Analysis of different approaches and methodologies on valuation of forest ecosystem services in the pan-European region

Second Draft reflecting the comments provided by Expert Group members

1 Introduction to [~~valuation of~~] forest ecosystem services

Forests are important ecosystems delivering multiple benefits for society in the form of goods and services such as wood, food, clean water, energy, protection from floods and soil erosion, regulation of climate cycles, recreation and cultural values. These benefits are known as forest ecosystem services (FES). They play an important role in human well-being, make significant direct and indirect contributions to national economies and contribute to environmental stability (MA 2005).

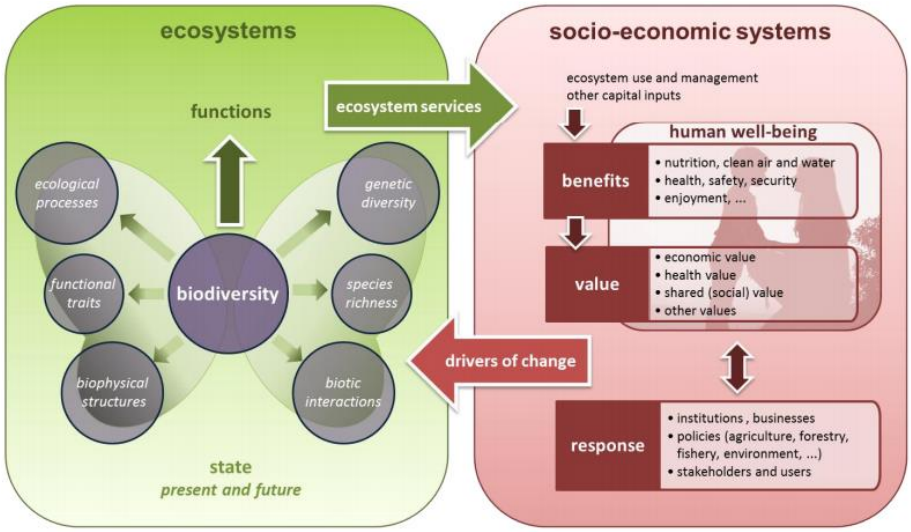
(Comment by LUB: Following the recommendations received from EC/JRC; EC/DG ENVI, supported by BG; original text referring to Millennium Ecosystem Assessment (2015) was replaced by a new one referring to MEAS concept)

[***New text:*** The Millennium Ecosystem Assessment (2005) was one of the first important global study on ecosystem services (ES) and its framework is widely accepted and seen as a useful starting point (Wallace 2007; Boyd, Banzhaf 2007; Fisher et al. 2009). However, more recently the Mapping and Assessment on Ecosystems and their Services (MAES 2013) framework was adopted by Member States of the European Union. It builds on the findings of the MA and TEEB global initiatives and was further refined as an operational framework at European level.

MAES (2013) defines ES as the benefits that people obtain from ecosystems - the direct and indirect contributions of ecosystems to human wellbeing (TEEB, 2010). The concept "ecosystem goods and services" is synonymous with ecosystem services. The service flow in the conceptual framework refers to the actually used service.

MAES, according to CICES (2013), classifies ES into three groups: Provisioning, Regulating/Maintenance and Cultural services. However, there are also other two international classifications of ES applied according to MA (2005) and TEEB initiatives (2010). Comparison of these main classification schemes was addressed by the former FOREST EUROPE Expert Group on Valuation of Forest Ecosystem Services during 2013-2014, and the results can be found in the FOREST EUROPE Final Report on Valuation of FES (2014).

The simplest version of the conceptual framework for EU wide ecosystem assessment (MAES 2013) links socio-economic systems with ecosystems via the flow of ecosystem services and through the drivers of change that affect ecosystems either as consequence of using the services or as indirect impacts due to human activities in general (Figure 1).(SK)]



[Figure 1 Conceptual framework for EU wide ecosystem assessments (MAES 2013)]

[***New text:*** Ecosystems are shaped by the interaction of communities of living organisms with the abiotic environment. Biodiversity - the variety of all life on earth - plays a key role in the structural set-up of ecosystems which is essential to maintaining basic ecosystem processes and supporting ecosystem functions. Ecosystem functions are defined as the capacity or the potential to deliver ecosystem services. Ecosystem services are, in turn, derived from ecosystem functions and represent the realized flow of services for which there is demand. For the purpose of this framework, ecosystem services also encompass the goods derived from ecosystems. People benefit from ecosystem (goods and) services. These benefits are, among others, nutrition, access to clean air and water, health, safety, and enjoyment and they affect (increase) human wellbeing which is the key target of managing the socio-economic systems. The focus on benefits implies that ecosystem services are open to economic valuation. However, not all benefits to people from ecosystems can be measured in monetary terms. Therefore, it is important to include other values as well, such as health value, social value or conservation value. The governance of the coupled socio-economic-ecological system is an integral part of the framework: Institutions, stakeholders and users of ecosystem services affect ecosystems through direct or indirect drivers of change. Policies concerning natural resource management aim to affect drivers of change to achieve a desired future state of ecosystems. Many other policies also affect these drivers and thus can be added to the framework as they have an impact on ecosystems even though they might not target them at all (e.g. through the construction of buildings or infrastructure, or industrial policy through pollution) (MAES 2013).

It can be stated, the MAES (2013) framework is successful in integrating the biophysical domain with the socio-economic drivers affecting ES and considers as well the role of biodiversity in ecosystem functions and services, therefore this is a good basis for consideration of European forests in terms of ecosystem service delivery and opportunity. (SK)]

[***Old text:*** ~~The Millennium Ecosystem Assessment (2005) was the first global study on ecosystem services (ESS) and its framework is widely accepted and seen as a useful starting point (Wallace 2007; Boyd, Banzhaf 2007; Fisher et al. 2009). MA (2005) defines ESS as the direct and indirect contributions of ecosystems to human well-being and classifies ESS into four groups: provisioning, regulating, cultural and supporting.~~

~~Besides MA (2005), also other two main classification systems of ESS are applied internationally i.e. Economics of Ecosystems and Biodiversity (TEEB 2010) and Common International Classification of Ecosystem Services (CICES 2013). Comparison of these main classification schemes was addressed by the former FOREST EUROPE Expert Group on Valuation of Forest Ecosystem Services during 2013-2014, and the results can be found in the FOREST EUROPE Final Report on Valuation of FES (2014).~~

~~The ESS concept encompasses not only the immediate outputs and contributions to quality of life that most people experience first hand as benefits, but also the biotic and abiotic processes that form and maintain the ecosystems that create the resource in the first place. The most widely used depiction of how ESS support human well-being is that proposed by MA (2005). The MA model for all ecosystems follows Costanza et al. (1997) in including both tangible and intangible services, from both natural and semi-natural ecosystems and the model shows how the constituents of human well-being rely upon the ESS (Figure 1).~~

~~Figure 1 The MA model of ecosystem services (MA 2005)~~

~~The inclusive nature of the model and the explicit links to well-being suggest this is a good basis for consideration of European forests in terms of ecosystem service delivery and opportunity.~~ (SK)]

[~~Why we should estimate values of forest ecosystem services?~~] / [Valuation of forest ecosystem services (SK)**]**

The importance or "value" of ecosystems is viewed and expressed differently by different disciplines, cultural conceptions, philosophical views, and schools of thought (Goulder, Kennedy 1997). [The basic for ES represents natural capital, which is defined by The Natural Capital Committee as "those elements of the natural environment which provide valuable goods and services to people" (NCC 2017). (SK)] One important aim of the Millennium Ecosystem Assessment is to analyse and as much as possible quantify the importance of ecosystems to human well-being in order to make better decisions regarding the sustainable use and management of ES. Valuation is used as a tool that enhances the ability of decision-makers to evaluate trade-offs between alternative ecosystem management regimes and courses of [~~social~~ (UK)] actions that alter the use of ecosystems and the services they provide (MA 2003).

The valuation of ES can provide input for decisions at many different levels (Turner et al. 2010). This ranges from national and international policy decisions to regional and sub-regional decisions and local planning decisions [and projects (UK)]. The challenge in each case is to identify all the ES that will be affected by the decision and to obtain sufficient information to conduct the ecosystem service assessment, including linking the assessment of changes in service provision to measures of changes in human welfare (DEFRA 2007).

There are a number of other reasons for undertaking valuation of FES. The most common are as follows (Merlo et al. 2005; FE 2014; Mavsar, Varela 2014,):

- to assess (and improve) the overall contribution of forests ecosystems to social and economic well-being,
- to obtain information about the relative importance of FES and preferences for their provision across and from different stakeholder groups and understand how and why stakeholders use forests as they do,
- to assess the relative impact of alternative actions, as a decision support tool,
- to identify potential winners and losers when adopting a certain management alternative,
- evaluating the impacts of environmental policies,
- establishing incentive schemes or markets of FES.

It should be also noted that [some kind of (DE)] valuation is [an implicit (DE)] prerequisite for developing mechanisms to capture benefits of the services and in establishing finance/incentive systems such as payments for ecosystem services (PES) (*Comment by UK: Not necessarily – many decisions are taken without valuation evidence*). PES covers a variety of financing arrangements through which the beneficiaries of ES pay the provider of those service (Gutman 2006), [thus offering incentives for protecting and supplying such services (DE)]. *(Comment by UK: natural capital angle is missing)* [Assessing the value of natural capital (elements of the natural environment that provide valuable goods and services to people), is fundamental to deciding how and where funds should be spent to restore, maintain and manage the natural environment (NCC 2017). (SK)]

A major challenge facing the delivery of the FES is that many of the services provided are not traded in markets, making it difficult to observe their values directly (FE 2014). [~~The most~~] /[Many (DE)] FES accrue to the recipients as public goods. [In practice, it's probably more of a continuum. Although, non-market goods may not all be pure public goods, but display some of the characteristics of public goods. (UK)] They may be enjoyed by any number of people without affecting other people's enjoyment. The problem with public goods is that, although people value them, no one person has an incentive to pay to maintain the good (Nasi et al. 2002; Šišák 1996, 1997, 1998, 2011).

Also, where these goods and services are supplied to either society or specific groups of users for free or at a price which is [~~far~~ (DE)] below the production costs of equivalent goods and services, forest owners receive little or no monetary incentive to provide them. This can result in declines in both the quantity and quantity of these services. Possible solutions include

applying regulations to enforce their provision or developing incentive mechanisms (including market-based instruments) which encourage woodland owners to provide them. Therefore, knowledge of how to estimate the [economic (DE)] value of these services is often a crucial step in providing evidence to support the introduction of such mechanisms (FE 2014). [Economic valuation in this sense relates to the demand side, i.e. preferences of society as a whole. For the supply side (forest enterprises), cost values count. As soon as both kinds of information are available, it is possible to establish "efficient" incentives for enterprises (forest owners). (DE, SK)]

(Comment by UK: It would be useful to have a short section in the report saying what economic value is, and what determines it e.g. see Binner et al, 2017). [According to Binner et al. (2017) the concept of economic value is based on the idea that value (or utility) is a human construct and that it provides a measure by which we might gauge what is the best for a human society. It is compatible with the idea that value may come from non-human entities, but only insomuch as they increase the well-being experienced by humans either by supporting our livelihoods, enhancing our existence or because of a sense of moral duty. Binnner et al. (2017) state, that the value flow from a FES is determined by at least two things:

- the FES's attributes, as determined by the environmental production function through which it is delivered,
- the context within which the FES are consumed, as determined by the other FES, FES and qualifiers that enter the human production function through which the FES delivers value.

Also the issue of aggregation has to be addressed in determining the economic value of a FES, because we need to add together the value flows accruing to all the individuals who gain benefit from that FES Binnner et al. (2017). (SK)]

[~~The concept of the Total Economic Value~~ (SK)**]**

Many [~~methods~~] / [frameworks (DE, UK)] are [~~used~~] / [discussed (DE)] to assign a monetary value to the benefits of forests ecosystems. [~~One has been used more than most for FES~~] / [A concept which is important in this context is that of the Total Economic Value (TEV) (DE)]. It has been developed in order to consider values, including non-use values, systematically and comprehensively. The study on the TEV of Mediterranean Forest (Merlo et al., 2005) is considered the first attempt at the comprehensive and systematic evaluation of FES in Europe (Mediterranean countries). This study filled a knowledge gap regarding the valuation of non-wood forest products (NWFPs) and provided a first estimate to the TEV including both NWFPs and wood forest products into a common framework.

The TEV approach is based on the different benefits that humans may obtain from forest ecosystems (Figure 2). The main aim of TEV classification, used in Pearce and Moran (1994) and Merlo et al. (2005), was to assess the overall contribution of forest ecosystems to "social and economic well-being."

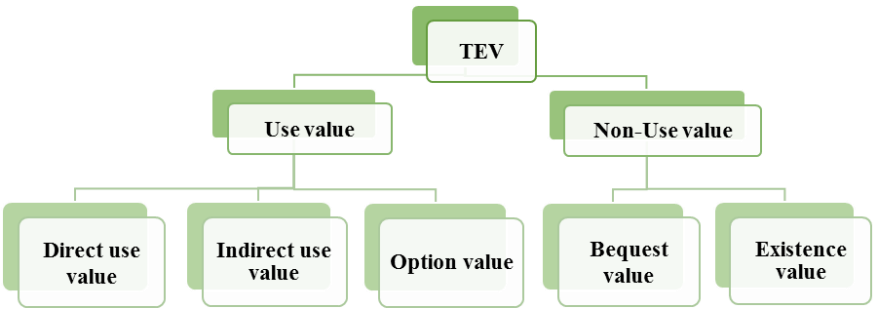


Figure 2 The Total Economic Value of the benefits of forest functions (Pearce, Moran, 1994; Merlo et al., 2005) *(Comment by LUB: examples were leaved out from the figure according to recommendations provided by DE)*

This framework typically disaggregates TEV into two categories: use values and non-use values (Pearce 1991; Groombridge 1992). [Traditionally the distinction between use and non-use values has been characterised as the difference between a value that is derived from physical interaction with a FES (use value) and one in which value is derived without physical proximity to or interaction with a FES (non-use values) (Binner et al. 2017). (SK)]

Use value refers to the value of ES that are used by humans for consumption or production purposes. It includes tangible and intangible services of ecosystems that are either currently used directly or indirectly, or that have a potential to provide future use values. The TEV separates use values as follows (DeFries, Pagiola 2005; Binner et al. 2017):

- direct use values are derived from FES that are used directly by humans. They include the value of consumptive and non-consumptive uses [~~Direct use values correspond broadly to the MA description of provisioning and cultural services~~ (DE, SK)] and they are typically enjoyed by people located in [or visiting (UK)] the ecosystem itself. [In other words, an environmental good or service generates direct value if it enters a human production function as a FES. (SK)]
- indirect use values are derived from a wide range of FES that provide benefits outside the ecosystem itself. [That means an environmental good or service generates indirect value if it contributes, through some biophysical process in an environmental production function, to the supply of some other FES.] / [~~This category of benefits corresponds broadly to the MA notion of regulating and supporting services~~ (SK)]
- the notion of option value introduced Weisbrod (1964). Option values are derived from preserving the option to use in the future services that may not be used at present (Krutilla, Fisher 1975), either by oneself (option value) or by others or heirs (bequest value). Quasi-option value is a related kind of value – it refers to the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay. This is to say that the information on value will only be revealed over time, mainly because there is uncertainty about the future value of a natural resource (Arrow, Fisher 1974).

  [As Binner et al. (2017) state, the distinction between direct and indirect values is important because it informs us as to when we can value an environmental good or service directly (as a FES) as compared to when we first have to understand the science of the biophysical process by which it contributes (as an intermediate environmental goods and services) to the production of FES. (SK)]

  Non-use values from ecosystems are those values that do not involve direct or indirect uses of ecosystem service in question. Humans ascribe value to knowing that a resource exists, even if they never use that resource directly. They reflect satisfaction that individuals derive from the knowledge that ES are maintained and that other people have or will have access to them (Kolstad 2000). In the first case, non-use values are usually referred to as existence values, while in the latter they are associated with altruist or bequest values. These kinds of values are the hardest and the most controversial to estimate. Non-use values involve greater challenges for valuation because they can be related to moral, religious or aesthetic properties, for which markets usually do not exist. This is different from other services, which are associated with the production and valuation of tangible things or conditions. Cultural services and non-use values in general involve the production of experiences that occur in the value's mind. These services are therefore co-produced by ecosystems and people in a deeper sense than other services (Chan et al. 2006).

  [However, Binner et al. (2017) pointed out, that the various categorisations (such as that under TEV) are just categories and that to a certain extent those attempts at categorisation are superseded by the ecosystem services approach's focus on environmental goods and services as arguments in human production functions. In short, an environmental good or service generates as many different values as there are human production functions to which it contributes. (SK)]

[~~Figure 3 captures the components of the total economic value of a forest. It clearly shows that the particularly important areas for forests, like biodiversity, carbon, and water are towards the less tangible end of the suite of direct-use benefits (EUSTAFOR, Patterson 2011).~~ (SK)]

[~~Figure 3 The components of the total economic value of a forest (Morton 1999)~~ (SK)]

2 Overview of valuation approaches and methods

In the last decades, valuation methods (VM) have reached a considerable degree of sophistication. The last decades have also witnessed a gradually emerging consensus on the state-of-the-art of the range of valuation methods at hand, which is reflected by the fact that recent handbooks and manuals on the topic provide very similar overviews and assessments of the individual tools, with differences remaining essentially on the level of terminology and classifications (Pagiola et al. 2004; de Groot et al. 2006; FE 2014; Plan Bleu, 2015).

The existing scientific literature on valuation of ES is based on two distinct foundations. [~~**The ecological valuation methods** derive values by following a cost of production approach~~.] (*Comment by DE: Not necessarily, there are various "ecological" valuation methods, which do not have anything to do with money, some of which are mentioned later in this text*) / [**The ecological valuation methods** aim to assess the significance of landscape characteristics. (SK)] Their common characteristic is the neglect of consumer preferences. **The economic valuation methods** focus on the exchange value of ES and their common characteristic is that they [~~are finally based on consumer preferences and do not adequately take into account the complex internal structure of ecosystems~~]. *(Comment by DE: not necessarily true e.g. for cost based methods)* / [do not address the complex internal structure of ecosystems (DE)]. The methods of economic valuation of ES are conventional economic valuation and non-monetizing valuation. A detailed historical overview can be found in various papers, e.g. Gómez-Baggethun et al. (2010) or Liu et al. (2010) (Figure 3).

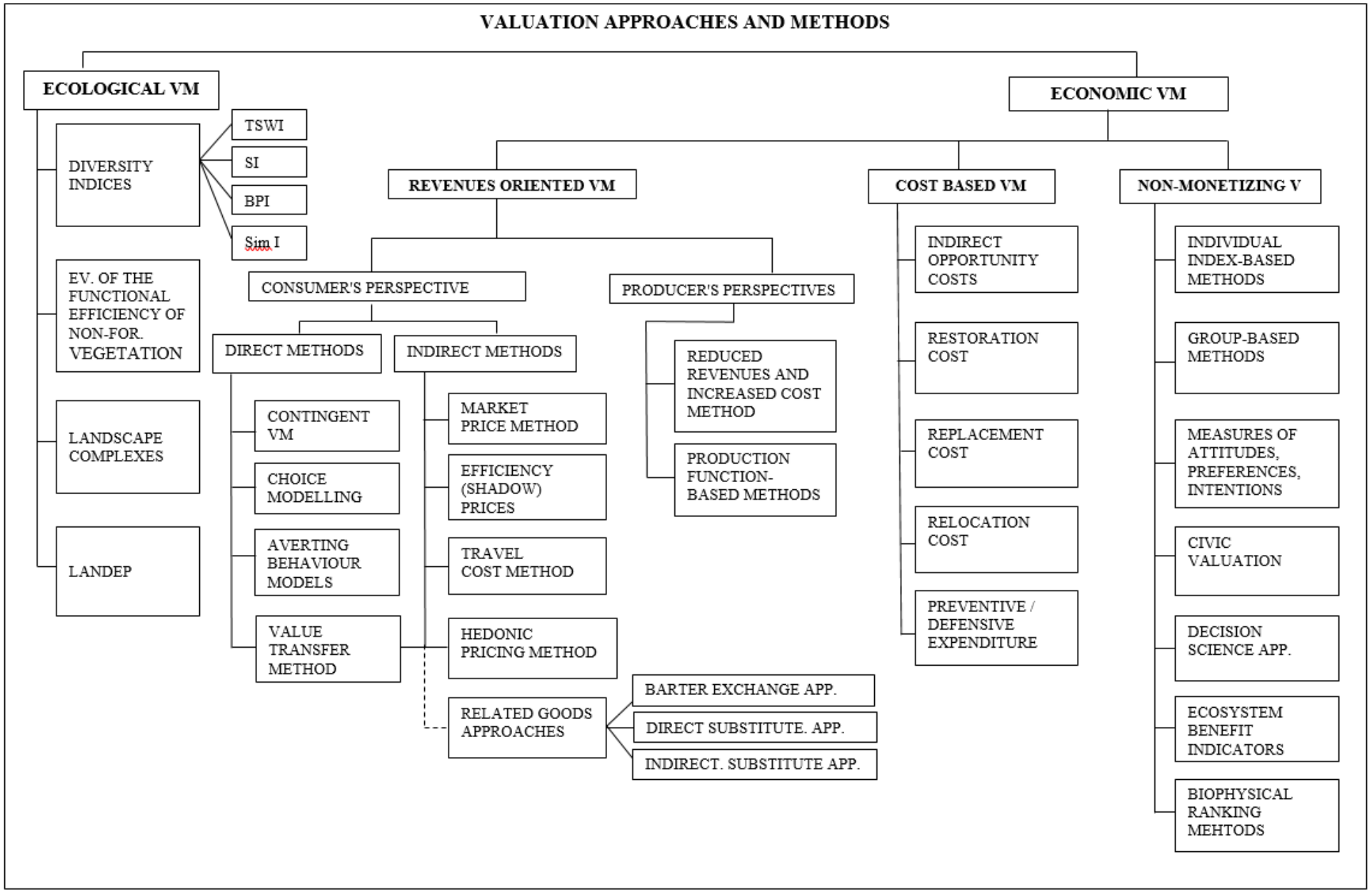


Figure 3 Overview of valuation approaches and methods *(Comment by LUB: Some methods under Revenues orientated VM were replaced according to comments received from Germany. Classification of valuation approaches and methods will be further discussed during EG meeting)*

TSWI - The Shannon–Wiener Diversity Index; SI - Simpson's Index; BPI - Berger–Parker Diversity Index; Sim I - Similarity indices VM – valuation method; APP. – approach; EV. – evaluation

There is also another [~~classification of~~] / [way to classify (SK)] economic valuation methods. A spectrum of non-market valuation techniques has been developed to value ES [~~including both non-monetary valuation methods and environmental economic techniques based on a monetary metric.~~ (SK, UK)]. *(Comment by UK: Confusing, both are monetary methods)* The use of a monetary metric assumes that individuals are willing to trade the ecosystem service being valued for other services represented by the metric. The [~~principle~~] / [basic (DE)] distinction among monetary valuation methods is based on the data source, that is, whether it derives from observations of human behaviour in the real world [("revealed preferences") (DE)] or from human responses to hypothetical questions [("stated preferences") (DE)] (Liu et al. 2010).

Economic valuation attempts to elicit [~~public~~] / [individual (DE)] preferences [within the general public (SK)] for changes in the state of the environment in monetary terms. These are based on the fundamental principles of welfare economics; whereby the changes in the well-being of individuals are reflected in their willingness to pay or willingness to accept compensation for changes in their level of use of a particular service or bundle of services (Hanley et al. 2001). The main types of economic valuation methods available for estimating public preferences for changes in ES are (DEFRA 2007):

- *Revealed preference* (RP) methods are based on actual observed behaviour data, including some techniques that deduce values indirectly from behaviour in surrogate markets, which are assumed to have a direct relationship with the ecosystem service of interest,
- *Stated preference* (SP) methods use carefully structured questionnaires to elicit individuals' preferences for a given change in a natural resource or environmental attribute. SP are based on hypothetical rather than actual data on behaviour; for the former the value is inferred from people's responses to questions describing hypothetical markets or situations (Figure 4).

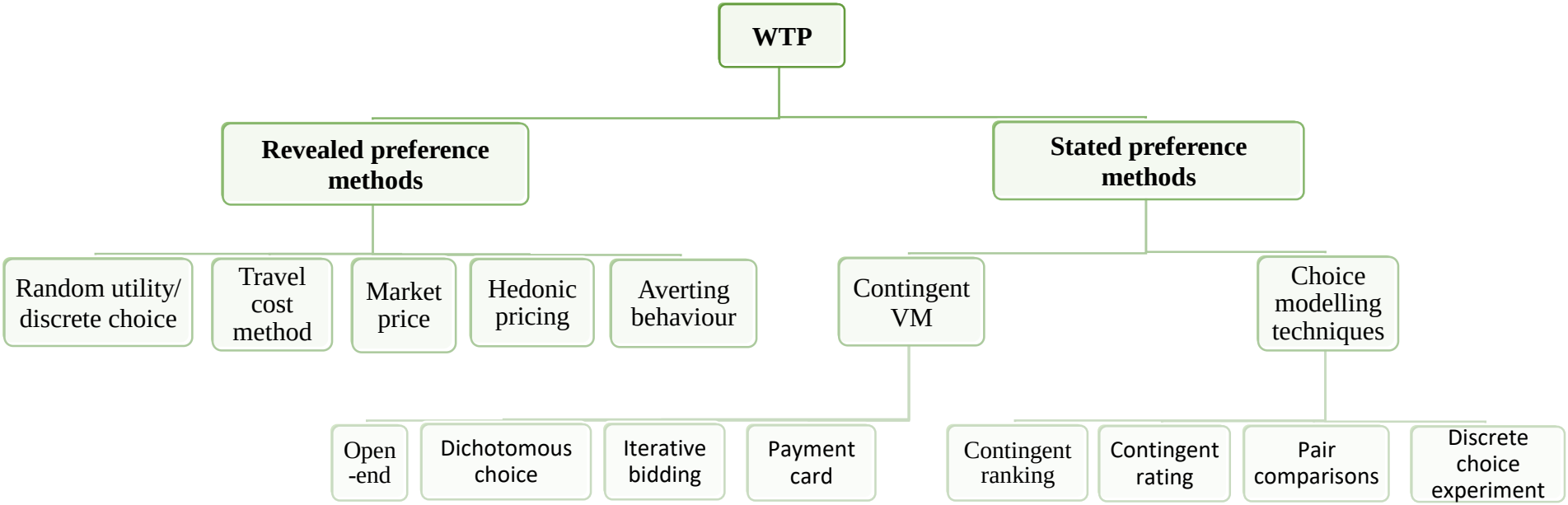


Figure 4 Economic valuation methods available for estimating public [~~public~~] / [individual] preferences (*Comment by DE: It may be confusing to use both figures 3 and 4. Suggestion to use figure 4 only)*

A/Ecological valuation methods

(Comment by DE: Consider the relevance of ecological methods for the work of the Expert Group)

Landscape ecological planning is an inseparable part of landscape ecology. It presents the application of the theoretical principles of landscape ecology for the solution of practical problems of ecologically optimum and sustainable development of mankind on Earth. The need for the development of landscape ecological planning is stressed by the growing problems arising from non-observance of natural rules and processes in the development of population and civilization processes (Sarvašová et al. 2014).

Landscape ecology methods use territory valuation and reflect the importance of the ecosystem service foremost in certain grades or relative units. They are based on an analytical and synthetic approach to landscape evaluation and its structure or elements on the basis of various landscape elements' (or ecosystems, geobiocenoses) inventory and their evaluation based on site conditions and relations to ecological stability (Izakovičová et al. 2008). Analytical evaluation is difficult (though feasible using landscape ecology indexes) and focuses on visual evaluation with discrete territory classification (e.g. on a scale 0–0,5–1). [~~It has been a major challenge for environmental/ecological economists to put price (monetary value) on many natural capital and ecosystem services~~ (SK)] (Gomez-Sal et al. 2003; de Groot et al. 2010; Spangenberg, Settele 2010; Chan et al. 2012; Baveye et al. 2013).

Various evaluation methods are used in landscape planning, such as:

Diversity indices - a diversity index is a mathematical measure of the species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundance of different species into account. The most commonly used are (Magurran 1988; Roth et al. 1994; Begon et al. 1996; Chao, Shen 2003; Sarvašová et al. 2014):

- *The Shannon–Wiener Diversity Index (H')* enables us to measure the diversity of the landscape. Its calculation takes into account the proportional representation of each type of land cover. The rate of the index increases when the number of various land cover types increases and/or if the proportional distribution of various land cover types is balanced,
- *Simpson's Index (γ)* is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the quantity of each species. It measures the probability that two individuals randomly selected from a sample will belong to the same species,
- *The Berger–Parker Diversity Index* is the proportion of the most common species in the community or sample. It is the simplest and most easily understood diversity index, since it only calculates the proportion of the commonest species in a sample,
- *Similarity indices* measure the similarity between communities based on species composition and are useful in comparing communities under different forms of management.

The evaluation of the functional efficiency of non-forest vegetation - non-forest vegetation is one of the significant components of the landscape structure that is important for humans' and other organisms' environment. It presents original, natural, semi-natural and synantrop or purposely human created communities (habitats). In the agricultural and urbanized landscape, these habitats provide various ES and therefore positively influence the improvement of its ecological stability. This landscape ecology method for landscape planning based on the site conditions and relations to ecological stability has been used by various authors, e.g. Múdry (1983); Ulrychová (1995); Rózová (1994); Sláviková (1987, 1990).

Landscape complexes - Míchal (1997a,b) proposes FES' valuation of the landscape on two levels:

1. typological classification (based on geoecological criteria) that focuses on the landscape as a set of ecosystems and how the history of ecosystems influenced by mankind is reflected in the landscape shape and arrangement,
2. land use, which is ecological and aesthetic valuation of ecosystems in a specific sense (foremost according to the environmental values or from the landscape scenery). Aesthetic valuation criteria are in principal social and take into account the share of subjective processes in phenomena evaluation.

Typing the area leads to the calculation of the ecological stability coefficient (CES) for individual cadastral areas [~~(the share of relatively stable ecological areas – forests, meadows, water areas, etc. and non-stable areas – built-up areas, arable land)~~] (*Comment by DE: Doubtful, e.g. one of the most "stable" areas is a desert. Nothing left to be destroyed*!) /. [for the purposes of lands consolidation according to the degree of their ecological stability. (SK)] In general, land use complexes with a low level of landscape values have a high need for new positive ecological and aesthetic values and thus greater ES.

Landscape Ecological Planning (LANDEP) - this conception brings to the fore the need for a multidisciplinary approach to landscape evaluation as an area in which the activities of man and society are developed on the bases of natural phenomena and processes. LANDEP is a widely drafted synthesis of knowledge of potential possibilities of ecologically optimum landscape utilization from the viewpoint of purposeful formation of the conditions for the conservation and development of healthy populations of organisms and humans and for the development of human society. From the methodological viewpoint, LANDEP is based on the analysis, interpretation, synthesis and evaluation of ecological features. The result of LANDEP is a proposal for ecologically optimum landscape utilization aimed at the harmonization of social activities in the landscape with its ecological features in time and space (Ružička, Miklós 1982; Karvonen 2000; Pitkänen et al. 2000; Sanderson et al. 2002; Mörtberg et al. 2007). *(Comment by DE: The methods mentioned in this paragraph are hardly compatible with welfare economic theory; some of the planning based methods are quite normative, some lack an empirical background. Therefore, consider to leave this part out.)*

B/Economic valuation methods

Economic values have been associated with forestry in the past, in keeping with the traditional orientation of forest management, which was towards production of timber and other products for the market. Market prices were thus considered to be the source of information determining the value of forest production. It is often incorrectly assumed that market price of a good or service measures its economic value. However, the market price only tells us the minimum amount that people who buy the good or service are willing to pay for it. [It may also only partially value a particular good or service (e.g. carbon prices do not reflect their social value). (UK)]

There has been an increased [realization of] / [demand for (SK)] a wide variety of goods (foods, fuels, medicines, fodder, and so forth) and services (land and water protection, amenity and aesthetics, biological diversity, influence on the biosphere, and so forth) [by humans (SK)]; however, [~~the traditional valuation~~] / [market based (DE, SK)] / [market price] UK)] methods cannot capture many of those goods and services which are non-marketed, or intangible, or relate to benefits derived outside the forestry sector or to influences on it that are external. The relevance of these goods or services at the local level must be identified; however, the relevance of others is of a wider nature such as encompasses the national, transboundary regional or global level.

There are no absolute values, as they are based on perceptions by individuals and groups which are subject to dynamic changes in their situation, needs and aspirations. These perceptions in the particular case of forests have been evolving rapidly in recent years with the broadening of

interests, the increasing number of interest groups, the diversity of perceptions by different groups and the awareness of the wide range of goods and services provided by forests at local, regional, national and global levels. Furthermore, values involve costs and benefits whose distribution among interest groups is often a significant element in terms of its political nature and of making decisions. The social and environmental impacts may also change rapidly and the direction of change may be different for the various groups affected (UNECE 1996).

Economic valuation (based on the concept of economic value) is essentially anthropocentric – that is, it stresses values that bring benefits to human beings, either directly or indirectly – and is preference based. Many also consider that forests have intrinsic value independent of human preferences; consequently, the question of their impact on human well-being emerges. However, while the importance of other value notions should not be downplayed, their operationalisation is very difficult and in that respect the concept of economic value offers significant advantages (European Commission 2008).

It is important to stress that economic value measures are useful in comparing and making decisions on [marginal (DE)] changes, in other words, in prioritizing practical action including alternative uses of forests as well as investments and, ultimately, change in land use [within limited areas (DE)] (UNECE 1996). [On the other hand, a point that should be discussed is the reliability of valuation methods and sometimes high uncertainty implicit in the results of these methods. There could be the case that different valuation methods provide divergent results, therefore using only one method could bias decisions.(EC/JRC)]

Valuation might also be required for setting levels of possible compensation to those who are obliged to conserve forests beyond their own needs or to refrain from using their full production potential. The valuation approach will therefore be shaped by the decision-making context within which the information is to be used and will focus on answering the basic questions when comparing a proposed change with the status quo. [~~In a case where no change is envisaged, valuation measures are not required for other than curiosity purposes~~ (EC/DG ENVI)] (UNECE 1996). [Knowing the value of the ecosystem services provided by a forest could also simply confirm or even reinforce the need to protect and conserve it and change peoples´ perception of that forest. Therefore, it always has practical implications which go beyond curiosity purposes or scientific interest. (EC/DG ENVI)]

In the following section, different approaches and methods for economic valuation of forest ecosystem services are broadly described.

B1/Revenues oriented valuation methods

Contingent Valuation Method (CVM) – CVM is a questionnaire based technique that seeks to discover individual preferences for an environmental change. It uses one of two measures of consumer's surplus: compensating variation (CV) or equivalent variation (EV). CV is the amount of [~~payment~~] / [money (DE)] or (change in income) necessary to make an individual indifferent with respect to an initial situation and a new situation with different prices. EV may be viewed as a change in income [~~equal to a gain in welfare resulting from a change in price~~] / [equivalent to a change in welfare after a change in prices has occurred. (DE)]. [~~This method~~] / [CVM (DE)] is used to estimate the consumer's WTP for a specified good or service, or [his/her (DE)] WTA compensation for [~~receiving an undesired~~] / [forgoing a desired (DE)] good or service. In practice, it is usually derived from the responses of potential consumers to a hypothetical exchange situation (UNECE 1996).

The method assumes that the consumer's expressed WTP in a hypothetical situation is a [~~measure of the value~~] / [utility indicator (DE)] to the consumer in an actual situation. The basic premise of the contingent valuation method is that individuals are sensitive to a given environmental change and that their preferences could be measured in terms of their WTP to undergo (or their WTA a compensation to avoid) this change. Therefore, the given change is presented to individuals through a survey where the environmental change is presented and where people are directly asked to state their WTP or their WTA the given environmental change (Plan Bleu 2015).

- *Suitability for the FES to be valued* – all forest services
- *Benefits of the method* (FE 2014; Plan Bleu 2015):
  - Measurement of non-use values possible (to provide a true measure of TEV)
  - Valuation of future goods and services possible
  - The use of surveys allows to collect relevant socioeconomic and attitudinal data on the respondents that could be relevant for understanding the variables influencing social preferences and choices
  - The use of surveys allows to estimate hypothetical changes and their impact before they have taken place
  - Participative/deliberative approaches before valuing the good or service at stake seem to provide with more stable results
- *Limitations of the method* (FE 2014; Plan Bleu 2015):
  - Results sensitive to numerous sources of bias in survey design and implementation
  - Preferences for non-use values tend to be less stable
  - Budget and time demands are high
  - [~~High risk of biases that may lead to inaccurate WTP estimations (DE)~~] *(repetition)*

The most used variants of CVM [are Open-ended, Dichotomous or Polychotomous choice, Iterative bidding game, Payment card etc. (SK)](Bateman, Turner 1992).

[~~*Open-ended* - respondents are asked "how much are you willing to pay?". So, the person states the amount money. Thus, the result is a continuous bid variable that may therefore be analysed using ordinary least squares approaches (OLS).~~

~~- *Dichotomous or polychotomous choice* - instead of open questions the respondents are asked whether they would pay a certain amount. Dichotomous choice allows only for "yes" and "no" answers, polychotomous choice provides more options such as "probably pay", "certainly pay" or "not sure". Questions can be single-bounded, where only one question is asked, or multiple-bounded, where follow-up questions with higher or lower amounts, depending on the initial reply, are asked.~~

~~- *Iterative bidding game* - submit to respondents different rounds of discrete choice questions or bids, with a final open-ended WTP question. They may suffer from lack of incentive compatibility and starting point bias, and fatigue effects.~~

- ~~*Payment card* - card indicates range of possible values, one of which is pointed out by interviewee. Respondents may have problems of starting point bias~~.] *(Comment by DE: Too much technical details. There are even more possible variants. Skip this)*

Choice modelling – attempts to [~~model the decision process of an individual in a given context~~] / [determine the WTP of an individual by analysing his choices between different alternatives (DE)] (Hanley, Wright 1998; Philip, MacMillan 2005). Individuals are faced with two or more alternatives with shared attributes of the services to be valued, but with different levels of attribute (one of the attributes being the money people would have to pay for the service). The alternatives are designed so that the respondent's choice reveals the marginal rate of substitution between the attributes and the item that is trade off (e.g. money) (Pascual, Muradian 2010).

The basic premise of the choice experiment is that a forest good or service can be decomposed in a bundle of attributes or features and that individuals are sensitive to changes in these attributes. Therefore, individuals are asked through a survey to state their willingness to pay to undergo these changes (Plan Bleu 2015).

- *Suitability for the FES to be valued* – all forest services
- *Benefits of the method* (FE 2014; Plan Bleu 2015):
  - Measurement of non-use values possible (to provide a true measure of TEV)
  - Valuation of future goods and services possible
  - Valuation of several goods/services at the same time (including their trade-offs)

- The use of surveys allows to collect relevant socioeconomic and attitudinal data on the respondents that could be relevant for understanding the variables influencing social preferences and choices
- The use of surveys allows to estimate hypothetical changes and their impact before they have taken place
- Participative/deliberative approaches before valuing the good or service at stake seem to provide with more stable results

- *Limitations of the method* (FE 2014; Plan Bleu 2015):
  - High data requirements
  - Analysis mathematically complicated
  - Interpretation not straightforward for lay people
  - Preferences for non-use values tend to be less stable
  - Budget and time demands are high
  - High risk of biases that may lead to inaccurate WTP estimations

The most used variants of choice modelling (Hanley et al. 2001):

- *Contingent ranking* - respondents are required to rank a set of alternative options, characterised by a number of attributes, which are offered at different levels across options. A status quo option is normally included in the choice set to ensure welfare consistent results.
- *Contingent rating* - exercise respondents are presented with a number of scenarios and are asked to rate them individually on a semantic or numeric scale. This approach does not involve a direct comparison of alternative choices and consequently there is no formal theoretical link between the expressed ratings and economic choices.
- *Pair comparisons* - exercise respondents are asked to choose their preferred alternative out of a set of two choices and to indicate the strength of their preference in a numeric or semantic scale. This format is also known as graded or rated pairs.
- *Discrete choice (stated choice) experiment* - respondents are presented with a series of alternatives, differing in terms of attributes and levels, and asked to choose their most preferred. A baseline alternative, corresponding to the status quo or "do nothing" situation, is usually included in each choice set. This is because of the options must always be in the respondent´s currently feasible choice set in order to be able to interpret the results in standard welfare economic terms.

(Comment by LUB: Suggestion of UK to place Averting behavioural models under monetary valuation methods. It was originally marked as "other approaches") **Averting behaviour models –** are based on the presumption that people will change their behaviour and invest money to avoid an undesirable [~~health~~ (DE)] outcome. Thus, averting behaviour analyses the rate of substitution between changes in behaviour and expenditures on and changes in environmental quality in order to infer the value of certain non-marketed environmental attributes (Dickie 2003). This models are similar to the travel cost method and hedonic pricing, but they differ as they use as a basis individual behaviour to avoid negative intangible impacts as a conceptual base. However, the situation is complicated by the fact that these market goods might have more benefits than simply that of reducing an intangible bad. Averting behaviour occurs when individuals take costly actions to avoid exposure to a non-market bad. It is needed to take account the fact that valuing these alternative actions might not be a straightforward task, for instance, if time which would have been spent doing one thing is instead used to do something else, not only avoiding exposure to the non-market impact in question, but also producing valuable economic outputs (Hadley et al. 2011).

- *Suitability for the FES to be valued –* [~~health protection~~ (DE)] / [regulating services (SK)]
- *Benefits of the method:*

- Has a sound theoretical basis
- Uses data on actual expenditures and data requirements can be modest

- *Limitation of the method:*
  - Not a widely used methodology
  - Can only estimate use values
  - Limited to cases where households spend money to offset environmental hazards/nuisances
  - Confined to cases where those affected are aware of the environmental issue and act because of them
  - Appropriate data may be difficult to obtain

[~~**Benefit**~~ (UK)] **Value transfer method –** [it is not a straightforward direct method, because it would also be possible to transfer results from indirect methods. (SK)] It is used to estimate economic values for ES by transferring the available information from studies already completed in another location and/or context (Sarvašová et al. 2014). Value transfer method is not a valuation method as such, but it is a method that involves transferring economic estimates from previous studies of similar changes in environmental quality to value the environmental change at the policy site. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context (Plan Bleu 2015). There are two main forms of the value transfer method (Navrud, Ready 2007):

(i) Unit Value Transfer - it is the simplest method which builds on the transfer of actual value estimates from other studies, appropriately adjusted for inflation, the differences in purchasing power of income across regions and, in some cases, the income variation.

(ii) Function Transfer approach - it is more ambitious and suggests transferring value functions from other studies. The benefit function statistically relates people willingness to pay to ecosystem characteristics and the people whose values were elicited

- *Suitability for the FES to be valued* – all forest services, however, it was showed that it is more reliable for transferring use values.
- *Benefits of the method* (Plan Bleu 2015):
  - Typically less costly than conducting an original valuation study
  - Economic benefits can be estimated more quickly than when undertaking an original valuation study
  - The method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted
  - [~~The method can easily and quickly be applied for making gross estimates of recreational values. The more similar the sites and the recreational experiences, the fewer biases will result~~ (DE)] (*Comment by DE: Method is possible for all kinds of services. Why to stress recreation?*)
- *Limitations of the method* (Plan Bleu 2015):
  - [~~Benefit~~]Value transfer may not be accurate, except for making gross estimates of recreational values, unless the sites share all of the site, location, and user specific characteristics
  - Good studies for the policy or issue in question may not be available
  - It may be difficult to track down appropriate studies, since many are not published
  - Reporting of existing studies may be inadequate to make the needed adjustments
  - Adequacy of existing studies may be difficult to assess
  - Extrapolation beyond the range of characteristics of the initial study is not recommended
  - [~~Benefit~~] Value transfers can only be as accurate as the initial value estimate
  - Unit value estimates can quickly become dated

Market price method – it estimates the economic value of ecosystem goods or services that are bought and sold in markets. The market price method can be used to value changes in either the quantity or quality of a good or service. It uses standard economic techniques for measuring the economic benefits from marketed goods and services, based on the quantity people purchase at different prices, and the quantity supplied at different prices. [~~Market price represents the value of an additional unit of that good or service, assuming the good or service is sold through a perfectly competitive market.~~] (*Comment by DE: Not for those consumers whose WTP is above/below the market price*) The standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using the market price and quantity data (Plan Bleu 2015; UNECE 1996; Sarvašová et al. 2014).

[~~This method is used when the actual market for the valued good or service exists. Where market values exist, they should be preferred to any other valuation technique.~~ *(Comment by UK: Carbon prices for example do not currently reflect the true value of a tone of carbon. Market prices can be heavily distorted)* ~~However, it should be remembered that market prices represent only a lower range estimate of value; some people may in fact be prepared to pay much more than the market price (European Commission 2008).~~ (*Comment by DE: "Market price method" compatible to CVM/TCM approaches would not simply use market prices – rather it would observe quantity changes due to price changes, and construct a demand curve (and thus, consumer surplus) from this information. These two concepts seem to be confounded here.*)]

- *Suitability for the FES to be valued* – all marketable services
- *Benefits of the method* (FE 2014; Plan Bleu 2015):
  - People's values are likely to be well-defined as it reflects an individual willingness to pay for costs and benefits of goods or services that are bought and sold in markets
  - Data availability
  - Uses observed data of actual consumer preferences
  - Uses standard, accepted economic techniques.
- *Limitations of the method* (FE 2014; Plan Bleu 2015):
  - Market data only are available for a limited number of goods and services
  - True economic value of goods or services may not be fully reflected in market transactions
  - Seasonal variations and other effects on price must be considered
  - Cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service
  - Usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits
  - [Some goods/services of forests are not directly used by consumers, but by producers, and undergo further processing before entering the consumer sphere; therefore "consumer surplus" is simply not observable even if there are markets data available (e.g. timber) (DE)].

Efficiency (shadow) prices - The market price does not necessarily mean the "proper" price and/or reflect the true economic efficiency price. There are market and policy failures that can distort market prices. Market failures [~~concern~~] / [refer (UK)] to the inability of market prices, under certain conditions, to reflect accurately the value of environmental goods or services. Policy failures concern instances where government policies have unintended effects, or sometimes even side-effects or cause resource-use behaviour inappropriate from a societal perspective.

In financial analysis, no account is taken of any of these failures that distort market prices. Therefore, it is advisable to look at their economic value in order for their value to society as a whole to be reflected, as in the case, for example, of alternative forest land uses. To do so, the market price is adjusted. There are various methods for correcting market and policy

distortions. A variant of the market price-based method uses shadow prices (market prices adjusted for transfer payments, market imperfections and policy distortions). Shadow prices may also incorporate distribution weights, where equality concerns are made explicit. [~~This variant is generally applicable as shadow prices may also be calculated for non-marketed goods~~] (*Comment by DE: There is a contradiction with statement below*) (UNECE 1996).

- *Suitability for the FES to be valued* - goods and services that are traded in [domestic or international (SK)] markets [and it may also be calculated for non-marketed goods (SK)]
- *Benefits of the method:*
  - reflect the true economic value (opportunity cost) to society as a whole [~~for ESS traded in domestic or international markets~~]
- *Limitations of method* (UNECE 1996):
  - Derivation of shadow price is complex and may require substantial data
  - Decision-makers may not accept what they might consider to be artificial prices
  - Market prices are often more readily accepted by decision makers than artificial values derived by the analyst
  - Market prices are generally easy to observe, both at a single point and over time
  - Market prices reflect the decision of many buyers, whereas calculating shadow prices often relies on the objectivity of judgement of the analyst
  - The procedures for calculating shadow prices are rather imperfect and therefore estimates can, in certain cases, introduce larger discrepancies than even the simple use of imperfect market prices
  - Each case should be analysed within the context in which the valuation is being made, and should take into account the data and resource constraints. There cannot be a simple blueprint for every case.

Travel Cost Method (TCM) – derives willingness to pay for environmental benefits at a specific location by using information on the amount of money and time that people spend to visit the location. It is based on the rationale that recreational experiences are associated with a cost (direct expenses and opportunity costs of time). The value of a change in the quality or quantity of a recreational site (resulting from changes in biodiversity) can be inferred from estimating the demand function for visiting the site that is being studied (Bateman et al. 2002; Kontoleon, Pascual 2007)

This method assumes that the value to the consumer is at least equal to the travel costs the consumer is willing to incur to obtain the desired good or service. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples' willingness to pay for a marketed good based on the quantity demanded at different prices (Plan Bleu 2015).

- *Suitability for the FES to be valued* – recreational services
- *Benefits of the method* (FE 2014; Plan Bleu 2015):
  - Similar to more conventional approaches to estimate economic values based on market prices
  - Based on actual behaviour and therefore more reliable that methods based on hypothetical behaviour of the respondents
  - On-site surveys provide opportunities for large sample sizes.
  - Results are relatively easy to interpret and explain
  - Relatively inexpensive to apply
- *Limitations of the method* (FE 2014; Plan Bleu 2015):
  - Value of time can be problematic, because the time spent traveling could have been used in other ways. It has an "opportunity cost"
  - Assumption that people respond to changes in travel costs the same way that they would respond to changes in admission price might not always be true
  - Limited in its scope of application because it requires user participation

- Standard approaches provide information about current conditions, but not about gains or losses from anticipated changes in resource conditions
- The simplest travel cost models assume that individuals take a trip for a single purpose
- The availability of substitute sites will affect values

The modern variants of travel-cost models are known as **Random utility/discrete choice models** (RUMs). Random utility models arise from the empirical assumption that people know their preferences (utility) with certainty, but there are elements of these preferences that are not accessible to the empirical observer (Herriges, Kling 1999; Parsons 2003). Thus, parameters of peoples' preferences can be recovered statistically up to a random error component. This econometric approach is used to estimate modern travel-cost models.

- *Suitability for the FES to be valued* - recreational services
- *Benefits of the method (NRC 2004):*
  - Uniquely designed to estimate values for attributes of recreation sites, which include the quantity and quality of the ES
  - The best approach to use to estimate benefits for specific characteristics, or quality changes, of sites, rather than for the site as a whole
  - The most appropriate approach when there are many substitute sites
- *Limitations of the method* (Grünigen 2016):
  - Data needed not only from one site but also concerning all other sites
  - Econometric models are more complex

Hedonic pricing method - relies on market transactions for differentiated goods to estimate the economic benefits or costs associated with environmental quality. The basic premise of the hedonic pricing method is that the price of a marketed good is related to its characteristics, or the services it provides (Rosen 1974). It is based on the assumption that goods can be considered aggregates of different attributes, some of which, as they cannot be sold separately, do not have an individual price (FE 2014).

It utilizes information about the implicit demand for an environmental attribute of marketed commodities. For instance, houses or property in general consist of several attributes, some of which are environmental in nature, such as the proximity of a house to a forest or whether it has a view on a nice landscape. Hence, the value of a change in biodiversity or ES will be reflected in the change in the value of property (either built-up or land that is in a (semi-) natural state). By estimating a demand function for property, the analyst can infer the value of a change in the non-marketed environmental benefits generated by the environmental good (Plan Bleu 2015).

- *Suitability for the FES to be valued* - air pollution, water pollution, noise, cultural services (aesthetic views) and recreational services
- *Benefits of the method* (FE 2014; Plan Bleu 2015):
  - May be conducted with already existing data (no separate data collection costs)
  - Can be used to estimate values based on actual choices
  - Property markets are relatively efficient in responding to information, so can be good indications of value
  - The method is versatile, and can be adapted to consider several possible interactions between market goods and environmental quality
  - Property records are typically very reliable
- *Limitations of the method* (FE 2014; Plan Bleu 2015):
  - It can be applied only in presence of a good number of market exchanges, as the model representing the market requires a certain number of good quality data
  - The market must be sufficiently transparent
  - Scope of environmental benefits that can be measured is mainly limited to things that are related to housing prices, it is not possible to estimate the TEV of the

environmental good, but only the value connected to present and, with some caution, future uses
- Only captures people's willingness to pay for perceived differences in environmental attributes, and their direct consequences
- Assumes that people have the opportunity to select the combination of features they prefer, given their income
- Results depend heavily on model specification
- Large amounts of data must be gathered and manipulated
- Relatively complex to implement and interpret, requiring a high degree of statistical expertise
- Time and expense to carry out an application depends on the availability and accessibility of data
- [The respective price records usually aren't very reliable (DE)]

Related goods approaches – (*Comment by DE: Can be count as separate methods – rather these are pragmatic approaches in order to surmount lack of data*). A non-marketed good or service may be related to a marketed good or service. By using information about this relationship and the price of the marketed product, the analyst may be able to infer the value of the non-marketed product. This broadly defined related goods approach consists of three similar valuation techniques (UNECE 1996):

(i) *Barter exchange approach* - There are many forest products that are not widely traded in formal markets, for example, wild fruits, nuts and vegetables, medicines and structural fibres. However, some of these forest products may be exchanged on a non-commercial basis through a process of barter. If the bartered good that is exchanged for the forest product is also sold in a commercial market, then it may be possible to derive the value of the non-marketed good using information on the relationship (that is, the units of exchange) between the two goods and the market value of the commercial good. As with all valuation techniques, care must be taken in applying this approach. Bartering may occur in an "imperfect" non-commercial market and the rate of exchange may reflect a wider range of socio-economic factors than just the value of the goods exchanged. There are few, if any, studies that have attempted to infer the value of a forest product from the marketed value of a bartered good. However, this should not exclude the technique from being considered a potentially useful valuation approach, especially in developing countries where bartering is common.

(ii) *Direct substitute approach* - if forest goods used directly are non-marketed, then the value of their use may be approximated by the market price of similar goods or the value of the next best alternative/substitute good. The extent to which the value of the marketed good reflects the value of the non-marketed good depends, to a large extent, on the degree of similarity or substitution between the two goods. That is, if the goods are perfect substitutes then their economic values should be very close. As the level of substitution decreases, so does the extent to which the value of a marketed good can be taken as an indication of the non-marketed forest good. Once again, market imperfections may distort the economic value of the good or service reflected in the market-place.

(iii) *Indirect substitute approach* - if the value of the substitute good cannot be determined directly from the market then it may be possible to derive its value indirectly, by analysing the change in value of economic output caused by a change in the use of the substitute good as an input into production. However, the indirect substitute approach is necessarily based on fairly stringent assumptions about the level of substitution between the two goods, the role of the substitute good as an input into economic output, and the value of the economic output. This technique is also fairly data-intensive. Given the tenuous link between the item being valued

and the actual valuation procedure and the heavy data requirements, this approach can be expected to provide only rough indications of value.

Reduced revenues and increased costs method – it is based on valuing the compensation requirements for the production of public goods, which are reflected in reduced revenues and increased costs (Sarvašová et al. 2014).

Production function-based methods - estimate how much a given ecosystem service contributes to the delivery of another service or commodity which is traded on an existing market. That means, this approach is based on the contribution of ES to the enhancement of income or productivity (Patanayak, Kramer 2001). The idea thus is that any resulting "improvements in the resource base or environmental quality" as a result of enhanced ES, "lower costs and prices and increase the quantities of marketed goods, leading to increases in consumers' and perhaps producers' surpluses." (Pascual, Muradian 2010).

- *Suitability for the FES to be valued* – applicable to regulating and supporting services
- *Benefits of the method* (Pascual, Muradian 2010):
  - Improvement in resource base or environmental quality, i.e. enhanced ES, lowers costs and prices or increases quantity of goods
  - Use data from actual markets, and thus reflect actual preferences or costs to individuals
  - Data are relatively easy to obtain
- *Limitations of the method* (Daily 1997; Pascual, Muradian 2010):
  - Requires knowledge of relationships between ecosystems services and valued end points
  - Adequate data on and understanding of the cause-effect linkages between the ecosystem service being valued and the marketed commodity are often lacking
  - Rarely understood well enough to quantify how much of a service is produced, or how changes in ecosystem condition or function will translate into changes in the ES delivered
  - The interconnectivity and interdependencies of ES may increase the likelihood of double-counting ES

B2/Cost based valuation methods

(*Comment by UK: These methods may not reflect the full value of a good or service*)

Indirect opportunity costs - is used to calculate the value of non-market environmental goods when individual labour is involved in harvesting or collection. The basic assumption of this technique is that the decision to spend time in the collection and harvesting of, for example, Non-timber forest product (NTFP) is weighed against alternative productive uses of labour. However, in many cases, it is almost impossible to assess how much labour is used for collecting NTFPs. These "user cost-based techniques" suffer from the same deficiency - what something is worth has no necessary relationship to the costs involved to produce it. The fact that it is hard to estimate the users' cost to produce, for such joint products as NTFPs in the informal sector, makes this technique somewhat dubious (UNECE 1996).

Restoration cost - uses costs of restoring ecosystem goods or services (Pascual, Muradian 2010). It is based on the idea that given an alternative land-use option the non-marketed benefits provided by an intact ecosystem or the particular goods and services provided by such an ecosystem can be measured by estimating what it would cost to re-create the original ecosystem (or environmental good or service). The assumption is that by restoring the original ecosystem the original level of benefits will be restored (UNECE 1996).

In the case of primary forests, this method would involve costing the restoration of the original forest cover. Clearly, this is not something that, even with active intervention in silviculture and forest management, could be concluded quickly if it could be accomplished at all. Such considerations suggest that the technique is unlikely to prove useful (UNECE 1996).

- *Suitability for the FES to be valued* – provisioning services (non-wood forest products, water, raw material), regulation services (water regulation, water purification and waste treatment, soil formation), cultural services (aesthetic values)
- *Benefits of the method* (Pascual, Muradian 2010):
  - Potentially useful in valuing particular environmental functions
- *Limitation of the method* (Pascual, Muradian 2010):
  - Diminishing returns and difficulty of restoring previous ecosystem conditions make application of this method questionable

Replacement cost method - the loss of a natural system service is evaluated in terms of what it would cost to replace that service (Sarvašová et al. 2014). It is perhaps more realistic method of re-creating non-marketed benefits consists in replacing specific natural ecosystem functions or assets with man-made production processes and capital, instead of relying on the restoration of the original ecosystem or function to provide the original level of benefits. This technique generates a value for the benefits of an environmental good or service by estimating the cost of replacing the benefits with an alternative good or service. It rests on the availability of such an alternative for the original good or service. The alternative should produce, as nearly as possible, the same level of benefits supplied by the resource or environmental function being valued. This technique rests heavily on the assumption that replacing the original good or service is worthwhile, and that the benefits generated by the investment in replacement outweigh the costs of replacement (UNECE 1996; FE 2014).

- *Suitability for the FES to be valued* – provisioning services (non-wood forest products, water, raw material), regulation services (water quality, erosion protection services, water purification services, storm protection services, biodiversity and nursery services), cultural services (aesthetic values), supporting services (nutrient cycling)
- *Benefits of the method* (Pascual, Muradian 2010; FE 2014):
  - Costs incurred by individuals in order to avoid damages at already existing goods can be interpreted as a lower bound of the willingness to pay for this good
  - Useful in estimating indirect use benefits when ecological data are not available for estimating damage functions with first-best methods
- *Limitations of the method* (Pascual, Muradian 2010; FE 2014):
  - No measure of individual utility if only decision-maker´s preferences count [or if only “experts” decide about costs of public budgets (DE)]
  - Difficult to ensure that net benefits of the replacement do not exceed those of the original function
  - May overstate willingness to pay if only physical indicators of benefits are available.

Relocation cost - method uses the costs of relocating threatened communities (Barbier 2007; Pascual, Muradian 2010). This technique involves estimating how much it would cost to relocate (and re-equip) communities in order that they might obtain a level of benefits in their new location similar to those derived at their original site. Instead of investigating the cost of bringing substitute benefits to populations in existing sites, this technique examines the potential for moving people to alternative locations where such benefits exist.

Application of the relocation cost technique to forests is typically restricted to a different purpose, namely, assessing the direct costs of establishing new protected areas that require the resettlement of forest-dwelling communities.

- *Suitability for the FES to be valued* – forest conservation
- *Benefits of the method* (Pascual, Muradian 2010):
  - Only useful in valuing environmental amenities in the face of mass dislocation such as a dam project and establishment of protected areas
- *Limitation of the method* (Pascual, Muradian 2010):
  - Benefits provided by the new location are unlikely to match those of the original location
  - [No measure of individual utility (DE)]

Preventive/defensive expenditure - uses the costs of preventing damage or degradation of environmental benefits. It involves obtaining a figure for what it would cost to maintain environmental benefits by investing in the prevention of their degradation (Pascual, Muradian 2010; FE 2014).

- *Suitability for the FES to be valued* - water quality, erosion protection services, water purification services, storm protection services, fish habitat and nursery services
- *Benefits of the method* (Pascual, Muradian 2010; FE 2014):
  - Useful in estimating indirect use benefits when prevention technologies are available
  - Costs incurred by individuals in order to avoid damages at already existing goods can be interpreted as a lower bound of the willingness to pay for this good
- *Limitations of the method* (Pascual, Muradian 2010; FE 2014):
  - Mismatching the benefits of investment in prevention to the original level of benefits may lead to spurious estimates of willingness to pay
  - No measure of individual utility if only decision-maker´s preferences count

B3/Non-monetizing valuation

(Comment by DE: t may be problematic for some readers to understand why some of the non-monetizing methods are labelled as "economic valuation methods" at all, e.g. biophysical ranking methods)

Individual index-based methods - participants are asked to value particular ES by ranking them in surveys. By looking for trends in the ranking process, the most valuable ES can be determined. Because they are not expressed in financial terms, the applicability of this method to management decisions is limited. It does, however, provide a means to determine value for services such as cultural preservation which cannot be expressed monetarily. Individual index-base methods including rating or ranking choice models (Young Ko 2007) and expert [~~opinion~~] / [approach, that consists generally of two steps (Šišák et al. 2010):

1. In the 1st step, mutual relative importance of the respective non-market forest service to the market one whose pecuniary value is known is derived, based on points or percentage of importance, and a coefficient is created. The relative importance and coefficient is expressed by a set of experts;
2. In the 2nd step, the pecuniary value of respective non-market forest service is expressed on the basis of the market service price and the derived coefficient (by multiplication of the two mentioned quantities) (CZ)]

Group-based methods – use focus groups and citizen juries rather than individual preferences to rank ES. The group-based method offers advantages similar to the individual index-based method in that it provides a mechanism to value services that cannot be expressed monetarily. [The main drawbacks to this method are representativeness and the fact (DE)] that sociological factors such as peer pressure can influence how participants rate (Young Ko 2007). Group-based methods, including voting mechanisms, focus groups, citizen juries (Aldred, Jacobs 2000, Howarth, Wilson 2006), stakeholder analysis (Gregory, Wellman 2001; Frederick et al. 1996).

- *Voting mechanisms* - voting is used widely to choose options, often because of its ease of application. It is used most often in informal settings to generate group preferences.
- *Focus groups* - used to elicit information about values and preferences from small groups of relevant members of the public engaging in group discussion led by a facilitator. They use of qualitative measures and the uncertainty of any generalizations of results from small respondent. That samples limit the utility of these methods for formal policy and decision making.
- *Citizen juries* - also incorporate elements of the deliberative valuation process. In principle, a jury could be asked to generate a value for how much the public would, or should, be willing to pay for a possible environmental improvement, or, conversely, willing to accept for an environmental degradation. In contrast to estimates of willingness to pay derived from economic valuation methods, the estimates from citizen juries would not reflect the budget constraints of the individual participants and would reflect community based values rather than economic values. To the extent that a citizen jury engages in group deliberation, resulting value estimates also would reflect constructed values.
- *Stakeholder analysis* - is a process of identifying stakeholders and categorising them according to their relationship with the issue or activity and determining what this means in terms of how / whether to work with them. Stakeholder analysis helps the manager to identify each stakeholder, each stakeholder's interest, and the changes in stakeholder perceptions of issues and in the balance of influence over time

Measures of attitudes, preferences and intentions - are social-psychological approaches to assessing the value of ecosystems and ES employ a number of methods to identify, characterize, and measure the values people hold, express, and advocate with respect to changes in ecological states or their personal and social consequences. These methods elicit value-relevant perceptions and judgments, typically expressed as choices, rankings, or ratings among presented sets of alternative ecosystems protection policies and may include comparisons with potentially competing social and economic goals. Individuals making these judgments may respond on their own behalf or on behalf of others. The basis for judgments can be changes in individual well-being or in civic, ethical, or moral obligations (USEPA SAB 2009).

Social-psychological value-assessment approaches have relied most strongly on survey methods. Survey questions eliciting information about attitudes, preferences, and intentions are most often presented in a verbal format, either in face-to-face or telephone interviews or in printed questionnaires. Assessments of values for ecosystems and ES can be well-conveyed in perceptual surveys and conjoint surveys. Quantitative analyses of survey responses are usually interpreted as ordinal rankings or rough interval-scale measures of differences in assessed values for the alternatives offered. Survey questions about social and psychological constructs may be especially useful when the values at issue are difficult to express or conceive in monetary terms, or where monetary expressions are likely to be viewed as ethically inappropriate (USEPA SAB 2009).

Civic valuation - Civic valuation seeks to measure the values that people place on changes in ecosystems or ES when explicitly considering or acting in their role as citizens. These valuation methods often seek to value changes that would benefit or harm the community at large. They purposefully seek to assess the full value that groups attach to any increase in community well-being attributable to changes in the relevant ecosystems and services (USEPA SAB 2009).

Civic valuation, like economic valuation, can elicit information about values either through revealed behaviour or through stated valuations. One source of information based on revealed behaviour is votes on public referenda and initiatives involving the provision of environmental goods and services. Another source is community decisions to accept compensation for permitting environmental damage. Where revealed values are difficult or impossible to obtain, citizen valuation juries or other representative groups can be charged with determining the value they would place on changes in particular ecological systems or services when acting on behalf of, or as a representative of, the citizens of the relevant community (USEPA SAB 2009).

Decision science approaches - derive information about people's values through a deliberative process that helps individuals to understand and assess trade-offs among multiple attributes. The ultimate goal is for an individual or group to assign scores to alternatives (e.g., different projects) that can then be used to choose among those alternatives, recognizing that those alternatives will differ along a number of relevant dimensions or attributes. Generally, one alternative will score higher along some dimensions but not others, suggesting that trade-offs must be made when choosing among alternatives (Clemen 1996; Arvai, Gregory 2003).

- *Suitability for the FES to be valued* – spiritual, cultural services, knowledge systems & education (Kenter et al. 2015)
- *Benefits of the method* (Arvai, Gregory 2003; USEPA SAB 2009):
  - Ability to not only integrate multiple attributes value, but also engage a broad spectrum of stakeholders, holders of traditional ecological or cultural knowledge, and technical experts in the valuation process
  - High potential for identifying changes in ecosystems and their services that are likely to be of greatest concern to people
  - Method may potentially overcome (primarily) public or stakeholder objections to other approaches that are not perceived to adequately include moral and other non-monetary aspects of value
- *Limitations of the method* (Arvai, Gregory 2003; USEPA SAB 2009):
  - The trade-offs are typically not easy to make
  - It requires time and expertise resources
  - Engaging with stakeholders and technical experts to identify attributes that will be the focus of analysis, collecting data that characterizes these attributes, and the process of making trade-offs all will require effort on the part of Environmental Protection Agency

Ecosystem benefit indicators - offer quantitative metrics that are generally correlated with ecological contributions to human well-being and hence can serve as indicators for these contributions in a specific setting. They use geo-spatial data to provide information related to the demand for, supply (or scarcity) of, and complements to particular ES across a given landscape, based on social and biophysical features that influence – positively or negatively – the contributions of ES to human well-being (Boyd et al. 2001; Wainger et al. 2001; Boyd, Wainger 2002; Boyd 2004).

Ecological benefit indicators can serve as important quantitative inputs to valuation methods as diverse as citizen juries and economic valuation methods. They provide a way to illustrate factors influencing ecological contributions to human welfare in a specific setting. The method can be applied to any ecosystem service where the spatial delivery of services is related to the social landscape in which the service is enjoyed. However, although the resulting indicators can be correlated with other value measures, such as economic values, they do not themselves

provide measures of value (Boyd et al. 2001; Wainger et al. 2001; Boyd, Wainger 2002; Boyd 2004).

- *Suitability for the FES to be valued* – can be applied to any ecosystem service benefit where benefits are related to the spatial delivery of services and social landscape in which the benefit is enjoyed, except existence benefits
- *Benefits of the method* (USEPA SAB 2009):
  - Relatively non-technical way to express the factors that contribute to conventional economic measures of benefits provided by ES
  - Simple and transparent
  - Can be used to communicate and educate.
- *Limitations of the method* (USEPA SAB 2009):
  - Do not directly yield money-based ecological benefit estimates
  - Do not in themselves weight or estimate the trade-offs associated with different factors relating to benefits
  - Because indicators can be cheaper to generate than econometric value estimates they better allow for landscape assessment of multiple services at large scales

Biophysical ranking methods - try to value ES' values based on the quantification of biophysical indicators. Quantification of ecological changes in biophysical terms allows these changes to be ranked based on individual or aggregate indicators for use in evaluating policy options based on biophysical criteria previously determined to be relevant to human/social well-being. Possible indicators include measures of biodiversity, biomass production, carbon sequestration or energy and material use (Stoms 2005; USEPA SAB 2009).

Use of a biophysical ranking does not explicitly incorporate human preferences. Rather, it reflects either a non-anthropocentric theory of value (based, for example, on energy flows) or a presumption that the indicators provide a proxy for human value or social preference. This latter presumption is predicated on the belief that the healthy functioning and sustainability of ecosystems is fundamentally important to the well-being of human societies and all living things, and that the contributions to human well-being of any change in ecosystems can be assessed in terms of the calculated effects on ecosystems. Opinion is mixed – among both committee members and the broader scholarly community – on whether it is an asset or a drawback that these ranking methods are not tied directly to human preferences. [Another problem is measuring trade-offs between services which are measured in different biophysical units (DE)] (Stoms 2005; USEPA SAB 2009).

[~~Other approaches:~~

~~Averting behaviour models~~] (*Comment by LUB: This method was placed under monetary valuation methods*)

3 Suggested output of the analysis

Each FES and valuation purpose requires a specific or more suitable valuation method, and every forest ecosystem service valuation is only valid for a specific area and period i.e. must be spatially and temporally explicit. Therefore, the output of the analysis of different approaches and methodologies on FES valuation is to design an interactive table located on a web portal (Table 1). The table should document the suitability of valuation methods for individual FES (considering benefits and limitations of each method) in a clear, concise and comprehensive way. Its location in the virtual environment provides opportunities to create a user-friendly interface, that should provide simple orientation within different valuation methods. It should also relatively quickly and clearly propose suitable method, which could be used to value individual FES in a given situation.

It also allows to show simple references to the explanatory notes (description of the method, its benefits and limitations as well as practical example of its use) where, if necessary, the user will find detailed information.

(Comment by LUB: Proposal of interactive online table will be presented during the Expert Group meeting within the Agenda item 6)

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