Goods, Services and Environmental Impacts Economic Valuation Methodologies

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Goods, Services and Environmental Impacts Economic Valuation Methodologies

First edition ISBN: 978-607-8948-02-4
Editorial Seal ECORFAN: 607-8948
Control number B: 2023-03
Classification B (2023): 300823-0003

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Goods, Services and Environmental Impacts Economic Valuation Methodologies

Metodologías de Valoración Económica de Bienes, Servicios e Impactos Ambientales

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D. Ruiz, F. Sandoval, O. Arana and S. Godbout (AA. VV.). Goods, Services and Environmental Impacts Economic Valuation Methodologies. Books-©ECORFAN-México. 2023.

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Abstract

All human activity causes impacts on the environment, and this generates changes or alterations in the ecosystem services that ecosystems provide us. However, it is difficult to know the price or the cost that these impacts generate in the economy of a place, since very few goods and services that are commercialized in a market. This paper provides a general framework for the economic valuation of goods, services and environmental impacts, which ranges from traditional forms of valuation such as the hedonic price method or contingent valuation, to some non-traditional ones such as the multicriteria method or the benefit transfer method.

Environmental valuation, Valuation methods, Contingent valuation, Benefit transfer, Non-use values, Ecosystems, Valuation, Hedonic, Criteria, Impacts, Traditional methods, Economy

Resumen

Toda actividad humana provoca impactos en el medio ambiente, y ello a su vez genera que pueda haber cambios o alteraciones en los servicios ecosistémicos que nos brindan los ecosistemas. Sin embargo, es difícil conocer el precio o el costo que generan en la economía de un lugar estos impactos, ya que muy pocos son los bienes y servicios que se comercializan en un mercado. El presente trabajo proporciona un marco general de la valoración económica de los bienes, servicios e impactos ambientales, que va desde las formas de valoración tradicional como el método de precios hedónicos o la valoración contingente, hasta algunas no tradicionales como los son el método multicriterio o la transferencia de beneficios.

Valoración ambiental, Métodos de valoración, Valoración contingente, Transferencia de beneficios, Valores de no uso, Ecosistemas, Valoración, hedónico, Criterios, Impactos, Métodos tradicionales, Economía

Introduction

Population growth has generated greater demand for space for the establishment of: residences, businesses, services and industries, space is evidently a limited resource that cannot be reproduced so existing space is taken and through a change in land use, natural areas around the world have been reduced or negatively impacted (Barsky, 2005; Delgado, 2008).

This situation has generated social concern about the loss of natural heritage and poor environmental quality. The protection of natural areas not only generates economic benefits through the production of products, but also important gains in terms of use and non-use values derived from the eco-systemic services that the environment provides. The vast majority of these services, goods and impacts do not meet the characteristics of a market, so their valuation is less effective, resulting in a high rate of degradation and even the risk of disappearance of undervalued areas (Sanjurjo & Welsh, 2005).

The absence of a market for these services and the need to evaluate their impact has led specialists to develop a tool known as "environmental economic valuation", with the aim of assigning an amount that reflects the importance of a natural area simply because it exists. These valuations apply the cost-benefit logic; the social and environmental benefits generated by green areas are multiple, but the lack of information in this regard has complicated the real valuation of environmental goods (Cruz, 2005).

It is against this backdrop that this work is presented, describing through a rigorous conceptual review of both traditional valuation methods and those based on modern methods of multi-criteria analysis.

Chapter I. Importance of environmental assets

1.1. General

Due to rapid population growth and as a consequence of the rapid urbanisation of the world, the demand for natural resources and energy has increased (Vilches, et al., 2014). As cities grow, natural spaces are shrinking and species biodiversity is decreasing. Contradictorily, the existence of green areas, i.e. spaces normally occupied by trees, plants, etc., which can be used in a variety of ways, in urban communities is essential for the environmental, social and economic well-being of society (CONAMA, 2002).

Green areas not only imply vegetation and elements of furniture and equipment, but are also a satisfier of multiple needs, due to the fact that the services they offer are diverse and their identification is often complicated because they cannot be seen with the naked eye as it would be in the case of a product (Delgado, 2001), and for this reason they are not valued.

1.2. Definition of ecosystem services

All definitions are established in order to give clarity and precision to the meaning of either a word or a concept, so that we can describe the characteristics, attributes and properties that characterise the object or idea. Specifically speaking about ecosystem services, it is essential to specify what is considered an ecosystem service and which environmental functions can be covered. Although there is no definition as such through which they can be fully valued, there are several definitions that maintain some similar characteristics (De Groot et al., 2002).

Some of the definitions of ecosystem services that have been proposed over the years include:

- "The conditions and processes through which natural ecosystems, and their constituent species, support and satisfy human life" (Daily, 1997).
- "The goods (such as food) and services (such as waste assimilation) of ecosystems, which represent the benefits that human populations derive, directly or indirectly, from ecosystem functions" (Costanza et al., 1997).
- "Ecosystem functions: the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly" (De Groot et al., 2002).
- "Those ecological functions or processes that directly or indirectly contribute to human well-being or have the potential to do so in the future" (U.S. EPA, 2004).
- "Are components of nature, enjoyed, consumed or directly used to produce human well-being" (Boyd and Banzhaf, 2006).
- "Are aspects of ecosystems used (actively or passively) to produce human well-being" (Fisher et al., 2009).
- "Contributions of ecosystems to human well-being" (TEEB, 2012).

Undoubtedly one of the best accepted definitions that has become a reference on the subject is that established by the initiative known as the Millennium Ecosystem Assessment (MA), promoted by the UN (2005). They define ecosystem services as "The benefits that people obtain from ecosystems" (MEA, 2005).

The main objective of the Ecosystem Services (ES) concept is basically to include ecological concerns in economic terms, to emphasise society's dependence on natural ecosystems, as well as to foster public interest in biodiversity conservation.

For example, although the work carried out by Daily (1997) and Costanza et al. (1997) are contemporary, they consider different approaches, Daily points out processes and conditions, while Constanza et al. separate services into goods (physical, tangible objects) and services (intangible processes) (Camacho and Ruiz, 2012).

Other definitions allude to very particular aspects, such is the case of the Environmental Protection Agency (EPA) of the United States of America, which contemplates "potential services", a characteristic that is not even mentioned by the other definitions. Boyd and Banzhaf (2006) consider the idea that the consumption or enjoyment of services should be direct, however, Freeman III (2010) mentions that doing so would be advantageous, and suggests that to avoid duplication it is necessary to consider only the final phase of the processes in the estimation of the value of services so that the population can benefit directly. On the other hand, Fisher et al. (2009) mention that environmental services are strictly ecological phenomena that become services when human beings benefit from them; consequently, if there are no human beings benefiting from them, then there are no services.

However, as we can see, there is still no general concept that unifies and encompasses all the dimensions of ecosystem services, so in order to have greater clarity in their classification, it is necessary to identify which components, aspects or processes are prioritised.

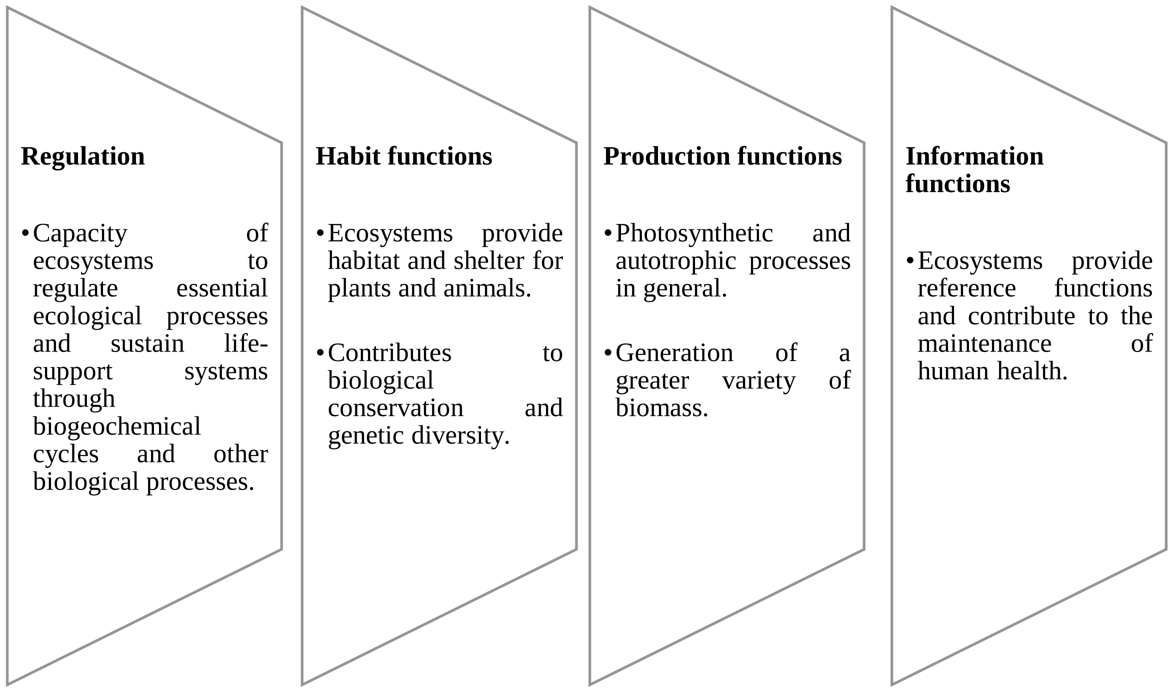
Ecosystem processes have a dynamic that is quite complex to understand, in addition to this, each and every one of the characteristics that define each ecosystem service are different and very diverse, making it really difficult to have a general classification scheme; as a result of this situation, the position of some authors was to propose various classification schemes and not to stick to a single system, so that in each case the most appropriate one should be applied (Costanza, 2008). Attempts to design a single classification system should be approached with caution and therefore the design of an ES classification system should be based on the characteristics of the ecosystem or phenomenon to be investigated and the decision-making context in which ES are to be considered (Turner et al., 2008; Fisher et al., 2009).

If we go back in time we can find that some of the first attempts to classify ecosystem services were made by Costanza et al., (1997) in their work the authors define 17 different ecosystem services, in which they include ecosystem goods, however, this first approximation is only a list. Subsequently, De Groot et al. (2002) made a classification more focused on three main characteristics: a systematic typology, the design of a general framework, through this classification it is intended that analyses of ecosystem services and functions can be carried out, and that it is considered essential to focus on the subset of ecosystem functions and not on the services themselves.

The interrelation of some ecological functions and the associated ecosystem services in the proposal of these authors results in the need to develop dynamic models that consider not only the goods and services, but also include the interdependencies that exist between the functions and the goods and services.

As a result of the authors' work we can find a classification of 23 basic functions of ecosystems, these are grouped into four main categories, and in these we can find various goods and services, as shown in Figure 1 below, which lists these categories and their characteristics:

Figure 1 Classification of basic functions of an ecosystem



Source: Own Elaboration with information from Costanza et al., 1997 and De Groot et al., 2002

A widely accepted classification of ecosystem services and one of the most widely used in academia is that of the Millennium Ecosystem Assessment (MEA, 2005). This classification is based on the idea of integrating sustainability, conservation and human well-being, based on four functional lines within the MA conceptual framework: supporting, regulating, provisioning and cultural services (Table 1), this classification, as well as some others, is intended to help decision-makers to generate a greater awareness of the environment.

Table 1 Classification of environmental elements and their characteristics

Element	Characteristics
Eco-systematic services	Grouped into four strands: Provisioning Services: The consumer receives them directly from ecosystems; food, water, raw materials, genetic resources. Regulating Services: Obtained through ecosystem processes: regulation of air quality, climate regulation, erosion, etc. Cultural Services: Recreation, scenic beauty, tourism, inspiration for culture, art and design. Supporting Services: Services necessary to produce other services: nutrient cycling, soil formation, primary production.
Environmental Goods	Resources used as inputs in production or final consumption, which are spent and transformed in the process.
Environmental Services	They are not spent or transformed, but indirectly generate utility to the consumer, e.g. the landscape provided by an ecosystem. They generate economic benefits.
Environmental Impacts	Externalities, the result or effect of the economic activity of one on the welfare of another.

Source: Own elaboration with information from Millennium Ecosystem Assessment (2005)

The Millennium Ecosystem Assessment (MEA, 2005) as well as several experts (Wallace, 2007; Turner et al., 2008; Fisher et al., 2009) are aware that ecosystem services do not necessarily have a price (amount of money you pay), but all have a value (consumer utility). In the event that humans cause changes or alterations as a consequence of their economic activities and natural environmental processes are converted, a total cost will be generated that is likely to exceed the benefits obtained by that conversion and whose condition may be irreversible.

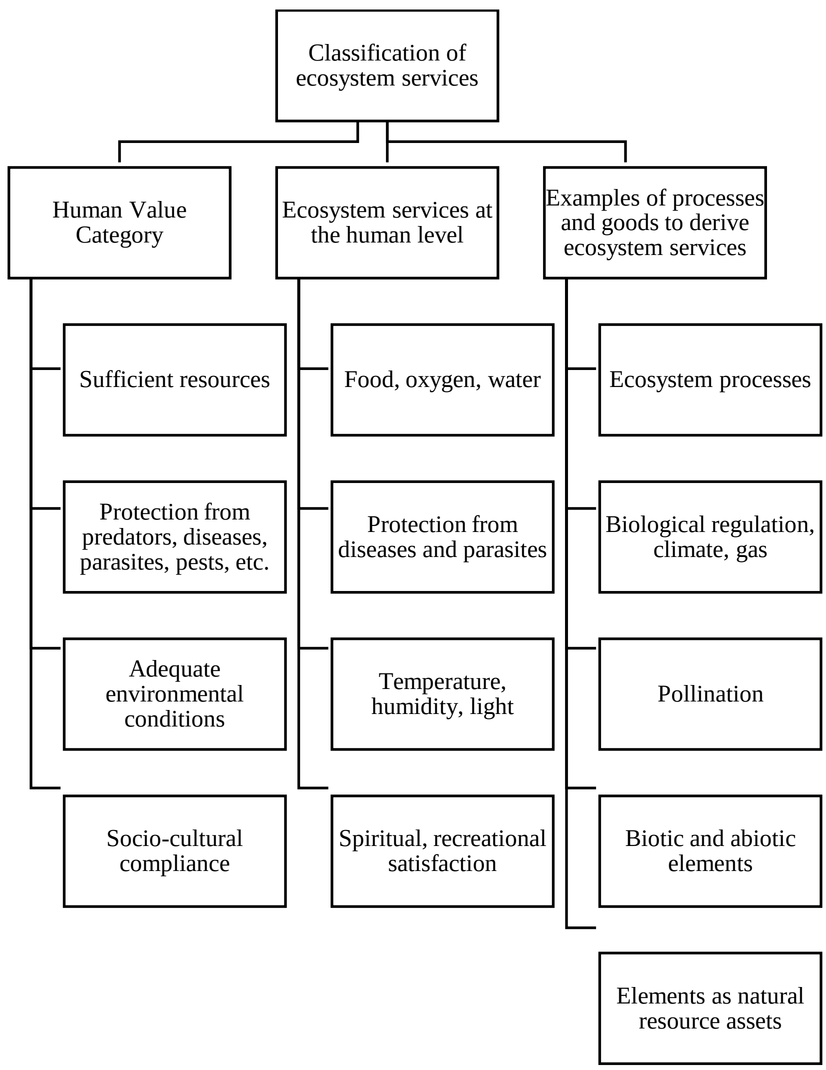
The classification established by MEA is broadly simple to handle and accessible to all research, however, it is not necessarily the most useful, Fisher et al., 2009 has pointed out that, in the contexts of environmental estimation, landscape management and economic valuation, it could not be applied. In this type of research, other types of classifications are proposed that could be more functional (Wallace, 2007; Turner et al., 2008).

Wallace (2007) also criticises the MEA classification, considering that even though it is one of the most popular, it is inadequate because it is, according to the author, a mixture of processes (means) to obtain ecosystem services, with the ecosystem services themselves (end or purpose) even in the same classification category, a practice that creates inherent problems for decision-makers.

This situation prompted Wallace to develop a different classification system in which he emphasises that the consequences of manipulating ecosystems for human well-being can be assessed. This classification of services describes them in terms of the structure and composition of a particular element of the system (expressed as a good). Furthermore, these services are further differentiated according to the human values they support, where human values are understood as the end-state conditions that together circumscribe human well-being, including survival and reproduction.

Wallace (2007) in his work proposes four categories of human values: sufficient resources, protection, enabling environmental conditions and socio-cultural fulfilment, and their association with ecosystem services (Figure 2).

Figure 2 Classification of ecosystem services and their connections to human values, ecosystem processes and natural assets



Source: Own elaboration with data from Wallace (2007)

Considering the various proposals, with their differences, similarities and assuming that the processes of the various ecosystems as well as the innate characteristics of ecosystem services are highly dynamic and complex, it would be incorrect to assume that any of these can be applied as a single classification scheme. That is, it is possible to apply any of the above-mentioned classifications or new approaches, but the choice must be reasoned, considering the complexity of ecosystems and the purpose behind the need to classify ecosystem services without overlooking this in an attempt to impose order and coherence.

1.3. Importance of valuing environmental resources

Awareness of the economic value of environmental resources has a direct impact on the promotion of environmental protection, and can help government intervention for better decision making.

The importance of estimating the value of the environment lies in the fact that society today is a market society, so the best way to recognise the importance of an asset is through its monetary value, so determining the monetary value of an environmental asset can convey to society the importance of the natural resource. Therefore, one of the ways to measure and convey the importance of environmental assets would be to determine their value in accordance with the elements that compose it and the goods it generates or the services it provides (Liu et al., 2010).

Valuation is a tool that allows us to improve the management of natural resources, since through it we will be able to measure and compare the different advantages they confer (Barbier et al., 1997; Liu et al., 2010). Azqueta (1994) mentions that valuation can be used to improve resource use by making it possible to allocate funds between different conservation, preservation and restoration initiatives. However, valuation involves a number of problems such as:

- Difficulty in evaluating complex assets due to selective perception that tends to ignore anything in which we are not directly interested.

- The absence of monetary value of a non-marketable asset and includes two strands: Gregory, et al., (1993) conclude that an expert's skill and reliability in comparing monetary values are related to his or her experience in the process.

- The last problem can occur in some valuation methods that obtain the overall value by aggregating the value of the various functions or values of an asset, authors such as Keeney and Raiffa, 1976; Fishburn, 1982; Hoehn and Randall, 1989, Hoehn and Loomis, 1993; have criticised this way of obtaining an overall value. However, experts such as Colombo et al., 2006 and Mogas et al., 2006, argue that when the assigned values are not market values, as in the case of environmental assets, it is admissible to sum the partial values and that this can be considered as a good proxy for the real value.

Valuation should be seen as a tool that allows us to make efficient decisions that will have an impact on the well-being of both the current generation and future generations (TEEB, 2010).

Chapter II. Economy and environment

2.1. Economic valuation of the environment

Valuations of ecosystems and ecosystem services are still vague, and often insufficient and incomplete. Valuing ecosystem services economically, socially and environmentally under the Millennium Ecosystem Assessment (2005) criteria and valuing them as the benefits that people derive from the ecosphere and its ecosystems can be challenging as services must first be identified and classified before they can be valued (Kumar, 2010; MEA, 2005).

In addition, because there is no particular method or system defined, the value has to be expressed in terms of externalities, i.e. in terms of the benefits generated or the costs of damage to third parties. For example, one can take into account the value for recreation within parks, damage to ecosystems due to construction (urbanisation) or valuation for setting economic compensation to the environment (Sanjurjo and Islas 2007; Jónsson and Davidsdóttir, 2016).

Most research related to the economic valuation of natural areas has coincided in making two major distinctions between use and non-use values in order to make a more efficient valuation (Sanjurjo & Welsh, 2005; Barzev, 2002; Aznar & Estruch, 2015).

Now, although it is true that what we are interested in is the care and protection of the environment, this does not have to be superimposed on development, which is why the interest lies in incorporating cost-efficiency measures. In this way, a value can be given to the environmental good or service and then decisions can be made to restore, sustain and protect the natural systems and as a result, the initial environmental quality can be maintained (before the implementation of the projects or the occurrence of natural events such as hurricanes, floods, earthquakes, droughts, burns, etc.).

When carrying out an environmental assessment, the inclusion of factors should be considered:

- Physical,
- Natural,
- Social and
- Economic

Each assessment should consider the collection of data and information and their analysis prior to the identification of potential problems, so that it will be easier to determine the possible alternatives, and in the end, the alternative with the greatest economic feasibility and the least environmental impact will be considered. Having an answer, the only thing left to do is to make the necessary changes to protect the environment before it is too late.

Environmental valuation not only serves to place a value on the environment, it also allows us to identify and quantify the impacts of projects and natural events and provides information necessary for further economic analysis. It also plays an important role in the establishment of regional, sectoral and national priorities, as it allows us to recognise that the problems to be dealt with are numerous and the financial and human-institutional resources are limited (Barzev, 2002).

In order to make decisions on the exploitation and use of natural resources and the environment, it is necessary to generate quantitative indicators and to consider the consequences of changes in environmental quality on the quality of life of individuals, but at the same time it is necessary to obtain a value and interpret in economic terms the effects of environmental impacts on the standard of living of human beings (Barzev, 2002).

In order to avoid information gaps and a better understanding of the subject, some terms related to the Economic Valuation of natural resources and the environment should be defined, so that there will be no room for misinterpretation. The most relevant ones are presented below:

- **Economy:** Originally from the Greek and means administration of the household. The science that studies the most efficient methods of satisfying material human needs, through the use of scarce goods (RAE, 2022).

- **Ecology:** Originates from Latin and means Knowledge of the house. It is the study of the structure and function of nature. The study of ecosystems (RAE, 2022).

- **Environment:** The set of physical-natural, biological, social, cultural, economic and aesthetic factors that affect individuals and influence their development, character, relationships and behaviour.

- **Preservation:** Protection or care over someone/something to conserve its state, minimising or eliminating human intervention.

- **Conservation:** This includes actions aimed at the preservation, maintenance, sustained use, restoration and enhancement of the natural environment (USDA, 2019). It is the maintenance and care of a natural resource to prevent its disappearance.

- **Sustainable development:** According to the United Nations, it is development that focuses on meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. According to IUCN, (1980) it consists of at least the following conditions and strategies:

- Endogenous economic growth, without damaging the natural environment
- Increased national and international social equity, social justice, and social justice
- Decreasing high population growth rates
- Conservation and increase of resource bases
- Use of resources wisely, as they are finite
- Balancing financial interests and resource continuity.

Although having these concepts helps to have a better clarity regarding the fact that natural resources are inputs to all economic activity developed by man, the problem that natural capital is becoming increasingly scarce persists, as disuse would imply ceasing to produce, to feed oneself, i.e., ceasing to live. It is therefore impossible to speak of preservation, except in a few specific cases. This fact gives rise to the need to understand the value of ecosystems and the services they offer, how to obtain these values and what constraints may arise (Daily et al., 1997).

For these valuations, the study areas of ecology and economics are not contradictory but rather complement each other, as it is necessary to have both physical information, qualitative and quantitative data on ecosystems, input flows and services and impacts.

2.2. Circular economy

The economy with a linear approach encourages short-term consumption, because it starts with the extraction of the resource, goes through transformation and ends in consumption, contributing to the extinction of resources, as it turns them into inputs and raw materials for any production activity; and also the sink for the rights generated for their exploitation and use, with the advent of new technologies, linear cycles have become shorter and shorter (Pearce and Turner, 1995; ECOLEC, 2023).

In contrast to the linear economy, the circular economy aims to put social and environmental benefits before economic profit. The circular economy system has the following principles:

1. To preserve and increase the natural capital, the use of finite resources is controlled and in the case of renewable resources the flow is balanced for their maintenance, the flow of nutrients and the regeneration of the soil is encouraged.

2. Reprocess, renew and recycle to contribute to the economy through the circulation of materials and components. The objective is to optimise the reuse of a product by extending its life.

3. Manage externalities (water pollution, noise pollution, climate change) to promote the effectiveness of the system (Cerdá & Khalilova, 2008).

It should be taken into account that resources are divided into renewable and non-renewable, which implies the following (Barzev, 2002):

a) The sustainability of natural resources depends on the rate of extraction (h). That is, if the rate of extraction is higher than the growth rate of the resource (y), the resource will become extinct. Conversely, if the rate of extraction is lower than the growth rate, regeneration of the resource is possible and its exploitation becomes sustainable.

b) Sustainability in the use of non-renewable resources basically depends on the rate of extraction. The faster it is exploited, the faster it becomes extinct, as these resources cannot be reproduced. In this case, sustainability will depend on a technological level that allows for greater efficiency in the use of the resource and a slower rate of exploitation.

In order to generate a sustainable use of resources, some challenges must be met (Cerdá & Khalilova, 2016):

– Socially: essential human needs must be met such as job security, reducing population growth, reducing unemployment among others.

– Environmentally: include all those characteristics that contribute to an ecological balance, for example, reducing greenhouse gases, reducing the use of energy from fossil fuels, reducing the overexploitation of renewable resources, and so on.

– Economically: fair prices for goods and raw materials; credits for entrepreneurs, linking MSMEs with transnational companies, and more.

– The circular economy system adds to the linear model the effects that human activities have on the environment, considering the latter as the factory from which the so-called raw materials are obtained, but also converts goods with a limited useful life into resources for other goods.

2.3. Approaches to economic valuation

A) Environmental

The environment should be a key component of a region's economic development strategy and should not be marginal to it. Gibbs and Jonas (2001) developed this idea by introducing the notion of an "urban sustainability arrangement" to selectively incorporate ecological objectives into local territorial structures during an era of ecological modernisation.

Environment-related indicators may include: emission of pollutants (emission of greenhouse gases, emission of ozone-depleting substances, etc.), resources used (energy, materials or water consumption), among others (UN Division for Sustainable Development, 2001).

B) Economic

Cerda (2008) reflects on the concept of economic value "it is important to highlight that neither "the environment" nor "life" is being valued, as many detractors of valuation methodologies assume, but rather people's preferences in the face of changes in environmental conditions and their preferences with respect to changes in the levels of risk they face" in this case the change in land use from natural to urban.

From the point of view of economic indicators for the value of the product/service, the following can be taken into account: "quantity of goods or services produced or provided to the customer, net sales, added value of benefit, cost associated with environmental burden (cost of traffic congestion) (UN Division for Sustainable Development, 2001).

C) Social

With regard to social impacts, the changes brought about by urbanisation can go in several directions, starting with stress that is accompanied by health problems, psychological problems and problems in nutritional status. Even alterations in consumption behaviour and the nature of what is consumed (Sepúlveda et al., 2009).

The evaluation of an environmental system can be carried out in different ways depending on the element being evaluated, and the characteristics of each valuation are explained below.

Another important point to consider in understanding the theory behind economic valuation is that natural resources can be tangible or intangible. Tangible environmental goods or products are, for example: water; while non-tangible environmental services could be, for example: water catchment. And environmental impacts (water quality) could be tangible or intangible because they are directly or indirectly measurable. Therefore, the difference between goods, services and impacts implies the use of different methodologies for the valuation of each.

2.4 Difference between environmental goods, environmental services and ecosystem functions

An environmental good is any tangible material product of nature used by humans. Meanwhile, ecosystem functions are the relationships between the elements of the ecosystem and give rise to environmental services, i.e. environmental services are the ecosystem functions used by humans, which are not spent and are not transformed in the process. (Table 2).

Table 2 Difference between environmental services and ecosystem functions

Environmental service	Function	Example
Gas regulation	Regulating Ecosystem Services	CO2/O2 balance
Climate control		Greenhouse gas regulation
Disturbance control		Protection from storms, floods, droughts, etc.
Water regulation		Storage, circulation and discharge to water bodies
Sediment retention		Prevention of soil loss due to wind, etc.
Soil formation		Rock weathering and organic matter accumulation.
Nutrient regulation		Fixation of nitrogen, phosphorus, potassium, etc.
Waste treatment		Waste treatment
Pollination		Provision of pollinators for breeding plant populations
Biological control		Predator effect for species control
Species refuge		Seedbeds, habitat of migratory species
Food production	Ecosystem Service Provision	Fish production, gums, crops
Raw material		Production of timber, fuelwood, fodder
Genetic resources		Medicine and products for scientific advancement
Recreation		Ecotourism
Culture Water supply		Aesthetic, artistic, etc.. Water supply through watersheds and aquifers

Source: Own Elaboration with information from Barrantes and Castro 1999

2.5. Difference between environmental goods and environmental services

Identifying the difference between environmental goods and services facilitates the analysis of any environmental problem. While environmental services are non-tangible ecosystem functions, environmental goods are raw materials used by humans in their economic activities and are tangible.

Examples of goods and services of a forest ecosystem (Figure 3) are intended to highlight the importance of the interdependence between natural and social sciences. They explain different aspects of the environment and are complementary, feed each other and allow for a better management of natural resources based on scientific criteria.

Environmental goods and services can quantitatively express the value of natural resources, their structure corresponds to levels of organisation and can be classified according to levels of hierarchy of biological organisation (Barzev 2002).

Figure 3 Environmental goods and services

Environmental good	Environmental service
wood, firewood, charcoal, vines and logs	scenic beauty
medicinal plants	carbon fixation
mangroves	research
fishing	water harvesting
non-timber products	soil protection
animals (hunting)	energy
wicker	genetic diversity
ornamental and edible plants	oxygen production bank
biological material	

Source: Own elaboration with information from Barrantes and Castro, 1999

Chapter III. Economic valuation of natural resources

3.1 Considerations

Population growth, the extension of urban areas and industrialisation lead to an increase in the pollution of the most important physical-natural factors such as air, water and soil. These problems are the result of inadequate development. One of the solutions lies in the planning of economic growth (Carbal, 2012).

The relationship that existed between economics (quantifies, in monetary terms, the flows of inputs and services from these and the impacts called externalities, both positive and negative) and ecology (studies ecosystems and provides quantitative and qualitative physical information) has not been balanced, so it is possible to think that the economic growth that developed countries have had has been achieved at the expense of the environment.

However, the imminent concern of society in general about current and future urban and environmental problems generates in economics a need to consider new variables as well as their interactions including environmental, social and economic ones (Barzev, 2002; López, 2008; Hernández et al. 2013; Barrantes, 2016).

The efficient allocation of (increasingly scarce) resources should be one of the main objectives of economics. However, the existence of a wide range of imperfect competition and government intervention hinder the functioning of the economy and its nexus with ecology in the attempt to achieve sustainable development (Hernández et al., 2013; Barrantes, 2016; Diaz-Balteiro and Romero, 2004).

In addition, there are a number of elements that lack a market; therefore, they also lack a price and are known as externalities. It is then that the need arises to give a monetary value to these goods and services. Given the above, it is necessary to formulate policies for the protection and conservation of natural resources, such as the creation of a green belt (Hernández et al., 2013; Barrantes, 2016), water treatment (Pacheco-Vega, 2010), etc. (Hernández et al., 2013; Barrantes, 2016).

Environmental assessment makes it possible to identify and quantify the impacts of projects and other natural events and to provide the necessary information for further economic analysis.

3.2. Definition and analysis of value

The dictionary of the Royal Spanish Academy (2022) states that the act of "valuing" involves a process by which the value of a thing is indicated or recognised.

If value is considered as a property derived from satisfying needs or wants, then value will be a function of the ability to satisfy (Seják, 2000).

Value is called "the degree of usefulness or aptitude of things to satisfy needs and provide well-being", under this concept we can understand that the value is not found in the product as such, but in the satisfaction of a need (Salvador, 2016).

Value can also be understood as the closest price that buyers and sellers assign to a good or service for their transaction. That is, it is the representation of a hypothetical or theoretical price, which is more likely to be established by buyers and sellers for the good or service.

In such a way that the value is not in itself a fact, but the most likely estimate of the price that will be paid for an environmental good or service available for purchase at a given time (Alcázar, 2003; Aznar and Guijarro, 2005; Caballer, 2011; International Valuation Standards, 2005).

3.3. Valuation of environmental goods and services

Methodologies from an economic-ecological point of view to give value to environmental services and assets have been carried out with the aim of seeking efficient and productive processes. These methodologies can be basically divided into direct and indirect methods (Constanza et al., 1997; Castro & Barrantes, 1998).

Economic valuation is important because of the role it plays in decision-making concerning the use of environmental services, as it allows measuring and comparing the different benefits of such services and can therefore serve as an effective instrument for facilitating and improving the rational use, management and administration of environmental services and represents a contribution to the search for sustainable development (Barbier et al., 1997; Tietenberg & Lewis, 2009).

When considering the economic valuation of environmental goods and services, it has to be taken into account that they are both produced and non-produced natural assets; therefore, they should be considered as such when assigning their value (Department of Environment 1994; Hanna and Munasinghe 1995; Bowers, 1997).

On the other hand, monetary values of natural and environmental resources are necessary to determine compensation for damages associated with pollution suffered by individuals or in the community due to exploitation or irrational use of resources. Government and other institutions responsible for the management of natural assets have a need for such indicators. Even to prosecute those responsible for environmental pollution or misuse of natural resources can involve significant revenue transfers and significantly affect the allocation of resources in the economy (Barzev, 2002).

The first is the importance of establishing institutional mechanisms, through which the rights of ownership and use of natural resources and the environment will be precisely defined. Secondly, the so-called environmental (social) costs that are not adequately reflected by the market must be identified and established, and with these two considerations it will be possible to determine the rates of use, mitigation measures, compensation systems and regulations that ensure the highest level of benefits that these are capable of generating in a sustainable manner (Agüero, 1996).

The economic valuation process should, among other things, provide at least the necessary information to (Barzev, 2002):

- Conduct national development planning consistent with the sustainable use of goods and services provided by natural resources.
- Record ecosystem change and environmental impacts in national accounting and the system of environmental accounts.
- Manage national natural goods and services appropriately.
- Assess the environmental impact of investment projects.
- To provide information needed to improve market performance.

Before reviewing the different methods that are used to value the costs and benefits of renewable natural resources and the environment, it is important to establish the conceptual basis of these methods. Once they are known, it will be easier to adapt them according to their limitations and to obtain better results at the time of their application.

3.4. Total Economic Value

Hernandez et al. (2013) were inclined to the idea that economists should not only consider the value of ecosystems for their contribution as a raw material factory, but that their valuation should go much further. As a consequence of this suggestion, the theory of Total Economic Value (TEV) is proposed. The TEV of an ecosystem comprises direct or indirect commercial and environmental benefits, considers characteristics such as integrated systems, whether stocks of resources or goods, flows of environmental services or attributes of the ecosystem as a whole (Emerton & Bos, 2004; Hernández et al 2013).

Considering the wider range of values that a site possesses makes TEV theory one of the most widely used theories in the international scientific literature, even if they are not real prices, it offers the possibility of having a value that comes very close. The value of Goods, Services and Functions can be divided in different ways:

a) Whether or not they are determined in the market

Environmental goods provide benefits to society. For some there are markets in which there is a price that reflects their value, but for others there are no markets (Barrantes 2016; Barzev 2002). The service of a forest as a habitat for diverse flora and fauna is not traded or valued in a market. Neither is the scenic beauty provided by a snow-capped mountain. However, these examples are only two of many, which directly or indirectly constitute important benefits to society. Two types of values are derived from these:

- **Values of market godos**
- **Values of non-market goods**

b) Are determined in direct or non-direct use

Within total economic valuation there are two types of values, use values that include direct use values, i.e. goods that can be consumed directly, as well as indirect use values that include environmental functions and services, and non-use values, which include option values and existence values that are direct and indirect future use values respectively and other non-use values, which focus on the knowledge of values that will continue to exist (Barrantes 2016; Barzev 2002; Lomas et al., 2005).

1. Direct use value

Direct use value (DUTV) refers to the income from the sale of environmental goods and services provided by the exploitation of the biodiversity of an ecosystem, for the satisfaction of human needs. Most of these goods can be valued at market prices through methods such as change in productivity, profit losses, opportunity costs, cost-effectiveness (Barzev, 2002), avoided costs (Herruzo, 2002; Samuelson & William, 2002) for their efficiency (Barrantes, 2016; Aznar & Estruch, 2015).

In the same way it can be applied to inventories of produced natural assets and their environmental services when a change in environmental quality or availability of a resource affects production or productivity through the methods already mentioned (Barzev 2002; Barrantes, 2016; Hernández et al., 2013; Department of Environment, 1994).

But goods that do not have a market price can be measured through travel cost, hedonic pricing or contingent valuation as valuation techniques to produce a range of benefit, however, as they are based on preferences the values obtained could represent a certain bias (Dixon et al., 1994).

2. Indirect Use Value

Indirect use value (IUV) is the value of environmental goods and services that are difficult to observe and quantify, and therefore cannot be directly valued by the market. The valuation is based on the use of the avoided cost to estimate the cost of potential damage measured through ex ante estimates; if the damage of pollution were to occur in this way, the benefits generated by the environmental good would be valued (Barrantes, 2016; Aznar and Estruch, 2015).

This value is constituted by a series of primary and economically important functions that the market does not detect, for example soil protection, carbon sequestration, tourism value, water supply and quality, among others (Barrantes, 2016; Aznar and Estruch, 2015; Department of the Environment, 1994; Pearce and Turner, 1995). These types of environmental services can be quantified through contingent valuation.

c) Whether the good is consumed or not

i. Option value

Option value can refer on the one hand to the value for a person of guaranteeing that in the future he/she will be able to have some environmental good or service, even though at present he/she is not enjoying it. It could then be understood as a guarantee of ensuring the future availability of the service flow (Barrantes, 2016; Aznar and Estruch, 2015).

On the other hand, it is a value generated by the uncertainty of the decision-maker not knowing which possible future uses could benefit him/her and which, with current knowledge, are difficult to establish and foresee since current technology and science do not detect them (Turner et al., 2000 Urciaga, 2014).

ii. Existence Value

This is the value that society gives to a service, due to the fact that it is an essential resource for the conservation and development of the ecosystem, for the enjoyment of future generations, for example, animal species (Barrantes, 2016; Aznar and Estruch, 2015; Jansson, 1994; Constanza et al., 1997; Urciaga, 2014).

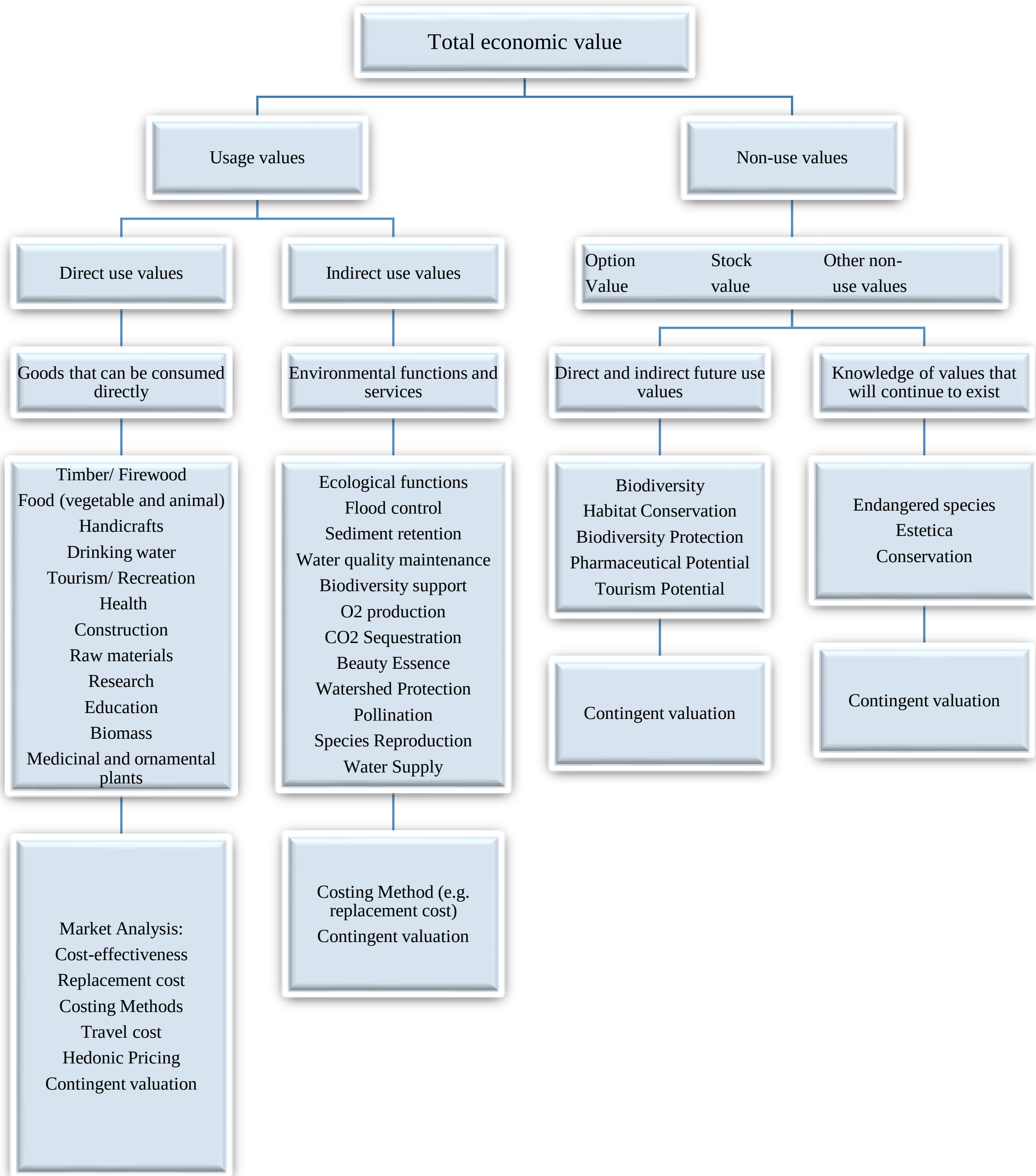
This can be calculated using contingent valuation methods, especially in cases where the asset has unique characteristics or cultural or religious significance to society (Pearce and Turner 1995).

Over the years the concept of value has been analysed and interpreted in different ways. In the case of economic valuation, the concept of "Total Economic Value" (TEV) began to be homogeneously and fairly widely accepted not long ago (Randall 1987).

This concept of TEV encompasses a number of characteristics greater than the traditional cost/benefit assessment, the former allowing for the inclusion of both traditional (tangible) goods and services and environmental functions, as well as values associated with the use of the resource itself, among others (Figure 4).

However, by the very concept itself, care must be taken not to duplicate in the valuation the indirect functions in addition to the direct use value resulting from the same resource.

Figure 4 Ranking of Total Economic Value



Source: Adapted from Barrantes 2016; Barzev 2002; and Lomas et al., 2005

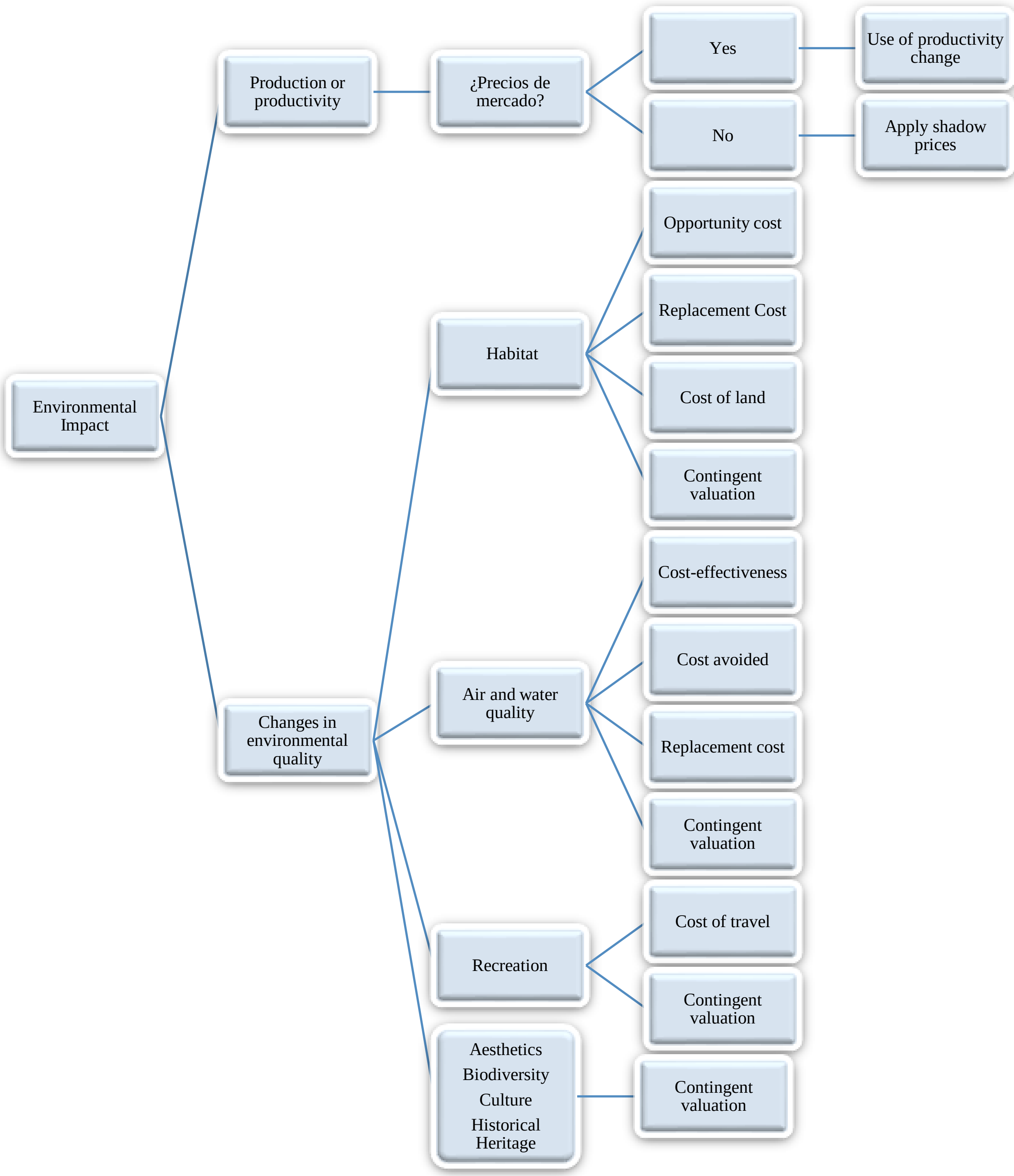
3.5. Economic valuation methods

There are several methods that emerged in the 1950s with valuation exercises in natural parks in the United States through surveys (Freeman, 1993).

These methods represent an important contribution of economics to the decision-making process regarding environmental resources (Dixon et al., 1994, Dixon & Pagiola. 1998, Hufschmidt et al. 1983). They are generally classified in different ways, depending on the value concept adopted, the solution algorithms used and the degree of availability of the required information (Agüero, 1996; Carbal, 20121).

Figure 5 illustrates a guide to selecting the most appropriate method depending on the situation or element to be valued. It starts by defining the impact by differentiating between a measurable change in production and an environmental change. It then presents the possible scenarios and impacts, presenting the most frequently used techniques for estimating impact values.

Figure 5 Simplified screening guide



Source: Adapted from Dixon and Pagiola 1998

3.6. Classification of methods of economic valuation of environmental goods, services and impacts

There are various classifications as authors in this branch of economics, however, it is observable that in the different methodologies, economic considerations stand out over ecological or social variables, to mention a few we have those carried out by Hufschmidt et al., (1983) and Dixon & Hufschmidt, (1986) who classified the existing valuation methods in two categories:

- Methods that value benefits
- Methods that value costs

Benefit valuations are the result of a change in the quality of the environment or availability of a given resource, and value is placed on the benefits obtained from the use of natural resources, since if these uses are lost then they would become costs.

In the case of cost valuation, this is done from the point of view of prevention, since negative environmental changes would have a negative impact on economic and social welfare.

Dixon and Pagiola, (1998) proposed another classification, in which they group both types of previous methods according to:

- Direct market use values or changes in productivity.
- Market values of complementary or substitute goods or services
- Values determined under hypothetical or contingent conditions.

A further proposal comes from EDIEN, (1995) in which techniques are divided into only two categories, and are assigned depending on the approach: whether it is used to value the social costs of environmental damage or the benefits of preventing damage.

- Valuation Approaches Objectives
- Subjective Valuation Approach

One of the most complete classifications is the one made by Dixon (1988) and Reverded (1990), for this work this is considered as it includes the vast majority of valuation methods, however, any other type of classification can also be very useful. For this purpose, they will be grouped according to the origin of the information:

- Direct valuation methods
- Indirect valuation methods
- Contingent valuation methods
- Other methods

3.6.1. Direct valuation methods

The main characteristic of these methods is that they are based on available market prices or observation of changes in productivity. They are usually applied for changes in environmental quality or when the availability of a resource affects production or productivity, i.e. it is an indirect valuation method since a dose-response relationship is calculated (Pearse & Markandya, 1989). For this type of valuation, observed behavioural parameters are often used as a source of information, e.g. prices paid or expenditures incurred, which will be reflected in conventional markets.

3.6.2. Market-based valuation methods

These are the simplest and most efficient, as they are based on available market prices. Many of the goods and services provided by agriculture are traded in local or international markets. Prices can be used to build financial accounts or to cover costs. It is important to determine the appropriate market (Barzev 2002; Barrantes, 2016; Hernández et al., 2013). Market prices, production function, replacement or avoided costs can be used (Martin-Lopez & Montes, 2010).

A weakness is that the market is only able to value those goods that are traded in it, however, it can easily be applied to inventories of produced natural assets and their environmental services when a change in environmental quality or availability of a resource affects production or productivity.

In the case of non-produced environmental services, it could be calculated using data on the rents or rentals that were paid in order to obtain permission to use these assets (DM Department of Environment, 1994).

Within these methods we can list the following methodologies:

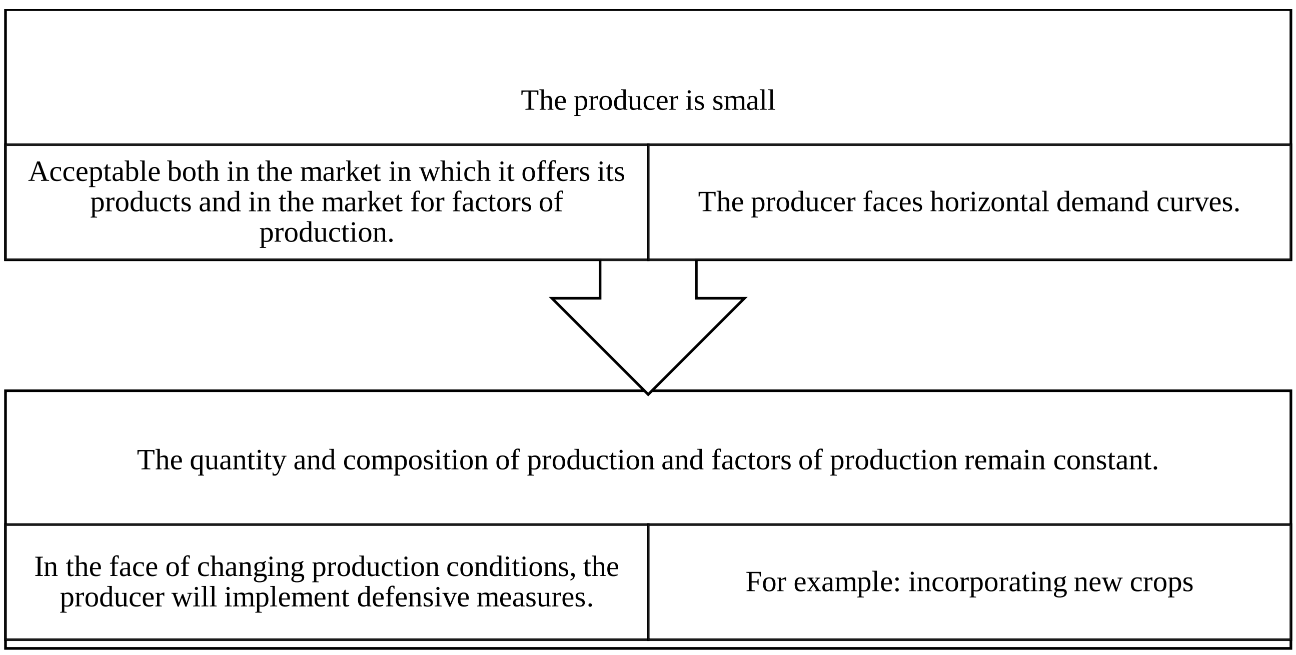
a) Change in productivity

Valuation of the environmental impact on a natural resource through the estimation of the effect it has on production, on the cost or on the profits for a good that does have a market. That is, some development projects may affect production or productivity, therefore, these changes can be valued using normal economic prices or corrected for market distortions. This method is based on neoclassical welfare economics and involves the determination of the physical effect and the monetary estimation of the effect (Herruzo, 2002; Samuelson & William, 2002, Barzev, 2002).

For decision-makers it is a technique that is easy to understand, however, it also has some weaknesses: the cause-effect relationship can be determined by factual assumptions, it is complex to determine the particular effect within a set of an environmental good, in some cases market information is difficult to obtain or non-existent (Osorio & Correa, 2004).

Some assumptions of the productivity change method are listed in Figure 6.

Figure 6 Assumptions of the productivity change method



Source: Own elaboration with information from Cristeche and Penna, 2008

– Under these premises it is necessary to consider some options when using the productivity change method:

– Conduct a general equilibrium analysis considering all factors and not limiting to smallholder cases.

– Value environmental changes taking into account the cost of defensive actions.

– Estimate the production function of the activity affected by a change in the environmental service that is combined with the rest of the production factors.

b) Loss of earnings (health effects)

Changes in human productivity (loss of earnings (wages), medical expenses, other payments) as a result of negative health effects due to alterations in the quality of environmental factors or changes in the availability of natural resources. This method maintains the assumption that earnings (wages and other payments) are a reflection of the marginal value of labour.

The use of this method may present some difficulties when the relationship between environmental quality and disease is not clearly established or when the disease is chronic. In addition, it requires information on age, sex, income, race, marital status, smoking status, and with these data a regression is estimated, and with the mean of the variables and the coefficients the elasticities can be calculated. And thus respond to the effect of environmental impacts on health (Osorio & Correa, 2004).

Due to ethical issues, this technique is often controversial, as valuing human life by assigning values to changes in the statistical probability of illness or death (in the style of life insurance premiums) is not feasible, as it is argued that life has infinite value (Herruzo, 2002; Samuelson & William, 2002, Barzev, 2002).

c) Cost-effectiveness

An attempt to estimate the cost of environmental protection in terms of the alternative cost of achieving a certain level, e.g. water or air quality standards. Evaluate trade-offs between the perceived but unmeasurable benefits of an action and the costs of implementing the action.

This method arises from the need to respond to criticisms made of cost-benefit analysis; especially the relationship of the monetisation of benefits and because such an estimate depends on people's ability to pay (Espinoza, 2017).

The process of cost-effectiveness analysis has certain similarities with cost-benefit analysis, however, the process of this method is characterised by (Azqueta, 2007):

- Defining the problem and the objectives to be achieved
- Identifying alternative solutions to the problem
- Identifying and calculating the costs of each alternative
- Analysing the costs, effectiveness and cost-effectiveness of each alternative.
- Conduct a sensitivity analysis

The method itself does not indicate whether the action or policy is worthwhile or not, rather, once the decision (action) is made, the method constitutes an important tool to ensure the rational use of limited resources. It focuses on the information available and provides values implicit in the objective of the action (e.g. the marginal value of increasing output by one unit). Similarly, it does not consider the relative importance of the output (Herruzo, 2002; Samuelson & William, 2002, Barzev, 2002).

d) Avoided costs

Estimates the value of an environmental damage through the avoided costs incurred by individuals, firms, governments or communities to prevent or mitigate undesirable environmental effects or to reverse damage that has already occurred. This method uses a dose-response function that requires multiple data for its valuation, the problem is that these may not be available to the researcher, which induces the use of other methods (Cristeche & Penna, 2008).

Through the valuation of avoided costs it is intended to reflect that in the case of no environmental protection measure the change in the welfare of individuals (measured through consumer and producer surplus) will be negative.

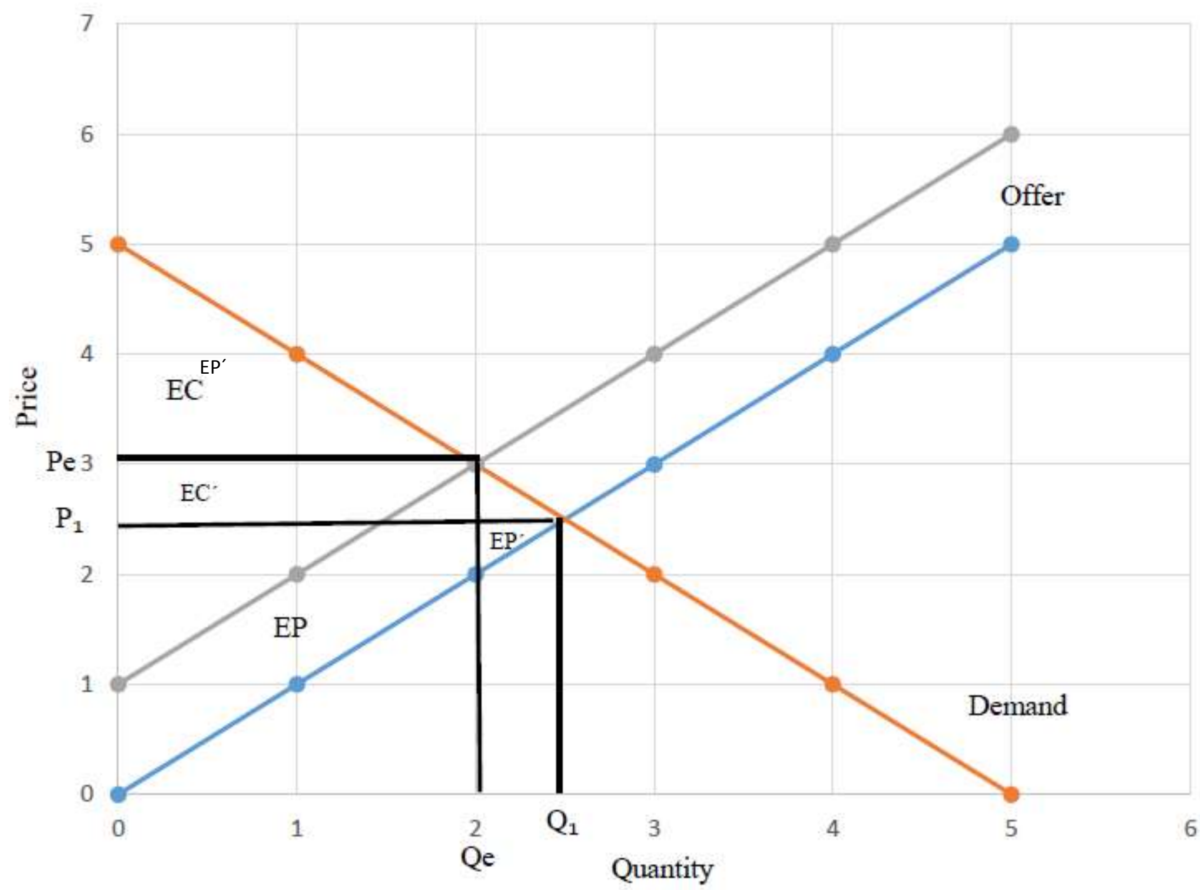
Consumer surplus is the area between the demand curve for any good and its price line, the difference between what one would be willing to pay for each quantity consumed and what one actually pays. The producer surplus is the area between the price curve and the supply curve, i.e. the difference between what the producer is willing to accept for each unit produced and what he actually receives (Herruzo, 2002; Samuelson & William, 2002).

For example, if urbanisation of rural areas is allowed, this land use change would imply (Barzev, 2002):

1. A decrease in environmental quality will lead to a decrease in the quality of the good, in this case water quality will decrease.
2. Decrease in the quantity of the good - the supply curve (marginal cost of production) will shift to the left on the graph. It implies less quantity of the good at a higher price.
3. Decrease in supply will generate less consumption of the good.
4. 4) The social benefits will be reflected in the decrease in consumer and producer surplus.

These changes can be seen in the following graph:

Figure 7 Changes in producer and consumer surplus.



Source: Own Elaboration with data from Barzev, (2002)

3.6.3. Non-market valuation method

Contingent valuation is generally used since the natural environment is exploited as a public good. In this way it can be given a value in the case of a decrease in the quality of a certain resource and each person can be asked how much they would be willing to pay to avoid the change in quality (Barrantes, 2016; Pearce & Turner, 1995). Another way would be to put a value on the costs incurred by the degradation of the ecosystem and its services or the restoration of existing damage.

3.6.4. Indirect valuation methods (surrogate market values, use of proxy markets)

By using a surrogate market, a hypothetical demand curve is obtained. It is necessary to apply price information from real markets to indirectly value the benefits of environmental goods or services for which markets do not exist. Indirect valuation is generated from the fact that some benefits of environmental services can be indirectly reflected either in consumer spending, in market prices of goods and services or in the level of productivity of some market activities (Barzev, 2002; Barrantes, 2016; Hernández, et al, 2013).

The basic assumption is that the price differential obtained after all variables have been considered reflects the valuation that individuals make of the good or service in question. Some of the methodologies used are the following:

a) Property values (hedonic pricing)

Based on neoclassical consumer theory, where the utility of a good is determined by the set of attributes that make it up. Among other factors, the quality of the environment, size, type of construction, location and architecture are taken into account (Barzev 2002; Barrantes, 2016; Hernández, et al, 2013; Sarmiento, 2004). Hedonic pricing attempts to discover all the attributes of the good that explain its price, and to discriminate the quantitative importance of each of them, i.e. to attribute to each characteristic of the good its implicit price.

It is used to estimate the value of pollution in certain areas (compared to other pollution-free areas) and assumes the existence of a relatively competitive market. It also assumes that buyers will reveal their preferences for a set of attributes (aesthetic, environmental, structural, etc.) through their willingness to pay. Some of the factors necessary to apply this method are shown in Figure 8.

Figure 8 Requirements for the application of the hedonic pricing method

Agents trained to perceive differences in environmental quality

Significant number of transactions per unit of time relative to market size

Have data on all variables affecting the price of the property

Source: Own Elaboration with data from Azqueta 2002

b) Cost of travel

Based on the assumption that consumers value an environmental service at no less than the cost of access to the resource, mainly for valuing tourism goods and services or scenic resources, it includes the direct costs of transport as well as the opportunity cost of time spent travelling to the site. Through surveys that identify socio-economic characteristics, the implicit price for the use of a site is determined. The process of this method involves the following steps:

- The surrounding area of influence of the study site is divided into zones and each zone is characterised by a certain cost.
- Visitors are surveyed for their place of origin and socio-economic data.
- The average propensity to visit the site in each zone is constructed.
- The demand curve is obtained by fitting the regression leaving the average propensity to visit the area as the dependent variable and the cost of travel as the independent variable.

c) Potential expenditure values

Potential or future actions are valued through conventional markets in this way providing a measure of environmental degradation, within this category we find:

– Replacement cost

It is basically used to value the costs of pollution. It is obtained through the measurement of the potential costs of damage, measured by estimators of the replacement or restoration costs of a physical asset or natural resource considering that there is pollution. It considers that it is possible to predict the nature and extent of the expected physical damage and that the replacement or restoration costs can be estimated with a reasonable level of accuracy and used as a proxy for environmental damage costs. The method has some restrictions as it is very common that it is more expensive to replace a given asset than to pay for its original value.

– Relocation Costs

Estimates the costs necessary to relocate a given natural resource, community or physical asset caused by environmental damage. It is basically an indirect measure of the benefit derived from preventing damage. Relocation costs are indirect measures of the benefit of preventing damage from occurring.

– Project or shadow Price

It is based on obtaining the costs of replacing or substituting the environmental services lost by an environmental damage or natural resource, rather than the resource or asset itself. It is necessary to design and cost a "shadow" project or equivalent that provides a substitute environmental service to compensate for the loss of natural resource goods or services or environmental quality. It is particularly useful when environmental resource characteristics need to be kept intact in the face of potential risks.

3.6.5. Expressed preference methods

The methods described below are used when there is no market information or surrogate values about individuals' preferences for certain natural resources or environmental services. They consist of asking individuals about their likely reaction to hypothetical situations presented in a questionnaire or other experimental technique in which participants respond to stimuli under controlled conditions.

a) Contingent valuation

Mostly used when there is no market information or when surrogate values about individuals' preferences for certain natural resources or environmental services are unknown. Most studies use information from survey interviews (Mitchell and Carson, 1990; Barzev, 2002; Barrantes, 2016; Hernández, et al, 2013).

The estimated values are derived from a hypothetical situation of the possible reaction to such a situation. This technique is gaining popularity for the valuation of natural and environmental goods and services because of its flexibility in the absence of information.

The basis of the CVM consists of knowing the willingness to pay or to receive for an environmental improvement or for suffering an environmental deterioration respectively, to determine this willingness it is necessary to apply a questionnaire containing at least:

- Comprehensive information on the asset or subject to be valued
- Information on changes in the object of study
- Price scales with willingness to pay or receive
- Socio-economic characteristics of the respondent

Some of the aspects that can affect the results obtained through contingent valuation are:

– The interviewees must be sufficiently familiar with the asset to be valued, otherwise they will not be interested and there will be a bias in their answers.

– The time factor may have an influence, since as time passes since the event being valued takes place, the interviewee's perception capacity decreases.

– The same factor can influence the variability of a response, as the respondent does not answer in the same way at the time of the interview as he/she does when he/she is giving the individual time to calmly consider his/her response and answer later in writing.

– There must also be time consistency, because if the same individual is interviewed at different times, the answers will not be the same.

– There are protest responses, which arise because some respondents do not agree with the valuation of environmental assets and therefore refuse to answer this type of survey.

– Significant biases can arise depending on the amount to be paid or received, the information available, the interviewer and even the order in which the questions are asked.

b) Bidding games

Estimates the willingness to pay for an environmental good. Based on the hypothetical creation of a market based on the Hicksian concepts of compensated variation and equivalent variation, with the intention of knowing the area under the demand curve for goods not traded in a market.

The application of this method presents problems of bias (Mitchell & Carson, 1985), not so in developed countries due to validation items (Barzev, 2002; Mitchell & Carson, 1990). Over time, these have been remedied by the development of surveys with validation items in some countries, but this is not a widespread situation.

c) Take it or leave it

Based on revealed preference theory and all-or-nothing demand theory. The method uses only one question to determine whether or not they are willing to receive compensation in exchange for harm or whether they are willing to pay in exchange for preserving a good (Barzev, 2002).

The aim is that by offering a complete package of benefits or harms, the entire consumer surplus can be extracted. It can then be deduced that, if the respondent accepts to receive for the package the value offered, his surplus is positive, while, if he does not accept, then his net surplus for the package is negative. Normally, to avoid any bias on the part of the respondent, it is necessary to explain in detail and in a very clear way what the game is about in order for the answer to be valid.

d) Exchange Games

Also with the idea of approximating consumer preferences, this method presents the potential consumer with bundles of goods including sums of money and levels of environmental resources.

A number of different combinations of goods are made and the bundles are exchanged. The exchange shows the equivalences between money and increases in the level of environmental goods, so that the willingness to pay (exchange) for one and for the other can be known.

e) Least Cost Choice Method

It tries to measure the implicit valuation of environmental goods. It consists of asking participants to choose between several hypothetical groups of natural resources, as a way of constructing an indifference curve that allows an ordering of the alternatives, from the most preferred to the least preferred. When these have been determined, the choice is made to preserve the group of goods that implies the lowest cost to society, according to the preferences of the respondents.

It is a method that does not consider money, so its use is more advisable in situations where there is self-production and goods. When carrying out the valuation, it is important to consider preferences versus costs, so a double-entry table could be designed to help make the relevant comparisons.

f) Delphi technique

With this technique, experts are asked to respond with a social perspective on the value of a natural resource good or service. Linstone and Turoff (1975) defined the Delphi technique as "a method of structuring a group communication process in such a way that it is effective in enabling a group of individuals, as a whole, to deal with a complex problem".

One of the advantages of this technique is that it puts expert opinion above individual opinion, as well as maintaining the anonymity of the respondents as the answers are group responses. In addition, the application of this technique is low cost and quick in terms of obtaining results.

Table 3 Traditional methods and values it detects

Method	Aplication	Description and importance	Limitations
Market prices	Direct use values, mainly products	Estimated value from the price in commercial markets	Market and policy imperfections
Avoided damage cost, replacement cost or cost of substitute	Indirect use values: protection, avoided erosion, pollution control, water retention, etc.	Pollutant removal costs can be estimated from the cost of construction and operation of a treatment plant.	Under- or over-estimates can occur.
Cost of travel	Recreation and tourism	The recreational value of the site is estimated from the amount of money spent by individuals to get to the site.	A lot of quantitative data is needed. Travel may involve other motives
Hedonic price estimation	Indirect use, future use and non-use value	Used when values influence the price of traded goods, i.e. receiving services from environmental goods increases the price of housing or land.	It only captures people's willingness to pay for a perceived benefit. The method itself is data intensive
Contingent valuation	Tourism and non-use values	Directly asking individuals how much they are willing to pay for a given environmental service is also known as the "stated preference method".	Sources of bias can be introduced through interviews. It cannot be assumed that people are actually willing to pay the amount indicated in the interview.

Source: Adapted from Barbier et al., (1997)

Chapter IV. Market-based approaches to the economic valuation of environmental goods and services

4.1 Contingent Valuation Method

The contingent valuation method was proposed by Ciriacy-Wantrup in 1947, in a study of the economic valuation of erosion prevention, he suggested that one of the ways to arrive at an economic valuation of erosion prevention would be to ask people directly how much they would be willing to pay for it. However, the methodology was not applied. Robert K. Davis in 1963 made the first practical application to determine the economic value of the recreational possibilities of Maine's forests.

And in 1979 Bishop and Heberlein introduced a variant of this method called a referendum (dichotomous format), in which respondents can only give "yes" or "no" answers. This version is better than others as it eliminates the bias introduced by cross-examination and is less costly to implement.

Hanemann (1984) developed theoretical formulations of the CVM that allowed estimating changes in people's welfare. He formulated the problem as a comparison between two indirect utility functions.

In this model the author represents the utility function of the tourist (consumer) as follows:

U= U (J, Q, Z, S) (1)

Where:

U= the utility function
J= takes the value of 1 in situation of action (making improvement or avoiding damage) and 0 in situation of no action.
Q= complementary activity with level of environmental quality
Z= Hicksian good (any good that is consumed by the individual)
S= Observable attributes of the individual (social characteristics).

To determine a change in the individual's welfare the two forms consistently used are compensated variation (CV) and equivalent variation (EV). Each has two options, depending on which of the parties involved has the right over the use of the resource.

The CV can then be interpreted as:

- The maximum amount that people are willing to pay (WTP) for a favourable change.
- The minimum amount people are willing to accept (DAA) for an unfavourable change.

And it is expressed as:

$$VC = E(P, Q^0, U^0) - E(P, Q^1, U^0) = \int_{Q0}^{Q1} \partial E/\partial Qi(P, Q, U^0)dQi \qquad (2)$$

Where:

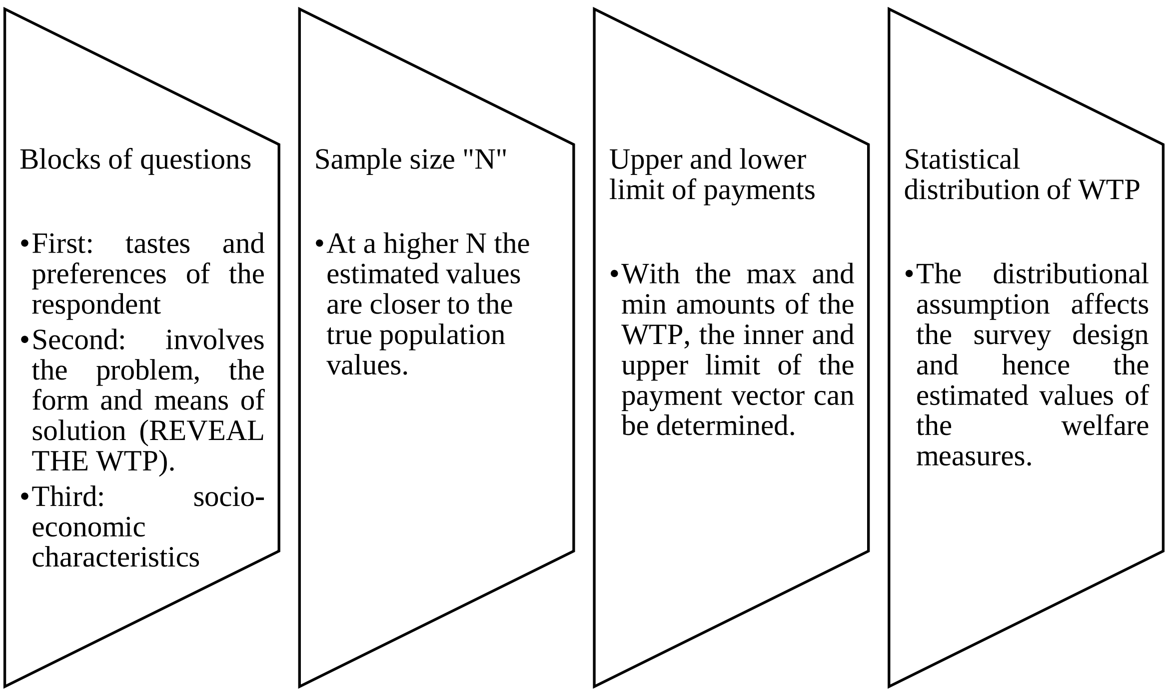
Q^0= is the environmental quality before deterioration
Q^1= is the deteriorated environmental quality
$(Q^1 < Q^0)$= the environmental quality has deteriorated as a result of a human activity
$E(P, Q^0, U^1)$= is the expenditure function when damage is avoided
$E(P, Q^1, U^1)$= is the expenditure function with damage to environmental quality

4.1.1. Survey design in the contingent valuation method

In order to obtain answers as close to reality as possible, a credible hypothetical situation must be presented. When designing the survey, it should be considered that the variables that influence the respondents' decision should be identifiable, thus avoiding biases and facilitating subsequent econometric calculations.

Certain rules and elements should be considered when drafting a survey to ensure proper design. It is usually written considering the general guidelines outlined by Mitchell and Carson (1989,1995) (Figure 9):

Figure 9 Elements of a survey



Source: Own Elaboration with data from Mitchell and Carson (1989, 1995)

4.1.2. Mechanisms for applying surveys

The most recommendable way of applying surveys is through personal interviews, however, there are other ways, which are listed below.

a) Personal interviews, with this type of interview it is possible to offer detailed information and to use visual material, as well as to answer the respondent's doubts.

b) Telephone interviews, which are practical because they are less costly, but have limitations such as the lack of visual aids and the length of the interview.

c) Questionnaires or surveys by mail, their main advantages are that they are low cost and that visual aids can be included, however, it is not possible to keep track of the questions for clarification of doubts and there is uncertainty as to whether or not the answers will be sent back to the respondent.

d) Laboratory experiments, these allow a group of people to be brought together and subjected to controlled tests. The disadvantage is the difficulty of gathering a representative sample that has the specific and necessary characteristics sought.

The selection of the most appropriate application option will depend, among other things, on the complexity of the questions, the time and budget available to the researcher. In addition, it is important to pre-test for proper implementation.

4.1.3. Questionnaire format

Knowing the type of survey to be applied, it is important to find the best way in which the questions can be formulated, so that the questions will be clear and the respondent can answer as honestly as possible, thus the interviewer will get the expected results. The possibilities are:

a) Open format: this format is combined with the auction format to give the respondent a hint on an approximate amount of what is being asked.

b) Multiple format: the respondent is presented with different options, which must be ordered by the respondent from highest to lowest according to his or her assessment.

c) Binary format: in this format, questions are asked in such a way that the respondent answers yes or no to a proposed number.

d) Iterative format: this allows the respondent to modify their previous answers in order to arrive at a more reflective assessment.

4.1.4. Aggregation

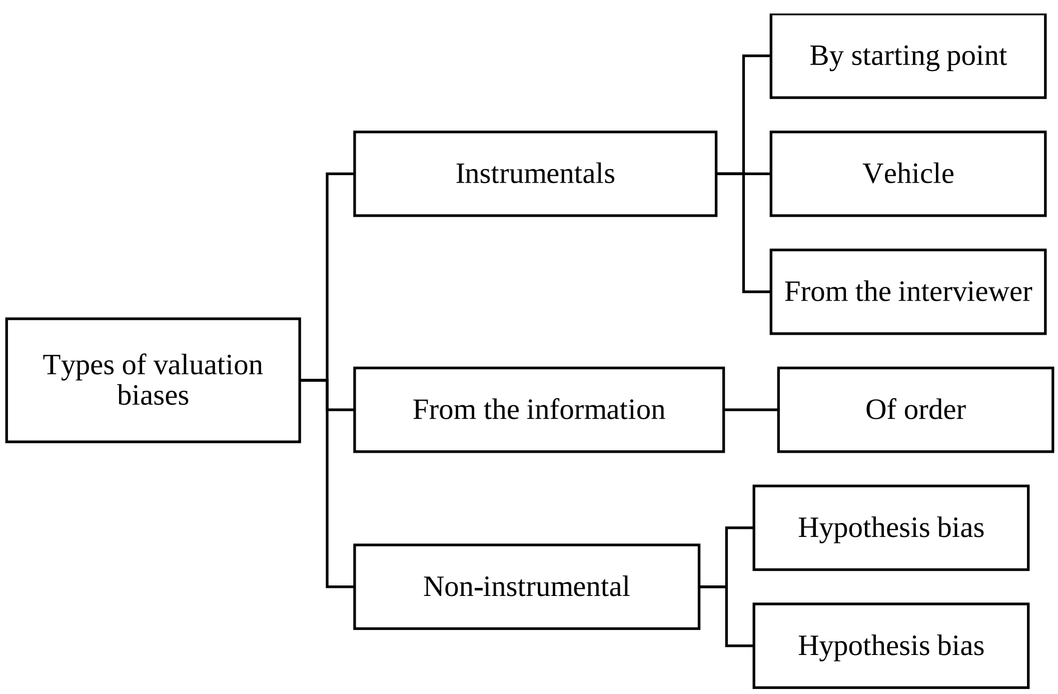
Special attention needs to be paid to determining how the information obtained on willingness to pay or be compensated from the sample can be made representative. From the data obtained in the sample, either the mean or the median can be obtained and multiplied by the relevant population.

Some researchers have chosen to use the mean as a measure of aggregation. This can be used as an estimator of what a person would be willing to pay to obtain a higher quantity or quality of a good and, in turn, can be multiplied by the relevant population to estimate the total value of the change in the good.

4.1.5. Biases

The simulation of hypothetical markets generates a considerable number of biases, which is one of the most important shortcomings of the application of the contingent valuation method (Whitehead, 1990). The most important of these are presented below:

Figure 10 Biases in contingent valuation



Source: Own Elaboration with data from Whitehead, 1990

a) Starting point bias, when a suggested amount is associated with the question of willingness to pay or be compensated.

b) Vehicle bias, where the way of paying tends to influence the respondent's answers.

c) Interviewer bias, this is generated when the individual, for fear of appearing unsupportive, gives a different answer to the one he/she would have given.

d) Order bias, which occurs when several goods are valued at the same time and the valuation of one of them is determined according to the position it occupies in the sequence of presentation. Kahneman and Knetsch (1992) suggest that there is a tendency to increase the willingness to pay for goods in the first places, since it can be induced that if it is first it is because it is more important.

e) Hypothesis bias, which arises from the simple fact that the contingent valuation method consists of obtaining hypothetical valuation.

f) Strategy bias, which is related to free rider behaviour on the part of respondents, where the individual does not reflect their true valuation, but lies in order to gain some kind of benefit from their false answer**.**

Loomis (2000), Riera (1993), Lockwood and DeLacy (1992) and Carson (1991) used probabilistic econometric models, while Ibarran et al., (2001) used ordinary least squares (OLS) to determine the economic value of an improvement in environmental quality, so it can be concluded that the econometric model is subject to the type of information collected during the survey.

4.2. Travel Cost Method

The Travel Cost Method has its first reference in 1949 and was proposed by Hotelling who suggested that national parks in the United States should consider having an entrance fee, i.e. it emerged and is still used for the valuation of natural areas that fulfil a recreation function in the household utility production function. The most important advantage of this technique is that the valuation is calculated on the basis of respondents' stated expenditures rather than their preferences.

This form of valuation is estimated by calculating the area under the demand curve (consumer surplus) that relates the number of visits to a location to the expenditures incurred by visitors to reach that location. The travel cost model is:

$$Travel_i = \beta_0 + \beta_1 TCV_i + \beta_2 + \beta_3 Income_i + \beta_4 Other\ Variables_i + \varphi_i \qquad (3)$$

Where:

Trips = represents the number of trips made to the site during a year by the i-th household.
TCV_i= is the price or variable cost of travel to access the site by the i-th household.
Income = is the monthly liquid income of the household.
Other variables = all other variables affecting the demand for travel to the site
Φ_i is the stochastic or random error.

In theory, the sign of the coefficients of the travel cost variable should be negative, since a higher cost of travel to the site will lead to fewer trips being made. The assumptions implicit in the theoretical model are as follows:

– The number of trips (x) and the environmental quality of the site are complementary in the utility function. Then, the number of trips is an increasing function of the environmental quality of the site.

- Individuals perceive and respond to changes in the cost of travel, just as they do to changes in site admission prices. Therefore, careful attention needs to be paid to the calculation of the monetary value of the cost of travel.

- Visiting the study site is the only reason for the trip, otherwise the cost should be spread over the different sites.

- The length of stay is exogenous and fixed, as it is not part of the individual's decision process.

- No substitutes are considered as there are no alternative locations.

- The wage rate represents the opportunity cost of time.

- The individual does not perceive utility or disutility during the trip.

One limitation is the high costs of survey or econometric implementation, so its applicability is not always possible. Another problem is that the particular characteristics of some ecotourism sites or the number of surveys conducted make it impossible to vary the quantity demanded. If the amount of demand for recreation does not change from person to person, we have a problem of limited dependent variable, which prevents econometric estimation through ordinary least squares, since the basic principle of homoelasticity of errors is violated.

Here the possibility of demand determination using the ordinal regression model is possible. Although it is not possible to obtain a valuation in monetary terms (contingent valuation or travel cost), it is possible to know the probabilities of demanding a certain amount of recreation (days of visit) according to the characteristics of each visitor.

4.2.1. Travel cost components

a) Unavoidable costs:

Within these are considered those derived strictly from travel: payment for petrol per kilometre, vehicle depreciation and maintenance costs; cost of bus ticket, airfare, parking cost, entrance to the site, etc.

b) Discretionary costs:

There is a question whether food and accommodation costs can be considered as part of the cost of enjoying the recreational services of the site. However, only those expenses that are not discretionary, i.e. that add their own utility component to the whole experience, are considered as part of the cost of travel.

c) Time and its economic value:

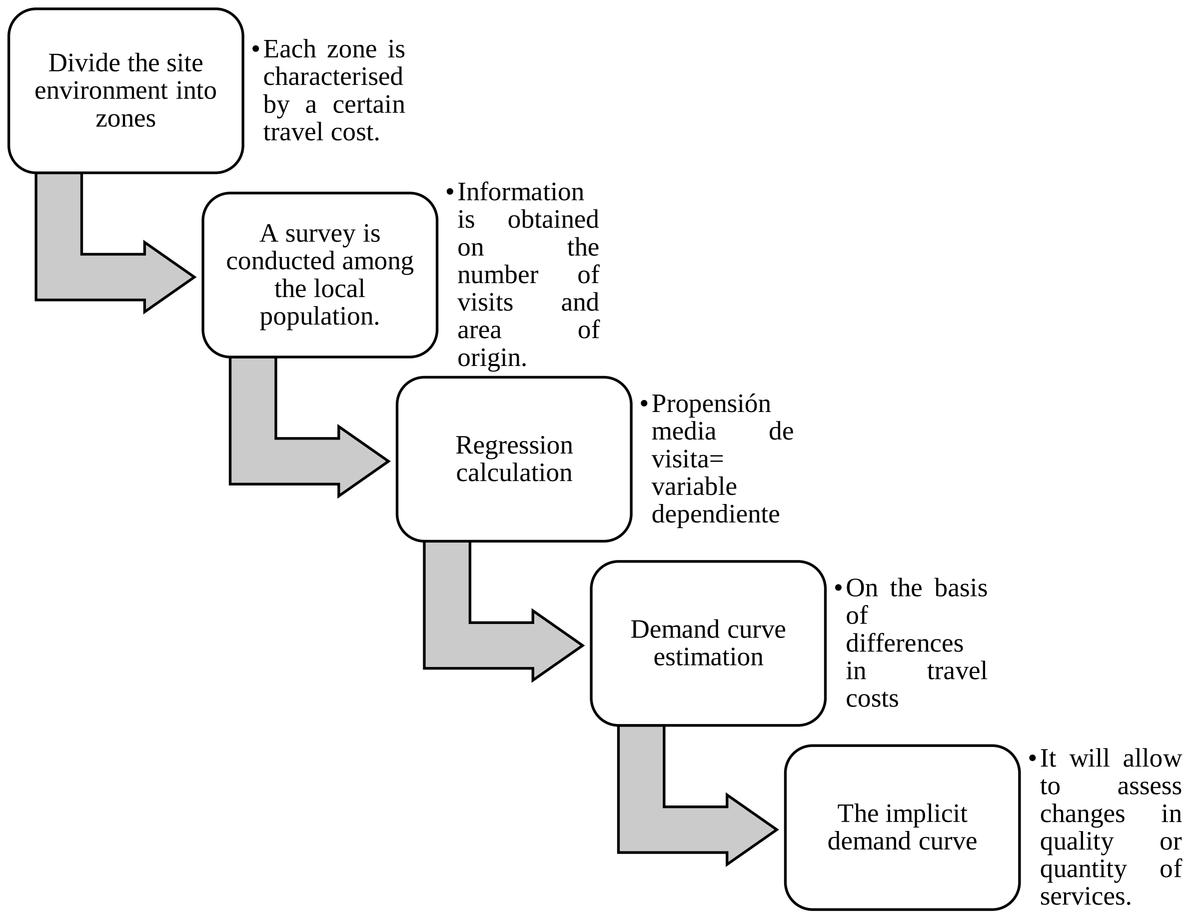
With respect to time, it is questioned whether it should be included as an additional cost, and if so, how it should be valued. In this case, we must address the concept of opportunity cost: the time invested in something could have been spent on an alternative activity, or rather, the individual can dedicate the time to a productive activity (work) or to enjoying more free time (leisure).

d) Economic value of work

As mentioned in the previous point, time has an opportunity cost that is expressed in terms of production. The measure of the economic value of labour is the wage that the individual concerned receives, which is a reflection of his or her marginal productivity (contribution to total output). Therefore, the economic value of time would be given by the wage/hour.

4.2.2. Steps for the application of the Travel Cost Method:

Figure 11 Methodological sequence of the travel cost method



Source: Own Elaboration with data from Barzev, 2002

4.3. Hedonic Pricing Method

Each good and service is made up of a series of characteristics or attributes that cannot be sold or bought separately, so that, as a whole, they make up the basic unit that is traded in the market. These attributes, to the extent that they are inevitably passed on by the supplier to the consumer at the time of purchase of the good, have the particularity of positively or negatively affecting the price of the good, depending on the valuation that the demander maintains for each of these attributes. In other words, the market price of a good must be an aggregate of the individual prices of each of the attributes that the good contains; this statement in economic theory is known as the hedonic hypothesis.

The first applications of the hedonic pricing method date back to 1967, when Ridker and Henning, for St. Louis, United States, analysed the effect of air pollution on the market price of housing, as well as other characteristics of the property and its neighbourhood. It was not until 1974, however, that Rosen formally enunciated a model of hedonic pricing, the hedonic theory states:

– Sellers and buyers try to maximise their individual welfare in the multi-attribute goods market.

– Most attributes are taken as given: for example, the size of the property, however, there are others that are the result of externalities, for example, the level of congestion on the access road.

– When with the existing prices, buyers and sellers consider that their best decision is the one they have made, the market will have reached equilibrium.

The Hedonic Price Theory aims to explain the value of a real estate property, understood as a set of attributes: surface area, land use suitability, quality of construction, interior and exterior design, green areas, location, etc., according to each one, in order to obtain their respective valuations and, therefore, implicit demands.

That is to say, the theory helps to identify the importance of each attribute in the value assigned to a real estate property, from there it is possible to determine how this value will change by modifying the quantity and quality in which each of these attributes is present, and therefore, prices could be predicted.

The general form of the model is as follows:

$$P = f(I, V, U, Z, S, E; w) \tag{4}$$

Where:

P= corresponds to the price of the real estate, which is assumed to be determined by the arguments of the function f and is used as the price per square metre instead of the total price of the property, assuming the theory that the surface area of the property exerts a strong influence as an explanatory variable of the square metre.

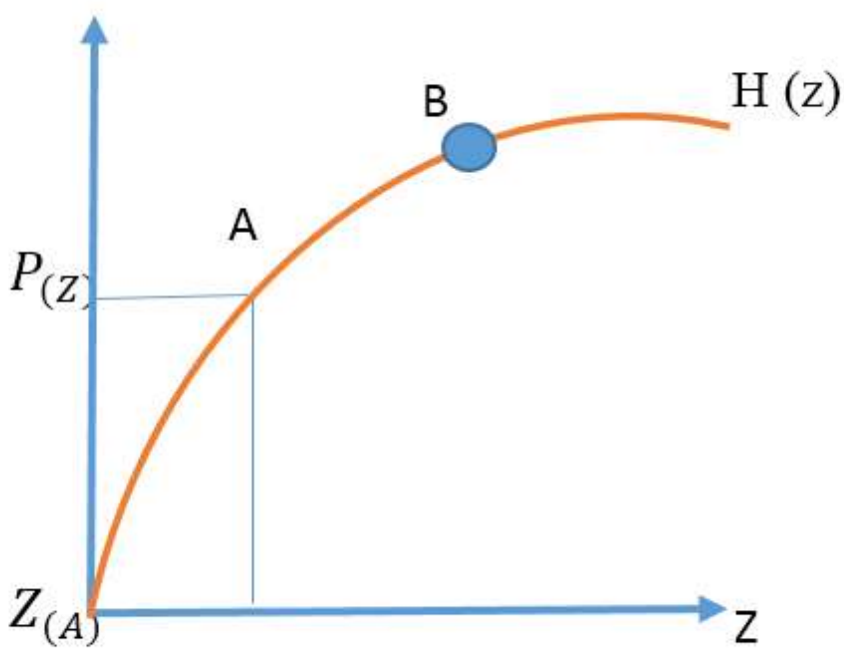
The elements in the equation of the hedonic price model are grouped into 6 categories:

I: inherent characteristics of the property, which include but are not limited to land area, architectural features, design and quality of materials.
V: characteristics of the neighbourhood, i.e. socio-economic status, type of residents, etc.
U: characteristics of the location of the property within the city's Regulatory Plan,
S: characteristics determined by the level of exterior equipment, services and infrastructure that the property receives (electricity, drainage, etc.).
E: externalities of the environment in which the property is located (green areas, rubbish dumps, etc.).
w: set of parameters that accompany each attribute and that constitute the implicit prices (shadow) of each characteristic of the property.

The pricing function can take different forms. However, it is always intended to be an increasing function in the desirable attributes of the property to be valued, such as security, but decreasing with respect to the negative attributes, for example, noise levels. This function will allow us to solve a fundamental problem: the non-existence of explicit prices of the attributes.

The hedonic price function (4) implies that when acquiring higher environmental quality Z_A the price increases P_Z. It is a production function of consumer welfare

Figure 12 Hedonic price function



Source: Own Elaboration with information from Barzev, 2002

The direct use of semi-logarithmic models is suggested, which correspond to a traditional linear model, in which the variables "price" and "surface area" are replaced by their respective natural logarithms, this method leads to obtain the logarithm of the price of a property, which must subsequently be "reconverted" to price by applying the algorithm (or exponential).

4.3.1. Multicollinearity

It is very common for multicollinearity problems to exist among the explanatory variables of house prices, since it is usually the case that large houses have many bedrooms, several bathrooms, are made of better materials and are even located in good neighbourhoods. The opposite is also expected: houses without water and sewerage will be located in marginal neighbourhoods, will be smaller, have fewer bedrooms, and will be built with lower quality materials. This phenomenon implies that there tends to be an association between variables, so that samples drawn from any given universe will tend to show high degrees of multicollinearity, i.e. correlation, between several of the variables.

In econometric terms, multicollinearity means that it is not possible to isolate the effect that each of the variables individually has on the price of housing and that they are also correlated with each other, which results in the estimators of the regression parameters having a high variance. This multicollinearity problem can be solved by using principal components of the correlated variables. Principal components can be considered as a change in the data that synthesises the information within a set of variables with some degree of correlation between them into a minimum number of uncorrelated factors, and which also has a significant proportion of the variability existing in the original set of variables (Lever 2009).

The hedonic pricing method is often used in cases where it is desired to identify the effect on the price of the property of a particular characteristic. A clear example might be when valuations of certain basic services, such as drinking water, sewerage or paving, are desired, it is useful to consider each of the variables that determine prices in principal components so that the analysis can be concentrated only on the variables of interest.

When it is necessary to value or assign a price to a dwelling, other techniques must be used, since the important thing is to be able to collect a reduced number of variables, but one that allows to reproduce, through the hedonic equation, the values of a specific type of dwelling, with well-defined characteristics. Because the variable exclusion method is simple, straightforward, and does not require auxiliary econometric models, its use is recommended in most cases:

– Exclusion is a simpler technique that consists of omitting from the model, (in the case of more than one variable explaining the same phenomenon), those variables that are less relevant or more difficult to measure. For example, if the variables "state of conservation" and "age" explain the same phenomenon, it is advisable to eliminate one of them from the equation, without significantly affecting the quality of the price estimate.

– Residualisation of variables consists rather of constructing new (residualised) variables from regressions run between correlated variables. In this way, the variables can be "orthogonalised", cancelling out the cross effects, but maintaining the explanatory power of each variable on the price.

The main applications for starting from a hedonic equation are (Figure 13):

Figure 13 Main applications of the hedonic pricing method

If the characteristics of the project are given
- It is possible to determine the market value of this.

If there is a change in one of the characteristics
- It is possible to determine how much the market values this change.

In the design of a project
- It is possible to determine the optimal combination of attributes that it should contain
- Maximise project value vs. cost

Identify areas of potential urban development
- It is necessary to study the population density of the sector and its dynamic trend.

Projecting current market saturation processes
- Prices and time sequences of processes are anticipated.

Projecting sales velocities
- The average market price is considered as "normal speed".

From consecutive samples of hedonic prices
- A general price index for the sector can be obtained.

Obtain databases
- On real estate statistics

Source: Own Elaboration with information from (Lever, 2009)

a) Preventive and avoided cost method

In this case, the method uses market prices: either the prices directly of the environmental good being analysed, if they exist, or the prices of some goods directly or indirectly related to the good to be valued. The method aims to measure the change in the welfare of individuals through consumer and producer surplus. Some of the advantages that can be found in this method are:

– It is a relatively simple and practical technique because it is possible to value the positive effects of public investment in conservation works, preventive measures against natural disasters, health prevention campaigns, campaigns for course management or environmental problems such as fires.

– The direct effect that the investment generates on the assets analysed or the indirect effects on assets related to the main asset analysed but which guarantee its sustainability are observable.

– The greater the identifiable positive effects (avoided costs), the greater the social benefit generated by the investment in prevention.

While there are advantages, the method has some disadvantages, precisely related to the estimation of non-tangible benefits (Barzev, 2002):

– Estimating economic and social benefits and determining how they are apportioned between consumer surplus and producer surplus is difficult.

– In the face of changes in environmental quality, producers take defensive measures, which makes it difficult to measure whether changes in quality and quantity are due solely to the preventive measures taken.

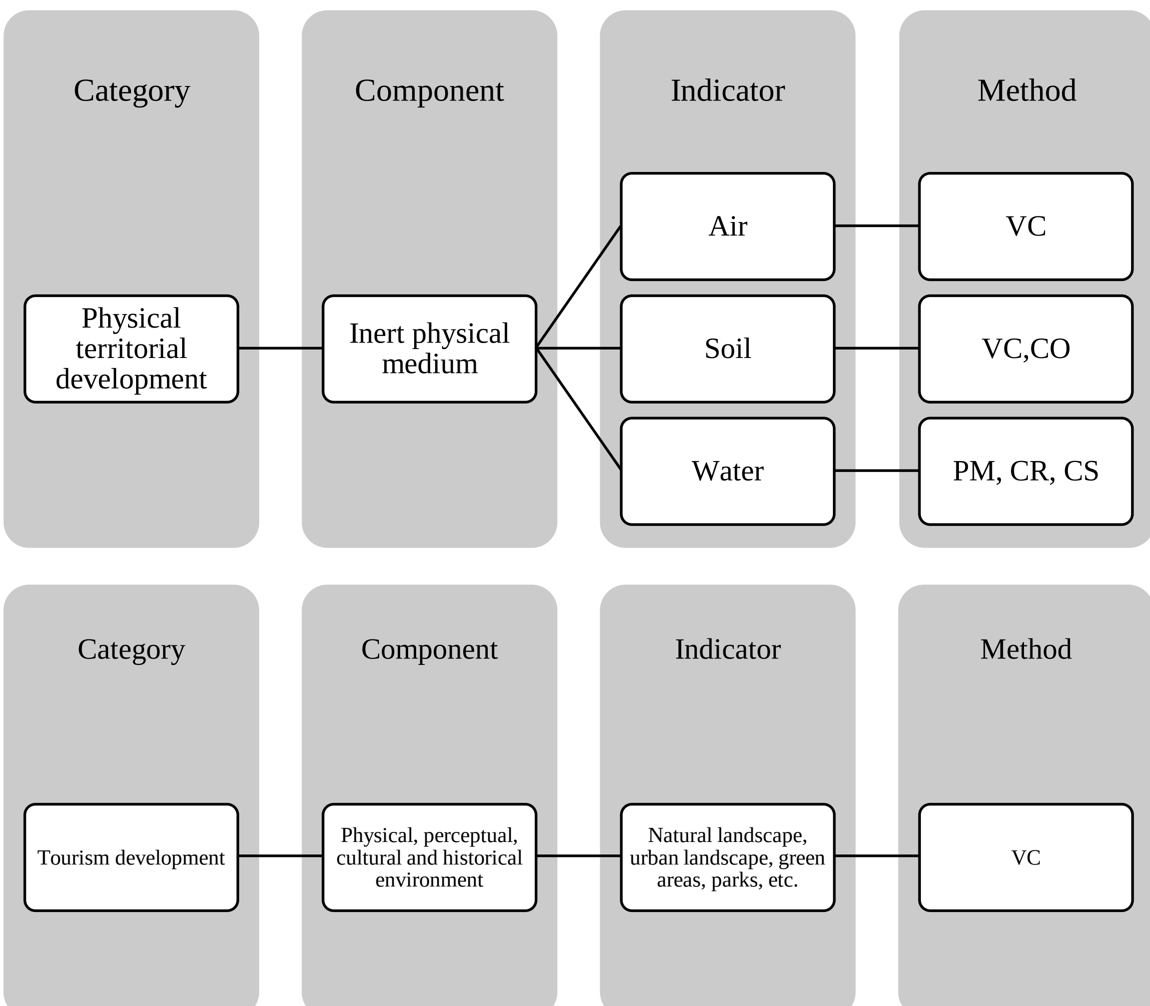
– Changes in environmental quality also mean that prices do not remain constant. Thus, the change does not necessarily reflect only the environmental improvement resulting from the preventive measures.

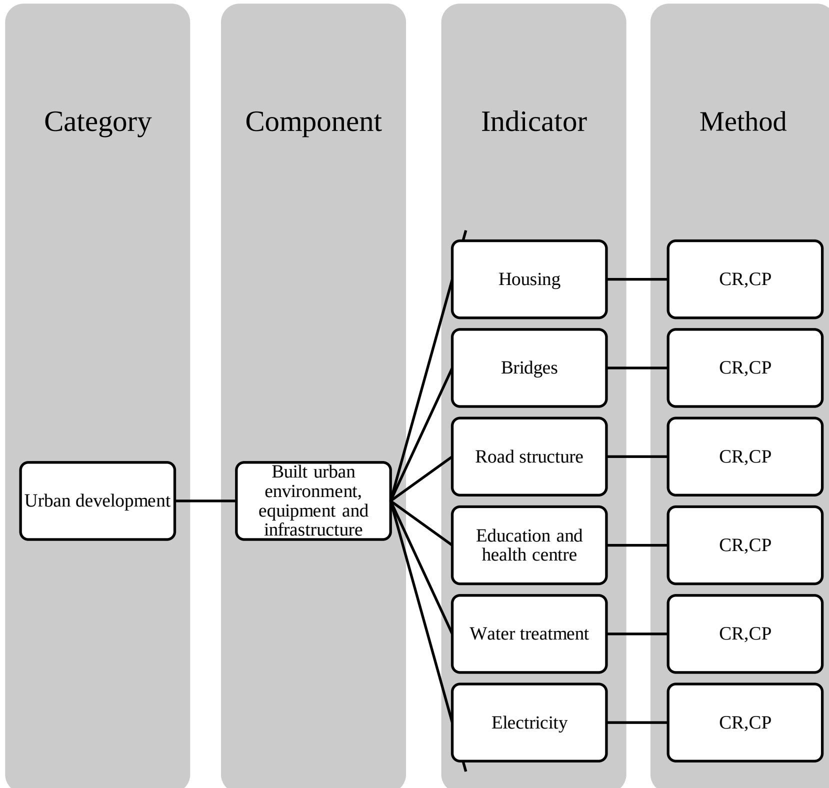
– The combination of factors changes, therefore, they are not easily comparable situations.

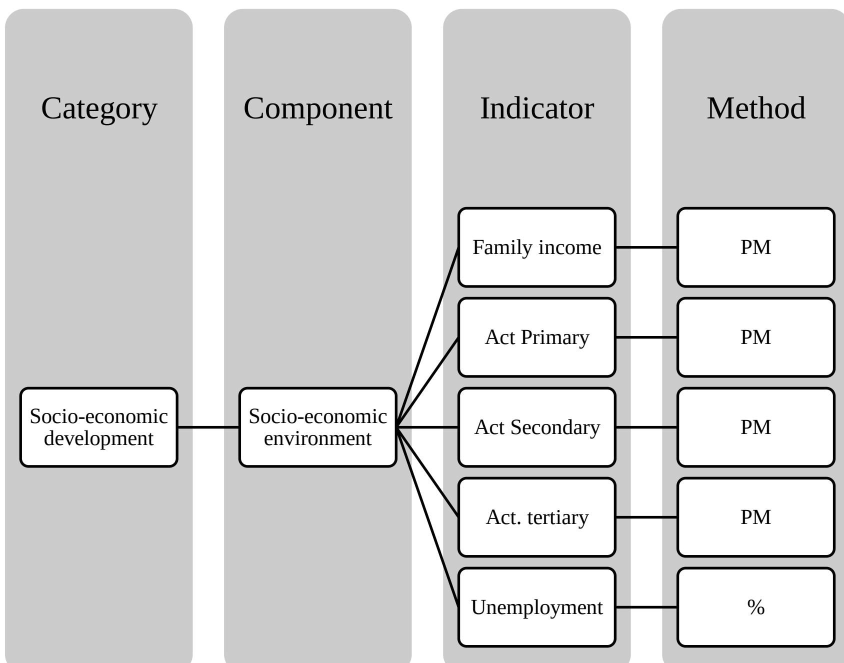
b) Environmental economic indicators

By using valuation methods, different environmental economic indicators are obtained, which measure environmental quality physically. For this purpose, the environment can be divided into categories, in order to break down its components and define measurable and quantifiable physical indicators. The level of indicators to be generated is directly proportional to the information that is obtained about the environment under study, as well as the knowledge of its elements, so that there will be greater accuracy in the expression in monetary terms.

Figure 14 Environmental Economic Indicators







VC Contingent Valuation
CO Opportunity Cost
CR Replacement/Relocation Costs

CS Health cost
PM Market prices
CP Preventive and Avoided Costs

Source: Own Elaboration with data from Barzev, 2002

Chapter V. Non-traditional methods of environmental economic valuation

5.1. Multi-criteria methods

Among the multi-criteria methods there are at least three that stand out, the first of which is the aggregation of criteria procedure, in which the decision-maker gives relative weights to each criterion in order to later compare the decision with some aggregation criterion. Secondly, we have the multi-attributed utility theory, which says that there is a utility function U defined over the set A of possible solutions, which the decision maker wants to maximise. Finally, we have the hierarchical analytical process which has been applied more extensively in the practice of multi-criteria evaluation and will therefore be the one that will be explained in more detail (Contreras, 2004).

5.1.1. Analytical Hierarchical Process

Performing a Total Economic Valuation (TEV) is possible through the construction of a Hierarchical Analytical Process, considering the five components of TEV to determine the total value of the evaluated area.

Multi-criteria methodologies help to integrate various factors into the evaluation process. They transform measurements and perceptions of specialists into a scale to compare and prioritise elements, so that the effects of a project can be understood on a common metric (Contreras & Pacheco, 2007).

The Analytic Hierarchical Process (AHP) is a method of selecting alternatives based on a series of conflicting criteria or variables. The AHP hierarchical analytical process function in the valuation of environmental assets helps to prioritise the components of the Total Economic Value (TEV) associated with those assets (Satty, 1980).

AHP can be understood as a technique that allows the resolution of multi-criteria, multi-environment or multi-actor problems and that, in addition, incorporates intangible and tangible aspects, subjectivism and uncertainty inherent in the decision-making process into a model. But also as a mathematical theory of measurement applied to the dominance of the influence between alternatives, with respect to a criterion (Jiménez, 2002).

Many problems involve attributes, both physical, i.e. tangible, and psychological, referring to the intangible, including the subjective ideas, feelings and beliefs of individuals (Jiménez, 2002). Multi-criteria evaluation considers different qualitative and quantitative factors, in turn contemplating the plurality of the perception of the actors involved in the decision problem (Uribe, 2001; Chen, et al., 2012).

This method has been used for academic purposes in the assessment of goal programming (Aznar and Guijarro, 2004, 2007), the hierarchical analytical process (Aznar and Caballer, 2005; Aznar and Estrutch, 2011), the network analytical process (Aragonés et al., 2008; García-Melón, et al., 2008) and the conjunction of several of these techniques (Cervelló et al., 2010; Guijarro and Guijarro, 2010).
The application of AHP considers the following steps:

a) It starts from the interest that a decision-maker has to select the most suitable one, among a group of alternatives.

b) The criteria to be used for the selection of these alternatives are determined, and the characteristics that will make one alternative more desirable than another are considered.

Once the alternatives are known and the criteria are well established, the next step is to weight the different interest of each of these criteria in the selection of the alternatives.

A paired comparison matrix is created, constructed by two-by-two comparisons of the different criteria, and the comparison is quantified by means of a FUNDAMENTAL SCALE. The result is an eigenvector of the given matrix indicating the weighting of the criteria (Figure 15).

Figure 15 Pairwise comparison scale

1=equal importance

3= moderate importance

5= great importance

7= very great importance

9= extreme importance

2. 4. 6 y 8 Intermediate values between the above, used for nuancing

Reciprocals: in case of high importance of A versus B the notations would be:
Criterion A against criterion B 5/1
Criterion B against criterion A 1/5

Source: Own Elaboration based on Aznar Bellver & Estruch Guitart (2015)

a) Once the weighting has been established, the different alternatives are weighted according to each criterion. It is necessary to compare all the alternatives according to each criterion, to finally obtain n matrices, where n is the number of criteria and the vector of each of them is obtained, which in each case will indicate the weighting of the different alternatives according to each criterion.

b) Two matrices are generated, a column matrix nxl with the weighting of criteria (n= the number of criteria) and another mxn formed by the weightings of the alternatives for each criterion (m= the number of alternatives).

c) At the end, the product of both matrices will give a column matrix mxl indicating the weighting of the alternatives according to all criteria and their importance.

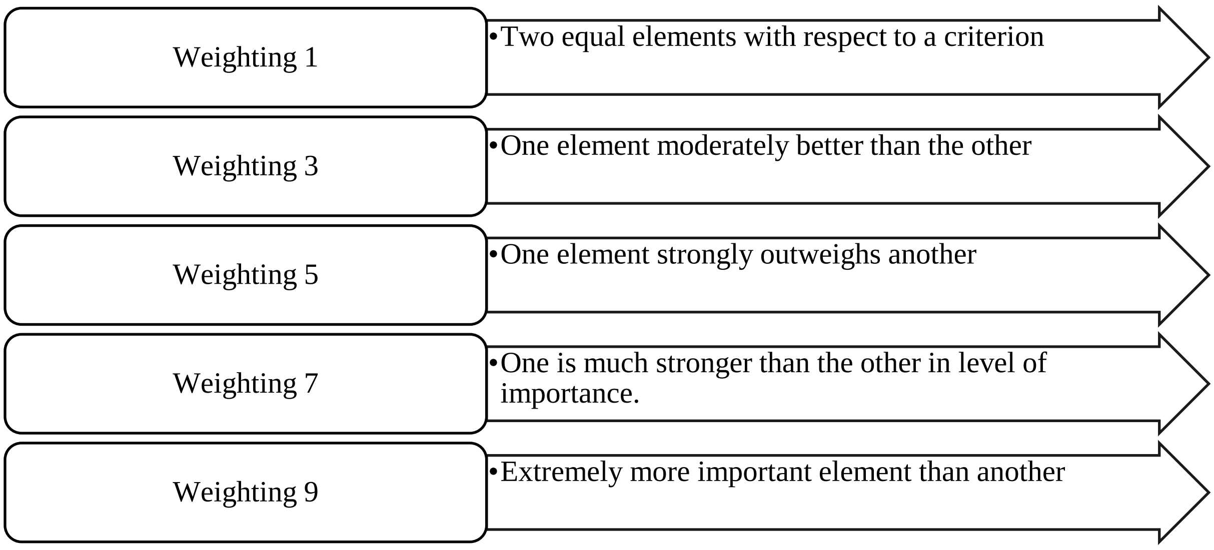
Each of these steps is described in more detail below:

The weighting of the criteria and the alternatives could be done through a direct quantification of all of them, however, comparing all the elements at the same time can be quite complex, especially when there are a large number of elements, which is why they estimate that 4 alternatives is the maximum complexity that can be dealt with by human beings.

Saaty (1980), for his part, proposes what he calls a "fundamental scale" of paired comparisons between different elements, since the human brain can perfectly assimilate comparisons of two elements (Figure 16).

Pairwise comparisons are determined as follows:

Figure 16 Pairwise weights



Source: Own Elaboration with information from Saaty 1980

When these comparisons are obtained, square matrices A_{mxn} are constituted which must comply with the properties of:

- Reciprocity
- Homogeneity
- Consistency

The consistency property is one of the strengths of the method, as it ensures that the information entered in the model is correct. Consistency is measured by the consistency ratio, which must be less than a certain percentage depending on the matrix rank (Table 4).

Table 4 Consistency ratio of paired comparison matrices

Matrix range	Consistency ratio
3	<5%
4	<9%
5 or more	<10%

Source: Aznar y Estruch, 2015

When the consistency has been verified, the eigenvector is calculated. Either through the EXPERT CHOICE or SUPERDECISIONS programmes or an approximation can be calculated using the Excel spreadsheet with the mathematical function MMULT.

The eigenvector of the criteria matrix is called Vc, which shows the relative weight or importance that each of the criteria used has in the evaluation of the set of alternatives. But if it is the eigenvector obtained from the matrix of alternatives for a criterion then it is called V_{ai} column vector which indicates the relative weight or importance of each of the alternatives for criterion i (Aznar and Estruch, 2015).

Once the different vectors and the corresponding matrices are known, finally, the eigenvector matrix of the alternatives is multiplied by the column matrix of the ranking of the criteria such that:

$$V_a * V_c = w \quad (5)$$

Where: $V_a = [V_{a1}, V_{a2}, \dots V_{an}], \dim(V_a) = m * n$ (6)

At the end, a matrix w is obtained that expresses the relative weight of each alternative. In this way, the alternatives can be ranked from most to least interesting and also quantify the interest of each alternative with respect to the others in terms of all the criteria and their importance, so that we have the option of selecting the best one.

5.2. AHP methodology

To begin with, it is necessary to carry out surveys applied to a small group of specialists who have a direct relationship with or knowledge of the space to be evaluated (owner or producer, technician, researcher, student, politician, etc.) (Aznar & Estruch, 2015).

The survey is the tool that allows obtaining the matrices of paired comparisons, necessary for the application of the AHP method, also known as the Hierarchical Analytical Process.

The interview consists of the application of a comparison questionnaire based on fractions (A/B) between two variables, in this case the values that make up the Total Economic Value. With the answers from these questionnaires, square matrices A_nxn are formed with values between one and nine, according to the importance of some element (one less important and nine of maximum importance). To collect the required information Aznar and Estruch (2015) propose the use of the survey as shown in Table 5. In it, the importance that each expert gives to each of the components of the TEV is compared two by two, considering the expressions at the top.

Table 5 Expert survey

	Extremely important	Mmuch more important	More important	Moderately more important	same	Moderately more important	More important	Much more important	Extremely more important	
VUD										VUI
VUD										VO/O
VUD										VE
VUD										VL
VUI										VO/O
VUI										VE
VUI										VL
VO/O										VE
VO/O										VL
VE										VL

Once the surveys have been completed, the corresponding matrix is constructed. Each one is normalised and its consistency is checked by considering the inconsistency coefficient: CI= (Landa Max-n)/(n-1), the consistency ratio and the eigenvectors of the consistent matrices are calculated by dividing CI by the random consistency corresponding to the size of the matrix, thus ensuring that the information in the model is correct,

In the case of inconsistency, the interview is discarded. Subsequently, an eigenvector is obtained from each matrix and a table of criteria representing the weighting of the alternatives for each criterion is constructed. Finally, a final column vector is obtained, with the weighted TEV components, and the Direct Use Value (DUTV) is used as a pivot value, since this involves activities of the environmental asset that are controlled by a market, and for this reason the income and expenses are known, the difference of which reflects the cash flow of the DUTV.

The income discount method is applied to update the cash flow and the value obtained will be the value of the environmental asset through the ELV.

$$VUD = \frac{FC}{ENVIRONMENTAL\ FEE} \quad (7)$$

Finally, the Direct Use Value is obtained and then, with the weighting, the values of the rest of the components are obtained.

The AHP method has been successful in various fields from business planning, strategic planning, project and investment selection, research and international conflict resolution.

5.3. Benefit transfer method

The different environmental valuation methods and their application have been increasing in recent years due to the growing importance of environmental protection and care for the environment. Estimates of the willingness to pay (WTP) for the benefits provided by natural resources or the willingness to receive compensation to avoid the costs caused by economic activities due to their inappropriate use have followed the logic of environmental economics (Osorio, 2006).

In 1997, Constanza et al. carried out one of the first and most relevant studies in their field, since they obtained values based on different studies obtained in different cases.

On the other hand, in the UK at the beginning of the century, benefit transfer was used within policy making and regulatory bodies, a clear example being in the setting of water quality targets for private water companies and also in the design of agri-environmental policy (Oglethorpe et al., 2000).

In 2006 Viglizzo and Frank conducted a study comparing different biomes and the ecosystem services they provide. They carried out a comparative study of different regions between Paraguay, Brazil and Argentina, considering as a basis the ecosystem services measured in different types of ecosystems and compared them with agricultural services in the region.

In the United States, a 2011 report by the President's Council of Advisors on Science and Technology raised awareness of the importance of valuing ecosystem goods and services in decision-making. The report recommends that federal agencies with responsibilities related to ecosystems and ecosystem services use available techniques to value the ecosystem services impacted by their decision making and incorporate the results of their analysis for better planning and management decision-making (President's Council of Advisors on Science and Technology, 2011).

Traditional valuation studies can be time-consuming and labour-intensive, and are often costly. On the other hand, most approaches including market, non-market, biomass, productivity methods, which are consistently applied to assess ecosystem services (Costanza et al., 2014; Costanza et al., 2017; Yi et al., 2018) are often flawed. Market-based methods, as mentioned in another chapter, are the simplest to apply as information on prices and quantities is available, however, not all ecosystem services can be valued in this way, and it is essential to determine the appropriate market (Barzev, 2002; Hernández et al., 2013).

Some ecosystem service benefits can be reflected indirectly in consumer spending, market prices or the productivity of some activities, however, this valuation is not done directly (Barzev, 2002; Hernández, et al., 2013; Sarmiento, 2004).

Other traditional valuations such as Contingent Valuation (CVM), Travel Cost (CVM) or Hedonic Prices (HP), could generate obstacles to find the value due to their high implementation costs or lack of knowledge of the methodology (Sarmiento, 2012).

To avoid all these limitations, economic-environmental values can be estimated indirectly by value transfer, which uses value estimates from one or several previous studies and transfers it to an alternative site or context of interest (Akter and Grafton, 2010). This alternative for determining the economic value of an environmental good or service is obtained by applying the Benefit Transfer Method, which is an attractive option as it can generate acceptable estimates of value at a lower cost than market valuation studies for each new site or region (Baskaran et al., 2010).

The Benefit Transfer Method (BTM) is the use of monetary values of environmental goods and services measured at a given site to estimate the benefits of a certain good or service to estimate the benefits of a similar environmental good or service at a similar site for which the value is unknown (Wilson and Hoehn, 2006), and the results of these valuations can be used as an efficient tool to quantify the environmental impacts of implementing land-use or other ecologically related policies (Bateman et al., 2013; Schmidt et al., 2014).

The MTB has been used in several situations (Wilson and Hoehn, 2006; Bergstrom and Taylor, 2006; Spash and Vatn, 2006; Ruiz-Agudelo and Bello, 2014; Richardson et al, 2015). At the same time it has been compared with different methods (Rozan, 2004) to analyse the reliability of benefit transfer studies in a meta-analysis study (Lindhjem and Navruda, 2008).

According to Cristeche & Penna (2008), "Benefit transfer is not a separate valuation method but a technique sometimes used to estimate economic values of ecosystem services. It is normally used when it is too expensive or there is little time available to carry out an original study, however, it is essential to take into account the transitivity of costs as well as preferences from one situation to another. In turn, it is necessary to ensure that the environmental quality attributes to be assessed are the same, as well as the characteristics of the affected population. A number of case studies are presented below where it can be seen that the benefit transfer method yields accurate values.

Rosenberger and Loomis (2003) define this method as "the adaptation of information obtained from original research for application in a different study context". TB extrapolates existing information on non-market values of goods and services, i.e. it uses information from previous research in order to value a new site (Colombo and Hanley, 2008).

In 2006, Osorio argued that the benefit transfer method could basically be divided into three classes: transfer of fixed values, transfer of functions and transfer of meta-regression analysis functions. However, Ruiz-Agudelo et al (2011) argue that there are only two approaches to benefits transfer: a) value transfer and b) function transfer.

For value transfer Osorio (2006) mentions that the way to obtain values for transfer is by averaging data across a study site, applying statistics from an original research to a policy site directly. However, this methodology can be criticised because when research is carried out in regions with large differences or different quality of life, benefit transfer cannot be applied (Ruiz-Agudelo and Bello, 2014). According to the literature, there are three ways of applying value transfer within benefit transfer (Table 6).

Table 6 Applications of value transfer

Transfer of estimated points.	Transfer of measures of central tendency.	Expert judgement
Uses measurements obtained in the original study conducted in context i to estimate the measurements needed in the policy site with context *j*.	Take an average or other measure of central tendency from numerous studies available in the literature.	The total benefits of the policy site are estimated by taking per unit values from a specialist judgement or opinion process.

Source: Own Elaboration with information from Bruno and Sarmiento (2020)

From a climate policy perspective, TB is an economic-environmental and adaptation technique that makes it easier for policymakers to work at larger levels of aggregation and better respond to intensive changes in the natural and social environment (Huntjens et al., 2010; Colombo and Hanley, 2008). The method is meaningful and attractive because: analysts have access to a wider source of primary valuation studies that may be absent in developing or transition countries (Ready and Navrur, 2006). It is also a method for identifying the likely locations of ecosystem services, as it is based on empirical spatial associations that are found in different geographical locations (Brown et al., 2016).

5.3.1. Main Benefit Transfer methods

Following Saldarriaga and Patiño (2016), Richardson et al., (2015) and Osorio (2006), the benefit transfer method is essentially divided into: unit value benefit transfer, function transfer and meta-analysis.

a) Unit Value Benefit Shifting

This is the transfer of a value from a pre-existing primary study to a new study (Saldarriaga and Patiño, 2016). It is based on three approaches: first, identify a study in the literature that best matches the characteristics of the policy site according to the transfer criteria, and this single point estimate, adjusted for inflation, is transferred; second, apply an average value from several studies to the policy site of interest (transferring a measure of central tendency may be preferable to a single point estimate transfer) (Richardson et al., 2015); third, administratively approved values could be used, for example, US Forest Service Resource Planning Act values for recreation and other resources, or US Water Resources Council unit daily values for recreation. These are typically derived from a combination of existing empirical evidence, expert judgement and political selection (Rosenberger & Loomis, 2003).

b) Benefit transfer of functions:

The transfer of information is through an estimation, typically a parametric function derived from a primary study, a meta-analysis that summarises the results of multiple studies or a preference calibration that builds a structural utility model (Rosenberger & Loomis, 2000).

c) Meta-analysis:

In environmental economics, meta-analysis models are often used, where the dependent variable is a result obtained from existing studies, whose independent variables represent observable factors in a hypothetical context, i.e. the combination of valuation results from different studies is performed to estimate a common benefit function. The validity of the meta-analysis and thus the outcome of the benefit transfer depends on the quality, extent and objectivity of the primary study data. As with any economic valuation technique, TB results are subject to measures of error, which in this case can occur if a good in the study site is different from the site of policy implementation interest, either because of differences in quality attributes or in the actual quality and quantity of service provision (Correa et al., 2011).

One of the most important advantages of this method is the low cost of its application (Pena et al., 2011) because although the information on the known value of the other good is accurate and adjusted, the studies to be carried out will be smaller, in addition, it is not necessary to conduct surveys or obtain samples to carry out the study (Sarmiento and Prieto, 2005).

The possible disadvantages of this method are (Sarmiento and Prieto, 2005):

a. The reliability of the study using the benefit transfer method is determined by the quality of the original studies.

b. There is a limited number of studies for certain environmental goods, therefore, the information is restricted.

c. The use of the benefit transfer method is limited to the need for precision in the welfare measures under.

Now, if the decision has been made to use the benefit transfer method for the policy site, then the choice between different TB methods depends on several factors, including: the type of information, the number of studies available, the type of value that is required, the similarity between the study site and the policy site, the level of expertise of the analyst, the time and resources available, and the accuracy needed for different types of policy decisions (Richardson et al., 2015; Loomis & Rosenberger, 2006).

Troy and Wilson (2006) clearly show how each application of the method is subject to variability in relation to limitations in available spatial data and economic valuation studies, as well as differences between site characteristics, spatial and temporal scale and management objectives. Paletto et al. (2015) conducted an assessment of ecosystem services in the Austrian Alps, using the benefit transfer method, but also a primary economic assessment, complementing the information to obtain a Total Economic Value. However, authors such as Morrison et al., (2002) pointed out that the Choice Experiments method is possibly the most suitable for Benefit Transfer because it allows accepting differences in environmental improvements between sites as well as in socio-economic characteristics between affected populations.

In addition, surplus trade-off estimates allow for a wide range of potential policy scenarios that can be calculated from the estimated choice models, i.e. this method is more flexible than contingent valuation (DeShazo and Fermo, 2002; Horne and Petajisto 2003; Colombo et al., 2005).

5.3.2. Case studies of the benefit transfer method

The benefit transfer method for valuation in an environmental context has become increasingly important over the years, the growing use of this method is due to an initial set of articles on the subject that appeared in a special issue of Water Resources Research in 1992. Some of the important applications of the benefit transfer method are by Rozan (2004) in France and Germany, Muthke and Holm-Muller (2004) who conducted a study on water quality improvement and Jiang, et al., (2005) who used the benefit transfer method as a tool for coastal soil management. Recent studies listed in Table 11 are oriented towards different aspects, but each has implemented the use of the benefit transfer method.

Table 7 Case studies that used benefit transfer as a valuation method

Biome	Method	Main advantages	Main disadvantages	Reference
River Aoos in Greece and Piave River in Italy.	Method of Transference of Benefits (MTB) (Experiment of Choice)	Evaluation and comparison of two different sites. They used use and non-use values.	More analytical work on primary valuation to increase the accuracy of secondary valuation methods.	Andreopoulos and Damingos, 2017
Viticulture lands in New Zealand Hawke's Bay and Marlborough	MTB (Experiment of choice)	Socio-economic variables that allow adjustment of willingness to pay. Assume all attributes except cost (triangular distribution) as random variables with normal distribution.	Respondents belong to the same region so the results show some similarities in terms of socio-economic interactions..	Baskaran, Cullen and Colombo, 2010
Cultural ecosystem service, in Norway: Sogn and Nordland	MTB	Cultural values particularly abundant in both regions. Spatial value transfer coefficients determined by the ecosystem value-vegetation cover relationship, which, in turn, influences value transfer outcomes between regions. Evaluated spatial value transfer results for six cultural ecosystem values using primary data collected in two different regions.	Cultural ecosystem services are often not valued because they are not adequately defined or integrated into the ecosystem services framework. Proxy variables must be used to be valued, however, the validity of these variables is often questioned. Limited range of circumstances in which transfer mapping may be appropriate.	Brown, Pullar and Hausner, 2016
Ecosystem services in China's Yangtze River economic belt	Tupu Geo-informatics Method	Valuation through the use of equivalent coefficients, based on the land use value and not on the regional biomass equivalence table, as they considered that it could generate deviations. Additionally they improved other studies, using the geo-informatics method Tupu.	The study is not complete, as it does not consider the heterogeneity of urban land uses.	Wanxu Chen, Hongbo Zhao, Jiangfeng Li, Lijun Zhu, Zheye Wang and Jie Zeng, 2019
4 regions in England:: North West, Yorkshire and Humberside, West Midlands and South West	MTB (Experiment of choice)	They examined the sensitivity of the transfer error. They considered a list of twelve landscape attributes and narrowed it down to five	Making use of more information by pooling data across multiple study sites does not always reduce transfer errors and can be economically inefficient.	Colombo and Hanley, 2008

Andreopoulos and Damingos (2017), obtained a likelihood ratio in the test statistic for comparing the parameters of the choice model between the two regions of 77.88. Furthermore, the critical chi-square value was 33.92 at the 5% significance level, a value well below that calculated in the test statistic. These results cause the hypothesis of parameter equivalence between the two models to be firmly rejected especially when considering scale differences. That is, the samples share different utility functions, therefore, the transfer of functions between populations and sites may lead to estimation errors.

Meanwhile Baskaran et al., (2010) applied the two-sided convolution test, which is used to examine the tolerance levels of transfer error in a policy context. They obtained a tolerance limit of 30% which did not indicate any transferability between sites and populations. The 50% and 80% tolerance limit may be too large to convince policy makers of the merit of benefit transfer. Furthermore, their results indicate that, for most attributes, the average absolute transfer errors of the mean values of welfare measures are in the range of 10-40%.

Chen et al., (2019), considered that the review based on regional biomass would lead to biases, particularly in terms of ecosystem service valuation (ESV) of water areas (Wang et al., 2018; Xie et al., 2017). They made modifications to that study to alleviate this error to some extent. This arrangement allowed their paper to be easily applied in other regions of the world, which would help with other research making use of benefit transfer. The estimates of ESVs in the study were consistent with the results of two previous studies (Chen et al., 2019; Ying et al., 2018) in terms of quantity. However, the assessment results in Chen et al., 2019 and Ying et al., 2018 showed fluctuating variations that increased during 1995-2005 and decreased during 2005-2015, and the assessment results in the Chen et al., (2019) study showed a continuous increasing trend during these two periods.

The main conclusion that emerged from the research by Colombo and Hanley, (2008) is that benefit transfer error is highly dependent on the selection of the study site(s) from which values are transferred. They reduced transfer errors by including three indicators of similarity (disposable income, land cover and geographical distance) in study site selection, however, no clear pattern emerged. It is difficult to design a sampling regime (in terms of site selection) that is efficient in minimising expected transfer errors. Although there is a requirement for similarity between the study site and the policy site, there are no clear criteria defining the concept of "similarity".

All or at least most research agrees that economic valuation relates directly to the conceptual framework that states that monetisation of ecosystem services should be a priority in decision-making (Atkinson et al., 2012). However, the variability found in the TB method and the differences in populations and ecosystems make it difficult to aggregate the results of different TB research. In addition, welfare, quality of life, social and cultural aspects must be considered (Haynes-Young & Potschin, 2013; Chan et al., 2012).

5.3.3. Benefit transfer methodology

In order to carry out benefit transfer, it is necessary to review databases for studies that will estimate the economic value of the site to be valued. In the case of function transfer, more information on the differences between the policy site and the study site and the effect on the population can be used. Some of the categories of information that should be considered in the search for the valuation of environmental services study are:

- Geographical characteristics and types of ecosystems valued.
- Economic measure and market characteristics
- Objective of the monetary quantification

To obtain the valuation of a policy site through the transfer of benefits, the studies used could have obtained their results through different methodologies: revealed preferences (RP), travel cost (CV), hedonic prices (PH), contingent valuation (VC), etc. In order to carry out the transfer the estimated benefit function is (Saldarriaga and Patiño, 2016):

$$DAP_{ij} = f(G_j, H_i) \quad (8)$$

Where:

DAP_{ij}: is the willingness to pay of population i for an environmental good at site *j*;
G_j: s the environmental characteristics of the good at site *j*; and
H_i: are the characteristics of population *i*.

This function can estimate the average WTP for the population at site j based on the aggregate measure for H_i.

Once the data are available for each independent group of variables G and H in the policy site described in the equation, the WTP of the population in the policy site is calculated (Rosemberger and Loomis, 2000).

Once the WTP values estimated by the various studies considered are available, the values are transferred to the study site using the purchasing power parity (PPP) adjustment. This adjustment for PPP is calculated from equation 9:

$$PPA2020 = \left(value\,\frac{DAP}{month}\right) * \left(\frac{IPCcountry\ under\ study\ 2020}{IPC\ ayear\ of\ study}\right) * \left(\frac{INB\ per\ capita\ Mexico\ 2020}{INB\ per\ capita\ country\ under\ study\ 2020}\right) * \left(\frac{1}{exchange\ rate}\right) * \left(exchange\ rate\ \frac{weights}{dolar}\right) \quad (9)$$

When the measures of central tendency and finally, a confidence interval is calculated to generate transfer values in two scenarios on the WTP estimate, in this case the upper and lower bounds are used.

Finally, as part of the method, a feasibility test is estimated to test the validity of the results obtained through the benefit transfer method (Rosenberger and Loomis, 2000). This assumes that the value estimated in the baseline study or developed at a certain study site is observable, or the study when calculating this value approximates the real value of the environmental asset.

In the application of the benefit transfer method Vpp is considered an estimated value, which refers to a value similar to the real value of the environmental asset. Vps is the value transferred to a different site, but with similar characteristics:

$$V_{ps} = V_{pp} + \delta_{ps} \quad (10)$$

Where:

V_{ps}: is the value transferred
V_{pp}: is the value of the environmental good
δ_{ps}: is the error associated with the transfer of benefits from site i to site j.

The empirical feasibility convergence test allows for the calculation of the percentage difference betweenV_{ps} and V_{pp}:

$$\%\Delta V_{ij} = \left[\frac{(V_{ps} - V_{pp})}{V_{pp}}\right] * 100 \quad (11)$$

Where i ≠ j,

Then the convergence measure of viability is δ_{ps}/V_{pp}.

There are two events that δ_{ps} contains and that can provide an answer to the transfer error:

Different characteristics between the study site and the policy site which can be denoted as ϕps and.

Errors associated with the estimation of V_{ps} by V_{pp}, which can be denoted as εi (Woodward and Wui, 2001).

Benefit transfer is an ideal option if one wants to obtain welfare measures, but does not have the resources to do a study with primary information.

Conclusions

Valuation of nature-related elements is a complex task. Unlike other valuations, it is necessary to define exactly what kind of value is to be obtained. The need for monetary allocation is due to the fact that as a market society, the importance of goods and services is primarily expressed in terms of their monetary value.

Environmental valuation is therefore an economic valuation. This means that one or more indicators can be used to highlight the importance of a site in the well-being of society, which allows us to compare it with other components of that well-being.

All methods of economic valuation of ecosystem services are relevant as they allow the importance of natural areas to be highlighted by giving a price to each element within the site to be valued.

The choice of whether to apply each of the above or other methods will depend on the type of value to be captured and the focus of the research depending on the site. However, factors such as: the information required for the study; the resources available for the analysis, whether financial, human or time, and the scale of the system at the study site, should not be overlooked in order to make the best decision on which method is the most appropriate to use in each case.

In order to optimise the use of valuation methods, it is necessary in each case to determine the factors that will define the analysis to be carried out, and in this way, depending on the scale of the study, a method or a range of valuation methods will be more or less appropriate for each particular case.

Finally, once a particular method or a suitable group of methods has been selected, its use, effectiveness, results and application are subordinated to what has been previously established in relation to the limitations, assumptions, methodology, etc., that each one presents.

Glossary

Environmental economics: Area of economics that quantifies in monetary terms the flows of inputs and services from ecosystems and the impacts on the environment resulting from human economic activities.

Physical indicators: Quantitative and qualitative physical measurement of natural resources.

Environmental economic indicators: Monetary quantification of physical indicators.

Species diversity: Population in which each gene flow occurs under natural conditions.

Ecosystem functions: Relationships between the different elements of an ecosystem.

Environmental goods: Tangible resources used by humans as inputs in production and final consumption, and which are expended and transformed in the process.

Environmental services: Ecosystem functions used by humans that generate economic benefits for humans and indirectly generate utility for the consumer.

Environmental impacts: Result or effect of one person's economic activity on the welfare of others (externalities).

Direct use value: The economic value of environmental goods and services for direct use, for the satisfaction of human needs.

Indirect use value: The economic value of environmental goods and services for some unobservable uses that make immediate quantification of the benefit difficult.

Total Economic Value: The sum of direct use value, indirect use value, option value and existence value. It is the opportunity cost of the resource if we exploit it without optimal use.

Option value: Potential future use of the resource.

Opportunity cost: The best alternative use of the resource that one gives up in order to carry out a specific project.

Economic valuation methods for EGS: Economic and statistical techniques used to quantify the costs and benefits generated by the use of EGS.

Externality: Economic term for environmental impact (negative or positive).

Payment for environmental services: The cost of conservation works is man's payment to nature to ensure the regeneration of the resource.

Willingness to accept compensation (WTA): The value of forgoing or avoiding the loss of an environmental benefit.

Willingness to pay (WTP): Quantifies the value of obtaining environmental benefits or avoiding their loss.

Study site: Location where an economic valuation study was conducted and primary information was obtained.

Policy site: Location of interest where the policy is to be applied (Benefit Transfer context).

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Table 1.1 Title

Variable	Descripción	Valor
V_V	Volumen de Venta	20000
P_V	Postura de venta	490.61
V_C	Volumen de Compra	20000
P_c	Postura de Compra	485.39
P^{Uh}	Precio último Hecho	491.61
V_o	Volumen Operado	1241979
P_u	Precio/Utilidad	0
P^{VL}	Precio/Valor Libro	0
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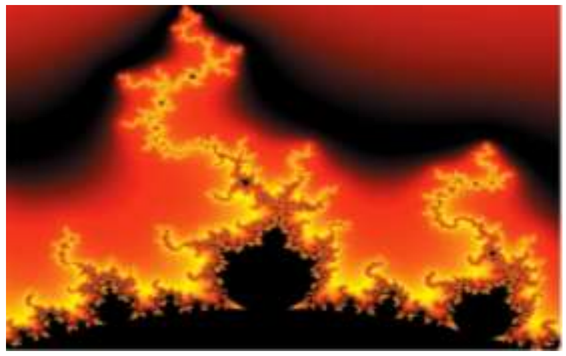

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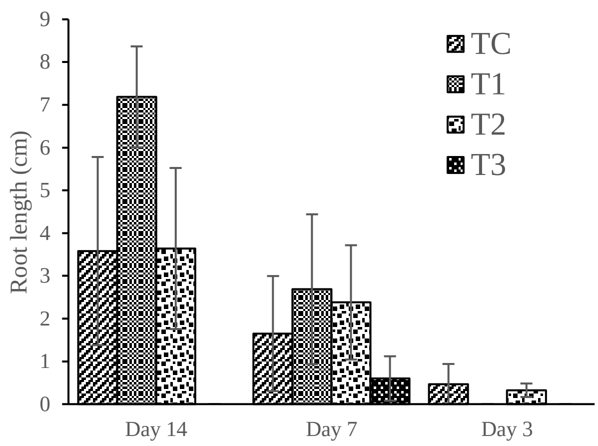

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