage must be completed with the analysis of the effects that each change determines on public health: any richness loss suffered by the community because of the harmful effects on this element must be surely included in the economic calculating previously explained. The variations in income streams for market assets cannot be envisaged without taking into account that the new configurations may change the essential factor of production and consumption that is represented by the men. It is therefore necessary to establish whether and to what extent the harmful effects to the health of a number of individuals have an influence on income streams of things: of course, these evaluations are also done assuming ordinary situations, referring to the most probable extent of the damage to health and in order to share this probabilistic damage between different social components. The man, that has a public function that can be monetized in relation to changes that affected the income streams of things, has an individualist function and the calculation of these elements in this model is made considering the human person as a single element, a unique biologic unit able to meet his/her own needs that ultimately are to be carried out by men/women also in the collective function. In monetary terms, the greater or lesser ability, that everyone has to meet their own needs of biological nature, is to be quantified by the income stream that is able to ensure himself/herself to offer his/her services to the society. The man has, therefore, a dual economic function within an ecosystem: the first one is to be defined by the ratio of complementarity that he/she has with other economic goods, when he/she participates in production activities or when he/she becomes user of these assets; the second one is directly determined by the income stream that is able to provide to himself/herself the same flow of his/her work.

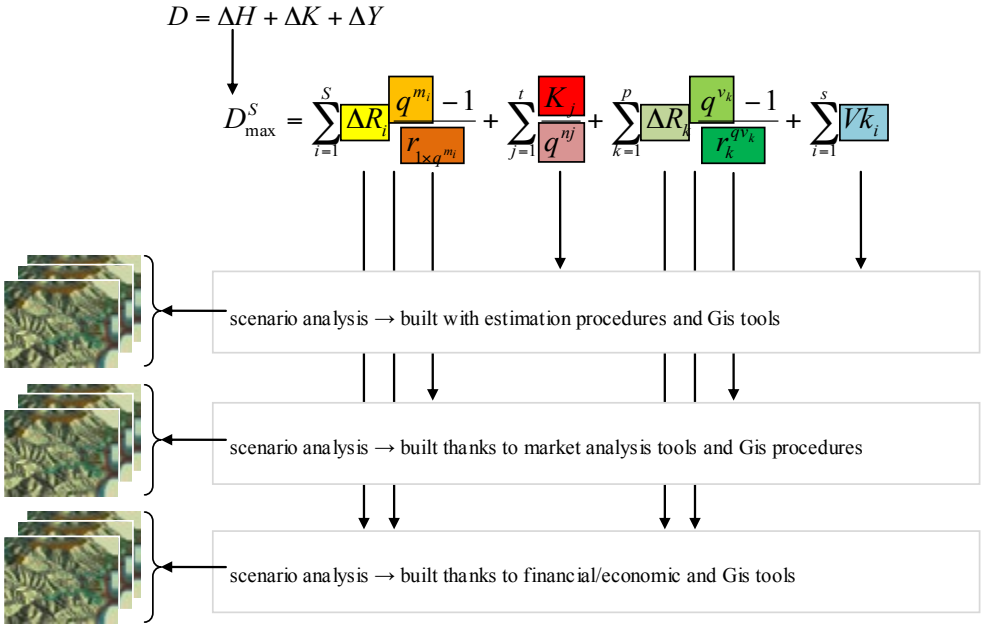
The monetary function of the social damage is then to be calculated as follows:

$$D^{S}_{\max} = \sum_{i=1}^{S} \Delta R_i \frac{q^{m_i} - 1}{r_{1 \times q^{m_i}}} + \sum_{j=1}^{t} \frac{K_j}{q^{nj}} + \sum_{k=1}^{p} \Delta R_k \frac{q^{v_k} - 1}{r_k^{qv_k}} + \sum_{i=1}^{s} Vk_i \tag{2}$$

in which:
D_{max} is the value of the social damage;
R_i is the variation of the ordinary income flows that is suffered by the good i underlying to the action that takes the ecosystem from the initial situation C_0 to the configuration C_1, that is not permitted by the in force laws;
r_i is the capitalization rate determined in reference to the reference market for every ΔR_i;
K_j is the reproduction cost for the damaged parts of that out of market assets, that even if damaged do not have an effect on income flows of market assets;
ΔR_k are the variations of the ordinary income flows that are suffered by people damaged from the environmental transformation action;

r_k is the capitalization rate determined for every single ΔR_k;
m_i and v_k are the durations of every loss flow;
V_{ki} are costs values for the recovery or recomposition of the involved elements.

Figure 1. Scheme for the maximum acceptable social damage.



About the esthetic and cultural damage (K), the model postulates that it depends on the changes of social values that each society attaches to any given configuration of the natural or built environment that surrounds it, because of the impossibility of recovery actions to the complete recomposition of such places. If we describe with V_{c0} the social and esthetic-cultural value of the configuration before the harmful action of a given environment and with V_{c1} the situation resulting from the event, the esthetic-cultural damage is expressed by the following formulation:

$$D^{EC}_{\max} = K = V_{C_0} - V_{C_1} \tag{3}$$

in which, of course, V_{c0} and V_{c1} are the social and esthetic-cultural value of the configuration (respectively before and after the harmful action) of a given environment. In case of repairs or reconstruction actions, that same damage is given by:

$$D_{\max}^{EC} = K = \left(V_{C_0} - V_{C_2}\right) + V_{kr} + w(V_{C_0} - V_{C_1})a \tag{4}$$

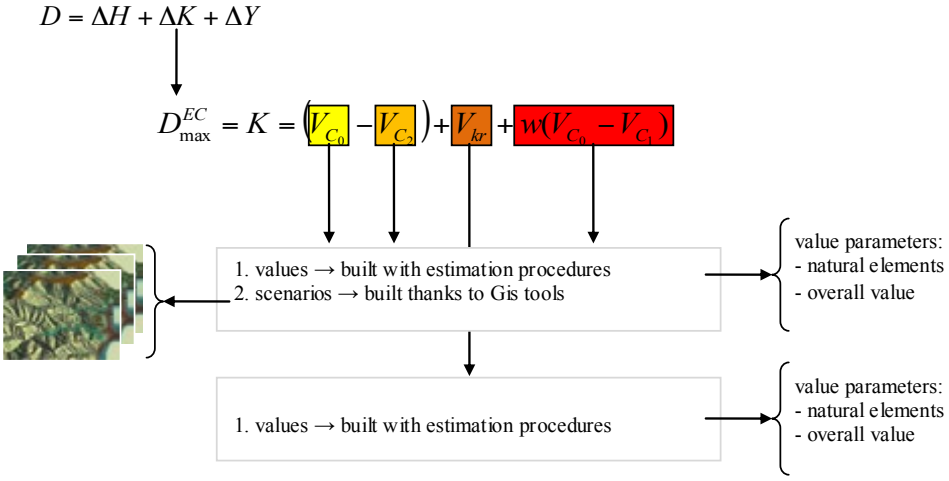
in which:
V_{c0} and V_{c1} still are the social and esthetic-cultural value of the configuration (respectively before and after the harmful action) of a given environment;
V_{c2} is the esthetic-cultural value of the configuration given by the repairs or reconstruction actions;
V_{kr} is the actualized intervention cost value;
w (V_{c0} - V_{c1}) is the damage obtained in the period between the harmful event and the end of the repairs or reconstruction actions.

As regards the calculation of single esthetic-cultural social values, we believe that the more viable method is the direct poll of population that is more directly attracted by the configuration C_0, using different techniques, such as the Contingent valuation method (Mattia, Bianchi, 2000). The surveys could be a significant element of participation[14] that will bring to the determination of the density function of its subjective estimation values (the Willingness to pay, or WTP) and to find the most relevant value levels for the final result, that should be interpreted by estimates extended to all remaining categories of intensity, based on historical behaviors.

The natural damage (Y) must be considered in terms of overall change that the effects on directly connected areas can determine: the natural environment must be considered as an elastic body, whose deformations, up to a certain limit configuration, are not able to create changes in the well-being levels that are in-

[14] The first classification of the different levels of participation, better known as "ladder of participation", was defined by Sherry Arnstein in 1969, in reference to the citizens involvement practices carried out within the framework of some planning experimentations in the United States. The ladder identifies different participation levels, starting from the widespread interests exclusion from the decision-making process to the citizens power control. In particular, the different forms of consensus creation around the decision-makers choices (*manipulation* and *therapy*) are not considered as participation; the information, consultation and debate steps are classified as formal participation, if the judgment on the positions legitimacy is part of the decision-makers duties (*tokenism*); forms of partnership and reassignment of the decision-making powers to citizens, so that they can verify autonomously the transformation process, are considered as actual participatory approaches (Arnstein, 1971). This classification has been reviewed by several authors, that have read the different levels of participation in a less rigid way, referring to the temporal dimension of the decision-making process. Burns defines a scale of powers assignment to citizens, recognizing that not all the steps of the ladder are equally spaced, because the latter ones require a real change in the institutions, that in the first levels is not necessary (*Ladder of citizen empowerment*) (Burns, Hambleton, Hoggett, 1994). Wilcox suggests a simplification of the ladder in five approaches, all recommended in different contexts and stages: information, consultation, shared decision-making, joint action, support to autonomous local communities initiatives (Wilcox, 1994). Wates suggests a participation matrix, in which the four levels of involvement of local communities (information, consultation, partnership and communities control) are in relationship with four different phases (promotion, planning, implementation and maintenance over time) of the design and implementation process of interventions (Wates, 2000).

Figure 2. Scheme for the maximum acceptable cultural and aesthetic damage.



terrelated to the other two components and, therefore, to socio-economic activities, including public health and the landscape. The model should be based on an actual definition of what could be achieved, however, only at a later time, to changes of a certain configuration, when it should be defined a non-alteration of welfare conditions for the effects produced on the other environmental components: these are issues to be solved in the specific practical application, as these phenomena should be expressed in monetary terms, because they could occur in very different forms and do not have an appreciation in the market, in all their different kinds of nature and consistency. For a useful interpretation of these matters, the evaluator should set, in an *a priori* and clearly definition, an expression of the maximum damage to indemnify situations adversely affecting the quality of the natural elements, if carried out in contrary to the decision taken at the legislative level[15].

[15] The actual reference could be the wide planning tools production, available in every regional context in Italy, starting from regional plans about pollution and environmental components preservation (e.g. water and atmosphere) and continuing with all that lower-level plans that have an environmental content (Coordination plans of parks and provincial administrations, township general and sector plans, and so on). We must say that the authors of the essay of 1989 suggested that the maximum extent of damage to nature should be fixed in the definition of appropriate environmental protection plans for homogeneous areas: these plans could be of regional initiative (or at lower levels) and should have appropriate interpretative skills. The degrees of freedom for this additional schedule that the authors proposed, however, must be clearly defined at the central level: each control, steering and coordination power must be kept by the Ministry of the Environment and each plan must essentially lead to the identification of homogenous areas in function also of more general assessments on the development

It is necessary, then, to build the following function:

$$D_{\max}^{N} = Y - \rho_1 \Delta E_1 + \rho_2 \Delta E_2 + \ldots + \rho_n \Delta E_n \tag{5}$$

in which the symbols should be meant as following:
D is the maximum acceptable natural damage in a certain area;
Y describes the effects that a potential environmental damage might have on the natural and ecological elements of ecosystems;
E_n stand for the maximum variations of all the factors and natural elements, not able to determine variations in the wealth of other environmental components;
ϱ_n represent the parameters that create value, to be determined in function of the importance that the evaluator would like to give to every single natural element and obviously able to determine the overall value of Y as the pre-determined total damage.

Once the two scenarios have been identified, the turning point is a prospective comparison referred to the decreased capability of the environment to sup-

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of socio-economic sector that the agencies would like to pursue. The essay continued saying that, at least in a first phase in that period, these plans may well coincide with landscape plans referred to in law n. 431/1985, even if it was better to find a different kind of plan as soon as possible, as each area must be associated with a specific expression of the damage, given by the sum of all the maximum acceptable variations of every natural element multiplied by coefficients or weights that both have a value. In this sense, both weights and the amount of damage in its maximum consistence must be set in the training phase of the plan with periodic updates: in the definition of this choice it can be especially helpful to use the principles of the Multicriteria analysis (MCA). The MCA is used to compare different options in projects or heterogeneous variables as: *a)* it has been created to help decision-makers in combining different choice options; *b)* it reproduces a synthetic framework for the future or on past data, whose results are generally able to provide for operational suggestions or recommendations for future activities/actions. It could be organized around a vision, or a scenario, that is able to produce a single synthetic conclusion or more results that could be adapted to preferences and priorities of involved actors: in this sense, it is similar to development or information systems management techniques. As a matter of fact, it is used with the costs-benefits analysis, even if it is not able to reduce situations complexity to a single measure unit in terms of money. The MCA is a compound set of techniques, characterized by some common factors for different procedures, mainly comprising the main components of the process: *a)* decision-makers (the central element on which the entire process should be based and adapted); *b)* alternatives (at least, at the beginning, selected from decision-makers referring to the evaluation context; this element is influenced by the issue of the technical steps of the analysis); *c)* preferences (or the complete opinions given to project options); *d)* criteria (the opinion elements from which the alternative evaluation setting depends). Even if there are many MCA techniques with different procedures, a multicriteria process is usually based on 4 principal steps, whose result are the four main elements of the procedure: *1)* performance or effect score matrix (the numeric estimation of the most relevant impacts of a group of alternative options); *2)* weights vectors and matrix (the numeric estimation of the referring priority related to every single decisional criterion); *3)* scores matrix (the numeric transformation of performance scores in an appropriate range); 4) final synthesizing formula on the weighted scores matrix.

Figure 3. Scheme for the maximum acceptable natural damage.

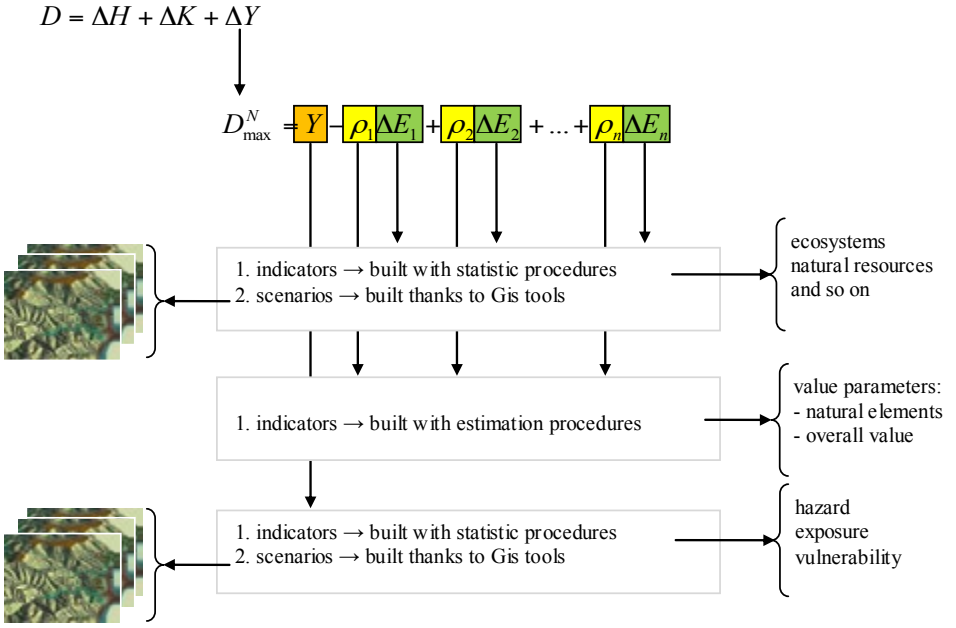
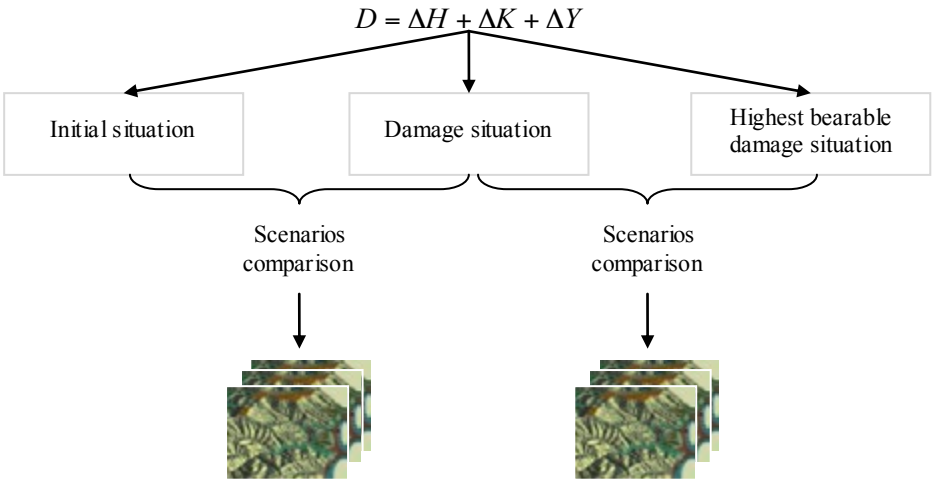


Figure 4. Scheme for the evaluation of all the elements of the damage.



port the activities of its three components and to the evaluation of "value parameters", depending on the importance given to each element, in order to identify the damage costs (Mattia, Miccoli, 1989). At this point, the damage value could be quantified not only considering the actual reclamation costs (the only element that is directly computable), but also outlining the uniqueness of each area and ecosystem and the actual inability of exactly restoring the previous configuration after the harmful event, even using variables considered as ephemeral, since they are hardly measurable and valuable.

3. Conclusions: the application of the model and its future development

This model is particularly significant, because it could be used not only in judicial terms, but also in decisional terms to direct (in an *ex-ante* evaluation process) a MCDA[16] process applied on different projects, plans, or programs that could have a modification effect on the environment, yet influencing the attitude that is

[16] The Multicriteria decision aid (Mcda) methods have been significantly developed in the last thirty years, because of the increase of complexity and conflicts in the decision making process (Bobbio, 2004). These techniques could be considered as tools that support stakeholders and shareholders involved in the Decision making (DM) to organize the available information and to analyse the effects of every single choice, exploring people expectations and minimizing the failure probability of the final decision (Mattia, 2007; Dtlr, 2009). Moreover, recent delays of the DM process, first of all, concerning great interventions) have pointed out the need of involving all the possible stakeholders and shareholders in the appraisal procedures (Bobbio, 2004); for those reasons, the multidimensional assessment methods are increasingly applied as part of the deliberative process, launching research experiences towards the new challenge of giving broader meaning and stronger consistency to the outcomes of the decision making process. Looking at the multicriteria decision aid systems developed for the multiple criteria decision making, it is possible to identify some common features (Mattia and Pandolfi, in Mattia, 2007): *1)* the definition of different options to be analysed, starting from alternative criteria, *2)* the involvement of a wide range of stakeholders and shareholders and *3)* the concern for the uncertainty that forces the decision makers to assume a certain relativity about the process outcomes. For these reasons, as it is widely acknowledged that the need for evaluation tools aiding complex decisions comes from the consciousness about uncertainty (Funtowicz and Ravetz, 1994), their most important requirement is the attention paid to the process (instead of focusing on the outcomes), which should be as democratic and transparent as possible, to be able to face the problems of the legitimacy of multiple points of view (Proctor and Drechsler, 2006). According to these general assumptions, in the last years the interest of the local administrations into the active involvement of citizens, stakeholders and shareholders in the decision making process has also been experienced in several contexts, where the different initiatives impacted directly on the local communities (Bobbio, 2004; Proctor and Drechsler, 2006; Mattia, 2007). This trend points out the growing demand of advanced methodologies of public involvement in the different stages of the decision making process, because of the lack of participatory infrastructures that would be able to promote an effective contribution of those social groups that are generally excluded from the decisions (Bobbio, 2004; Mattia, 2007) and because of the increasing mistrust in the capability of the actual economical development model to ensure a sustainable and fair future to the contemporary society as a whole (Mattia, 2007).

usually concerning the classic environmental assessment procedures[17], as the most interesting element in this model is the methodology used in the calculation and simulation of damages according to instance of achieving a balance between environmental, social and economical dimensions of (sustainable) development, as it was stated in 1989 by the Bruntland Report.

Under this perspective, this model could become a sort of common procedure for the assessment of the effects (and not only the harmful ones) that a single action, or even a plan, have on the reference context, developing this flexible and operative procedure in order to build a method to be used to evaluate the results that the transformation activities could have in terms of economical impact of the implied changes.

In this context, one of the future development of this methodology could be focused on the implementation of the indicators to be calculated in order to define the practical procedure to be applied through the Gis tools, identifying a sort of protocol to be easily shared and pervasively used in the different planning activities, with a specific reference, on the one hand, to the evaluation of the damage value in harmful events and, on the other hand, of the impacts of the various functions in regular operation situations. As a matter of fact, such a flexible and dynamic approach could be made operationally and widely applicable by identifying a significant set of indicators to be used as a guide line, from which starting to create each one of the scenarios to be evaluated by the model itself, moving from common data resources (that could be easily implemented nowadays, thanks to the widespread realization of local geographic information databases in Italy, even regulated by some regional laws, such as the article n. 3 of the Lombardy urban planning act, the law n. 12 of 2005, that establish the definition of Regional and Township database systems, to be created and integrated after the legislative provisions). These indicators could be selected from the huge range of variables described in the massive existing literature referring to all the different topics involved in the three main stages of evaluation (the social matters, the esthetic and cultural elements, and the natural issues), or created on the purpose to integrate that components that since now haven't been satisfactorily described in the current debate.

Another fundamental element is represented by the possibility of integrating the significant existing literature about hazard and damage topics, that have been considerably developed in the last years, even in Italy (see Menoni, 1997, 2005, 2006 and 2011), including all the planning activities and redeveloping some of the referring tools in the scenario approach that this method proposes. In this sense, the integration of the classic triple division of hazard is particularly interesting to be introduced in this model, as it could easily ensure the correct consideration of the elements that creates the harmful event (hazard, vulnerability and exposure), including some evaluations that only estimation experts could be able to do. For

[17] For example, the Environmental impact assessment (EIA) procedures and, more recently, the Strategic environmental assessment (SEA).

example, as the vulnerability is the attitude of an individual or an object to be damaged by the different kinds of harmful events, all the elements referring to this concept applied to the cultural heritage (in terms of income flows loss after a damaging occurrence) could be one of the challenges to be faced, in order to improve this significant approach for its wider application. Another noteworthy issue to be analyzed in this sense could be the vulnerability of men and women in terms of loss of capability of offering their service to the society after an harmful event, both in physical and psychological terms: these matters could be faced only by the Appraisal discipline, since it is able to appreciate all the different elements that characterize such a complex problem.

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