ECOSYSTEM SERVICES - A CONCEPT NOTE

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DISSEMINATION PAPER - 9

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Ecosystem Services – A concept note

Natural ecosystems provide variety of goods and perform fundamental life-support functions upon which human civilization depends. Ecosystem goods are direct material benefits derived from any ecosystem (e.g., wood, edibles, fodder, raw material, etc. from a forest ecosystem), whereas, ecosystem services (ES) are indirect benefits (e.g., soil fertility maintenance, soil and water conservation, purification of air and water, microclimate regulation, carbon (C) sequestration, aesthetic value, etc. associated with the same ecosystem) (Costanza *et al.*, 1997). In spite of the crucial ecological and economic importance of these ES, ecosystems are facing continual degradation and deterioration in their service provision. It is argued that their value to human welfare is still underestimated and the ES are at most partly captured in conventional market economics (Pagiola *et al*., 2005).

This note gives in details the different types of ecosystem services as provided by the nature. Taking few ecosystems as illustrations, the note expounds on their services. Since the ecosystems are deteriorating, the note then discusses the kind of pressures faced by the ecosystem. Of late there is an almost consensus that ecosystem can be protected if those who benefit from the ecosystem compensate the stakeholders who manage it. Payment for ecosystem services is therefore discussed in the penultimate section. The note concludes with what else can be done so that the ecosystem continues to provide goods and services.

1. Ecosystem and Ecosystem Services

An ecosystem is a community of animals and plants interacting with one another and with their physical environment. Ecosystems include physical and chemical components, such as soils, water, and nutrients that support the organisms living within them. These organisms may range from human beings to large animals to plants to microscopic bacteria. Ecosystems include the interactions among all organisms in a given habitat. The health and wellbeing of human population depends upon the services provided by ecosystems and their components — organisms, soil, water, and nutrients.

Colloquially, *Ecosystem Services* (ES) are the processes by which the environment produces resources that we often take for granted such as clean water, timber, habitat for fisheries, pollination of native and agricultural plants etc. These services are extensive and diverse and affect the quality of our land, water, food, and health. Some of the key services include:

- moderation of weather extremes
- seeds dispersal
- drought and floods mitigation
- protection of people from the sun's harmful ultraviolet rays
- nutrients cycling and movement
- protection of streams, river channels and coastal shores from erosion
- detoxification and decomposition of wastes
- controlling agricultural pests
- maintaining biodiversity
- generating and preserving soils and renewing their fertility
- contribution to climate stability
- purification of air and water
- regulating disease carrying organisms
- pollination of crops and natural vegetation

Millennium Ecosystem Assessment (2005) has divided different ES into four categories. These include: (i) provisioning services, such as food, fiber, timber, medicine etc.; (ii) regulating services, such as climate moderation, C-sequestration, disease and pest control, pollination and hydrological regulation; (iii) cultural services, like recreational, spiritual, educational, and aesthetic; and (iv) supporting services, such as soil formation, nutrient cycling, biodiversity and succession (Figure 1). Most of these ES have value to society but there exists no relevant market where these values are expressed. Across the globe in the wake of ever escalating human activities, there is an exigency for identification and monitoring of ES both locally and globally, so as to consider their worth and importance in decision making processes.

Although early references to the concept of ecosystem functions, services and their economic value date back to the mid-1960s (Titenberg, 1998), the concept of ES has gained popularity only since the 1990s. Realizing their worth, several conferences placed ES quantification and valuation high on the agenda. The release of the Millennium Ecosystem Assessment (2005) report is an important milestone in recognizing the relevance and value of ES. The report has reinforced the dependence of humans on ecosystems, and stressed the need to describe, quantify and value (ecologically, culturally and economically) the ES. Concerns have been shown that the data on ES often appears at incompatible scales of analysis and is classified differently by different authors. In order to make a comparative analysis, a standardized framework for the comprehensive assessment of ecosystem functions, goods and services is needed.

Earlier view considered natural resources like water, mineral, air etc. as biotic and geologic stock of extractable resources intended for economic use. Of late, the view is to consider ecosystem as a capital *fund* which is capable of generating *flows* of ecosystem services (Millennium Ecosystem Assessment, 2005). This flow has also been termed as natural income by some authors (see for example, Daly and Farley, 2003). Recently, some researchers (see for example, Boyd and Banzhaf, 2007) have given a new definition of ecosystem services which requires separating ecosystem end products and intermediate products. According to this definition "ecosystem services are component of nature directly enjoyed, consumed or used to yield human well being" (*ibid*.). Clean drinking water, which is consumed directly by a household, is an ecosystem service. It depends on a range of processes or functions like hydrological cycle etc., which are intermediate products, hence should not be counted as ecosystem services. It is to be noted that this classification has been done keeping measurement in focus and is a step forward to welfare accounting.

Value / Worth of Ecosystem Services - Illustrations

Natural ecosystems and the plants and animals within them provide humans with services that would be very difficult to duplicate. While it is often impossible to place an accurate monetary amount on ecosystem services, we can calculate some of the financial values. Many of these services are performed seemingly for "free," yet are worth many trillions of dollars. Recent efforts have estimated the ecosystem service benefits at roughly 33 trillion USD (in 1994 dollars) which is about 5000 USD per capita (Costanza *et al.*, 1997). Following examples illustrate some of these services and their values:

- Much of the Mississippi River Valley's natural flood protection services were destroyed when adjacent wetlands were drained and channels altered. As a result, the 1993 floods resulted in property damages estimated at 12 bn US $ partly from the inability of the Valley to lessen the impacts of the high volumes of water.
- Velachery – one of Chennai's fastest growing suburb was severely flooded in November 2005. The reason being 20 years ago the area had a wetland, which occupied over 225 acres. The pressure of urbanisation meant that the lake had to be shrunk and land to be reclaimed. After the reclamations and illegal encroachments the wetland shrunk to only 25% of its original area (i.e., 54 acres). The consequence of these reclamations is that the rainwater instead of going into the lake enters homes and offices. Same is the situation in some other suburbs. The city that used to have over 270 small lakes now has just over 10 lakes.[1] As a result of this, any heavy downpour results in immediate water logging and loss of property.
- Cherrapunji, India, which lies at the foot of the Himalaya Mountains, is one of the wettest places on earth. During the monsoon season, it receives 350 inches (≅ 9,000 mm) of rainfall. Ironically, Cherrapunji also suffers from water shortage. This is because no vegetation is left to hold the water. The water rushes away almost as quickly as it falls from the sky. Within two months after the monsoon rains have gone, water becomes scarce in Cheerapunji.[2] On the flip side, this causes sudden flood in the downstream areas.

[1] Source: ibnlive.in.com/news/urbanisation-pressure-submerges-chennai/869-3.html accessed in Feb. 2009.

[2] Source: http://www.watchtower.org/e/20010622/article_02.htm accessed in Feb. 2009.

- 80% of the world's population relies upon natural medicinal products. Of the top 150 prescription drugs used in the U.S., 118 originate from natural sources: 74% from plants, 18% from fungi, 5% from bacteria, and 3% from one vertebrate (snake species). Nine of the top 10 drugs originate from natural plant products.
- Over 100,000 different animal species — including bats, bees, flies, moths, beetles, birds, and butterflies — provide free pollination services. One third of human food comes from plants pollinated by wild pollinators. The value of pollination services from wild pollinators in the U.S. alone is estimated at 4-6 bn US $ per year.
- *New York City uses nature's water filtration system to save billions* - Before it was engulfed with agricultural and sewage runoff, the watershed of the Catskill Mountains provided New York City with water ranked among the best in the Nation by Consumer Reports. When the water fell below desired quality standards, the City investigated what it would cost to install an artificial filtration plant. The estimated price for this new facility was 6-8 bn US $, plus annual operating costs of 300 mn US $ — a high price to pay for what once was free. New York City decided instead to invest a fraction of that cost ($660 million) in restoring the natural capital it had in the Catskills watershed (Nickens, 1998).

Taxonomy of Ecosystem Services

At a very basic level, services provided by the ecosystem can be distinguished between *use value* and *non-use value*. Use value implies that attributes of nature are being utilized in some manner. The manner could be traditional or classic e.g., when water is used to irrigate crops, which are then harvested and consumed (Field, 2001), whereas, bird watching and boating use the resource in a different sense. Non-use values, on the other hand, are values expressed by human beings simply for the existence of natural resources. Existence may be associated with expectations for future use, called as *option value,* or the yearning to leave a healthy ecosystem for future generations, called *bequest value*. People may not be using a resource at present, but may prefer suitable actions that ensure availability of the resource in future. The examples include polar ice-caps, polar bears etc.

The use values can also be divided into *extractive* or *consumptive* and *non-extractive* or *non-consumptive* resources. Extractive resources are those that are subject to some process of physical removal from their natural surrounding and perhaps physical transformation during their use. Examples include fishing, harvesting of timber, hunting etc. Non-extractive resources are those that yield services without being removed from their natural setting. This includes nature tourism, river rafting etc. Many resources produce both extractive products and non-extractive services. An important non-extractive resource service is ecosystem protection. One part of a resource system provides support and protection for other parts. For example, wetland are integral part of wider hydraulic system, hence their protection is key if water resources such as groundwater aquifers are to be protected. Similarly, forests provide important services in flood control and the regulation of water quality.

It is to be noted that the dividing line between extractive and non-extractive resources is sometimes blurred. Some extractive resources are not necessarily transformed during use or are entirely lost to nature. For instance, water that is extracted from an aquifer or river and used for irrigation or industrial use may flow back into the hydraulic system at a different location, possibly in diminished quantity and also degraded in quality. The flow of zoo animals is extractive in the sense that they are removed from their natural habitats, but no physical conversion is involved (Field, 2001: 30). Table 1 gives the different ecosystem services available. Since for many of the services benefits spill and accrue to the larger boundaries, the table also gives the likely beneficiaries of the ecosystem services. Though resource is available locally and needs to be managed locally, it can be clearly seen from the table that the benefits accrue at a much larger scale.

Table 1: Ecosystem services – types and likely beneficiaries

	Type of Value	Ecosystem Service	Scale of Area Benefited			
			Local	Regional	National	Global
1	Use	Grazing	Y			
2	Non-use	Succession (Land slide / slip stabilization)	Y			
3		Protection from sun's harmful ultraviolet rays	Y			
4		Controlling Agricultural pests	Y			
5		Nutrient recycling and movement	Y	Y		
6		Purification of air and water	Y	Y		
7		Regulating disease carrying organisms	Y	Y		
8		Soil Formation / Fertility Maintenance	Y	Y		
9	Use/ Non-use	Hydrological Regulation	Y	Y		
10	Non-use	Climate Moderation	Y	Y		
11		Seeds Dispersal	Y	Y		
12		Drought and Flood mitigation	Y	Y		
13		Pollination	Y	Y		
14	Use	Non-timber forest products	Y	Y	Y	
15	Non-use	Carbon Sequestration				Y

	Type of Value	Ecosystem Service	Scale of Area Benefited			
			Local	Regional	National	Global
16		Protection of streams, river channels and coastal shores from erosion	Y	Y	Y	Y
17		Maintaining biodiversity	Y	Y	Y	Y
18		Recreation / Landscape Beauty	Y	Y	Y	Y

Source: Own compilation from different sources

2. Ecosystem services from Wetland, Forest and Mangrove Ecosystems

There exist several important ecosystems that are vital to the sustenance of life. These include marine ecosystem, forest ecosystem, mangrove ecosystem, urban ecosystem, inland water ecosystem, mountain ecosystem, dryland ecosystem, polar ecosystem, island ecosystem and cultivated ecosystem (Millennium Ecosystem Assessment, 2005). This section talks briefly of three key ecosystems – wetlands, forests and mangroves.

Wetland Ecosystem

Wetland ecosystems include lakes, rivers, marshes, and coastal regions to a depth of 6 meters at low tide (Millennium Ecosystem Assessment, 2005). Wetland ecosystems provide a variety of services which are vital for human well-being and poverty alleviation. These include fish and fiber, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, and, tourism.[3]

[3] It is estimated that wetlands cover an area of over 1,280 million hectares. Estimates also exist suggesting that more than 50% of specific types of wetlands in parts of North America, Europe, Australia, and New Zealand have been destroyed during the 20th century, and many others in many parts of the world degraded. It is to be noted that despite their vital role, the degradation and loss of wetlands is more rapid than that of other ecosystems. Similarly, the status of both freshwater and coastal wetland species is deteriorating faster than those of other ecosystems (Millennium Ecosystem Assessment, 2005).

The following discussion illustrates one key ecosystem service provided by wetlands. Excessive sedimentation results when soil is eroded and washed down into waterways or blown in from exposed earth. Construction, road building, logging, and agricultural activities can trigger this process. Large quantities of sediment can reduce the ability of waterways to control floods by exhausting the system's capacity to store the extra sediments that are brought along in floods. Excess sedimentation can increase stream turbidity and directly harm fish and other aquatic organisms. It can also bring in other pollutants such as fertilizers and pesticides. It is estimated that wetlands can trap 80 to 90% of sediment from runoff (Ewel, 1998), thus provide a very vital ecosystem service. Table 2 lists out the different services provided by wetland and the intended beneficiaries.

Table 2: Ecosystem services from Watershed

	Type of value	**Services**	**Local**	**Regional**	**National**	**Global**
1	Use	Production of fish, fruits and grains	Y	Y		
2		Production of logs, fuelwood, peat, fodder	Y	Y		
3		Storage and retention of water for domestic, industrial and agricultural use	Y	Y	Y	
4		Provide genes for resistance to plant pathogens, ornamental species	Y	Y	Y	Y
5		Source of medicines & other materials from biota	Y	Y	Y	Y

	Type of value	Services	Local	Regional	National	Global
6		Ground water recharge/discharge	Y	Y		
7		Retention, recovery & removal of excess nutrients and other pollutants for water purification and waste treatment	Y	Y	Y	
8		Habitat for pollinators	Y	Y		
9	Non-use	Control of storms, floods and erosion	Y	Y		
10		Retention of soil and sediments	Y	Y		
11		Soil formation	Y	Y	Y	
12		Source of and sink for greenhouse gases – climate regulation	Y	Y		
13		Protection of habitat for birds	Y	Y		
14	Amenity	Recreation (tourism potential)	Y	Y	Y	Y
15	Option	Related to future use - biotechnology & genetics	Y	Y	Y	Y
16	Existence	Existence and bequest value of ecosystem	Y	Y	Y	Y

Source: Adapted from Millennium Ecosystem (2005)

Forest Ecosystem

Forests are vital and self regenerating ecological units and provide a range of ES. In the central Himalayan region a variety of forest ecosystems exist owing to varied geology, topography and climate, and they occupy about two-thirds of the landscape, though the forest cover is only 45% of the total geographical area. Himalayan mountains are of critical importance as they help capture essential atmospheric moisture, regulate river flow, and reduce erosion and sedimentation downstream (Bruijnzeel and Bremmer, 1989). They are also the storehouse of biodiversity. The two dominant forest types of the populated belt (1000-2000 masl) of this region, viz., Oak and Pine forests occupy about 3001 and 3994 Km^2 area and are facing varying degrees of degradation due to anthropogenic pressure. The different ecosystem services provided by Himalayan forests are given in Table 3.

Table 3: Ecosystem services from Himalayan forests

	Type of service	**Ecosystem services**	**Scale of area benefited**			
			Local	**Regional**	**National**	**Global**
1	Non-consumptive	C sequestration				Y
2		Soil formation	Y	Y		
3		Hydrological regulation	Y	Y		
4		Climatic amelioration	Y	Y		
5		Succession	Y	Y		
6		Nutrient	Y	Y		
7		Recreation	Y	Y	Y	Y
8		Biodiversity	Y	Y	Y	Y
9	Consumptive	Providing habitat for NTFPs, maintenance of organic agriculture and native crop diversity	Y	Y		

Source: Compiled from different sources

Mangrove Ecosystem

Mangroves are trees and shrubs that grow in saline (brackish) coastal habitats in the tropics and subtropics. Once established, roots of mangrove plants provide a habitat for oysters and help to impede water flow, thereby enhancing the deposition of sediment in areas where it is already occurring. Usually, the fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which are scavenged from the overlying seawater by colloidal particles in the sediments. Table 4 gives diverse ecosystem services as provided by mangrove forests.

Table 4: Ecosystem services from Mangrove Forest

Use No.	Type of value	Services	Local	Regional	National	Global
1	Use value	Habitat, nutrients and breeding of shrimp, crustaceans and mollusks	Y	Y		
2		Spawning and breeding of demersal fish species at the bottom of the ocean			Y	Y
3		Spawning and breeding of pelagic species of fish in the open sea			Y	Y
4		Providing fuelwood, construction wood etc.	Y	Y		
5		Source of plants, herbs, and small game used locally	Y	Y		

Use No.	Type of value	Services	Local	Regional	National	Global
6		Production of salt and shrimp	Y	Y		
7	Non-use value	Control of storms, floods and erosion – extension of current land into sea	Y	Y		
8		Sequestration of carbon, nitrogen, phosphorus and other nutrients				Y
9		Protection of other marine and coastal ecosystems (e.g., coral reefs)	Y	Y		
10		Sequestration of toxins	Y	Y		
11		Protection of habitat for birds	Y	Y		
12	Amenity value	Bird watching (tourism potential)	Y	Y	Y	Y
13	Option value	Related to future use such as biotechnology and genetics	Y	Y	Y	Y
14	Existence	Existence and bequest value of ecosystem	Y	Y	Y	Y

Source: Adapted from Sterner (2002)

3. Issues in sustaining Ecosystem Services

Ecosystem services are fundamental to life, and are often taken for granted. The provision of these services is so widespread and large in scale that it is hard to imagine that human activities could destroy them.[4] Yet, of late, ecosystem services are severely threatened through two pressures: a) growth in the scale of human enterprise (population size, per-capita consumption, energy-intensive life-style, and effects of technologies to produce goods for consumption); and b) a mismatch between short-term needs and long-term societal well-being. As a consequence of these pressures, ecosystems services are being disrupted and impaired. Figure 1 gives different direct and indirect pressures on ecosystem services and the likely impact of these pressures as given by Millennium Ecosystem Assessment (2005). Some of the human activities that affect ecosystem services are:

- runoff of pesticides, fertilizers, and animal wastes
- pollution of land, water, and air resources
- introduction of non-native species
- over-harvesting of fisheries
- destruction of wetlands
- erosion of soils
- deforestation
- urban sprawl

Sufficient evidence exist that all these factors have contributed to deterioration in ecosystem and decline in ecosystem services. The United Nations Environment Program has estimated that a quarter of the destruction of mangrove forests stems from shrimp farming.[5] In areas of the world where mangroves have been removed for development purposes, the disturbance of these underlying sediments often creates problems of trace metal

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[4] Source: http://www.actionbioscience.org/environment/esa.html accessed January 2009.

[5] Source: Botkin, D. and E. Keller (2003) *Environmental Science: Earth as a living planet* (p.2) John Wiley & Sons.

contamination of seawater and biota. Similarly, in the U.S. (excluding Alaska), more than half of the wetland area has been lost over the last two centuries.[6] Stream riparian zones have also suffered declines throughout the U.S. due to these pressures. To give an example, the state of Mississippi has lost 80% of its riparian hardwood forests.

This implies that unless human activities are carefully planned and managed, valuable ecosystems will continue to be impaired and destroyed. In fact, the choices we make today of how we use land, forest and water resources will have enormous consequences on the future sustainability of earth's ecosystems and the services they provide. This is all the more relevant in the current scenario as the findings of Millennium Ecosystem Assessment (2005) has shown a distinct bias towards services that are marketable over services that are either non-marketable or where the natural capital from which the services are derived lacks clearly defined property rights. To give an example, among provisioning services crops, livestock and aquaculture fish production are increasing whereas capture fisheries and other wild foods, fuel wood, genetic resources, natural chemicals and fresh water are declining. Similarly, most of the regulating services (air quality, regional and local climate, erosion, pest and natural hazard regulation, water purification and pollination) are declining, while only C sequestration, where efforts are on to create markets, has been enhanced (*ibid*.).

Management of Ecosystem - Issues

Similar to the benefits of universal education and improved governance, the protection, restoration and enhancement of ecosystems services tends to have multiple and synergetic benefits. Yet, there are a number of issues surrounding ecosystem that makes management of ecosystem extremely tricky and difficult.

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[6] Source: Postel, S., and S. Carpenter (1997) Freshwater Ecosystem Services. Pp. 195-214. In G. C. Daily ed.. *Natures Services: Societal Dependence on Natural Ecosystems*. Island Press. Washington DC.

a) Economic growth, demographic changes and individual choices has put extensive pressure on ecosystem services with increase in demand of these services

b) Ecosystems are highly nonlinear complex adaptive systems having many features that create market failures (Sterner, 2002). There is a sudden possibility of threshold change in dynamics. For instance, long periods of drought in tropical drylands can lead to soil erosion which will be followed by loss of tree cover and eventual desertification. Similarly, large nutrient inflow in a lake may suddenly switch the threshold state leading to permanent eutrophication. Figure 2 indicates this in the case of nutrient run-off and increased food supply with added application of fertilizers

c) Resilience of ecosystems is an important factor in preventing irreversible change. The resilience depends on several things including ecological memory of the system designated by its seed banks, migratory animals and patchiness[7] (Sterner, 2002: 40)

d) Ecosystem is a source of joint production – where some of the products have characteristics of pubic goods or common pool resources. This makes it difficult to deny potential beneficiaries use of the resource once it has been created. In other words, several eco-services are non-excludable. This very characteristic endangers not only the quantity and quality of future flow of services but also the viability of the natural capital itself.

e) With increasing demand for ecosystem services, the trade-off among services have become a rule rather than an exceptions. To give an example, a country can enhance food supply by converting forests to agriculture, but in doing so it decreases the supply of services that may be of equal or greater importance, such as clean water, timber, ecotourism or flood regulation and drought control.

[7] Patchiness is defined as the existence of heterogeneity in local conditions that may allow species to survive and recolonize a territory when conditions improve after a period of perturbance.

f) At one end we have increasing demand for competing ecosystem services, at the other end last few decades has witnessed rapid degradation in the capability of ecosystems to provide these services. Erosion, salinization, nutrient depletion, pollution and urbanization, for instance, has led to degradation of a significant amount of agriculture land. In several parts of the world, this decline in ecosystem services has been abated by associated loss of traditional knowledge - knowledge and understanding held by local communities (Millennium Ecosystem Assessment, 2005). The human well-being is affected not only by the gaps in supply and demand of ecosystem services but also by the increased vulnerability of individuals, communities and nations

g) Market mechanism do not always ensure the conservation of ecosystem services for two reasons: i) markets do not exist for services such as cultural, or regulatory services; ii) policies and institutions do not enable people living within the ecosystem to benefit from services it may provide to others who are far away. For instance, the institutions are still being formed that enable people benefiting of carbon sequestration to give incentives to local managers to leave a forest uncut.

h) For owners of natural capital, ecosystem service provision is a positive externality for which the landowner receives no compensation. Thus, has no incentive to continue providing them. Rather the landowners prefer to develop their properties to produce marketable commodities and services (private goods) as they obtain the benefits of doing so and bear only a small share of the opportunity costs associated with the weakening of ecosystem services (public goods). That is the reason why floodplains, wetlands, pollination, water purification and flood control services are increasingly drained, cleared and planted to crops, converted to pasture for livestock, harvested for timber or urbanized (Lant *et al.*, 2008).

i) Although substantial understanding of many ecosystem services and the scientific principles underlying them already exists, there is still sufficient gap in our learning. The tradeoffs among different services within an ecosystem, the role of biodiversity in maintaining services, and the effects of long and short-term perturbations are just some of the questions that need to be answered fully so as to effectively manage the ecosystems.

j) Lastly, given that some changes in ecosystem services are irreversible and some benefits may be unknown to current generation, market solutions often fail to address inter-generational equity issues.

Besides all these issues, the sustainable management of ecosystem services is all the more daunting because of a disproportionate share in access and consumption of these services by urban and wealthy. This negatively affects their further availability and affordability to rural and poor population, hence affecting their very survival. For instance, depletion in marine fisheries in the past has not affected the supply of fish to wealthy consumers, but this degradation of coastal fishery resources has resulted in a steady decline in protein consumed by the local community. This is because local fishers may neither have access to alternate sources of fish nor have enough income to purchase fish (Millennium Ecosystem Assessment, 2005).

4. Payment for Ecosystem Services as an Instruments to Sustain Ecosystem Services

The last few years have witnessed nearly consensus on the notion that ecosystem can be protected if those who benefit from the ecosystem compensate those who manage it. Payment for ecosystem services (PES) is thus an instrument that incentivises the involvement of local stakeholders in the conservation and management of ecosystem. In other words, PES creates markets for ecosystem services. These markets however differ in geographic scale, strength and structure of demand, the competitiveness, nature and price of services sold, and the number of transactions. The success of the PES schemes requires a thorough appreciation of the markets for the environmental services to be sold. Among the various environmental services from ecosystem, incidentally only few currently stand out for payment. These include watershed protection, biodiversity protection, landscape beauty and C sequestration and storage. Refer Scherr, S., A.White, *et al*. (2004) for a list of such PES across the globe. Table 5 illustrates the case of PES for biodiversity conservation. It is to be noted that the payment programmes for biodiversity conservation address components of biodiversity from the genetic to the ecosystem level and include both agricultural and wild biodiversity.

Table 5: Different types of Payment Mechanisms to Support Biodiversity Conservation

	Eco Services	Coverage	Details
1	Payment of High-value habitat	Private land acquisition	purchase by private buyers or NGOs - for biodiversity conservation
		Public land acquisition	purchase by govt. agency- for biodiversity conservation
2	Payment for Access to Species or Habitat	Bio-prospecting rights	rights to collect, test and use genetic material from a designated area)
		Research permits	right to collect specimens, take measurements in area)
		Hunting rights	Hunting, fishing or gathering permits for wild species
		Ecotourism use	Rights to enter area, observe wildlife, camp or hike
3	Payment for Biodiversity-Conserving Management	Conservation easements	Owner paid to use and manage defined piece of land only for conservation purposes; restrictions are usually in perpetuity and transferable upon sale of the land
		Conservation land lease	Owner paid to use and manage defined piece of land for conservation purposes, for defined period of time)
		Conservation concession	Public forest agency is paid to maintain a defined area under conservation only - comparable to a forest logging concession
		Community concession in	Individuals or communities are allocated use rights to a defined area

	Eco Services	Coverage	Details
		public protected areas	(forest/grassland), in return for commitment to protect the area from practices that harm biodiversity
		Mgmt contracts for habitat or species conservation on private farms, forests, grazing lands	Contract that details biodiversity management activities, and payments linked to the achievement of specified objectives
4	Tradable Rights under Cap and Trade Regulations	Tradable wetland mitigation credits	Credits from wetland conservation or restoration to be used to offset obligations of developers to maintain a minimum area of natural wetlands in a defined region
		Tradable development rights	Rights allocated to develop only a limited total area of natural habitat within a defined region)
		Tradable biodiversity credits	Credits representing areas of biodiversity protection or enhancement, that can be purchased by developers to ensure they meet a minimum standard of biodiversity protection
5	Support to Biodiversity-Conserving Businesses & Production Processes	Business shares	In enterprises that manage for biodiversity conservation
		Biodiversity-friendly products	Eco-labeling
			Niche market development for products with valuable agricultural biodiversity

Source: Scherr, S., A.White, *et al*. (2004)

5. Other instruments to Sustain Ecosystem Services

A number of instruments exist and have been implemented that have partially helped in conserving the ecosystem. Given the pressure on ecosystem services, innovative schemes are needed. It has been argued that some of the earlier instruments like quotas, time and space restrictions on use, taxes and fees, tradable permits are geographical nested and somewhat redundant for adaptation and checks and balances (Lant *et al*., 2008). The design of new instruments however requires understanding of the characteristics of the ecosystem services. For instance, awareness that if there are no *socially informed property rights* common pool resources tend to become open access resources and can be exploited to the point of collapse would require a new solution (*ibid*.). Developing the institutional framework and social capital for an effective self-governing common-property rights regime can be then one of the solutions for managing ecosystem.

It is to be noted that management of most ecosystems – be it coastal fisheries or forests or a wetland - require direct involvement of local communities. The conservation of forests through Joint Forest Management (JFM) involving local communities is one such example.

Further, as has been emphasized by Pagiola *et al*. (2005), policy incentives to encourage nature conservation are emerging around the world, and yet this trend remains handicapped by a lack of understanding of the economic benefits of conserving natural ecosystems. Recognizing the eco-system functions and their values will enable the society at large to take informed decisions about alterations in land use/land cover practices due to any proposed developmental projects (e.g., hydropower, urbanization, or due to land use policy change). For example, the comparative account of different forest ecosystems with regards to goods and services would be also helpful in the regeneration / afforestation programme in this region.

According to Lant *et al*. (2008) there exist three key ways to conserve ecosystem services. Implementing these would lead to avoiding the tragedy of ecosystem services.[8] These include: evolving a common law of property,

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[8] The tragedy of ecosystem services is coined by Lant *et al*. (2008) after the famous article of tragedy of commons by Gerrat Hardin in 1968.

reforming economic incentives and lastly developing ecosystem service districts. The recent judicial decisions in USA are testimony to the fact that when informed about ecosystem services, courts are ready to revisit previously settled principles. For instances, a Rhode Island court prevented a developer from filling a marsh area on the ground that the marsh benefits other properties by filtering and cleaning run-of, and a Louisiana court ruled that a freshwater diversion project would extend the public trust in navigable water resources by restoring coastal wetlands that mitigate storm surges (Ruhl *et al*., 2007 as referred in Lant *et al*., 2008). Examples also exist where innovative economic incentives are being used to increase ecosystem services. Some of these examples include: tradable pollution permits, especially for carbon emissions and sequestration (Tietenberg, 2006) to motivate private landowners to store additional carbon on their lands rather than in the atmosphere; trading debt relieve in developing countries for conservation of ecosystem services with global benefits (e.g., biodiversity, carbon storage) (Deacon and Murphy, 1997).[9] Lastly, devising ecosystem service districts[10] along the lines of school, fire etc. New Zealand is one such country where environmental administration has been realigned along watershed boundaries (Pyle *et al*., 2001 as referred in Lant *et al*., 2008) equivalent to creating ecosystem service district.

To conclude, there is a parallel between ecosystem services and several of the services that generate positive externalities (e.g., education, medical research, vaccinations, space research) or that are non-excludable (e.g., most roads, bridges, defense) and both will be underprovided under market forces. The similarity ends here. The point of departure is that massive public institutions informed by public policy and laws have been erected to provide these essential public services, whereas sufficient work is still needed to build institutions and policies that assures the continued provision of ecosystem services, without which human mankind may cease to exist.

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[9] Refer Lant *et al*. (2008) for few more such examples.

[10] These districts need to have 3 characteristics – focus on integrated approach instead of single purpose resource management, having full authority and institutional capacity to carry out complex scientific, economic and social analyses.

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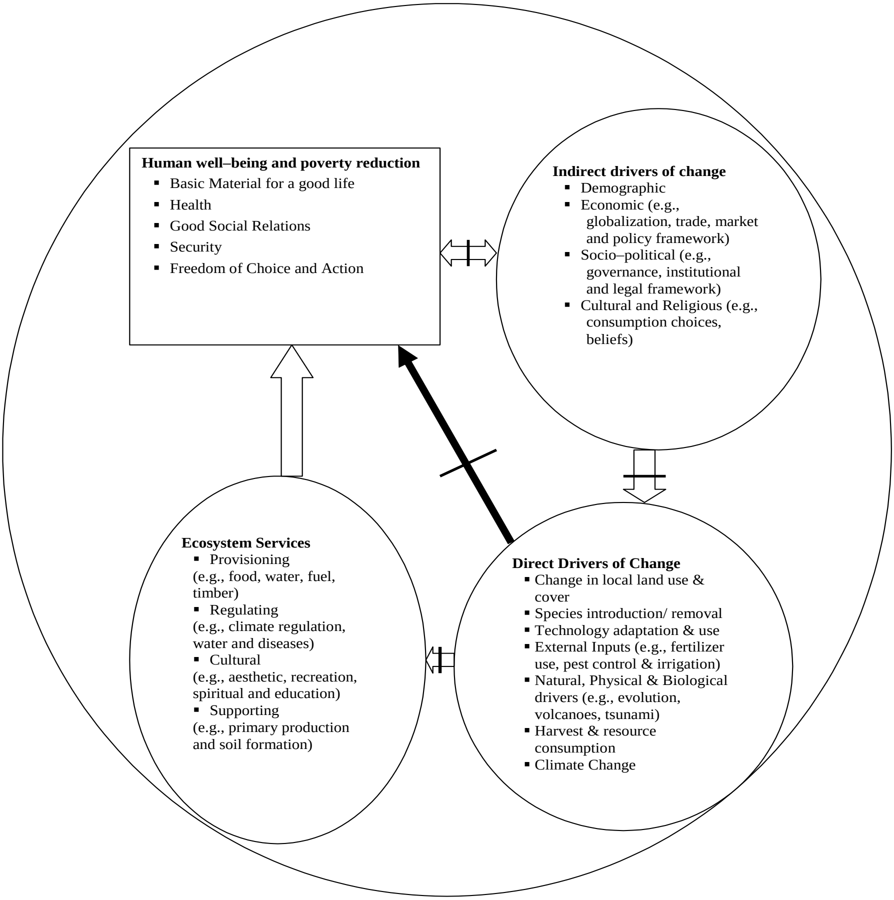
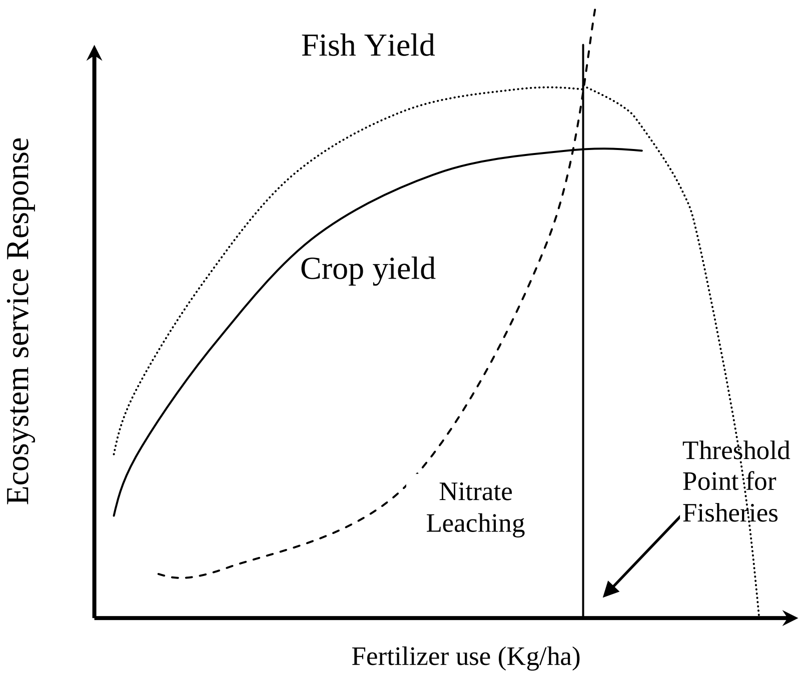
Figure 1: Ecosystem Services and Drivers of change to ecosystem



Source: Millennium Ecosystem Assessment (2005)

Note: An intercepted line implies actions are available to stem the effect

Figure 2: Example of non-linear response and flipping of State of two ecosystem services (Agriculture yield and fish catch in a wetland) and application of fertilizer



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