# INTEGRATED BIODIVERSITY VALUATION FRAMEWORK: ECOLOGICAL APPROACH

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**Abstract:** Considering biodiversity loss around the world and in line with The Convention of Biological Diversity (CBD) and Aichi Targets, many biodiversity valuation frameworks emerging from different approaches are established mainly based on economic approaches and not much information on ecological approach. Most of the frameworks ignore the biophysical components of the environment as the backbone, put structure-processes-functions in different levels, and less integrated action at the end. In order to make a comprehensive framework for biodiversity valuation, this paper presents a conceptual framework in valuing biodiversity based on ecological principles. The following analysis, integrating socio-cultural, economic, and ecological insights, can help any decision maker to generate better information in sustainable conservation. This paper highlights the importance of biodiversity and its physical environment in driving and promoting processes and functions to provide life support system where humans are part of. Furthermore, all of those results in joint products and functions as life support system which is very important for any components (including humans) of the system. The fact that the ecological value as basis of any valuation is strongly supported by ecological insights. This life support system is frequently viewed and captures as goods and services from economic approach, as ethno practices/perceptions from socio-cultural approach, and as ecosystem sustainability from ecological approach. Integrating these three approaches would help a decision maker investigate comprehensive information correlated with biodiversity value for conservation purposes.

**Keywords:** biodiversity, biophysical environment, ecological value, valuation

## Introduction:

Since ancient times people have learned lessons from the natural world depending on the environmental resources that surround them. They harvest and extract resources for consumption, medicine, clothing, aesthetics, energy sources, rituals and ceremonies, and many more. Natural resources have started to decrease since humans practised land conversion and deforestation, or mining at alarming rates especially with extraction of timber, coal, and other minerals. As a consequence the logged over did not have enough time to recover sustainably before the succeeding extraction had been done (Devi and Yadava 2006; Butchart et al. 2010; Cardinale et al. 2012). These

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anthropogenic practices also resulted in a more serious problem of biodiversity loss leading to genetic erosion especially at the species level and worse, this is driving an increasing number of vertebrates to extinction (Guarino 2011; Chen and Benton 2012). Every year mammals, birds, and amphibians are moving onto one category closer to extinction, adding to the existing red list (Spangenberg 2007; CBD 2009; Butchart et al. 2010). There is little doubt that many invertebrate species, other wildlife and microbes are also imperiled by the same pressure. The major causes of biodiversity decline are land use changes, pollution, changes in atmospheric $CO_2$ concentrations, changes in the nitrogen cycle and acid rain, climate alterations, and the introduction of exotic species, all coincident with human population growth. Biodiversity loss and ecosystem degradation are inter-correlated and complex, because the existence and health status of biodiversity ultimately impact on ecosystem sustainability. The degradation will create conditions of instability and less productivity and promoting desertification, water logging, mineralization, and many other undesirable outcomes (CBD 2009; Foley et al. 2005; Sagoff 2011).

Many action plans and strategies are continually proposed and developed by independent individuals or organizations to increase the number and improve the quality of biodiversity. However, there is less remarkable development and improvement, thus far. Involving all stakeholders such as decision makers, NGO, institutions or companies and local communities in a multisectoral, interdisciplinary discussion, may spark new hopes and could initiate promising ideas, concepts and programs, approaches, or actions concerning biodiversity, particularly, the concept of biodiversity valuation. Valuation captures and expresses the value of biodiversity. However, there are still debatable issues in the contextual definition and practices of valuation viewed at different angles or approaches especially from the ecological and economic perspectives. Even though they have different points of view and purposes, in fact they actually estimate similar values of biodiversity.

In order to capture and estimate biodiversity values, there had been many conceptual frameworks, theories, or practices introduced from different cognitive backgrounds and field that make resources (biodiversity) valuation practices more complicated than we thought. The original key concept of ecology as a basic concept of life support system becomes biased and less clear than the terms goods, services, or ecosystem processes and functions. The establishment of ecosystem goods and services concepts and practices has enhanced this bias to valuation of resources having obvious material and economic benefits to humans. There are also a significant increase of literature on ecosystem services with excellent conceptual framework and explanation established by some natural scientists. The terms goods, functions, or services have already been defined and practiced.

We do not want to debate all those excellent points of view. In fact, all those are actually one integrated system consisting of interdependency functions to provide life support system where humans are part of. Any changes or destructions in the system will affect the various components including humans. People do not realize that they are a part of the system because they always see the system as objects or goods. The fact is, anything that happens in the system will affect everyone in that system (or interconnected with it). So integrated resources management especially biodiversity valuation is very important to keep our life support system functioning.

This paper will address contextual valuation of biodiversity from ecological approach for better understanding in capturing non monetary values in the ecosystem. The basic concept is to emphasize the importance of ecological values as based on any valuation concept or practices and the importance of integrated resources valuation of any disciplines for conservation management purposes.

## Materials and methods:

These principles and concepts are fully analyzed comprehensively from many publications and reviews of biodiversity, ecosystem services, and ecosystem valuations. The new synthesis is proposed by investigating a quest in the Web of Science for articles with the words economic, socio-cultural, or ecological valuation, valuation, biodiversity value, ecosystem values and ecosystem services to synthesize an effective framework in understanding the mainstream of integrated diversity valuation. It is very important to clarify the importance of biodiversity and its physical environment based on ecological principles even under system or ecosystem services or spatial points of view. Compilation and investigation of ecological principles in structures, processes, and functions of system to establish a new integrated biodiversity valuation framework for conservation purposes are used in this review.

## Results and discussion:

The principle of biodiversity valuation framework is the underlying basic ecological principle and concept (Fig. 1). Therefore it is applicable for terrestrial, aquatic, wetland, coastal or any other ecosystems. Instead of boxes or full circle, the circle dash lines are applied to show that there is no boundary between human and the natural resources because people are part of the system. Each component is intercorrelated within the system which is frequently forgotten in other biodiversity frameworks (Turner et. al. 2003; de Groot 2006; Hermann et al. 2011). We should think ecocentric that anything humans do in the system will give feedback positive or negative to them.

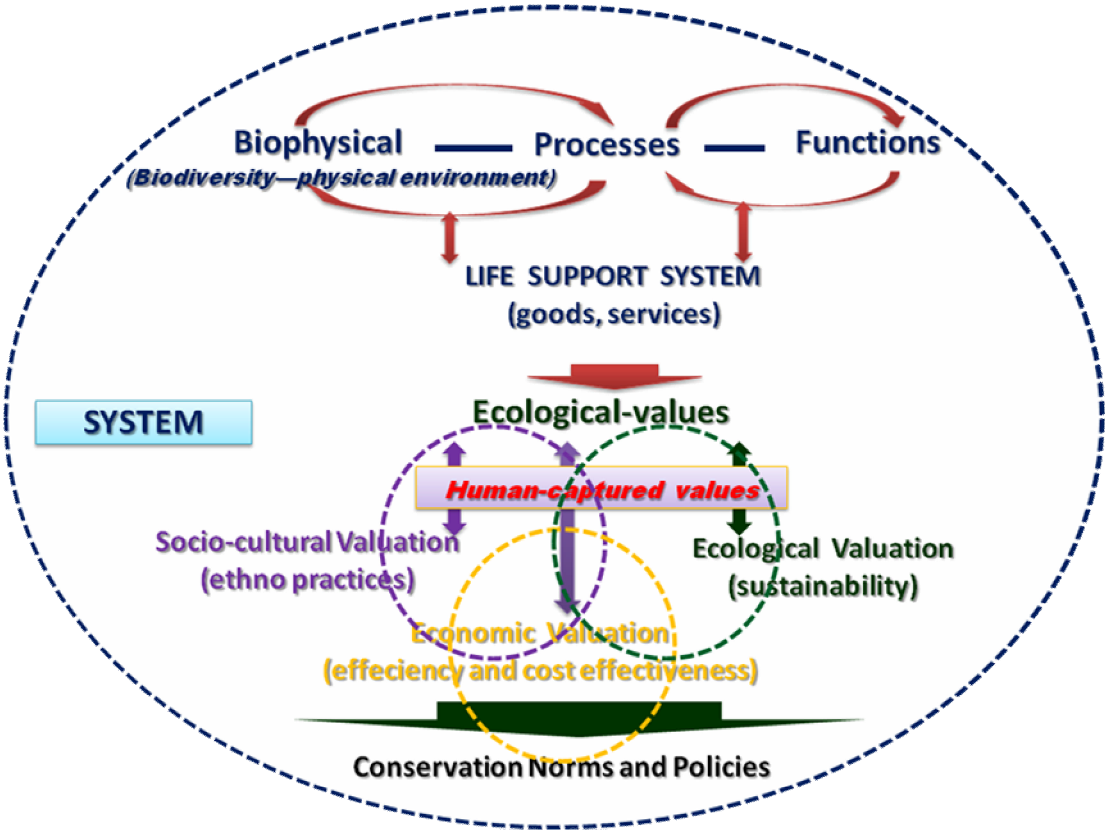
Biophysical basic concept

Fundamental to any discussion of biodiversity valuation is an understanding of the object of the valuation itself. Biodiversity in relation to physical factors initiate, promote, and trigger any processes individually or compositely as joint products in the ecosystem. In ecological context, it is a complex interlink or interconnection because once the living organisms are in contact with the physical environment this will be directly followed by a process or series of processes resulting in functions of the system. Therefore, this interdependency is shown by straight lines and blue curve arrows in Fig. 1. The existence of biodiversity in the system is interconnected with the physical environment where they live in (Odum 1971; Kimnis et al. 2007).

The physical environment provides media for living organisms such as water or soils, cycle material or biogeochemical or food web, or even favorable condition to live. On the other hand, living organisms contribute dead material, $O_2$, water vapor, or $CO_2$ to incorporate in their environments. Biodiversity plays important roles in soil development because the works of lichens, moss, plant roots, wildlife, or microbe or in coral reef formation are joint efforts of millions of individual organisms (coralline algae, polyps) working over very long periods of time. The interconnection of both biodiversity and physical environments results in productivity and functions of the system as life support system.

These interconnections of both biodiversity and its physical environment within the system also promote the web of life where humans entirely depend on. Those interdependencies also provide the basic necessities of life, protection from natural disturbances, and contribute a foundation for ethno-practices of humans. As life support system, the relationship between biodiversity and physical environment will support and regulate the productivity, energy flow, and material cycle. There will be no “goods and services” if there is no interdependency of biophysics altogether. Destroying biophysics will destroy the life support system which humans are part of. Biodiversity is a composite or glue that holds all nature structures and processes together as asserted by Turner et al. (2003).

**Figure no. 1** Conceptual framework of integrated biodiversity valuation




Structure - processes - functions - life support system

Natural system has three basic elements: structure, processes, and functions to provide life for every creature including humans. Structure is type and number of organisms together with the physical characteristic in space and time generating biophysical interactions. Biodiversity or biological biodiversity is variety of life on earth system at different levels or hierarchies /dimensions/ forms (Hamilton 2005). At first, biodiversity is viewed as species diversity or species richness. It is a narrow concept, because biodiversity is not just the number per se. When we talk about a biological diversity, it means there are intercorrelated aspects of species as individual and as composite community in the system.

Consisting of both photosynthetic and non-photosynthetic species, biodiversity hold the processes and interdependency in the ecosystem in a complex way but valuable not only for the well-being of the species themselves but also the system which humans are also part of. Biodiversity in relation to physical factors initiates, promotes, and triggers any processes individually or compositely as joint products in the ecosystem (Turner et al. 2003; Brauman et al. 2007; Norris 2013). Trees absorb water from the soil, $CO_2$ from the air, and energy from the sunlight to do photosynthesis. The product of this process will be deposited or stored in plant organs such as roots, stems, leaves, flowers, or fruits as biomass. The biomass will return back to the ecosystem through biogeochemical or matter cycles. The photosynthetic species such as phytoplankton, seaweeds, or trees transfer energy from the only source on earth, the sun, and build up energy storage, nutrients, or food for the non photosynthetic species consumptions. This is what some scientist said as starting point of exchange value in the system commonly known as energy theory of value (Odum 1971; Costanza 1997). Location, width area, and seasons are three important attributes which have to be recognized because topography, soils, riverbed, micro- or macro-climates, or dry-wet seasons as physical factors will affect the quality of biodiversity and its system.

All the interactions among the structures promote series of activities, events or reactions for certain specific results known as processes. The interactions are very complex and complicated because they work cooperatively so it is difficult to say that a product is a result of one reaction. The term function refers to the capacity of the processes and components in the system. All those elements and interactions generate complex life support system and provide both direct and indirect values that play an important role for human welfare such as security and safety, basic foods, or health (Tietenberg 2013; Dasgupta 1996; Harrington et al. 2010). They contribute fresh oxygen for breathing, water for drinking, or fruits, fish, and seeds for food as direct values. On the other hand, our system also provides variety of services from biogeochemical cycling and carbon sequestration to food production as indirect values.

Ecological values

So how do we put value on biodiversity in the system as a product or part of function? People are starting to capture the quantity and quality of biodiversity products, processes or functions based on space, scale, and time in order to weigh the important contribution of biodiversity to the ecosystem or human well-being. The issues “warm up” for years in order to visualize the value especially for conservation purposes, even if it had already been addressed in The Convention of Biodiversity (CBD), The Millennium Ecosystem Assessment (MA), and also two goals of Aichi Targets, namely; Goal A to address the underlying causes of biodiversity loss (Millennium Ecosystem Assessment 2005; CBD 2009; CBD 2011), and Goal D to enhance the benefits to all from biodiversity and ecosystem services (Butchart et al. 2010).

Value is a measure of a relationship between a subject and the object of valuation within a context of time and place, or hypothetical scenario (Douglas and Wunder 2002). And it is not only that, economic value of natural assets is a tricky matter because we have only partial knowledge on how ecosystems work. Therefore, frequently, people use assumptions to estimate economic values so it is subjectively determined by the analysts. There are many kinds of values based on the ecological, economic, and social point of views or interpretations. They value the same resources or the so called services but very different in approaches and context. Some economic valuation frameworks captured the resources as total economic values (direct or indirect, tangible or intangible, marketable or non-marketable) or goods and services (Turner et al. 2003; Mehmet 2010). Some socio-cultural valuation frameworks captured the resources as spiritual and religious values, aesthetic or recreation values, or ethno-practice values. Subjectively or not, we are talking about human perceptions of biodiversity values for humans themselves and the system’s importance.

Some values such as material benefits, the sheltering effects of forests, recreation use, scenery or landscape, plants and wildlife, or even carbon sink need to be estimated at ecological, economic and socio-cultural aspects for conservation policy (Constanza et al. 1997; Salles 2011). It is needed to conserve biodiversity or to put a stop or minimize habitat loss of forest ecosystem by local people. Justification related to losing one or even more species at the protected area is frequently difficult to make because there is not much information about the value of species itself. People know exactly how important are natural resources as life support system, however, they still overexploit them for their well-being without thinking about the consequences.

From the ecological point of view, biodiversity in the system is acknowledged as raw materials, part of ecosystem functions, products, or as life support system (Tietienberg 2013). As biomass or nutrient/food storage, biodiversity is needed for running processes, transferring energy, or cycling matter/nutrient in the system. Each species itself can be interpreted as products for other species, the surrounding system, and of course for human well-being. Insects need leaves for their nests or food, phytoplankton provide oxygen and food for fish, birds need insects, snails, or clamps for food, sea-turtles need seaweeds for food, the soil provides plants or animals to live, flowers provide nectars for bees or birds, and many other products direct or indirectly consumed or used by others. At last, any raw material or function regulations in the system (ecosystem) are very important for survival of any creatures on earth including humans. All of these are the ecological values (eco-values) of the biophysical environment either as individual or as composite components (Fig. 1). These eco-values are commonly known as inherent and intrinsic values. The values are not dependent on humans who seem to try hard to put price on, because those values exist in the species as predictable internal factors (inherent value) and will improve or not based on the unpredictable external factors (extrinsic value). How can you put a price on the existence of a species or on an ecosystem if it has its own value independent of humans?

While ecologists view the value of the biodiversity and its system as an ecological measure, economists view them as a monetary measure while sociologists deem the value as an ethic perception that enables them to breathe and sustain life or enliven and rejuvenate their minds such as scenery or serene landscapes like that of forest, lake, or river and stream (Fig. 1). We can, however, estimate the value of the resources by examining efficiency and cost effectiveness as done by economists. However, economic valuation cannot value everything – that is, not all benefits provided by life support system are fully translatable into economic terms (Christie et al. 2006; Christie 2012).

Capturing non-marketable value might be difficult to address and measure because of the complexity of the functions and human cognitive limitation which are prone to making misinterpretations of those values.

## Integrated Biodiversity Valuation

As life support system, nature contributes values that give benefit not only for the system itself but also for humans' well-being. The existence of all components in the system including biodiversity, processes and functions is very important especially for safety, food, ethno-practices, energy sources, and other values. In fact humans capture the ecological values of all the components in the system like density of forest that creates peaceful and fresh air, provides beautiful insects, minerals, or delicious fruits with high prices at the market. Humans also capture the ecological values of big tree trunks that contribute high amount of carbon storage or biomass, high soil fertility in certain areas where people can practice cultivation, density and diversity of coral reef that supply food and protection for diversity of fish and many other values.

All those values are captured, recognized, and estimated differently by ecologists, sociologists and anthropologists, as well as by economists. Preferences and perception of people on ecological values of resources are very important for sociocultural and economic valuation. While the sociocultural approach tries to get any information of ethno-practices done or set up by people, the economic approach tries to estimate the efficiency or cost effectiveness of any policies, environmental impacts, or system management.

Underlying the ecological approach is sustainability. So there should be integrated resources valuation that involves ecological, sociocultural, and economic valuation. In other words, valuation for further conservation action and policy formulation, especially in the natural areas is a matter of interdisciplinary decision making even with a transdisciplinary mindset. Hence, economics, ecology, sociology, anthropology or other fields are needed to generate comprehensive or integrated conservation norms and policies of certain natural area (Fig. 1) (Farber et al. 2002; Turner et al. 2003; de Groot 2006; Morse-Jones et al. 2010; Nijkamp 2010; Hermann et al. 2011, Mburu - 2005) as explained above.

The interconnection between or among approaches are shown by three circles in broken lines and varying colors. All these approaches are somehow interconnected with each other because of similar goods/products/services to value and/or desire and sustain. Ecologists need information of the economic value of certain species for biodiversity monitoring purposes. Economists need information of biodiversity values from ecologists to determine the approximate price of certain species for verdict purposes in penalizing illegal actions, or for ecotourism, or natural resources management practices. To cite an example, a verdict for anyone who captures sea turtle illegally will be different from the verdict of those who capture phyton snake illegally because the price of both species on the market is different depending on their IUCN conservation status. On the other hand, additional information of ethno-practices such as a ritual ceremony of certain tribes using sea turtle or python snake will be useful for decision makers to develop the policies or norms concerning those species together with the economic valuation. Furthermore, the decision makers also need information of those species richness or key roles in the system because these will affect the food web or loss of biodiversity or of the gene pool of the system. So, the integrated valuation of the three different approaches will address the need of a comprehensive decision for biodiversity conservation.

**Conclusions:**

The valuation of biodiversity whether in the terrestrial or wetland ecosystems should be based mainly on the ecological value itself. Biodiversity as a resource enhances the structure and processes in the system to generate functions that provide life support system. This ecological value is captured, recognized, and used in other different approaches to determine the perception of people on ethno-practices from a socio-cultural perspective, to measure willingness to pay (WTP) on goods and services from an economic perspective, and to estimate sustainability of the biophysical environment to generate better norms or policies for natural resources conservation and management in the ecological perspective. Integration of all these approaches is very important to establish the best management decisions in preserving a functioning life support system, where all organisms on earth including humans are part of and are wholly dependent upon for survival.

**Rezumat:**

INTEGRAREA BIODIVERSITĂȚII
ÎNTR-UN CADRU DE EVALUARE:
O ABORDARE ECOLOGICĂ

Luând în considerare pierderea biodiversității în lume și în conformitate cu Convenția Diversitării Biologice (CBD) și a țintelor Aichi, multe cadre de evaluare a biodiversității sunt stabilite cu precădere pe baza abordărilor economice și mai puțin pe baza informației ecologice. Majoritatea cadrelor ignoră componentele biofizice ale mediului ca ax central, punând triada structură-procese-funcții pe diferite niveluri, iar o acțiune mai puțin integrată la sfârșit. Cu scopul de a conferi o structură exhaustivă pentru evaluarea biodiversității, această lucrare prezintă un cadru conceptual în evaluarea biodiversității, bazată pe principii ecologice. Analiza realizată, ce a integrat perspective socio-culturale, economice și ecologice, poate ajuta orice factor de decizie printr-o mai bună informare privind conservarea sustenabilă. Această lucrare subliniază importanța biodiversității și a mediului său fizic în conducerea și promovarea proceselor și funcțiunilor pentru susținerea vieții, sistem din care și oamenii fac parte. Mai mult, toate acestea au ca rezultat produse comune și funcționează ca un sistem de susținere a vieții, care este foarte important pentru oricare componentă a sistemului (incluzând ființa umană). Faptul că valoarea ecologică reprezintă baza oricărei evaluari este puternic susținută din perspectiva ecologică. Acest sistem de susținere a vieții este adesea observat și asociat ca bunuri și servicii printr-o abordare economică, precum practicile/percepțiile etno din cadrul abordării socio-culturale, sau sustenabilitatea ecosistemului din abordarea ecologică. Integrarea acestor trei abordări, poate ajuta un factor de decizie să investigheze informațiile comprehensive corelate cu valoarea biodiversității pentru scopuri de conservare.

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