



REPORT

INVENTORY OF ECOSYSTEM SERVICES RIVERINE FOREST LANDSCAPES (Sindh)



IUCN, International Union for Conservation of Nature
February, 2020

INVENTORY OF ECOSYSTEM SERVICES

Kot Dhingano-Lakhat Riverine Forests and Sukkur Riverine Forest Landscapes

Forest ecosystem services are the benefits that people receive from ecosystems. Some of these, such as the Provisioning services (or goods) like food, timber and fresh water, are well-known and routinely included in assessments. Others, such as the Regulating services of carbon storage and sequestration, watershed protection, storm protection and pollination, Supporting services, i.e. the natural processes such as nutrient cycling and primary production, or the Cultural services of recreation and spiritual values, are often overlooked because they are to a lesser extent traded in the market and internalized in traditional cost-benefit analyses.

EXECUTIVE SUMMARY

The SFM project in Pakistan focuses on restoration, conservation and sustainable management of the high conservation value forests ecosystem to provide global environmental benefits as well as enhanced resilience and livelihoods to local stakeholders. Among these ecosystems, two prominent riverine forest landscapes are located in the Province of Sindh. These forests hold tremendous importance from both ecological and economic perspectives. This ecosystem is important for other non-timber forest products such as fuelwood, mushrooms, honey and biodiversity, which all positively contribute to local livelihoods. It also protects vital ecosystem services such as carbon storage, soil and flood protection, water regulation of downstream flows, which are essential for human consumption and irrigation purposes. Additionally, this ecosystem is home to globally threatened fauna, such as marbled teal and endemic Blind Indus dolphin, and other rare species of animals and migratory as well as resident birds.

The aim of this report is to build a robust inventory on riverine forests ecosystem of Sindh. After the millennium ecosystem assessment in 2005, ecosystem services have become increasingly prominent on the policy agenda of every country. The assessment of ecosystem services, including their economic valuation, is needed to better understand their importance and to inform decision making. Although this inventory of forest ecosystem services is intended to mainly focus on two riverine forests landscapes of Sindh i.e. Kot Dhingano-Lakhat and Sukkur riverine forests but the concepts and approaches discussed in the report can be used as helping tool to a broad range of situations.

A growing population, spreading urban settlements, changing climate and increasing demand for natural resources are factors posing serious threats to forest biodiversity and ecosystem functions, and services. The degradation of riverine forests ecosystem and the associated loss of biodiversity, particularly during last three decade mainly happened due to human-induced pressures. The failure to appropriately consider the full potential and value of forest ecosystem services in decision making enables the continued deterioration of this biodiversity rich ecosystem.

The high conservation value ecologically important riverine forests ecosystem of Sindh provide significant and diverse services to the environment and society. As primary habitat for a number of wildlife species, these forests support biological diversity maintenance and conservation. Riverine forest growth sequesters and stores carbon from the atmosphere and contribute in

climate change mitigation. The healthy riverine forest ecosystem ensure soil conservation, prevent land degradation and reduce the risks of natural disasters such as floods and soil erosion. Located on Indus plains along river and its tributaries, these forests also serve as sites of enormous recreational value and contribute to economic development by providing timber, grazing grounds, provisions of hunting, fishing and other forest products for subsistence of local communities and other segments of society.

During last 30 years continued degradation and forest loss of riverine forest ecosystem negatively impacted on the environment, wildlife and the livelihoods of dependent communities and poses serious challenges to sustainable development in these forest landscapes. However, the recent development of sustainable forest management in high conservation value forests including riverine forests of Sindh provided an opportunity to safeguard these precious resources for the present as well as future generation to get multiple-benefits sustainably. Further, the provincial forest department integrated and highlighted the forest ecosystem services into their draft provincial policy document. These efforts are just beginning and much more progress is yet to be made. At the same time, investments in forest conservation and forest ecosystem services provision are also growing, such as working on markets for forest carbon and habitat restoration.

The SFM initiative in three provinces of Pakistan including Sindh has provided a strong foundation for continued progress in enhancing the contribution of forest ecosystem services toward achievement of SDG 15 targets. In this report, a range of possible ecosystem services exists in two riverine forest landscapes has been identified, quantified and valued to highlight the importance of forest ecosystem.

We are in the midst of a climate crisis and a biodiversity crisis, preserving the critical riverine forests of Sindh along the river Indus are important for their potential to mitigate climate change through carbon sequestration, as well as to enhance biodiversity. Some of these intact patches of forests exists in two riverine landscapes. Preserving riverine forests in Sindh that have medium to high potential carbon sequestration are very important. The management of these high value forests would not only promote ecosystem resilience, but also play a key role in maintenance of biodiversity.

Climate change is impacting forests in many ways in different ecological regions. However, the intended objectives of the two riverine forest landscape management is very much clear to protect and restore riverine forests with high carbon sequestration potential, low vulnerability to drought, fire and pest attacks, and high biodiversity value. Smart and sustainable forest management can mitigate the effects of climate-induced ecosystem changes to biodiversity and river flow, which in turn influence ecosystem services that play a key role in human well-being.

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GLOSSARY

- Ecosystem:** A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Or
Ecosystem is a community of living (biotic) organisms – animals, plants and microorganisms – interacting with the physical environment (e.g. air, water and mineral soil) as an interdependent system (Odum, 1971).
- Ecosystem services:** The benefits that people receive from ecosystems. Some of these, such as the Provisioning services (or goods) like food, timber and fresh water, are well-known and routinely included in assessments. Others, such as the Regulating services of carbon storage and sequestration, watershed protection, storm protection and pollination, Supporting services, i.e. the natural processes such as nutrient cycling and primary production, or the Cultural services of recreation and spiritual values, are often overlooked because they are to a lesser extent traded in the market and internalized in traditional cost-benefit analyses.
- Ecosystem-based management:** Management systems that attempt to simulate ecological processes with the goal of maintaining a satisfactory level of diversity in natural landscapes and their pattern of distribution in order to ensure the sustainability of forest ecosystem processes (CCFM 2006).
- Forest inventory:** A systematic collection of data and forest information for assessment or analysis. A forest inventory determine the number and type of products exists within a forest. The statistical forest inventory is to provide comprehensive information about the state and dynamics of forests for strategic and management planning.
- REDD plus:** Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.
- Valuation:** Valuation refers to the process of identifying and assessing diverse kinds of values through (but not limited to) qualitative, quantitative, monetary and nonmonetary approaches.

INTRODUCTION

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) report stressed that action to stop deforestation and forest degradation, and to restore forests, is critical to avoid global temperature rise beyond 1.5 degrees. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) more than a third of the world's land surface is now devoted to crop or livestock production and around one million animal and plant species are now threatened with extinction. Majority of natural ecosystems around the world are under severe danger of continuous degradation and services they are offering for the well-being of humanity and environment are on decline.

In a country with so much economic instability, the conservation of biodiversity looks a secondary concern. However, on other side of the coin, it has now been established beyond doubt that human welfare is inextricably linked to the state of the environment. It is encouraging to note that SFM project involved in conservation of high conservation value riverine forests of Sindh. In this age of rampant consumerism, putting a price tag on the destruction of ecosystems is a practical way of getting the message across. The price of riverine forest stands are not limited to the value of their timber or the land in which they are growing. Riverine forests of Sindh serve as high conservation value hotspots and their importance as non-timber forest products and other ecosystem services is more significant than forest wood.

Riverine forests of Sindh represents an important ecosystem which is a stronghold of biodiversity and habitat for wildlife, source of fuelwood, food, fodder, fibre and timber, promote soil conservation, regulate weather and provide several other large number of non-consumptive needs of people including recreation and ecotourism. Also they play an important role in climate change mitigation as vital carbon sink. However, the net climate change arising from all sources combined, has several impacts on these forests as well which in turn affects the goods and services derived from riverine forest ecosystem. The list of beneficiaries of these goods and services is not restricted to the forest dwellers or communities residing in close vicinity to forests, but also includes the entire province. Therefore, it requires to protect the remaining ecologically intact areas of riverine forests and associated ecosystems that are of extremely high importance for biodiversity conservation, carbon storage and livelihood of local communities.

Sustainable forest management approach adopted in two riverine forest landscapes containing high conservation value protected areas and important biodiversity hotspots will increase the probability of improving ecosystem health of these two forests and help to achieve the desired sustainability. Important riverine forest and associated freshwater ecosystems, and the services they provide needs recognitions. The role and importance of landscapes ecosystem of Kot Dhingano-Lakhat (KDL) and Sukkur district riverine forest and wetlands for environment, livelihoods and well-being of local communities is quite significant.

This report mainly focuses on forest ecosystems of two riverine forest landscapes in Sindh. These forest ecosystems offer multiple benefits in the form of goods and services. Some of these services benefits are tangible and well known in daily life and others are intangible and less known.

ECOSYSTEM SERVICES

In the context of sustainable development in Sindh, among the different ecosystem types, riverine forests and inland freshwater ecosystems are the most vulnerable natural systems. From 1980 to 2019, Sindh showed a decline in forest cover, largely due to a forest lease policy and in result expansion of intensive agriculture practices. Even than the Indus riverine forests and associated freshwater ecosystems provide valuable services vital to human well-being. Properly regulated access to biodiversity and ecosystem services contributes to poverty alleviation, but unsustainable resource use practices are causing decline in the quality and quantity of ecosystem services.

Freshwater ecosystems around Sukkur riverine forest landscape and Kot Dhingano-Lakhat riverine forest landscape support several aquatic and semi-aquatic species, but many of these species are threatened by overfishing, pollution, infrastructure development and invasive alien species. The river water pollution pose persistent threats to human and environmental health of the adjacent areas.

Unsustainable use of riverine forest landscapes resources, such as illegal hunting, fishing, poaching, grazing, fuelwood collection, conversion of habitats, introduction of fast growing exotic tree species, pollution and climate change, are posing serious threats and stress to the natural forest ecosystems and depriving thousands of local people from their sustainable livelihoods and food security. However, effective measures through targeted policies and best forest management practices can halt this process of negative changes.

Biodiversity rich Indus riverine forest ecosystem is one of the important landscape of Sindh. Timely action to conserve and manage these critically threatened riverine forests on sustainable basis at landscapes level will generate positive effects at micro and macro levels.

Box 1: Definition of ecosystems, ecosystem services and biodiversity

The terms *biodiversity*, *ecosystems* and *ecosystem services*, in this document abbreviated to 'ES' are defined as follows: '*Biodiversity*' is short-hand for 'biological diversity'. The UN Convention on Biological Diversity (CBD), which defines biodiversity as "The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Article 2). According to the CBD, '*ecosystems*' are one component of biological diversity. The Millennium Ecosystem Assessment (MA, 2005) identifies an ecosystem as "a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit". MA elaborated '*ecosystem services*', as the benefits people receive from ecosystems. Ecosystem services are dynamic, as they are culturally determined, being conceptualizations of the 'useful things' ecosystems 'do' for people, directly and indirectly, whereby it should be realized that properties of ecological systems that people regard as 'useful' may change over time even if the ecological system itself remains in a relatively constant state" (TEEB, 2010, Chapter 1, pp. 12 and 15).

The ecosystem services offer by the two riverine forests are well established. Thousands of people live in and around these ecosystems are highly dependent on the diverse biodiversity and other material services for their food security, water needs, and energy requirements. Overall, these ecosystem services play an important role in socioeconomic development of the people living in the area. Ample evidence exists to demonstrate that human well-being in the two riverine landscapes is intricately connected with nature. However, the dependency is not uniform within

the ecosystems. Many local people in the both forest landscape are highly dependent on wild harvests from nature for their subsistence through fuelwood cutting, honey collection, acacia gum harvest, livestock grazing, timber needs for their houses, fisheries, recreation, combating soil erosion, fertility of farm lands and vegetable production. It is estimated that more than 50% local communities across the two riverine landscapes directly and indirectly depend on the forests for their non-timber forest products, as well as other subsistence needs.

Since last one and half decade, the province has undergone the most extensive land-use transformation due to introduction and implementation of forest land lease policy and conversion of forest land for non-forestry purposes. These rapid green land transitions have come at a high environmental cost, including a high rate of species and habitat loss, and deforestation and forest land degradation. This has accelerated and led to damage of the riverine forests and associated wetland ecosystems of the Sindh. These ecosystems directly support the livelihoods of communities through the provision of nature’s multiple material contributions to people. However, people also value substantially the wealth of nature’s non-material and regulating contributions derived from ecosystems all along the riverine tract, such as the habitat restoration, climate regulation, recreation and several others.

Across the riverine tract of Sindh, while forests biodiversity and ecosystem conditions are declining overall, they are well maintained in some areas including Kot Dhingano and Sukkur riverine landscapes. Particularly, the Kot Dhingano forest ecosystem exhibits varying trends in the status of biodiversity and ecosystem services. Among the various ecosystem types, forest wetland ecosystems are the most important and productive areas to contribute in development. Positive change in forest cover of Kot Dhingano is only because of community participation in the protection and management of left over resources.

The term ‘ecosystem services’ refers to the benefits humanity receive from natural resources. According to the Millennium-Ecosystem-Assessment, 2005, the ecosystem services can be grouped into four broad categories: provisioning (also known as goods), regulating, supporting and cultural services are further defined in below **Box 2**.

<p>Provisioning Services <i>Products obtained from ecosystems</i></p> <ul style="list-style-type: none"> • Food • Timber • Fuelwood • Fiber • Freshwater • Biochemical • Genetic resources 	<p>Regulating Services <i>Benefits obtained from regulation of ecosystem processes</i></p> <ul style="list-style-type: none"> • Climate regulation • Water regulation • Water purification • Pollination 	<p>Cultural Services <i>Nonmaterial benefits obtained from ecosystems</i></p> <ul style="list-style-type: none"> • Recreation and ecotourism • Spiritual and religious • Inspirational • Aesthetic • Educational • Cultural heritage
<p style="text-align: center;">Supportive Services <i>Services necessary for the production of all other ecosystem services</i></p> <ul style="list-style-type: none"> • Soil formation • Nutrient cycling • Primary production 		

ECOSYSTEM SERVICES OFFERS BY RIVERINE FOREST LANDSCAPES

In the northern and central region of Indus River in Sindh province, the riverine forests of high conservation value riverine forests are mainly dominated by kandi and babul tree stands, and biodiversity rich wetlands ecosystem. This report aimed at the preparation of inventory and quantification and valuation of the ecosystem services provided by the two riverine forest landscapes to set the sustainable forest management and conservation priorities.

Riverine forest ecosystem as like other forests provides goods and services, the goods include; food, fuel, shelter, medicines, etc., can be valued like any manufactured goods, while the services such as clean water, fresh air, regulating climate, gene pool, aesthetic and recreational opportunities. These values are not yet exactly quantified in monetary terms except storage of carbon which has received a great importance in recent years due to global warming. Hence, the ecosystem services have still low priority in planning and policy decisions as they have not been quantified to make them comparable with other economic services. Presently, the forest ecosystem services are mainly categorized and grouped into four broad categories i.e., provisioning, regulating, supporting and cultural services.

Provisioning Services: The provisioning services provide direct inputs to livelihood and the economy from ecosystems. In the context of riverine forest landscapes, the main provisioning services are babul and bahan wood for furniture and boat making, construction and mining pit props, *tamarix* (lai) twigs for basket making, thatching material, high caloric value fuel wood and charcoal, leaf fodder, grasses, honey, tannin, fish, acacia gum, etc.,

Supporting Services: The supporting services are those services, which provide habitat or living spaces to plants and animals for maintaining diversity, maintenance of genetic diversity and forming the basis for ecosystems. The two landscapes provides the supporting services like a preferred habitat of Indus Dolphin, hog deer and other diversified fauna consisting of several species. Whereas, the flora of the area is also diversified ranging from grass species to climax tree species of babul. Though the biodiversity has been affected by anthropogenic and abiotic factors but still there is great potential of revival of ideal riverine forest ecosystem.

Regulating Services: These services are provided by the ecosystems through regulating the quality of soil and air by providing flood and disease control. Riverine forest trees provide shade, shelter and regulate air quality by removing pollutants from the air, while forests influence rainfall and availability of water. Other services are carbon sequestering, moderation of extreme weather, waste water treatment by wetlands, erosion prevention and maintaining of soil fertility, pollination and biological control of diseases.

Cultural Services: The riverine forest landscape being inhabited by original races of Sindh region is culturally rich source of old traditions and customs. They are the indigenous local people true custodians of preservation of Sindhi culture. The Sukkur landscape also provides recreational and mental health to third biggest city of province being situated closely. It has also potential of ecotourism which has not yet been explored and availed its full extent. However, due to methodological challenges, cultural ecosystem services are rarely fully considered in ecosystem services assessments. Cultural services are not scattered randomly across a landscape, but rather follow specific patterns in terms of the intensity, richness and diversity of their provision. Resulting hotspots of ecosystem services provision are related to landscape features and land cover forms.

COMPONENTS OF RIVERINE FOREST ECOSYSTEM SERVICES (ES)

Like any ecosystem, the components of Riverine Forest Ecosystems are an assemblage of biotic and abiotic components which include all living organism groups like producers, consumers and decomposers and all nonliving elements like soil, organic debris, climate and water interacting with each other in a defined boundary. Climate includes light, temperature and oxygen which are essential for the photosynthesis process through which primary producers prepare food for the survival of biotic components.

Riverine forests of Sindh contain most important and vibrant ecosystems with remarkable variety of biological diversity including animals (birds, mammals, reptiles), and plants. At some extent they prevent soil erosion and help to regulate climate. Further, they support millions of people directly and indirectly in generation of their livelihood. However, riverine forests of Sindh are facing several challenges, such as continued deforestation and forest degradation but since introduction and implementation of SFM project interventions, the forest managers started to find ways of conserving and sustainably managing of high conservation value riverine forests for the benefit of local communities and as a whole for improvement of environment.

In Sindh riverine forests and associated wetlands are more biologically diverse than any other land-based ecosystem and they are source of a wide range ecosystem services for livelihood of local communities. However, our market economy fails to recognize the real value of ecosystem services provided by meager leftover riverine forest.

Riverine forests of Sukkur and Kot Dhingano-Lakhat landscapes are source of many ecosystem services to support well-being of local people, such as i) cultural services like aesthetic and recreational services, ii) provisioning services like timber, firewood, honey, acacia gum, mushroom and livestock grazing, iii) regulating services include water recharge, purification of air, preventing soil erosion, protect pollinators, regulate climate, and iv) supportive services like creating habitat for wildlife, carbon sequestration, nutrient cycling, etc.

The two landscapes sustain valuable diversity of butterflies, birds, mammals, freshwater fish and turtles. Provide habitat for some of the rare species such as blind dolphin, smooth coated otter, hog deer and marbled teal. Both riverine forest provide a mosaic of ecosystems – river, lakes, swamps and forests.

It is really difficult to put a monetary figure on the value of riverine forests ecosystem. However, now it is widely recognized that we should need to improve the way our economies account for forest ecosystem services. We often take these services for granted. In recent past some international studies carried out by 'The Economics of Ecosystems and Biodiversity' (TEEB) have resulted in a better understanding of the economic value of forests and other ecosystems for societies.

PAYMENTS FOR ECOSYSTEM SERVICES

In many cases the beneficiaries who benefit from ecosystem services are not the people who help maintain the ecosystem. The "payments for ecosystem services" approach provides a way to transfer resources from beneficiaries of ecosystem services to the maintenance of ecosystem functions. Today, this approach has inspired new incentives and innovative financing for sustaining ecosystem services.

A new way to save forests Under the auspices of the United Nations Framework Convention on Climate Change, efforts are under way to establish a mechanism that would reward governments, local authorities and forest owners in developing countries for keeping their forests intact instead of cutting them down. This mechanism, called “Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries” (REDD-plus) is based on the idea that trees store carbon, as they absorb carbon dioxide, storing it into their roots, trunk, branches, leaves and the soil, and “breathe out” oxygen. Deforestation and degradation of forest ecosystems contribute to an estimated 12 to 15 per cent of annual greenhouse gas emissions from human activity entering the atmosphere, and therefore to climatic change and global warming. It has been estimated that the financial flows to developing countries from a successful REDD-plus mechanism, which would reduce these emissions by curbing deforestation and forest degradation, could reach up to US\$ 30 billion a year. REDD-plus is first and foremost an instrument that aims to reduce greenhouse gases in the atmosphere and thereby mitigate global climate change. However, if well designed and successfully implemented, it will also provide unprecedented benefits for biodiversity. Establishing and effectively managing protected areas, for example, not only protects the trees and the carbon stored in them, but also all other forest species, including animals. Establishing a whole network of parks and ecological corridors, and restoring forest landscapes, will provide wildlife and other species with enough space to freely move and maintain healthy populations. The forests can continue to play an important role in purifying water and conserving soil, and provide several other ecosystem services.

SUPPORT FOR PEOPLE’S LIVELIHOODS

Riverine ecosystems, with their rich biodiversity are essential for human livelihoods and for sustainable development. For example, fuelwood is the primary source of energy for cooking for millions of people living in and around these resources. Thousands of poor people directly depend on riverine forest ecosystem services for their subsistence and survival. Many non-timber forest products derived from these forest, such as honey, gums, mushroom, hunting and animal fodder are some of the essential items to sustain their way of life.

ECOSYSTEMS RESTORED AND RESILIENCE ENHANCED

Reduction in ecosystem degradation and increased biodiversity conservation are key objectives of NBSAP. Considerable efforts have been made on restoration of some of the country’s most threatened habitats over the past few years. In particular forests, dryland and coastal ecosystems have witnessed focused efforts, helping in enhancement of ecosystem resilience and climate change mitigation. Healthy and resilient forest ecosystems are the basis for economic and social development. Loss of forest biodiversity has potentially devastating effects on people and environment. The rural poor in particular depend heavily on their local ecosystem services for their livelihoods, and the impacts of ecosystem degradation and biodiversity loss affect them severely.

Riverine forests ecosystems of Sindh including two forest landscapes deliver a solid range of benefits to people and environment, which we call “**ecosystem services**”. So losing them by conversion to other uses (such as agricultural or urban land), or even degrading them by poor harvesting practices, means losing their services. The categories of ecosystem services offered by two landscapes are given in below **table 1**.

Table 1: Categories of ecosystem services, according to the Common International Classification of Ecosystem Services, and associated components of total economic value

Ecosystem services according to the Common International Classification of Ecosystem Services			Components of total economic value		
Section	Division	Class	Active Value	Passive Value	
Provisioning	Nutrition	Crop cultivation and their output	√		
		Livestock rearing and their outputs	√		
		Wildlife conservation and their outputs	√		
		Mushroom collection		√	
		Fish netting	√		
		Surface water for drinking	√		
		Ground water for drinking	√		
		Acacia gum collection		√	
		Honey collection	√		
	Materials	Commercial timber	√		
		Fibers and other materials from Plants and animals for direct use or processing (Tamarix, typha, wool, etc.)		√	
		River and groundwater for non-drinking Purposes	√		
		Materials from plants and animals for other uses (babul bark, animal hides, wax, etc.)		√	
		Energy	Plant based fuelwood	√	
			Animal based fuel from cow dung		√
Other organic resources used as fuel			√		
Regulating and maintenance	Mediation	Freshwater	√		
		Fresh air		√	
		Bioremediation by microorganisms and animals		√	
		Erosion control	√		
		Carbon sequestration	√		
		Flood protection	√		
	Maintenance	Seed dispersal and pollination		√	
		Chemical control of freshwater		√	
		Nitrogen fixation	√		
		Wildlife habitats	√		
		Climate regulation		√	
		Soil fertility		√	
		Dust storm control		√	
Cultural	Physical and intellectual interactions with ecosystem	Physical use of landscape	√		
		Experiential use of plants and animals		√	
		Scientific		√	
		Educational		√	
		Aesthetic		√	
		Natural heritage		√	

Spiritual, symbolic and other interactions with ecosystems	Entertainment		√
	Symbolic (dolphin)		√
	Sacred (Hindu temple)		√
	Bird watching	√	
	Dolphin safari	√	
	Hunting/ shooting	√	
	Captive breeding		√
	Grazing	√	

Source: Modified from Haines-Young and Potschin (2011a); Pascual and Muradian (2010).



Sukkur Riverine Forest

QUANTIFICATION AND VALUATION OF ECOSYSTEM SERVICES

Quantification of ecosystem services is important in understanding their value as monetary and non-monetary benefits to humanity. During implementation of SFM plans of two riverine forest landscapes, more detailed quantitative studies on the ecosystem services to better understand their contributions to human well-being will be required for future management.

QUANTIFYING AND MAPPING ES

Since the outcomes of the Millennium Ecosystem Assessment's in 2005, there has been rapid growth in the science and policy of valuing ecosystem services and biodiversity for natural resource management decision making. In this regard, the most prominent study carried out at the global scale is 'The Economics of Ecosystems and Biodiversity' (TEEB 2010).

Increasing attention in quantifying and valuing ecosystem services (ES), the benefits that ecosystems provide to people, has resulted in great interest among nature conservationist and environmentalist in recent years. However, choosing an appropriate tool and methods for measuring and modelling ES is still a challenging task, especially in key biodiversity areas like forests of unique nature, wetlands of international importance and protected areas containing hotspots. Information about important biodiversity areas can be useful for many reasons, including increasing support for protection of benefits provided by these forest landscape sites, informing management decisions and enabling evaluation of the results of management changes on ES provided by the forest landscapes.

Ecosystem services are produced as a result of ecosystem processes and functions such as soil formation, nutrient cycling and primary production. Then they flow to people in the form of benefits or goods, supporting human well-being. There is an increasing interest in measuring, modelling, and valuing ecosystem services to evaluate the scope and worth of these benefits that nature provides to people. Appropriate information and data about ES in any landscape area is important to guide decision making and support protection and management of natural ecosystems to ensure an ongoing sustainable flow of benefits for current and future generations. Two riverine forest landscapes of Sindh are sites of an immense value to provide variety of benefits for the humanity. Therefore, quantification and mapping of these benefits help forest managers and decision makers to justify the importance of both forest landscapes for sustainable development and biodiversity conservation.

REASONS FOR QUANTIFICATION OF ES

Quantification of ecosystem services support landscape management decisions and help ensure fairly in resource use and benefits sharing among forest stakeholders. Preparation of inventory of an ecosystem services and their quantification can be used to establish a baseline to monitor changes over time of the consequences of landscape management decisions. ES information support the development of mechanisms to compensate forest rights holders for implementing management practices and also support three objectives of the convention on conservation of Biological Diversity (CBD).

Information about ES provided by these two riverine forest landscapes can also demonstrate their importance in achieving management objectives of high conservation value forests. The basic purpose of carrying out an ES quantification and valuation of both riverine forest landscapes to support management planning process of high conservation value forests of two riverine tract in Sindh. The below Table 2 summarizes a range of potential applications of ES assessment for two individual landscape sites of riverine forest, i.e. Sukkur Riverine Forest Landscape and Kot Dhingano-Lakhat Riverine Forest Landscape.

Table 2. Reasons for measuring ES provided by sites

Areas	Potential applications of ES
Policy support	<ul style="list-style-type: none">▪ Provide additional evidence and justification for the importance of conserving a particular landscape site▪ Foster local awareness of the ES provided by a particular site▪ Link ES information of these sites to country (National Forest Policy, 2015), and or to international sustainability goals (e.g. SDGs)
Site management	<ul style="list-style-type: none">▪ Establish the baseline of ES at landscape levels to support management planning of two landscape sites and enable subsequent monitoring of changes during implementing phase▪ Develop and implement landscape management plans, building on the understanding of ES▪ Ensure a good understanding of the ES values that are important to local communities and resource managers as prime stakeholders
Planning	<ul style="list-style-type: none">▪ Support conservation planning and investment by identifying areas of particular importance for ES▪ Assess potential consequences of climate change scenarios on ES provided by a site▪ Integrate ES delivered by riverine forests into resource use planning at landscape levels, and understand implications for management of surrounding areas to improve resilience of forest areas with regards to ES
Funding/ investment	<ul style="list-style-type: none">▪ Attract funding and investment from government and donors for conservation of ES in high conservation riverine forests for sustainable development▪ Develop innovative and sustainable financial mechanisms for conservation of forest landscapes, such as Payments for Ecosystem Services (PES) or carbon financing such as Reduced Emissions from Deforestation and Forest Degradation (REDD+)
Knowledge generation	<ul style="list-style-type: none">▪ Encourage research on ES provided by forest landscapes locally, provincially or nationally▪ Inform research on the synergies and trade-offs between conserving biodiversity and ES

All ES quantification involves some level of local community engagements as important stakeholder. They help in identification and assessment of ES based on their experience, firsthand information and traditional knowledge that can result in a more robust assessment; and ensure that assessment results are actually used for management decisions. It also ensure that the information produced during the assessment process will be accepted by the department, who will ultimately be responsible for the management of the landscape resources.

Quantitative measurement of ES, can be particularly helpful if a landscape is under immense pressure of conversion to an alternative land use scenario. It can also help in clarification of trade-offs between alternative resource uses strategies and therefore inform management decisions. For example, stakeholders may disagree about whether to continue to allow timber harvesting within a riverine forest landscape. In this case, quantifying the ecosystem services provided by the site (such as carbon storage role, NTFP supply chain, erosion control, and flood regulation) under different management scenarios might help elucidate the implications of continued timber harvesting for other ES. However, when undertaking an ES measurement in riverine forest landscape, the primary conservation objectives of the sites, should be a protection of high conservation value forests alongwith their outstanding or globally significant biodiversity values should be considered and respected.

VALUATION OF ES

Monetary valuation of ES can sometimes be in conflict with conservation objectives if the economic values associated with conservation are not as high as alternative land uses in the short term (Schröter et al., 2014). This does not mean that the site should be converted, but that the conservation value as globally significant biodiversity values, irreplaceable cultural values or relational values (Chan et al., 2016). Also, certain ES (such as cultural heritage) are difficult to assess in monetary terms and may be better evaluated using non-monetary measures. It is important to keep these risks and limitations in mind and to be strategic about when and how to undertake an ES assessment. In particular, it is important to identify situations when conservation strategies and arguments based on biodiversity or other cultural or social values may be more effective than assessing economic values.

Some of the applications can be achieved with qualitative information, whereas others will be better served with quantitative data measured in either biophysical or monetary units. The need for quantitative information depends on the context. For example, a forest department seeking to understand the benefits of the forest landscape to the people of its province or country might simply need qualitative information documenting the various benefits that people receive from the area, such as a 'carbon sequestration, erosion control, water purification, pollination services, tourism. However, if there is interest in establishing a Payments for Ecosystem Services (PES) scheme, those benefits might need to be quantified to determine more accurately how much of a given service is being produced by a given site and how the delivery of that service is affected by management, in order to set up an equitable system of payments between the beneficiaries of the service and the service providers.

TOOLS USED FOR MEASURING, MODELLING AND VALUING ES

The increased awareness of nature's role in supporting sustainable development, a number of tools for measuring, modelling and valuing ES have been developed in recent years such as the Toolkit for Ecosystem Service Site based Assessment (TESSA; Peh et al., 2017), and the Protected Areas Benefits Assessment Tool (PA-BAT; Dudley & Stolton, 2008). They also include computer-based modelling tools such as Artificial Intelligence for Ecosystem Services (ARIES; Villa et al., 2014) and Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST; Sharp

et al., 2018), and many others. However, some time for field managers, selecting an appropriate tool for quantification of ES seems confusing. The focus of this report is builds upon an assessment of two riverine forest landscapes and associated important biodiversity in Sindh.



A typical riverine forest landscape in Sindh.

QUANTIFICATION AND VALUATION OF ES OF RIVERINE FOREST LANDSCAPES IN SINDH

The two high conservation value riverine forest landscapes included from Sindh province, in the SFM Project are Sukkur riverine forest landscape and Kot Dhingano-Lakhat riverine forest landscape. Babul, kandi and bahan are the traditional tree species of the primary riverine forest system in Sindh. The traditional furniture made of *Bahan* not only has local market value, but also has export potential. However, riverine forests, if grown and managed exclusively for timber production point of views, it may be uneconomical unless their other ecosystem services (ecological, environmental and social) are considered. The ES potential of both the forest landscapes including quantification and valuation have been captured in this section of the report.

Ecosystems rich in biodiversity is more resilient and productive to provide enormous benefits. Most, if not all, of such direct and indirect ‘flows’ of value into rural or forest-dependent households are goods and services – received free from riverine forest landscapes, and not priced or traded in organised manner in any markets. Because of this, ‘ecosystem services’ are economically invisible. And they do not generally figure in the accounts that measure a country’s economic activity. Putting a value on these services and factoring that into provincial or national accounting can help Forest Department and associated market chain to the fact that healthy economies rest on healthy ecosystems. It is tragedy that excluding ecosystem service from national accounts results in a lack of policy attention and public investment in ecosystem and biodiversity conservation.

ECOSYSTEM SERVICES POTENTIAL FOR PES

In both the riverine landscapes ecosystems are in a constant state of flux. However, it is crucial that they have capacity and strength to cope with likely changes and maintain their services at desirable level. In view of current quantification and valuation of ES, not all of the services of two riverine forest landscapes can be developed as payment for ecosystem services (PES). However, based on incomplete quantified baseline information, following few Ecosystem Services of Riverine Forests have the potential for marketing through PES approach:

- Climate change mitigation through carbon sequestration;
- Promotion of Non-Timber Forest Products;
- Biodiversity conservation (dolphin safari, wildlife watching, hunting, ecotourism, etc.).

In below table we list some of important component of ecosystem services which contribute to human well-being in two riverine landscapes:

Table 3: Some Important Ecosystem Services of Riverine Forest Landscapes

Provisioning Services	Regulating Services	Informational and Cultural Services	Supporting Services
Timber/ Wood	Air Quality	Aesthetic Values	Primary Production
Fuelwood	Buffering against Extremes	Effects on Social Interactions	Soil Formation
Fodder	Noise Abatement	Iconic Landscapes	Wildlife habitats
Food Products like Honey, Acacia Gum.	Carbon Sequestration and Climate Regulation	Inspiration	Biodiversity conservation with numerous terrestrial and aquatic species

Fishes and mushrooms	Protection from floods	Knowledge Systems	Nutrient Cycling
Genetic Resources	Storm and Erosion Control	Recreational Opportunities	
Water	Pollination	Spiritual and Religious Values	

SUKKUR RIVERINE FOREST LANDSCAPE

The SFM landscape is comprised of two blocks of three contiguous reserved forests each in Sukkur District, (1) Bindi Dhareja, Kadirapura and Keti Shah covering an area of 11,145 ha; and Keti Abad II, Keti Shahu and S K Shahu covering an area of 11,413 ha; the total area of the forests in the landscape is 22,558 ha. Total area of Sukkur landscape is 30,000 ha. These forests, commonly known as the "Bela Forests" occur as narrow belts on the flood plains and banks of the major rivers of the Indus Basin. The riverine forests are important seral stage of Tropical Thorn Forest type. The forests form a complete canopy of 12 to 15 m in height. Flooding for about six weeks/ year is necessary to sustain the growth of these forests. The main species are: *Babul* (*Acacia nilotica*), *Tamarix dioica*, *Prosopis cineraria* and to some extent desert poplar locally known as *Bahan* (*Populus euphratica*).

This landscape is best placed in terms of inundation of forests due to storage of water at Sukkur Barrage and back flows into the forests. The highest population of endemic Indus blind dolphin (*Bhulan*) is found in this section of the river. However, there are issues of encroachment of forest lands and non-compliant agro-forestry leases in this landscape, as elsewhere in the riverine forests of Sindh. This is one of the two riverine landscapes in Sindh that has comparatively better carbon stock. The terrestrial and aquatic biodiversity is also high. The number of households and human population in and around forests in Sukkur riverine forest landscape is around 12,000 and 72,000, respectively.

During baseline survey of Dolphin Reserve in 2013, the WWF Pakistan has documented 25 species of mammals, 43 reptiles, 8 fresh water turtles, 5 amphibians, 55 fish species and 190 resident and migratory bird species within Sukkur landscape.

DESCRIPTION OF POTENTIAL PAYMENT FOR ECOSYSTEM SERVICES (PES)

In both forest landscapes, the law does not permit any access by local people of adjoining villages in the reserve forest, however, there is defacto access are allowed mainly to collect non-timber forest products for household use. Although local communities are legally prohibited from managing the forest in Sukkur forest landscape but they are remain management partners of Sindh Forest Department in case of Kot Dhingano forest. The reason that forest department allow local communities of both landscapes to use the resources of NTFPs as their customary rights and in case of Kot Dhingano particularly for their commitment to protect the forest resources religiously. Further department of the view that small level extraction of fuelwood and controlled grazing possibly may not harm the basic principles of forest management in the area and on the contrary help in conflict resolution. The detailed account of ecosystem services and goods on the basis of studies carried out during implementation of SFM project and other available information in respect of two landscapes are given below.

EXISTING CARBON STOCK AND FUTURE POTENTIAL

The total carbon stock in the SFM Sukkur landscape area is 303,110 tonnes. Out of this 81.26% is in the soil, 10.0% in aboveground biomass, 5.60% in belowground biomass and 3.14% in litter.

Distribution of carbon stocks in various pools in different forest areas of Sukkur landscape is given in below Table.

Table 4: Distribution of carbon stocks in different pools of Sukkur forest landscape

Forest Area	Existing Forest area (ha)	AGC tonnes	BGC tonnes	Litter C tonnes	SOC tonnes	Total C (tonnes)	Carbon Density (t/ ha)
Bindi Dhareja	509	3624.1	2025.8	717.69	13249.27	19616.86	38.54
Keti Abad	1231	5588.7	3126.7	1600.3	24435.35	34751.05	28.23
Keti Shah	2878	11167	6245.3	3108.2	119178	139698.50	48.54
Keti Shahu	1196	5669	3169.4	1841.8	33715.24	44395.44	37.12
Kadrapur	257	1135.9	634.79	375.22	8239.42	10385.33	40.41
Shahpur	1076	3131.2	1753.9	1861.5	47516.16	54262.76	50.43
Total	7147	30,316	16,955.7	9,504.5	246,333	303,110	40.54

It was observed during field inventory that the forests are severely degraded and these are facing severe anthropogenic pressure. Open grazing and cutting for fuelwood are serious threats to these forests which have significantly reduced the aboveground carbon stock in the area. However, there is a potential of carbon sequestration up to 20 tCO₂/ha/year in this highly fertile landscape. This can be achieved with sustainable forest management practices and effective policy measures (PFI, 2018).

The cost-benefit analyses are dominated by the high value of carbon stored in the forest vegetation and soil. If deforestation in the Riverine forest landscapes could be avoided, a number of ecosystem goods and services will be preserved, including the benefits derived from timber and non-timber forest products (NTFP). However, the value of these NTFP's in two high conservation value landscapes are much higher than the value of ordinary forest.

NON-TIMBER FOREST PRODUCTS (NTFPs)

Non-timber forest products (NTFP) include all the materials (excluding timber) collected from the forests and associated habitats, and used to support local livelihoods through food, fibers, medicines, fuelwood, etc. In addition, large numbers of households generate some of their income selling by these products. NTFP thus constitute an integral part of the forest landscape and of the social and cultural structure of those living around it.

Non-timber forest products (NTFPs) constitute an important resource source of livelihood for the local communities. Many rural people add to their income by collection and sale of these NTFPs. However, the general perception about diversity, quality, and availability of many species of NTFPs in riverine forests are on decreasing. This situation has serious consequences for the people dependent on these services and for the biodiversity of the riverine forest ecosystems. The decline of the NTFP resources is causing enormous economic, social and environmental losses as well as accelerates the extinction of species and malfunctioning of the ecosystems.

NTFPs are collected by grazers and low income group local people. However, there is no community-based certified NTFP production mechanism at place. Some biodiversity conservation measures are being implemented by forest and wildlife departments under their regular management activities.

In the past, the rationale for conserving forests was simply to sustain the forests' productive role for the timber extraction. However, over the years, the pervading view that forests primarily provide timber as source of substantive revenue is losing ground. Instead now local people are gaining significant benefits from non-timber forest products. NTFPs in like other riverine forests, in Sukkur landscape is also often considered as common property resources, like fuelwood, fodder, fencing, poles, eatable ground plants like mushroom, and a variety of other foodstuffs, such as game, fruit, vegetables, honey, acacia gum, etc.

There is a long-standing tradition of forest product use by communities all along the riverine tract in the province. Certain households see the forest as their economic mainstay, while others see it as a supplementary source of household income. However, the most complete ecosystem based analysis of these products requires, a comprehensive assessment at landscape level on the 'traditional use' of forest products. Brief description of some of the NTFPs are given as under:

Fish production: The status of commercial fishing activities in river Indus component of Sukkur forest landscape and few small lakes within the jurisdiction are currently not working in well-organized manner. The sustainable licensed fishing is not in operation to earn substantial revenue as PES.

Free-grazing for livestock: Most of the livestock owners in riverine forest landscape of Sukkur are belong to local communities who they are unable to keep many livestock without the free-grazing opportunity. These people cannot be realistically asked to pay a fee for the free-grazing fodder, but as an important stakeholder they can contribute in sustainable forest management. Further, they should need to understand that where they can be allowed to graze their livestock and where the livestock should not be allowed to graze.

The cattle population in the riverine forest landscapes has significantly increased compared to the past. Presently this landscape sustain grazing pressure of total 52,935 livestock animals comprising of 26,233 buffaloes, 20,333 cows and 6,369 sheep and goat from within the forest and adjoining areas, which freely graze in this forest. Further, it is also a fact that open grazing by livestock cause damage to regenerating areas and reduce chances of natural regeneration of forest.

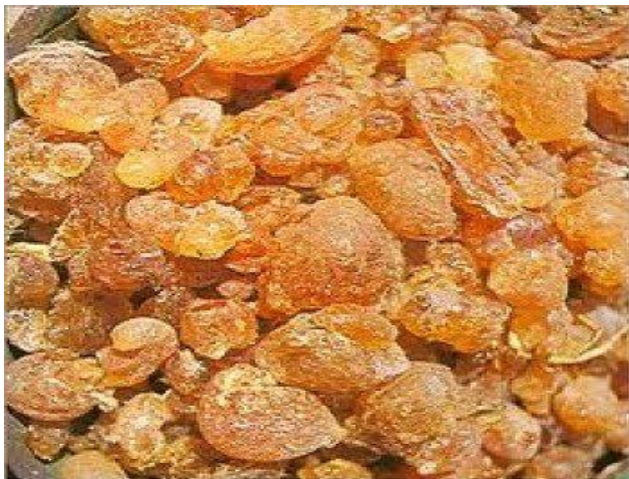
Honey collection: Honey is prized for both its nutritional and medicinal qualities. It is collected mostly for sale to markets. Riverine landscapes are renowned for very high-quality honey, so traders frequently come directly to villages to purchase it from individual households. However, no such baseline information regarding quantity of honey and beeswax production in the area and its local use and trade is documented yet. Further, the wild honey bee population in both landscape is highly vulnerable due to different factors, such as use of pesticides, faulty honey collection techniques, impact of climate change, etc.

The recent population crash in honeybees, a top pollinator, reminded us that life on the small and microscopic scale is a vital. Further, honey is considered as important commodity and due to the difficulty to meet the local honey consumer demands, the country depends highly on imported honey and honey products.



Acacia Gum collection: Flow of gum is more in hot weather therefore tapping is normally done in summer season between June-September. Acacia gum is precious edible commodity, also used for other purposes as well. However, in riverine landscape its production and marketing is not properly regulated. Gum *acacia*, also known as gum Arabic is an edible polysaccharide used in the food, pharmaceutical, cosmetic and textile industries, as an emulsifying, suspending and stabilizing agent. *Acacia* gum is common variety of the gum obtained from babul tree of riverine forests in the province. However, its quantitative statistics are not yet studied at landscape levels to determine the exact monetary value of the product.

Further, local communities are not well verse with the sound tapping techniques used worldwide. Only a few small longitudinal incisions should be made to collect the exudates. Long sharp cut blazes with sharp knife and chisel are best as they give pure gum and the bark heals faster. Irregular cuts add impurities to the gum. Incisions, too close to the ground, easily approachable by the domestic and wild animals, should be avoided and younger trees should not be tapped.



Babul (*Acacia nilotica*) gum and tree.

Ecotourism: In Sukkur riverine forest landscape potentially scope for promotion of ecotourism exists. However, no authentic data and monetary benefits is yet assessed in view of scope, potential and carrying capacity for sustainable ecotourism by any concerned agency including provincial tourism department. Therefore, such study or assessment during implementation of landscape management plan in future will be useful to tape maximum benefit of this ecosystem service. Presently this location is considered as poorly visited site in view of tourism activity.

Both the landscape areas have mix potential of natural and cultural heritage makes the sites an important tourist destination. However, tourism development has been hampered by the lack of policy guidelines, security concerns, insufficient investment, inadequate tourism infrastructure, insufficient human recourse development and weak marketing.

Wild Game: Legal and illegal partridges and waterfowl shooting, hog deer and wild boar hunting and netting of fish and freshwater turtles is widespread activity of local as well as outsiders in the area. However, somewhat strict enforcement by Wildlife and forest officials makes it difficult to openly sell wild game. The game species of riverine forests are mostly hunted for local consumption or use in small scale trade. However, there are prospects exists for community managed trophy hunting of hog deer in the area with strict protection measures and propagation of viable ungulate population. Long term SFM plan implementation in both the landscapes may allow this kind of sustainable trophy hunting income in future. However, currently it has been restricted in the forested areas of these landscapes.

Another group of hunters constitute local rural household and influential hunters (shikarees), they hunt partridges and migratory ducts/ waterfowl with low awareness about the game birds population dynamics. These hunters are allowed hunting of game birds through issuance of shooting licenses by Sindh wildlife department on nominal fees. In addition to this, events of illegal wild boar hunting, netting of freshwater turtles and trapping of falcons in the area of Sukkur landscape is quite common.



Game birds in Riverine Landscapes (Black partridge & a pair of Mallards)

Fuelwood: Forest wood is the most preferred source of fuelwood, especially because it burns better than other available fuel sources. Wood found in agro-forestry based croplands provides a secondary source of fuelwood. Most of local people in and around forest landscapes meet their

household fuelwood needs. Since fuelwood collection is carried for domestic cooking needs, therefore it is not viewed by local communities as an economic activity.

Table 5: Quantification of ES for the Sukkur and Kot Dhingano-Lakhat landscapes.

Main ecosystem services	Economic benefit valuated	Overall quantification of PES
Climate Change Mitigation	Carbon sequestration potential in in both riverine forest landscapes.	Estimated potential for each landscape is 20 tCO ₂ / ha/ year. Details based on study carried out by PFI under SFM project is given separately.
Non-Timber Forest Products (NTFPs)	Fish catch within river segment of landscape is allowed by Government to locals without any licensed fee.	No annual harvest data/ statistics based on recent baseline study or assessment available. In case of Kot Dhingano-Lakhat very limited scope exists.
	Free-grazing fodder for livestock.	No such assessment based on livestock population and products (milk, butter, wool, etc.) have been made under SFM project or earlier studies conducted for two landscapes.
	Honey collection from forest areas.	Total quantity of honey production at landscape level not yet worked out.
	Gum production.	No authentic quantitative figures available.
	Sar Kana	No quantitative data available.
Biodiversity conservation	Ecotourism	Potential assessment is not yet worked out under any study. However, it is believed that as compare to Kot Dhingano, enough scope exists in Sukkur landscape area.
	Wildlife hunting/ wild game	No such landscape specific statistics or data available regarding existing practices in both landscapes.
Forest wood products	Timber harvesting.	Green felling in Riverine reserve forest is banned. Further, in the area of Kot Dhingano forest by agreement local community is main defender of these resources.
	Fuelwood harvesting and collection.	Authentic quantitative data not available. However, in case of Kot Dhingano local community is allowed for free grazing and fuelwood collection.
Agro-forestry provisions	Forest lands within landscape on agro-forestry leases.	954 acres of forest land allocated for agro-forestry purposes on lease in Sukkur landscape area.

Box-3**The Valuation of Forest Landscape Ecosystems and Associated Biodiversity**

Ecosystem services have value for everyone, but this value cannot always be expressed easily. Therefore, The Economics of Ecosystems and Biodiversity (TEEB) approach is developed for the valuation task. TEEB, offers a method to determine the economic value and the costs and benefits of nature, biodiversity and ecosystem services.

This approach includes several analytical steps to determine the value of various, ecosystem services. First, ecosystems are characterised in terms of their structure and individual elements, such as species, populations and landscape elements. These elements are the carriers of natural ecosystem processes (functions) that deliver all kinds of services to society, such as biomass production and carbon sequestration. These functions provide a number of goods and services for society, such as food and timber, water purification and climate regulation. These goods and services represent a certain value and form part of the general well-being and economic welfare level of their recipient. The value can be made explicit by presenting them in monetary terms. This monetary value is an indication of the usefulness and necessity to conserve nature and biodiversity. In cost-benefit analyses, the financial costs of maintaining and sustainably managing ecosystems are compared against the societal and economic benefits these ecosystems provide. This kind of information always help in decision making on the governance of ecosystem management.

Source: TEEB, 2010

KOT DHINGANO – LAKHAT FOREST LANDSCAPE

The forest landscape site is situated along the Indus River, downstream of Sukkur Barrage on the left bank in the Shaheed Benazirabad (formerly Nawabshah) District. The landscape is comprised of Dhingano Reserve Forest (1,538 ha) and Lakhat Reserve Forest (1,462 ha). Both forests are also separately designated as wildlife sanctuaries under the Sindh Wildlife Protection Ordinance, 1972 in addition to their designation as Reserved Forest under the Forest Act. The total area of the Dhingano-Lakhat Riverine landscape is 3,300 ha.

One of the reasons of inclusion of this landscape in this project is that most of the forests downstream of Sukkur Barrage do not get inundation except in high or super floods whereas this landscape, situated between Sukkur and Kotri barrages that is in Central Sindh still receives substantial annual inundation. There are two villages and hamlets situated in and around these forests which consist of 1,670 households and 10,000 forest dependent local persons. One of the two dependent local communities are actively involved in protection and conservation of forests.

The Kot Dhingano Riverine forest is of the unique forests of Sindh from fauna and flora point of view. The forest is habitat of Hog deer and other wild animals as well as home of partridges, migratory birds and is also famous for wild honey. The main tree species are Babul (*Acacia nilotica*), Kandi (*Prosopis cineraria*), Lawa (*Tamarix aphylla*), Lai (*Tamarix dioca*) Bahan (*Populus euphratica*) and other tree species. The forest is spread over the area of 3815 acres and is being managed with the participation of local community. The forest community has played a vital role to safeguard the forest from encroachment. It is famous that when different land grabbers tried to cut trees and encroach upon the forest land, the local community not only vigilantly resisted the encroachers but also took oath on the Holy Quran and encircled it around the forest boundary.

This is the only forest in Sindh that is being protected with the help of the local community and maintained sustainably. The Kot Dhingano forest is mainly being used by the local community for grazing their animals, honey and fuel wood collection. However, heavy grazing pressure from the

animals of local community, less annual inundation due to non-occurrence of regular river flooding and forest fire has impacted negatively to the survival of Kot Dhingano forest.

The whole designated area of Lakhat forest is without trees. The area of forest is either under encroachment or under river course. The area under encroachment is being cultivated by the encroachers. The area under cultivation is 3275 acres; whereas the area under river course is 4270 acres. The Lakhat forest is adjacent to Kot Dhingano forest and is mainly disturbed by river flow. The boundary of the Lakhat forest was not clear on the ground that has been demarcated by the Survey of Pakistan under the Sustainable Forest Management (SFM) Project.

The flora and fauna of the riverine tract is almost similar except few species such as Indus Dolphin is not found in downstream Sukkur barrage and plant species that require regular floods such as *Phyllanthus reutilatus* (Kamo) are gradually replaced by xerophytic climax species downstream Sukkur Barrage.

EXISTING CARBON STOCK AND FUTURE POTENTIAL

The total carbon stock in the SFM Project area is 45588.8 tonnes. Out of this 70.70% is in the soil, 16.05 % in aboveground biomass, 9.0% in belowground biomass and 4.25% in litter. Distribution of carbon stocks in both forest areas of Kot Dhingano landscape is given in below Table.

Table 6: Distribution of carbon stocks in Kot Dhingano Riverine Forest Landscape

Forest Area	Existing Forest area (ha)	AGC tonnes	BGC tonnes	Litter C tonnes	SOC tonnes	Total C (tonnes)	Carbon Density (t/ha)
Kot Dhingano	984	7321	4103.3	1938.5	32226	45588.8	46.33
Lakhat	0	0	0	0	0	0	0
Total	984	7321	4103.3	1938.5	32226	45588.8	46.33

It was observed during field inventory that the forests are severely degraded and these are facing severe anthropogenic pressure. Open grazing and cutting for fuelwood are serious threats to these forests which have significantly reduced the aboveground carbon stock in the area. However, there is a potential of carbon sequestration up to 20 tCO₂/ha/year in this highly fertile landscape. This can be achieved with sustainable forest management practices and effective policy measures. (PFI, 2018).

NON-TIMBER FOREST PRODUCTS (NTFPs)

In the context of riverine forest landscapes of Kot Dhingano-Lakhat, a nature of the role and scope of non-timber forest products is same as in Sukkur landscape except tourism and fish catch. However, since this forest landscape mainly a community managed resource where community is obliged to collect fuelwood, collect honey and graze their domestic animals in the area, therefore quantification and benefits of NTFPs have been not made at any level. Non-timber forest products have not yet attracted the attention of forest managers, since the vast majority of the rural population is dependent on natural resources to meet daily energy requirements, livestock grazing, or to provide livelihoods. However, it is also important to collect data on NTFPs of Kot Dhingano-Lakhat landscape during SFM plan implementation to know the potential role of these resources, despite their importance to the local economy.

In above context animal grazing and fuelwood collection could be seen as common practice in the area.

Livestock grazing: Presently this landscape sustain grazing pressure of total 5,354 animals comprising of 1,158 buffaloes, 1,753 cows, 2,426 goat/ sheep and 17 camels from within the forest landscape and adjoining areas, which freely graze in this forest.



Livestock grazing in Kot Dhingano Riverine Forest, Lakhat

Fuelwood: Since local communities are partner in the forest resource management with Sindh Forest Department, therefore most of local people in and around forest landscapes meet their household fuelwood needs. Since fuelwood collection is carried for domestic cooking needs, therefore it is not viewed by local communities as an economic activity.



Fuel wood cutting by local people in Riverine Forest.

MONETARY VALUATION OF ECOSYSTEM SERVICES

Valuation can provide useful information that will result from ecosystem management actions. However, no valuation method is yet recognized as perfect. Each method has advantages and disadvantages, and should be carefully chosen based on the specific goals of the study. Valuation techniques have limitations that are as yet unresolved. Valuation practitioners should present their results as such, and policy makers should interpret and use valuation data accordingly. We must be careful to use monetary valuation in appropriate ways. Despite difficulties, limitations, and issues surrounding ecosystem service valuation, there does seem to be a general consensus that the value of ecosystem services often outweighs economic use and that protecting ecosystem services is, or should be, one of the most important responsibilities of today's resource managers and society in general. It is also important to realize that ecosystem service valuation can be a useful tool but cannot alone provide all the information needed to solve a problem. These economic arguments are best used along with and to support political and social considerations.

Many of the services, like in other forest ecosystems can be linked with these two riverine forest landscapes. The typical features of everyone's goods such that the people who benefit cannot be excluded from receiving the service provided and the scale of utilization by one does not lower the level of benefits enjoyed by another, such as climate change mitigation, habitat protection, water regulation and recreational value of the landscape. Due to these characteristics, the potential for private incentives to sustainably manage riverine forests ecosystem services looks limited with no appropriate markets mechanism in place.

A number of studies have developed world wide to calculate the monetary value of various forest ecosystems. But they do not provide a more specific insight in the values relevant to riverine forest landscapes.

Table 7: General Valuation of Riverine Forest Ecosystem Services

S.#	Ecosystem Services or Goods	Market Nature of Service	Important Services
1.	Climate regulation	NM	Great source for climate mitigation.
2.	Flood regulation	NM	Used as disaster control measures.
3.	Water supply regulation	NM	Ensure flow and aquifer recharge.
4.	Habitat protection	NM	Important for wildlife propagation.
5.	Erosion control	NM	Contribute in protection of land and other properties.
6.	Nutrient cycling	NM	Help in soil fertility.
7.	Biological control	NM	Sustain important agents used as source of biocontrol.
8.	Food production	M	Good source of wild food & fodder
9.	Raw materials	M	Important source for consumption and livelihood earning.
10	Recreation	M, NM	One of the potential area for revenue generation.

NM: A goods/ services that primarily Non-Market in nature, **M:** A good or service that primarily Market in nature, and **M, NM:** A good/ service that has both Market and Non-Market characteristics.

Carbon sequestration: The only carbon trading mechanisms is in place. Except for carbon trading there is no set level for pricing of the payment for ecosystem services. For other ecosystem services on the basis of fair quantifying assessment a valuation mechanisms have to be created for the future management requirements. However, at present no local buyers of carbon credits

available in Sindh province, therefore the sequestered carbon from forest landscapes should be traded with international organizations like 'Merlin Wood'. Further, in future it is expected that many potential national buyers may be available. At national level, there are different industrial companies or multi-national companies that are likely to be potential buyers of carbon credits. A good opportunity for such carbon trading is also expected in international market after post 2020 scenario. In this context the potential of Sukkur forest landscape and Dhingano-Lakhat landscape to sequester carbon with more afforestation activities on blank areas of thousands of acres can be increased considerably. With the currently used market price for carbon credits the total monetized carbon value could be worth millions of rupees each year.

Table 8: Monetized values of Ecosystem Services for the Riverine Forest Landscapes.

Identified main ecosystem services	Actual economic benefit analyzed and valued	Monetized value in PKRs
Biodiversity conservation and ecotourism	Ecotourism/ recreation	Only carbon sequestered and its potential has been assessed in both riverine forest landscapes, therefore, the secure estimation or calculation of economic values for other products in monetize terms looks difficult as there no quantified baseline statistics are available.
	Wild game harvesting	
	Habitat conservation for various natural processes	
Carbon and other forest wood products	Timber extraction	
	Fuelwood collection	
	Carbon sequestration	
Non-Timber Forest Products (NTFPs)	Free-grazing fodder for livestock	
	Honey collection	
	Commercial fish production	
	Acacia gum production	

WAYFORWARD

The real and fair valuation will be possible during implementation of forest landscape management plans and after detailed assessment of ecosystem services in each landscapes. Only the baseline information will tell how much annual and total financing these two forests can accumulate from these services. Ecosystem products and services are essentials for human survival and development, therefore it requires to be quantified and measured with total accuracy and potential of economic valuation. In this regard following few recommendation could be used as way forward:

- Establish guidelines for quantification of ecosystem services;
- Develop national and sub-national gross ecosystem product standards;
- Mainstream ecosystem values into policy decisions;
- Establish national expert panel to initiate pilot studies at landscape levels on different aspects of ecosystem goods & services;
- Study the linkages between ecosystems and human well-being so as to assist in the sustainable forest management.

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ACKNOWLEDGEMENTS

IUCN Pakistan is grateful to all those who helped in preparation of this report on ecosystem services (inventory, quantification & valuation). The development of report funded through GEF-UNDP Sustainable Forest Management project and its Sindh component, Project Management and Implementation Unit (PMIU).