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Integrated Approaches of Ecology and Economy for Sustainable Development with Special Emphasis on Ecosystem Services: A Review

Sheenu Sharma, Sabir Hussain, and Anand Narain Singh*

Soil Ecosystem and Restoration Ecology Lab, Department of Botany, Panjab University, Chandigarh, 160014, India.
sharmabotany20@gmail.com, sabirhussain17685@gmail.com, dranand1212@gmail.com*

Abstract: **Ecosystem services are the benefits people obtain from an ecosystem where they are. Ecosystem service valuation is the process of evaluating the contributions of ecosystem services to human well-being. Ecologists mainly focus on biophysical methods, while economists have developed preference-based tools for their service valuation. However, the integrated goal is to evaluate the effects of ecosystem services and trade-offs that support human welfare and try to fulfill sustainable development. This review aims to provide the ecological and economical methods for ecosystem service valuation and present coherent knowledge for decision making. First part of the review presents an overview of different ways of defining and classifying ecosystem services. The second part focuses on the quantification and assessment of ecosystem services and different valuation approaches. However, there are still many challenges that have to be resolved regarding the quantification and assessment of ecosystem services. In conclusion, several research efforts need to be conducted side by side to understand the linkage between ecological and economic systems and improve ecological and socio-economic dimension in human-dominated ecosystems.**

Index Terms: **Ecosystem, Ecosystem Services, Ecology, Economy, Sustainability, Valuation.**

I. Introduction

Dating back to Malthus, Darwin, Marshall, and Adam Smith, ecology and economics have a long history of sharing ideas. The past decade has seen a growing recognition of both the rewards and the challenges of conducting interdisciplinary research that draws from these two disciplines (Rapport & Turner, 1977; Polasky & Segerson, 2009). There is rapid growth in this direction that combines the two disciplines better to understand the bidirectional linkage between ecological and economic systems. More recently, there has been an exponential growth in publications on the benefits of nature to human society (Hermann et al., 2011), which now studied under the term ecosystem services. Despite increased interest in ecosystem service research, there are still many unanswered questions regarding ecosystem service concepts in assessment approaches and decision-making. Literature survey indicate that information is rich on the integration of environmental and social science in the field of ecosystem services (R. S. De Groot et al., 2002; Turner et al., 2003; Liu et al., 2010; Seppelt et al., 2011). But before its linking (ecological and economic), it is essential to examine which economic paradigm is helpful for their integration. Ecological economics is currently more disciplinary today, finding its origin within the 1980s (Røpke, 2004; Gowdy & Erickson, 2004), and unlike environmental economics, it is based on natural science. However, environmental and ecological economists both aim at achieving sustainability but have different ways to interpret sustainability. The former aims to keep the natural and human-made system intact; economic growth will not decline due to this. The latter aims to lower the natural system's pressure and hold the protective principle in dealing with complication and ambiguity (Bartelmus, 2008). Over the past 20 years, the ecosystem service concept has gained importance among scientists, managers, and policy-makers worldwide regarding how to speak societal dependence on ecological life support systems integrating both the natural and science perspectives (Bastian et al., 2012). Many international initiatives, for examples, the Millennium Ecosystem Assessment (MEA), The Economics of Ecosystems and Biodiversity (TEEB), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Carpenter et al.,

* Corresponding Author

2009; Seppelt et al., 2011) have developed interdisciplinary frameworks to hold the different value dimensions in which ecosystems benefit society and so that to make the ecosystem service concept operational.

The recent interest in combining ecology and economics shows a kind of interdisciplinary effort to interpret human impacts on ecosystem services and vice versa. The most notable work that laid the foundation of ecosystem services concepts was given by Westman in 1977 and later by Costanza and his colleagues in 1997. In 1977, Westman published a paper in Science examining the link between ecological and economic systems entitled “How much are Nature’s Services Worth?” (Westman, 1977). Another by Costanza et al. (1997) in the Nature (a high standard journal) on the value of global ecosystem services and estimated total economic value of ecosystem services globally. They estimated that global ecosystem services were worth $ 33 trillion annually, far more than the total GNP, which was $ 18 trillion at that time. It also highlighted the critical need for collaboration between ecologists and economists to ensure that assessment and valuation of ecosystem services are scientifically wide-ranging (Polasky & Segerson, 2009).

Moreover, remote sensing and GIS implementation have been widely used in the past two decades to quantify and map ecosystem services. Despite an increasing number of publications that present very new ideas from different perspectives, there is still uncertainty concerning methodologies and techniques or approaches for assessing ecosystem services. Therefore, we aim to investigate how to integrate ecological and economic approaches to assess ecosystem services and identify, analyze, and describe the methodologies used to evaluate the economic and ecological values of ecosystem services. Hence the paper presents an approach to attribute economic and ecological valuation of ecosystem services for sustainable development. The present study focuses on (a) a comprehensive framework on the concept, definition, and classification of ecosystem services. (b) ecological and economic values. (c) ecological and economic approaches in ecosystem service assessment. (d) ecological and economic sustainability.

II. METHODOLOGY

The following steps of analysis were performed: (i) a literature review on different classification system proposed to date, (ii) on methodologies adopted for ecosystem services valuation, (iii) a literature review of case studies on ecosystem services valuation, and (iv) ecosystem services for sustainable development. A literature review was conducted by using Scopus and Google Scholar. We used the combination of the following keywords: “Ecosystem service”, “Ecosystem services AND Classification”, Ecosystem services AND value OR Valuation”, “Ecosystem services AND Sustainability” in the Title, Abstract, keyword section of reference databases.

III. ECOSYSTEM SERVICES: CONCEPT, DEFINITION AND CLASSIFICATION

The ecological systems play an essential role in determining people’s economic performance and well-being by providing resources and services and by entrancing emissions and waste. Ecosystem services result from ecosystem processes and function (Fig. 1), the main flow provided by natural capital, benefits that nature provides to the people that ecosystems make to enhancing human well-being (Glushkova et al., 2020).

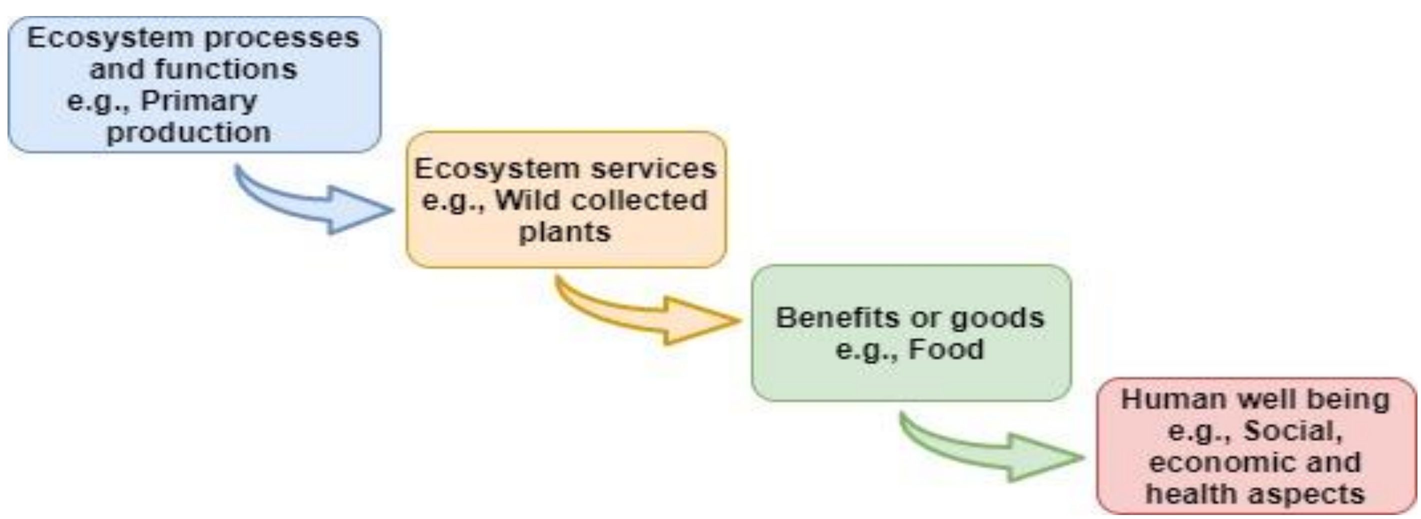

Fig. 1: A framework showing ecosystem services results from ecosystem function, which gives different human well-being benefits.

The concept of ecosystem services was first described as ‘Environmental services’ in the Study of Critical Environmental Problems (SCEP, 1970). It was introduced as ‘Nature’s service’ by Westman in 1977 (Westman, 1977). Although Ehrlich and Ehrlich in 1981 gave the term ecosystem services, the same concept can be traced back to the 1960s and 1970s, highlighting the societal value on nature's functions (Bormann & Likens, 1979; Helliwell, 1969; Dee et al., 1973). Ecosystem services are the conditions and processes through which natural ecosystems sustain and fulfil human life. They maintain biodiversity and produce ecosystem goods, such as forage and fodder, timber, biomass fuels, fibre, and many pharmaceuticals and industrial products (Daily, 1997). The publication of Man and Nature by Marsh Perkin in 1984 was the leading cause that motivated and enhanced interest in ecosystem services in modern times. It has described that the most critical work of Man and Nature was Marsh's stress on the unanticipated and unintended consequences, as well as the reckless greed, of technological enterprises (Gómez-Baggethun et al., 2010; Mooney & Ehrlich, 1997; Lowenthal, 2000).

Marsh also suggested that to keep the biological system alive and sustain the global natural resources, society should be aware of these losses on human beings. Mooney & Ehrlich, (1997) described how biodiversity assessment approaches were developed in the 1990s by international environmental programs like the Global Biodiversity Assessment of United Nations Environment Programme (UNEP), which integrated the economic and ethical issues with biodiversity science. In the second half of the 1990s, ESs began to receive increased attention in the scientific community and greater visibility internationally (Gómez-Baggethun et al., 2010). However, ecosystem services gained a place on the global policy agenda and were widely accepted within the international scientific community after a remarkable work of MEA (2005) on ecosystem services. They were focused on different aspects of ecosystem services such as ecosystem services concept, definition, classification and evaluation, which were explicitly determined to emphasize the significances of natural resources for human well-being. MEA (2005) defined ecosystem services as the benefits people obtain from the ecosystems. After MEA publication on ecosystem services, there showed a rapid increase in research related to ecosystem services. Various researchers differed in opinion regarding the concepts, classifications and evaluations of ecosystem services. Costanza et al. (1997) define ecosystem services as the benefits human populations derive, directly or indirectly, from ecosystem functions. The conditions and processes through which natural ecosystems and the species make them up to sustain and fulfil human life (Daily, 1997). MEA (2005) defines ecosystem services as the benefits people obtain from ecosystems.

The components of nature are directly enjoyed, consumed, or used to yield human well-being (Boyd & Banzhaf, 2007). Fisher et al. (2009) define ecosystem services as the aspects of ecosystems utilized (actively or passively) to produce human well-being. Direct and indirect contributions of ecosystem structures and functions are the ecosystem services (Müller & Burkhard, 2012. Recent initiatives developed to comprehend the significances of ecosystem services and their valuation include The Economics of Ecosystem and Biodiversity (TEEB) launched in 2007, and Wealth Accounting and the Valuation of Ecosystem Services Partnerships promoted by the World Bank in 2010. The most significant focus is also given on the economics of ESs through natural capital accounting and the identification and implementation of policy and market tools to compensate for the provision of ESs. The System of Environmental-Economic Accounting (SEEA), recently endorsed by the United Nations Statistical Commission, encourages the measurement, recording, and accounting of ecosystem services through its "experimental ecosystem accounting". The main aim of SEEA was to analyze the ecosystem services by linking ecosystem services with economics and other human activities.

A. *How Are Ecosystem Services Classified?*

Classification of ecosystem service is a vital requisite for any attempt to measure, quantify, map, or value the services delivered by the ecosystems and communicate the findings transparently (Burkhard & Maes, 2017). The classification of ecosystem services has been widely debated in recent years. Many classification schemes have been proposed to classify ecosystem services (Costanza et al., 1997; Daily, 1997, R. S. De Groot et al., 2002; MEA, 2005; Boyd & Banzhaf, 2007; Wallace, 2007; Fisher & Kerry Turner, 2008; TEEB, 2010; Haines Young & Potschin, 2017). MEA (2005) is a globally recognized and widely accepted classification and has been adopted in several studies and initiatives. Some of the significant ecosystem services classifications are presented below.

1) *Costanza et al. (1997)*

They tried to estimate the economic value of renewable ecosystem services for 16 biomes which were based on published studies and few original calculations. The selected ecosystem services were classified into 17 groups. According to the ecosystem, services are the benefits humans obtain directly or indirectly from ecosystem functions. Later on, using his classification as a platform, many other researchers' classified ecosystem services. They have made enough efforts to value the ecosystem services and natural capitals worldwide but were limited and unable to consider many services that the ecosystem offers. Their valuation methods for some biomes were insufficient (For example, tundra, croplands, and many more).

2) *Millennium Ecosystem Assessment (2005)*

One of the appreciating and extraordinary milestones of ecosystem services research was the Millennium Ecosystem Assessment (2005) sponsored by the United Nations. The work on MEA started in 2001 in cooperation with more than 1300 international experts with more than $14 million of grants. MEA made the idea prominent that human well-being is dependent on ecosystems, and such linkage can be marked out through the notion of ecosystem services. The most significant finding of the MEA is getting to know that more than 60% of ecosystem services are being degraded or transformed, endangering future human well-being. Most changes to the ecosystems have been made to meet a dramatic growth in the demand for food, water, timber, fibre, and fuel. The MEA has categorized ecosystem services into four major groups based on ecosystem services for human welfare (Table I): 1) Provisioning: Physical products obtained from the ecosystems. 2) Regulating: Benefits obtained from the regulation of ecosystems. 3) Cultural: Non-material benefits people obtain from the ecosystems. 4) Supporting: Includes services important for delivering other ecosystem services (e.g., soil formation).

Table I. Classification of ecosystem services (Source: MEA, 2005).

Major service types	Services
Provisioning	1) Food 2) Fiber 3) Genetic resources 4) Biochemical and Natural medicines 5) Ornamental resources 6) Freshwater
Regulating	7) Air quality regulation 8) Climate regulation 9) Water regulation 10) Erosion regulation 11) Water purification and waste treatment 12) Disease regulation 13) Pest regulation 14) Pollination 15)Natural hazard regulation
Cultural	16) Cultural diversity 17) Spiritual and religious value 18) Recreation and ecotourism 19) Aesthetic value 20) Knowledge systems 21) Educational values
Supporting	22) Soil formation 23) Photosynthesis 24) Primary production 25) Nutrient cycling 26) Water cycling

Although this classification is widely accepted and many schemes, initiatives and studies have been based on this classification, still, researchers disagree with MEA classification. This classification has been recognized as not fit enough for all purposes, out for contexts regarding environmental accounting, landscape management, and valuation. Alternative classifications have been proposed (Boyd & Banzhaf, 2007; Wallace, 2007; Fisher & Turner, 2008).

3) *J. Wallace, (2007)*

They stated that the classification by practitioners such as (Costanza et al., 1997; R. S. De Groot et al., 2002; MEA, 2005; S. Farber et al., 2006) mixes processes (means) for achieving services and the services themselves (ends) within the same classification category. Pollination, water regulation, photosynthesis, soil formation etc. are not that the manager seeks in their right. These are all means (processes) through which ecosystem services (ends) such as food, potable water is achieved. He has proposed a classification of ecosystem services and links to human values, ecosystem processes, and natural assets (Table II).

Table II. Classification of ecosystem services (Source: J. Wallace, 2007).

<table>
<tr><th>Category of human values</th><th>Ecosystem services – experienced at the individual human level</th><th>Examples of processes and assets that need to be managed to deliver ecosystem services (ecosystem processes)</th></tr>
<tr><td>Adequate resources: are defined as the ‘‘basic needs [that] support the life of individuals. They must be insufficient supply for survival and reproduction.</td><td>• Food (for organism energy, structure, key chemical reactions)
• Oxygen
• Water (potable)
• Energy (e.g., for cooking – warming component under physical and chemical environment)
• Dispersal aids (transport)</td><td rowspan="3">• Biological regulation
• Climate regulation
• Disturbance regimes, including wildfires, cyclones, flooding
• Gas regulation

• Management of ‘‘beauty’’ at the landscape and local scales
• Management of land for recreation
• Nutrient regulation
• Pollination
• Production of raw materials for clothing, food, construction, etc.
• Production of raw materials for energy, such as firewood
• Production of medicines
• Socio-cultural interactions
• Soil formation
• Soil retention
• Waste regulation and supply
• Economic processes</td></tr>
<tr><td>Protection from predators/ diseases/parasites: ensuring that the abundance and distribution of harmful organisms are sufficiently low that human well-being is not threatened.</td><td>• Protection from predation
• Protection from disease and parasites</td></tr>
<tr><td>Benign physical and chemical environment.</td><td>Benign environmental regimes of:
• Temperature (energy, includes the use of fire for warming)
• Moisture
• Light (e.g., to establish circadian rhythms)
• Chemical</td></tr>
<tr><td>Socio-cultural fulfilment: encompasses ethical positions, including those related to intrinsic values.</td><td>Access to resources for:
•Spiritual/philosophical contentment
• A benign social group, including access to mates and being loved
• Recreation/leisure
• Meaningful occupation
• Aesthetics
• Opportunity values, capacity for cultural and biological evolution – Knowledge/education resources – Genetic resource</td><td>Biotic and abiotic elements
Processes are managed to provide a particular composition and structure of ecosystem elements. Elements may be described as natural resource assets, for example:
• Biodiversity assets
• Land (soil/geomorphology) assets
• Water assets
• Air assets
• Energy assets</td></tr>
</table>

J. Wallace classification system links values with ecosystem services, ecosystem processes, and natural and socio-cultural assets. The ecosystem values describe important aspects of human well-being and, thus, vital in understanding natural resources' significances.

4) *R. De Groot et al. (2010)*

They have also tried to classify the ecosystem service and defined ecosystem functions as an intermediate between processes and services and can therefore be defined as the “capacity of ecosystems to provide goods and services satisfy human needs directly and indirectly”. This classification is also based on MEA (2005) and R. De Groot (2006). The provided typology has four broad types of services. “Provisioning services”, “regulating services”, “habitat or supporting services” and “cultural and amenity services”. This classification was aimed to integrate the concept of ecosystem services and values into landscape planning, management, and decision making.

5) *The Economics of Ecosystem and Biodiversity, (2010)*

The European Commission took this initiative and the German Federal Ministry for the Environment, Nature Conservation, Building, and Nuclear Safety, responding to a proposal of environment ministers from the G8+5 countries meeting in Potsdam, Germany in March 2007. TEEB (2010) has slightly modified the MEA classification. TEEB also categorized ecosystem services into four primary services. All service types are the same as MEA classification except the supporting service. Supporting services such as nutrient cycling and food-chain dynamics to ecological processes. Instead of using supporting services, TEEB introduced a Habitat service to stress the importance of ecosystems to provide habitat for migratory species and gene-pool "protectors".

To avoid the overlapping and risk of double counting in valuation, the United States Environmental Protection Agency has proposed an additional classification. These include Final Ecosystem Goods and Services Classification System (FEGS-CS) given by Landers & Nahlik (2013) and the National Ecosystem Services Classification System (NESCS) by Rhodes (2015). In both classification systems, the main aim is to focus on benefits and beneficiaries. FEGS-CS classification proposes two criteria to define goods and services: I) a beneficiary, and; II value the potential good or service) the potential good or service is connected to at least the hydrosphere and lithosphere. In FEGS-CS classification, processes such as photosynthesis and carbon sequestration are included as ecosystem structural components. They are reflected as intermediate goods and services rather than final services because humans do not directly use them.

Another international approach in understanding the ecosystem services and their values was performed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). It was established in the year 2012, aiming to increase and strengthen practical-based knowledge on biodiversity and ecosystem services and conservation and sustainable use of biodiversity. This scheme was supported by UNEP, United Nations Educational, Scientific and Cultural Organization (UNESCO), Food and Agriculture Organization (FAO) and United Nations Development Programme (UNDP). IBPES is also aimed to assess biodiversity and ecosystem services at both regional and global levels. It provides a typology based on the values bases on nature and quality of life. The typology has three broad categories: (A) Intrinsic value of nature: Individual organisms, biophysical assemblages, biophysical processes, and biodiversity. (B) Nature's benefits to people: This category is provided by the biosphere's ability to enable human endeavour (e.g., life cycles, carbon and water footprint, land cover flows), nature's ability to supply benefits (e.g., the contribution of soil biodiversity for the sustenance of long-term yields, biodiversity for future generation), nature's gifts, goods and services (ecosystem services). (C) Good quality of life: This covers human beings' overall comfortability in every aspect (security, sustainability, livelihood).

6) *Common International Classification of Ecosystem Services (CICES)*

To overcome the translation problems between different ecosystem services classification, which are not always comparable due to different perspectives and definitions of the categories, CICES was proposed in the year 2007 and later revised. It was initially developed as part of the work on The System of Environmental-Economic Accounting – SEEA7, directed by the United Nations Statistical Division (UNSD), aiming to collect internationally comparable statistical data on the economy's environment in creating a basis for ecosystem service accounting system. CICES has made a more negligible modification to the conceptual framework given by (Haines-Young & Potschin, 2010) to show the linkage and dependencies between ecosystem services and human well-being. Unlike other ecosystem services classification, CICES has classified ecosystem services hierarchically. It consists of three significant sections of ecosystem services, 'provisioning', 'regulating', and 'cultural'. These three sections are then further split into 'divisions', 'groups', and 'classes (Table III). CICES didn't include the supporting services – ecosystem structure, processes, and functions, from which society is not benefiting directly, but through the flow of final service. The people derive ecosystem goods and benefits from final ecosystem services. While classifying the ecosystem services, it is essential to avoid double accounting, which helps value the ecosystem services. The differences between FEGS-CS and CICES are easily comprehensible by comparing the given conceptual frameworks. The conceptual framework of the FEGS-CS stresses the benefits, beneficiaries, and the socio-economic system, while CICES places more emphasis on the ecological system. CICES classification is used in various national and international projects.

After mentioning numbers of classification regarding the ecosystem services categorization, confusion and chaos are in the minds, which classification system is suitable for all assessment purposes. However, probably it would not be possible to point out a single classification for all types of ecosystem services assessment. The choice of the appropriate classification approach depends on the objective of the study or the decision-making context. However, the comparability and transparency of the various studies and approaches' results remain a challenge for ecologists, scientists, and researchers.

Table III. Classification of ecosystem services up to group level by Haines-Young & Potschin, (2018) (CICES V5.1 version)

Sections	Divisions	Groups
Provisioning	Nutrition	Biomass
		Water
	Materiel	Biomass, fibre
		Water
	Energy	Biomass-based energy sources
Regulation and maintenance	Mediation of wastes, toxic and other nuisances	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flow
		Liquid flow
		Gasses/ airflow
	Maintenance of chemical, physical and biological condition	Life cycle maintenance, habitat and gene pool protection
		Paste and disease control
		Soil formation and composition
		Water condition
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interaction with ecosystems and land/seascape	Physical and experiential interactions
		Intellectual and representational interactions
	Spiritual symbolic and other interaction with ecosystem and land or seascape environment	Spiritual and emblematic
		Other cultural outputs

IV. ECOLOGICAL AND ECONOMIC VALUES OF ECOSYSTEM SERVICES

After classifying the ecosystem services, one of the crucial steps is understanding and exploring their values about the welfare system's welfares and goodness, including human beings. Valuation is the process by which the ecosystem services delivered by the ecosystems are valued based on their significance and the level of dependency for human beings. Valuation is the process of attributing a value (either economic or non-economic) to something. Scientists have made different approaches for an absolute valuation of ecosystem services. Economists have developed several valuation methods that typically use the monetary unit (Freeman III et al., 2014) while ecologists and others have developed measures expressed in various non-monetary units such as biophysical trade-offs and qualitative analyses (Costanza et al., 2004). The word ecosystem service itself clarifies that ecosystems provide values either in monetary or non-monetary to humans (Daily, 1997). However, for purely ecological perspectives, valuation is initiated by ascertaining ecosystem processes and functions responsible for ecosystem services provisioning (Limburg et al., 2002). The ecosystem valuation raises important and genuine data and methodology issues and by no means captures the full range of normative and practical considerations that surround ecological resource management (Turner et al., 2000). Many scientists have opined that it is not possible to value ecosystem and ecosystem services. Sagoff (1988) claims that environmental systems are connected to core social values that cannot or should not be reduced to monetary terms. Wilson & Howarth, (2002) have argued that ecological resources management includes the question of equity that is poorly addressed using standard valuation methods.

Despite these negative perceptions, Howarth & Farber, (2002) develops the case that economic valuation can contribute positively to the formulation and evaluation of environmental policies. Environmental systems provide material and experiential benefits that contribute directly to human well-being, and it is meaningful and essential to quantify these benefits in understandable terms.

R. S. De Groot et al. (2002) has categorized the ecosystem values into three categories based on the earlier publications by S. C. Farber et al. (2002); Howarth & Farber (2002); Wilson & Howarth (2002) and Limburg et al. (2002). MEA also associated three domain-value with the ecosystem service value. Three concepts of ecosystem valuation are: - (a) Ecological values (b) Economic values (c) socio-cultural values. In this paper, we are discussing ecological and economic approaches for the valuation of ecosystem services. So, we will discuss only ecological and economic values (R. S. De Groot et al., 2002; MEA, 2005).

A. *Ecological Value*

An ecosystem's ability to deliver goods and services depends on the ecosystem structure, processes, and functions providing them. The ecosystem services supported by the ecosystem's different components should be limited to a sustainable level. The limits of sustainable use are determined by ecological criteria such as integrity, resilience, and resistance. Therefore, the 'Ecological Value' or importance of a given ecosystem is determined both by the integrity of the Regulation and Habitat Functions of the ecosystem and by ecosystem parameters such as complexity, diversity, and rarity (R. Groot et al., 2000). From an ecological viewpoint, the concept of value has a different implication because ecosystems do not have value systems. Ecosystem service is a term coined to make apparent that ecosystems' structure and function provide value (whether the value is monetary or non-monetary) to humans (Daily, 1997). It is noteworthy that most functions and related ecosystem processes of an ecosystem are interconnected and sustainable use levels should be determined under complex system conditions (Limburg et al., 2002), taking due account of the dynamic interactions between functions, values, and processes (Boumans et al., 2002). The ecological valuation can be done at any ecological level. At species level ecological valuation, it can be done by observing the importance of the species role in the ecosystem. The most common assessment method is risk assessment (Critically endangered, endangered, and vulnerable). The ecological valuation is assessed by measuring resilience against external disturbances and biodiversity plays a crucial role at the ecosystem level.

B. *Economic Value*

The economic valuation seeks to attach a monetary amount to the ecosystem services. Four methods can do this valuation. The Economists have developed various ways of understanding and quantifying the value of goods and services that can moreover be used for ecosystem services valuation. The Millennium Ecosystems Assessment (MEA, 2005) has recognized four values based on how humans perceive, use and value ecosystem goods and services.

1) *Direct use values*

It includes those ecosystem services that are directly enjoyed and benefitted by the people. It includes provisioning and cultural services**.** These values can often be obtained from examining the operation of existing markets.

2) *Indirect use value*

It includes those services that do not directly benefit the people, but they include the processes that contribute to the production of ecosystem services that may have direct use-values. It is derived from the regulatory services provided by the ecosystem and biodiversity.

3) *Non-use values*

Non-use values are evaluated by identifying that resource exists and people simply derive pleasure for its existence or because they wish to bequeath it for the future generation. These services may not have any use for the people and are not traded in the market due to which it becomes more challenging to attach a monetary value. However, people are usually able to state how important they consider these things to be compared to other goods or services that are traded and can be valued. For example, Cultural services.

4) *Option value*

It includes those presently not in use for human welfare but, even though many ecosystem services still hold value for preserving the option to use such services in the future either by the individual (option value) or by others (bequest value). These are not traded in the market that's why it becomes difficult for people to assign relative importance to them because doing so requires an understanding of future uncertainty.

Further, then the economic values expressed by MEA, (2005) and TEEB, (2010) has presented an extraordinary way to explain the total economic values framework for ecosystem services (Fig. 2).

V. ECOLOGICAL AND ECONOMIC APPROACHES FOR ECOSYSTEM SERVICES VALUATION

The valuation methods fall under two broad categories: (A) Economic or monetary valuation (B) Ecological valuation.

A. *Economic or Monetary Valuation*

Economic valuation has been frequently used to evaluate the total value of services of a particular ecosystem or landscape at a given time (Adger et al., 1995; Pimentel et al., 1997; Hein et al., 2006). The economic valuation method attempts to bring about the general preferences for change in the state of the environment for monetary purposes. The monetary assessments of ecosystem services are important for adopting so-called externalities in economic accounting procedures and in policies that affect ecosystems, especially when nature has attached with either infinite or no value (R. De Groot, 2006). The economic valuation for ecosystem services has different methods that the ecologists and researchers illustrate. Many research publications have stressed understanding and assessing the value of ecosystem services in terms of economic valuation. However, the most powerful methods for the evaluation of the ecosystem services have been presented in their works by R. S. De Groot et al. (2002); TEEB, (2010) and Christie et al. (2012). On comparing their evaluation methods, it is noted that they do have methods in common. However, the difference is either the way they have grouped those methods or having some additional methods.

According to R. S. De Groot et al. (2002), economic valuation methods fall into four basic types. These are:

1) *Direct Market Valuation*

It includes services that trade in the market and mainly applicable for ecosystem goods and functional for some information functions (e.g., recreation). For explanation, they have cited an example of New York City seeking to use natural water regulation services of largely undeveloped watersheds to deliver safe water. It has avoided a $6 billion water filtration plant. It suggests those watersheds are worth up to $6 billion to New York City.

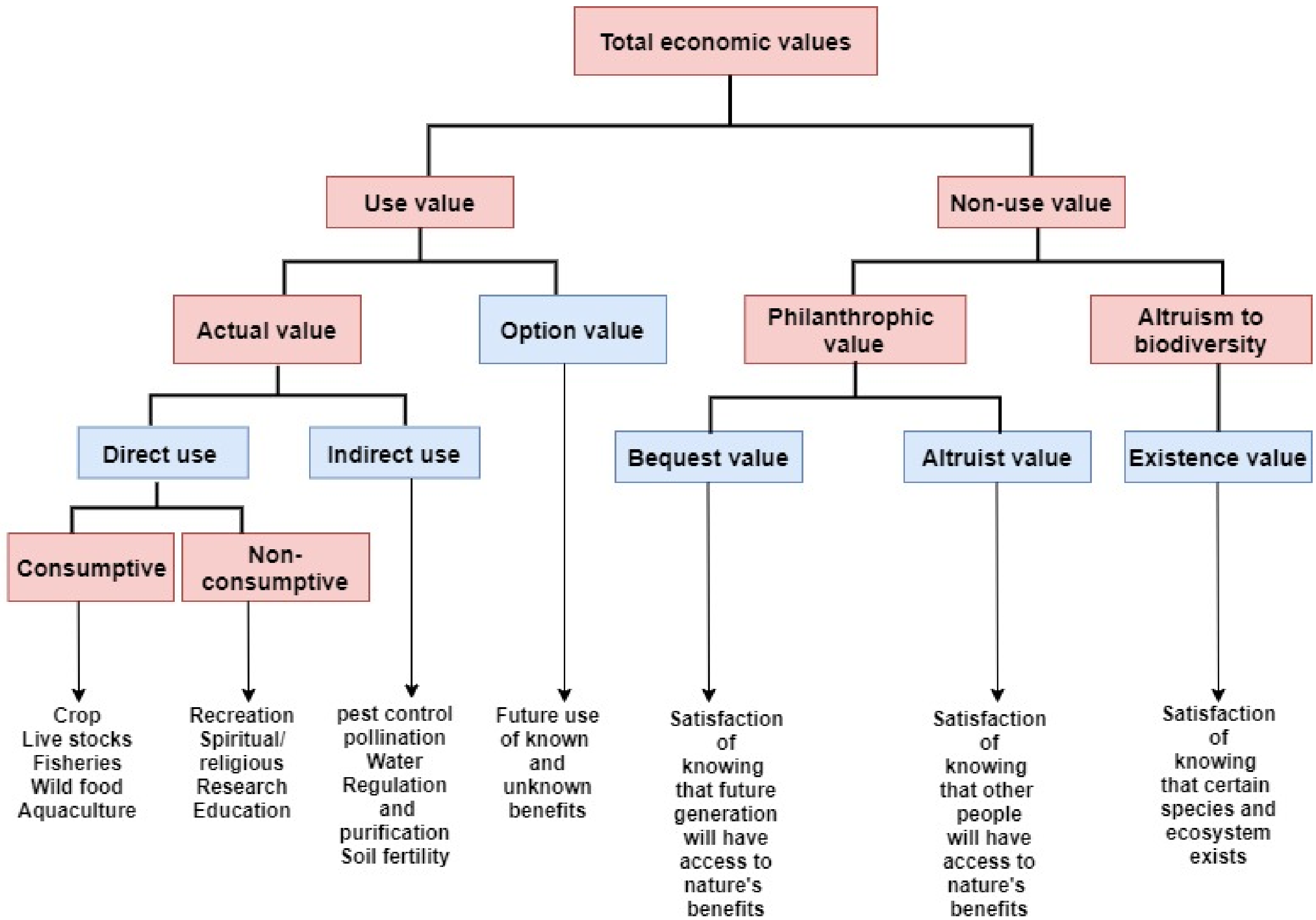

Fig. 2: Total economic values (TEV) framework by TEEB (2010). Boxes in sky blue and the examples below the arrows are directly addressed by value elicitation methods related to the TEV framework.

2) Indirect Market Valuation

This technique applies when the ecosystem services have no explicit market values. In such cases, indirect assessment of the services is needed and is done by establishing (revealed) Willingness To Pay (WTP) and Willingness To Accept (WTA) compensation for the accessibility and availability or loss of these services. It is further divided into:

a) Avoided cost

Services that allow the human society to avoid the cost that would have occurred in the absence of those services. For example, flood controls avoiding property damage.

b) Replacement cost

Some ecosystem services could be replaced by the artificial human-made system but are very costly. In such conditions, the replacement cost of the ecosystem services can be calculated.

c) Factor Income

It includes those ecosystem services that are the means of human income. E.g., natural water quality enhances commercial fisheries catch and thereby incomes of fishers.

d) Travel cost

It implies recreational areas that attract tourists and the Willingness to Pay (WTP) tourists to travel the recreational area.

e) Hedonic pricing

Hedonic pricing is the price people willing to pay for an associated service with the property they want to own. For example, a building near a beautiful scenic place will be more expensive than an identical building.

3) Contingent valuation

It is based on the service demands that may be identified by posing scenarios involving designing a social survey questionnaire to ask people their willingness to pay for enhancing ecosystem services or willingness to accept the loss or degradation of service.

4) Group Valuation

It values ecosystem services based on open public debate. This approach of ecosystem service evaluation involves group deliberation, not an aggregation of separately measured individual preferences.

TEEB, (2010) has also dealt with the economic valuation of ecosystem services (the total economic values). It classified economic valuation into three broad categories: Direct market valuation, revealed preference approaches and stated preference approaches.

1) Direct market valuation

This method Uses data from the actual market, thus reflects actual preferences or costs to individuals. It is divided into three main approaches:

a) Market price-based approaches

It is most applicable to the provisioning services because these are sold in the market and are readily available in the markets.

b) Cost-based approaches

It based on the estimation of the cost incurred if the services are to be recreated.

- Avoid cost method: Cost that would have been required in the absence of the ecosystem services.
- Replacement of cost method: Cost incurred by replacing ecosystem services with artificial technology.
- Mitigation or restoration of cost method: Cost is needed to improve and mitigate disturbed ecosystem services or the cost of restoring the ecosystem services.

c) Production function-based approaches (PF)

It assesses how much a given ecosystem service contributes to delivering other ecosystem services traded in the present market. E.g., regulating services contribution to the provisioning services. PF approach commonly uses scientific knowledge on cause-effect relationships between the ecosystem service(s) being valued and the output level of marketed commodities.

2) Revealed preference approaches

It relies on the data regarding individual choices or preferences for particular ecosystem services existing in the market. The economic agent reveals the choice of people regarding ecosystem services. The people's choices and preferences are analyzed in two ways: travel cost method and hedonic pricing method.

Both travel cost method and hedonic pricing are mentioned in R. S. De Groot et al. (2002), and economic valuation methods under Indirect Market Valuation Methods have discussed above.

3) State preference approaches

It estimates the demand for ecosystem services using a survey based on hypothetical changes in ecosystem services provision. It uses a carefully structured questionnaire to elicit the individual preferences for a given change in the ecosystem services or attributes. It is the only approach used for the estimation of non-use values. The state preference approach can be measured in three ways.

a) Contingent valuation method and Group Valuation

These two methods were separately described in the above given economic valuation methods by De Groot in 2002. Unlike him, TEEB classified both Contingent valuation and Group valuation under the State preference approach.

b) Choice Modelling

It attempts to modal and recognizes an individual's preference in a given context (Hanley et al., 1998; Philip & MacMillan, 2005). The individuals are faced with different levels of two or more alternatives with a shared feature of the services to be valued, but with different levels of attributes (One of the attributes being in terms of money people would like to pay for the services). It can be applied through different methods, including choice experiments, contingent ranking, contingent rating, and pair comparison.

The significances of economic valuation for ecosystem services quantification can be assessed through the number of case studies that have been published based on the economic valuation method over the years. The studies were conducted on various ecosystems in different countries with different economic methods (Table IV).

Table IV. Economic methods used to estimate the ecosystem services of the various ecosystem in different countries.

Methods	**Ecosystem**	**Ecosystem service**	**Values**	**Value estimated**	**Location**	**References**
Market price	Sunderbans Reserve Forest	Provisioning	direct and indirect use	744,000 US$/year	Banglade sh	Uddin et al., 2013
		Cultural	--	42,000 US$/year	--	--

	Alpine forest	Provisioning	direct and indirect use	15.54 M US$/year	Italy	Häyhä et al., 2015
	Urban orchards	Food	direct and indirect use	--	Boston	Goldstein et al., 2017
	mangrove ecosystem	Fisheries and agricultural products	direct and indirect use	230 US$ /hec/year	--	Christensen, 1982
	mangrove ecosystem	forestry and fishery products	direct and indirect use	311 US$ /hec/year	--	Gilbert & Janssen, 1998
Replacement cost and damage cost avoided	natural terrestrial, freshwater and estuarine ecosystem	provisioning, regulating, cultural	direct and indirect use	3.79 US$ billion per annum	South Africa	Turpie et al., 2017
	Alpine forest	Regulating	--	22.49 M US$ /year	Italy	Häyhä et al., 2015
		Cultural	--	4.44 M US$/ year	--	--
	Urban forest	Local climate regulation	Direct and indirect use	--	Beijing	Leng et al., 2004
	Forest reserve	Water conservation	direct and indirect use	1385.430 million US$/year	Japan	Ninan & Inoue, 2013
	Naharhole national park	pollination	direct and indirect use	--	India	Ninan & Kontoleon, 2016
	Urban ecosystem	Air purification	direct and indirect use	3.9 million US$/year	USA	--
	Forest	Hydropower and water consumption	--	152.71-268.77 US$ /hectare	Costa Rica	Reyes et al., 2001
Hedonic pricing	Urban forest	Aesthetic appreciation and inspiration for culture, art and design	direct and indirect use	--	New york	Peper et al., 2007
	Forest reserve	Soil protection	direct and indirect use	0.031 million US$/year	japan	Ninan and Inoue, 2013
	Tree cover	aesthetic quality, outdoor recreation,	--	--	USA	Sander & Haight, 2012
	Urban ecosystem	Air purification	--	1.48 million US$	USA	--
Travel cost	Urban wetland park	Recreation, mental and physical health	use-value	--	Guiyang	Wang et al., 2019
	Lake	water for recreational use	--	--	India	Jala & Nandagiri, 2015
	Lake	Water storage, climate regulation, recreation and tourism, oxygen service, carbon	--	--	China	--

		sequestration, food production service				
	National parks	Recreation services	--	2.01-3.27 billion US$/year	Germany	Mayer & Woltering, 2018
Contingent valuation	Olive tree cultivation	Carbon sequestration	use and non-use	1427 US$/hectare	Greece	Bithas & Latinopoulos, 2021
	agriculture	Carbon sequestration, water, recreation	use and non-use	--	Mexico	Perez-Verdin et al., 2016
	Forest ecosystem, central western ghats	Provisioning, regulating, cultural, supporting	use and non-use	1163.37crores US$/year	India	Ramachandra , 2016
	Constructed wetland	water	use and non-use	122935 US$ in 20 yr period	China	Yang et al., 2008
	forest ecosystem	Soil water conservation, climate regulation	use and non-use	--	China	Tao et al., 2012
	Coral reef	Fishery, tourism, recreation	use and non-use	3148 US$ /hectare	Hawaii	Cesar & van Beukering, 2004
	Forest	Water regulation and recreation	--	147.75 US$/hectare	Mexico	Martínez et al., 2009
Choice modelling	Green building	Regulation of water flow, local climate regulation, air quality regulation	use and non-use	--	Hong kong	Chau et al., 2010
	Green wall	habitat for species	use and non-use	--	Southamp ton	Collins et al., 2017
	Dryland	Provisioning, regulating, cultural	--	--	Ethiopia	Bekele et al., 2018
	Forest	Provisioning	--	--	Mozambi que	Kosenius et al., 2019
	Wetland	Provisioning, supporting, cultural	--	--	Kenya	Mulatu et al., 2014

B. *Ecological Valuation*

The non-economic valuation of ecosystem service includes the ecological and cultural values valued through non-economic and non-monetary terms. This valuation of ecosystem services has become significant due to harsh criticism over the use of economic approaches. It usually examines the importance, preferences, needs, or demands expressed by people towards nature, which are assessed through qualitative and quantitative measures other than money (Chan et al., 2012) and have been in practice for years in environmental policymaking protected area. Many recent initiatives such as MEA, Defra, TEEB, IPBES, etc., and several publications have acknowledged the vital role of non-monetary valuation in ecosystem service assessment. In several case studies, the evaluation of ecosystem services has been assessed through non-monetary manners such as regulating services by Jansson & Nohrstedt (2001), provisioning services by Fitzhugh & Richter (2004), and cultural services by Kliskey (2000). Kenter et al. (2011) have reported that better understanding and more sophisticated application of non-monetary valuation can improve monetary valuation performance. Several modelling tools are available for assessing the ecological values of ecosystem services. These tools must be selected concerning targeted ecosystem services for valuation, valuation scope and scale, available data, cost, time, technical capacity of stakeholders, and available technical support. This section includes four modelling tools potentially applicable to the valuation process. Tools for eliciting ecological valuation are discussed below:

1) Artificial Intelligence for Ecosystem Services (ARIES)

It is a new method and web-based application designed to assess ecosystem services, including mountain forest ecosystem services (Villa et al., 2014). This tool can lighten the values of these services to humans and helps decision-making related to ecosystem services. Currently, the following ecosystem services models have been developed and tested: carbon storage, flood regulation, Pollination, and cultural or recreational values. Models for several additional ecosystem services are under development: mangrove carbon storage, mariculture suitability, water provision, landslide risk, and sediment provision. Case studies have also been developed for carbon sequestration, coastal protection, cultural values, erosion, fisheries, biodiversity, crop production, scenic value, and sediment retention/delivery. Table IV shows a comparison of ecosystem service tools that can be used to assess different ecosystem services.

2) Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)

InVEST is a software package for assessing the consequences of different policies, climate, land use, coastal marine use, or other scenarios on ecosystem services' spatial provision (Tallis & Polasky, 2009). Currently, InVEST includes collecting computer-based models for mapping and quantifying 18 individual ecosystem services and supporting tools and models. Ecosystem services that can be modelled in InVEST include carbon, coastal blue carbon, coastal vulnerability, crop pollination, fisheries, habitat quality, habitat risk assessment, marine fish aquaculture, marine water quality, nearshore waves and erosion, offshore wind energy, recreation, reservoir hydropower production, scenic quality, sediment retention, and water purification.

3) Toolkit for Ecosystem Services Site-based Assessment (TESSA)

It is an interactive PDF that provides practical guidance on how to provide which ecosystem service, what data are needed to measure them, what methods can use to obtain data, the steps required for each method and how to communicate the results to inform decision making. It mainly focuses on stakeholder identification and engagement to discover various ecosystem services and to understand ecosystem services rights and value systems that different stakeholders obtain. Although TESSA uses a simple method and emphases stakeholders, stakeholder identification and their effective engagement might still be challenging owing to the complexity of ecosystem services management (Peh et al., 2013).

4) Multiscale Integrated Model of Ecosystem Services (MIMES)

It is a collection of linked economic and ecological models. It is tremendously versatile and can incorporate temporal (time series) and spatial (GIS) data to simulate ecosystem and economic dynamics through space and time (Boumans et al., 2015). MIMES can be used to model any ecosystem services. The availability of appropriate input data determines the accuracy of model output. The MIMES use input data from GIS sources and time-series data to simulate ecosystem components under different scenarios defined by stakeholder inputs.

5) Social Values for Ecosystem Services (SoLVES)

It is a GIS application for assessing, mapping and quantifying the social values of ecosystem services. The ecosystem services that can be assessed using SolVES depend on the social values typology used in the public value and preference survey but have commonly included aesthetic appreciation, recreation, spiritual experience and identity, learning, and future/bequest value.

Table IV. Comparison of ecosystem service tools can be used to assess ecosystem services (Source: Neugarten et al., 2018).

Ecosystem service	Modelling tools				
Provisioning	ARIES	InVEST	TESSA	SoLVES	MIMES
Fisheries		✓	✓		✓
Freshwater aquaculture			✓		✓
Harvested wild goods / Hunting / Non-wood forest products (e.g., honey, mushrooms, berries)			✓		✓
Livestock grazing			✓		✓
Material extraction (e.g., coral, shells, resin, rubber, grass, rattan)			✓		✓
Medicinal resources			✓		✓
Timber			✓		✓
Water-Water provision / Water supply / Water quantity / Water yield	✓	✓	✓		✓
Genetic material					✓

Regulating					
Carbon (sequestration)		✓	✓		✓
Carbon (storage) (terrestrial)	✓	✓	✓		✓
Coastal protection / Coastal flood regulation / Coastal vulnerability		✓	✓		✓
Erosion			✓		✓
Flood protection / Flood regulation / Flood prevention	✓		✓		✓
Pest & disease regulation					✓
Pollination / Crop pollination	✓	✓	✓		✓
Sediment retention / Sediment regulation / Sediment delivery / Sediment provision	✓	✓			✓
Seasonal water yield		✓	✓		✓
Water purification / Water quality		✓	✓		✓
Cultural					
Cultural and historical values / Cultural heritage / Inspiration, creative or artistic / Social relations/community benefits			✓	✓	✓
Health, mental & physical			✓		✓
Peace & stability					✓
Research / Knowledge			✓	✓	✓
Education			✓		✓
Recreation / Nature tourism / Leisure	✓	✓	✓	✓	✓
Spiritual values / Sacred natural sites			✓		✓
Scenic quality / Aesthetic viewsheds	✓	✓	✓	✓	✓

To synthesize as much as possible information about the tools in a single table, we evaluated each tool against a standard set of criteria and concise this information in Table V. Our review presents a comparison of ecosystem services tools based on criteria provided by Healy & Secchi, (2016) and Bagstad et al., (2013). The criteria used in these reviews included:

- Cost/availability (free/open-source)
- Time requirements (low to high)
- Data input demand (low to high)
- Skill requirements (low to high)
- Scale of analysis (site to global)
- Quantitative / qualitative
- Monetary / nonmonetary
- Spatially explicit / not spatially explicit
- Technical requirements (e.g., internet connection, GIS or other specialized software)
- User support provided (low to high)
- Level of development and documentation
- Approach to uncertainty
- Level of stakeholder engagement required

- Generalizability (i.e., can the model/tool be applied in new places or contexts)

Table V. Assessment of ecosystem service tools against standard criteria (adapted from Healy & Secchi, (2016) and Bagstad et al., (2013).

S.no.	Criteria	ARIES	InVEST	TESSA	SoLVES	MIMES
1.	Cost/availability (free/open source)	Free, open-source	Free, open-source	Free, open-source	Free, requires the purchase of ArcGIS software (closed source)	Free, open-source; requires the purchase of SIMILE software (closed-source)
2.	Time requirements (low to high)	Low for global models; High for new case studies	Moderate to high	Low to high	Low to high	High for new case studies
3.	Data input demand (low to high)	Low to high	Moderate to high	Moderate to high	Low to moderate	Moderate to high
4.	Skill requirements (low to high)	Low to high	Moderate to High	Low	Moderate	High
5.	The scale of analysis (site to global)	Local to global	Local to global	Local	Local to regional	Local to regional
6.	Quantitative/ qualitative	Quantitative or Qualitative	Quantitative or Qualitative	Quantitative or Qualitative	Quantitative	Quantitative
7.	Monetary/ nonmonetary	Monetary or non-monetary	Monetary or non-monetary	Monetary or non-monetary	Non-monetary	Monetary or non-monetary
8.	Spatially explicit / not spatially explicit	Spatially explicit	Spatially explicit	Not spatially explicit	Spatially explicit	Spatially explicit
9.	Technical requirements (e.g., internet connection, GIS, or other specialized software)	Computer and internet access	Computer, GIS software	Field equipment (optional)	Computer, ArcGIS	Computer access, SIMILE software, GIS software
10.	User support provided (low to high)	Moderate	High	Low	Moderate	Moderate
11.	Level of development and documentation	Case studies & global models developed and documented	Fully developed and documented	Fully developed and documented	Fully developed and documented	Case studies developed and documented
12.	Approach to uncertainty	Uncertainty through Bayesian networks, Monte Carlo simulation, and machine learning	Uncertainty through varying inputs	The guidance provided on the level of confidence	Report's statistics that indicate how well the model can reproduce reserved value observations	Uncertainty through varying inputs (automated)
13.	Level of stakeholder engagement required	Low	Low	High	High	Low to high
14.	Generalizability (i.e., can the model/tool be applied in new places or contexts)	High for global models, low for case studies	High, though limited by the availability of underlying data	High	Moderate	High, though limited by the availability of underlying data

VI. ECOLOGICAL AND ECONOMICS SUSTAINABILITY

A. Sustainable Development: Linking Ecological and Economic Concepts

Sustainable development has become an important question of international environmental policy since the United Nations' summit in Rio 1992. According to the Brundtland Report's definition in 1987, development is sustainable when it "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987). However, the definitions of the Brundtland Report and the Rio Conference are explicitly anthropocentric. However, the general definition of sustainability should touch upon almost all the aspects of economic, ecological, and social development (Rennings & Wiggering, 1997). The three most crucial management rules of resource use have been derived from it.

- Harvest rates of renewable resources should not surpass regeneration rates.
- Waste emissions should not surpass the appropriate assimilative capacities of ecosystems.
- Non-renewable resources ought to be exploited in a very quasi-sustainable manner by limiting their depletion rate to the speed of creation of renewable substitutes.

These three management rules characterize a sustainable use of natural resources.

Now, sustainability has two fundamental components. First is ecological sustainability, defines as the ecosystem's capacity to remain diverse, productive, and resilient over time and maintain the supply of ecosystem services essential for human beings and other species (Farley, 2012). Another component is economic sustainability, defined as an economic system's capacity at any scale from individual households to the global economy to remain diverse, productive, and resilient over time. Many ecosystem services are essential for human well-being, and their loss could have unacceptable economic impacts. For example, during Holocene, a geographical area characterized by a stable climate, agriculture, and civilization had evolved. Now we have entered an Anthropocene, an era in which impacts of anthropogenic activities on ecosystems are on the scale of geological forces (Crutzen, 2002). Anthropogenic climate change has a significant impact on ecological and economic sustainability.

There is one closely related central debate concerning the relationship between economics, ecosystem services, and sustainability (Farley, 2012). This is known as the strong vs. weak sustainability debate (Ekins et al., 2003). Economists interpret sustainable development as the need to leave the future generation with the same natural capital that the current generation enjoys. Weak sustainability derives from the perception that natural capital (the goods and services provided by nature) and human-made capital (including built, human and social capital) are alternatives. The current generation can only leave the same stock of natural capital as long the total value of the capital passed remain constant or non-declining? Many economists believe that natural resources play an insignificant role in economic output (Dasgupta, 2008). If we see from this perspective, all resources have alternatives.

Strong sustainability derives from the perception that natural capital and human-made capital are rarely alternatives. They are more often called complements because no human-made capital can replace natural capital (Daly & Farley, 2010). Hence ecosystem services are vital for the existence of humans and all other species. The natural capital stock that generates ecosystem services is known as critical natural capital (CNC). However, we always don't know what elements of natural capital are critical and what elements can be lost without reducing human beings' welfare. In this context, Leopold (1993) argued that we should treat all-natural capital as critical, then only the concept of ecological and economic sustainability can achieve. Fig. 3 shows different ecology and economics features and describes how the integration of both disciplines helps balance ecosystem services more sustainably.

There are many theoretical reasons for choosing strong sustainability over weak sustainability assumptions. Victor (1991) notes that if we are going back to Marshall, there is a recognition in economics that says human-made capital is fundamentally different from environmental resources. Human-made capital is reproducible in quantities, and environmental resources are gifts of nature, which is limited. Another reason is the devastation of human-made capital is irreversible (this would only occur if the human capital, or knowledge, that created the human-made capital had also been lost). On the other hand, species extinction, climate change, and fossil fuel combustion are expected in consumption in natural capital. Moreover, human-made capital requires natural capital for its production, and hence it can never be a complete alternative to resources.

If strong sustainability holds, two basic rules apply. First, humans cannot degrade any ecosystem structure element faster than it can restore itself. Second, humans cannot emit waste into any finite system at rates more significantly than absorbed. Otherwise, waste will accumulate and causing harm to the whole ecosystem. Unfortunately, the failure of economists is to acknowledge the importance of natural resources. Hence, it has been essential to reduce resource extraction and waste emission after that ecological and economic sustainability in relation to ecosystem services can be fulfilled.

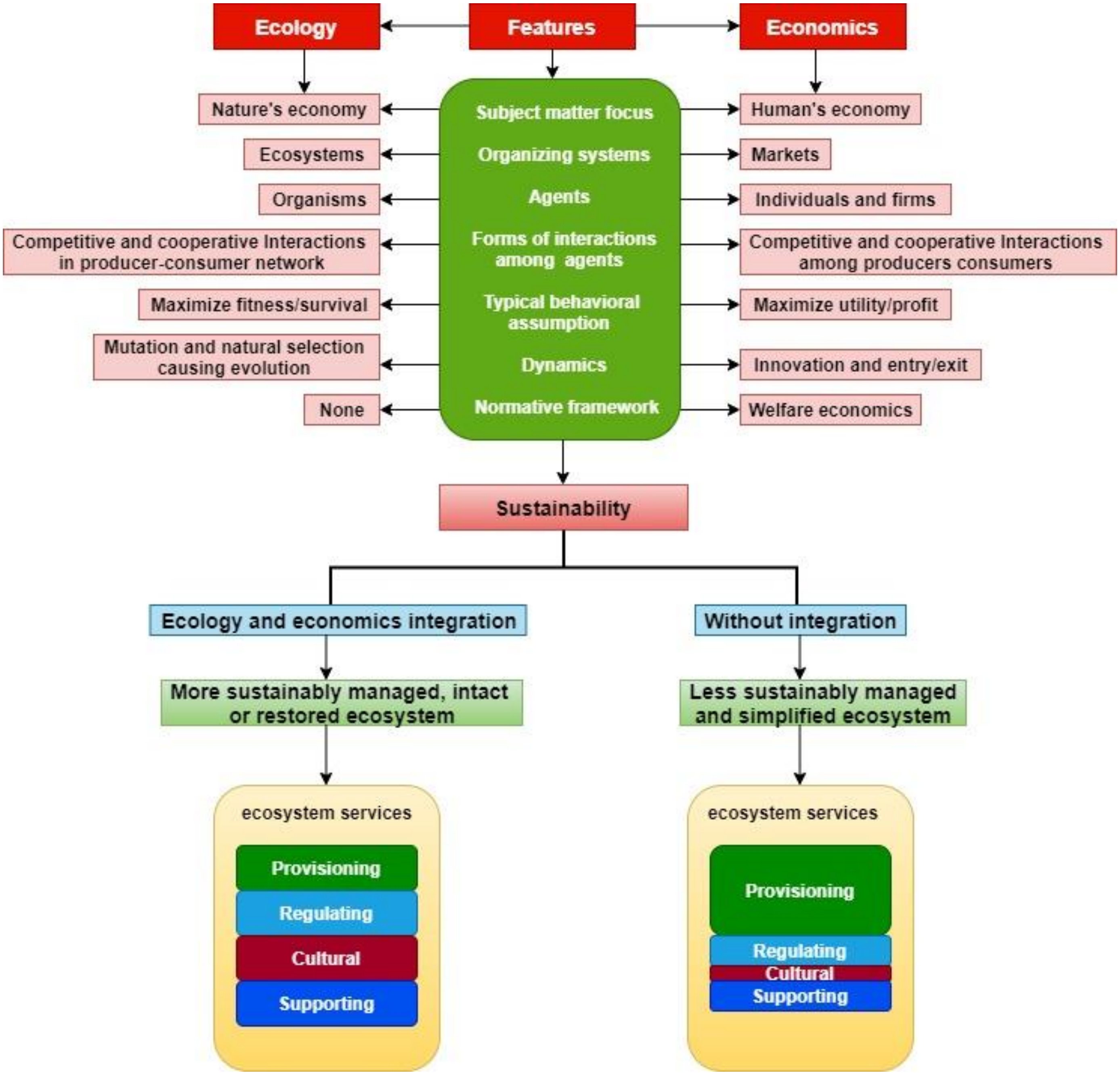

Fig. 3: A conceptual framework of the linkages between ecology, economics, ecosystem services and sustainability.

CONCLUSION

Ecosystems are the primary provider of sustenance to all forms of life with an additional supply of security, shelter and well-being at zero cost. However, these provisions have gone enormous decline in the last few decades due to both natural and anthropogenic causes. It has also forced human beings to account for environmental impacts before the starting of a project. The assessment of the targeted ecosystem's ecosystem services has been a magnificent tool to understand the significances and essentiality of the ecosystem for human welfare. Although the classification and valuation methods of ecosystem services have displayed some differences. Therefore, ecosystems' consequences would be perceived as a crucial step towards ecosystem sustainability. The difference in classifications can be seen as a result of the difference in opinions while defining ecosystem processes, functions, goods and services.

Similarly, the valuation methods for ecosystem services assessment have been analyzed into two different economic and ecological approaches. Despite differences in valuation approaches, both are considered as very crucial for evaluating ecosystem services. Furthermore, ecosystem services' valuation would help to get an exact value-oriented dimension of the specific ecosystem for ecosystem sustainability. Also, economic empowerment is a vital aspect of any state in the current developmental era. Therefore, the integration of economic and ecological sustainability could potentially act to uplift the state without ecosystem destruction.

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