IJSSS

International Journal of Social Sciences and Sustainability

CEPSS

Economic Valuation of Goods and Services Provided by Pine Forest Ecosystems in Pakistan

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ABSTRACT: Pine Forest represents the most significant natural asset values. Natural forest goods and services can be consumed as foods, timber, and non-timber forest products directly or indirectly-by getting benefits from clean air, water, soil protection, and environmental sustainability. Similarly, forest ecosystems also contribute in the form of intangible values such as sociocultural, scientific, religious, and natural inheritance to the forthcoming generations. Both the market and non-market values of natural forests are of prodigious standing for human life. In this paper, the attempt is made to evaluate the economic values of forest environmental assets, goods, and services provided by the Pine forest in Pakistan using the latest tools and techniques (GIS, Remote Sensing, and Socioeconomic survey). The Pine forest in the study region is rich in values, it contributes $ US 11.66 million (Pakistani Rupees 1883.03 million) in the form of forest goods. Forests services contributes a total of $ US 1621.59 million (261885 million PKR). The services further divided into two sub-groups; environmental services and socio-cultural services. The contribution of environmental services is $ US 1341.25 million while the socio-cultural values are $ US 280.32 million. In total, the pine forests contribution to local, regional, and the global community are of $ US 9156.79 million (PKR 1480275 million).

KEYWORDS: Environmental sustainability; forest products; Forest Service**;** Economic value of Forest; Pakistan

INTRODUCTION

Pine forest ecosystem goods and services, and the natural capital stocks are produced to make them significant due to their direct and indirect contributions to national economies and human welfare. There have been many attempts to value these contributions both globally and regionally. In the past two decades, a good deal of progress has been achieved in developing valuation methods for forest ecosystem services and promoting their inclusion in national economic accounts.

In Pakistan, the valuation of forest ecosystem goods and services is one of the most untouched topics. Most of the research has been done on the distribution and management of forest with a rising number of studies at national, provincial, and local management unit levels (Tufail et al, 2020: Ahmad and Abbasi 2011; Ahmad et al, 2012; Nazir and Olabisi 2012, Tariq et al, 2014). Many of those have been carried out with different scales, perspectives, purposes and using different valuation concepts and methods. However, they have come up with widely varying results.

Pine forest in Pakistan is mostly found in the North-West of the countryside and generally governed by governments and communities. Out of four Pine forest districts, district Chitral is under the management of Khyber Pakhtunkhwa Provincial government and District South Waziristan is managed by the local community while district Shirani belongs to the local community and District Diamer by the Gilgit Baltistan Provincial Governments. The total area of these four forest districts is 28069 Km^2. The districts have been facing rapid population growth. At the end of 2017, the total number of residents was 1.42 million (Pakistan Population Census 2017). Due to the remoteness of the districts, the region is facing high illiteracy and highly dependence on agricultural and forest-based income generation activities.

Pine natural Forests have a critical role in the ecology, aesthetics, and socio-economic development of the localities and regions. Pine forest in Pakistan mixed with other tree species are spread over a total of 365564-hectare area, where 177324 hectares of Pine forest mixed with other tree occur in Diamer Gilgit, 95647 hectares of mixed Pine forest in South Waziristan, 63241 hectares mixed forest of Pine in Chitral, and 29172 hectares of pure Pine stand in Shirani District (from the District Forest Office of the each District). These forests are very rich in biodiversity, hosting a variety of fauna and flora.

This report is an attempt to estimate the full market and non-market values of these forests, using the latest field survey data on Pakistan Pine forest resources and secondary data from government departments. Unlike most other valuation studies, it includes an analysis of the distribution of the benefits from forest goods and services among economic sectors and local, regional, and global beneficiaries.

There are naturally many limitations to both the current and previous studies, many of which are pointed out in this report, and it is recognized that experts are unlikely to reach a consensus on nonmarket values. Such efforts are nevertheless important to help raise awareness of the multifunctional roles of forest ecosystems and can ultimately contribute to the conservation and sustainability of forest resources.

RESEARCH METHODOLOGY

2.1. Study Framework

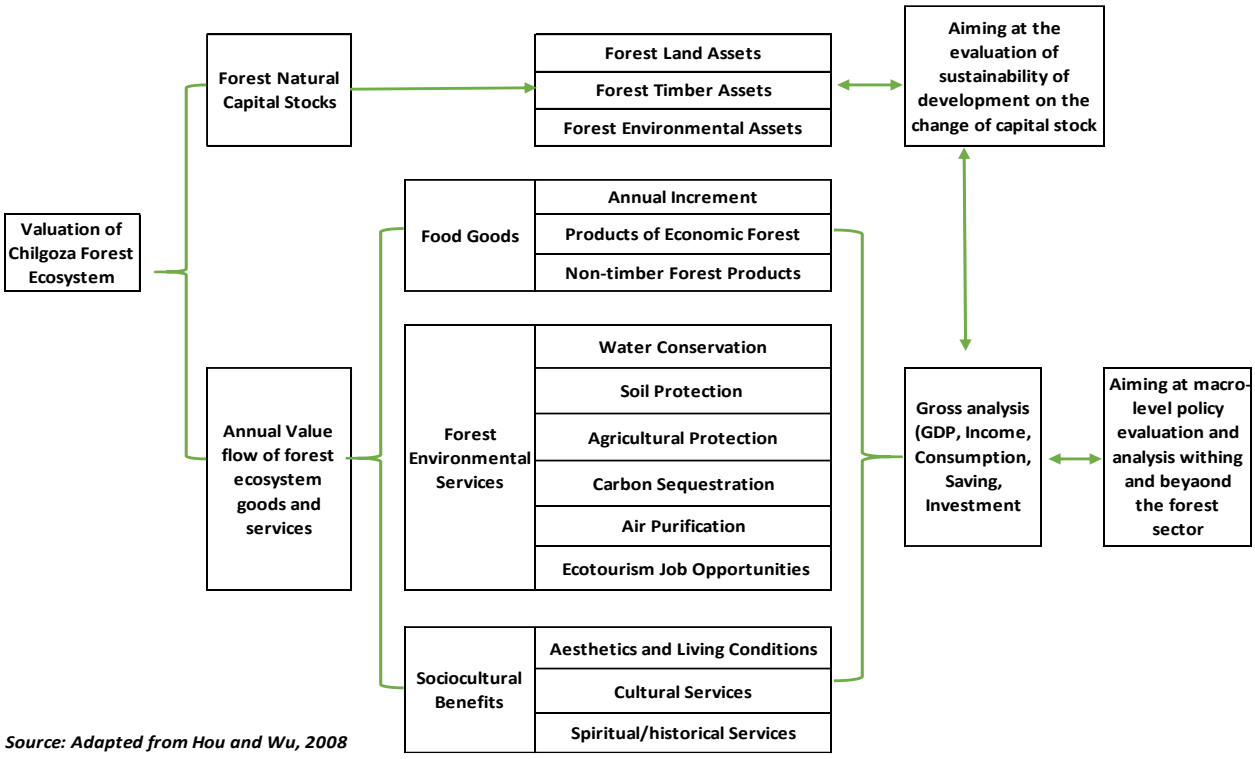
This study applies an updated framework for the valuation of forest ecosystems proposed by Hou and Wu (2008) concerning authoritative international documents in the field (Tufail et al, 2020: Eurostat, 2002a, 2002b; United Nations et al., 2003; Millennium Ecosystem Assessment, 2003; FAO, 2004).

The framework distinguishes between assets (natural capital stocks) and production (the flow value of forest goods and services), which have generally been mixed in other valuation studies globally. Change in the former indicates whether forest management is sustainable or not. Later is what should be counted in GDP (Gross Domestic Product) or green GDP.

In this framework, the benefits people obtain from forests are classified into three categories: forest goods, environmental services, and sociocultural benefits. Forest environmental services have been included in most studies in the world, but the new framework includes an additional and innovative category, forest environmental assets. This concept differentiates, for example, forest carbon storage (as an asset) from forest carbon sequestration flow (as a service).

The valuation method in this study involved the quantification of all forest ecosystem services and goods. The main methods used to value these amounts were the market value or (replacement costs, productivity loss, cost of illness, etc.) benefit transfer methods.

Figure 1: Study Framework



Source: Adapted from Hou and Wu, 2008

2.2. Valuation Categories

Forest natural capital

Forest land Assets: Forest land, one of the most important economic assets, is generally valued based on market transactions, either directly (e.g. using market prices for bare forest land) or as a ratio of the value of exchanged forest property. In this study, forest land was categorized into five types (forested land, open forest land, shrubland, nursery land, and bare forest land) and valued according to the prices of each type. A stratified sampling method has been applied to investigate the transaction Prices for different types of forest land in the Study area.

Standing Timber Assets: A simple stumpage value method was used for the valuation of standing timber. Stumpage prices by species and diameter were taken from existing transactions in the study area. In the latter case, the prices were adjusted using the ratio of the consumer price index for the area of origin (and other conversion factors as needed). These prices were applied to the stock according to its species and diameter composition.

Forest environmental Assets: The environmental assets considered in the study were forest carbon stock and forest wildlife. Estimates of forest carbon stock and stock changes were calculated based on growing stock and net increment using the biomass expansion factor (BEF) of the Intergovernmental Panel on Climate Change (IPCC, 2004). The value of forest carbon stock assets was calculated by multiplying forest carbon stock by the carbon price derived from the carbon project in Beijing forest (178 Yuan or US$23 per ton CO_2, 2007). The value was converted into rupees and dollars using the current exchange rate (April 2020).

Forest goods

Annual increment of standing timber. The value of the annual increment of the forest stand was estimated by the stumpage value method using the annual increment by species and age classes and the corresponding stumpage prices per cubic meter by species.

Products of economic forests. The market value method was used to estimate the value of fresh fruits, nuts, and flour products from economic forests, i.e. forests of economic value including those that have been specifically planted for these products. The production data were taken from the local farmers and the prices came from market surveys and direct observations.

Non-timber forest products (NTFPs). The value of the main non-wood forest products (wild medicinal materials, mushrooms, wild vegetables, bee products, and hunting, as well as tree breeding and planting, which are listed as NTFPs in Pakistan forestry statistics) was calculated using the market value method. Production data for these products were from a survey conducted in the study regions.

Forest Ecosystem Services

Water Conservation. "Green reservoir" services of forested watersheds include the capture and storage of water (contributing to the quantity of water available during the dry season) and the purification of water through the filtering of contaminants and the stabilization of soils. The total value of water conservation services was estimated based on the water regulating capacity and the cost of supplying water for the city (which includes the sewage treatment fee).

Water quantity was estimated by the water balance method, using the forest area and rainfall data to get the total water input into the catchments and subtracting evapotranspiration and surface runoff for each forest type. The maximum water quantity regulating capacity was equal to the total storage capacity of the catchment forests, and its value was estimated using the replacement cost method (using the cost of establishing a conventional water reservoir in Pakistan).

Soil protection. Forest vegetation helps stabilize soils, reduce surface erosion and sedimentation, and maintain soil fertility. The estimated value of soil stabilization primarily reflects the costs associated with sediment clearance, calculated with the replacement cost or avoided cost method, using the average cost for sediment dredging in the study area. The value of soil fertility protection was estimated by applying the market value method, assumed that the forested soil around the study area contains on average around (two) 2 percent compound fertilizer (Yu and Wang, 1999) and using the observed market price of compound fertilizer in 2020.

Agricultural protection. The study focused on the increased crop production benefits provided by forest shelterbelts. The market value method was adopted to estimate this value based on the increase in crop production, the area of cropland with forest shelter, and the price of the crop.

Carbon sequestration. Annual carbon sequestration was estimated using the net primary production of forest stands and the soil carbon sequestration by type of forest stand. Again, the carbon price was taken from the forest carbon project in the Beijing forest.

Forest ecotourism. The travel cost method has often been used to estimate the value of forest ecotourism. Because of limited time and funding, the present study applied the results from other research such as; the ecotourism value estimated by (TEEB Climate Issues Update 2009). This value was multiplied by the total forest area used for ecotourism to estimate the total value of forest ecotourism.

Biodiversity conservation. The study adopted the average per-hectare value of forest biodiversity conservation for the Beijing area estimated by Zhang (2002) using the opportunity cost method, multiplied by the forest area of Beijing.

Employment Opportunities. Employment creation was considered as a social rather than an economic benefit because the capacity of forests to provide traditional employment in remote communities was more important than the strictly economic benefits of employment creation since employment opportunities are very low in the study area. The analysis covered direct and indirect employment, using data on personnel and wages from the local markets.

Table 1. Data and Variables Measurements

Assessments of Environmental Goods and Services (Variables used)					
Topic	**Statistics and Related Information**		**Category of Measurement**	**Potential Aggregations and Scales**	**Methodological Guidance**
Forests	a.	Forest area		▪ By forest type ▪ National ▪ Sub-national ▪ By dominant tree species ▪ By ownership	FAO Global Forest Resources Assessment (FRA) ▪ UN Forum on Forests (UNFF) Monitoring, Assessment and Reporting (MAR) ▪ Montreal Process (Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests)
		1. **Total**	Area		
		2. Natural	Area		
		3. Planted	Area		
		4. Protected forest area	Area		
Use of forest land	b.	Use of forest land			
		1. **Area deforested**	Area		
		2. Area reforested	Area		
		3. Area afforested	Area		
		4. *Natural growth*	Area		
Timber resources	a.	Timber resources		▪ By type of product (timber, industrial Roundwood, fuelwood, etc.)	▪ SEEA Central Framework (2012) ▪ FAO ▪ Central Product Classification (CPC)
		1. **Stocks of timber resources**	Volume		
	b.	Forest production	Volume		
	c.	Fuelwood production	Volume		
Water resources	a.	The inflow of water to inland water resources		▪ Regional	▪ UNECE Standard Statistical Classification of Water Use (1989) ▪ UNSD: Environment Statistics Section-Water Questionnaire
		1. **Precipitation**	Volume		
		2. **Inflow from neighbouring territories**	Volume		
	b.	1. **Evapotranspiration**	Volume		
		2. Outflow to neighbouring territories	Volume		
		3. Outflow subject to treaties	Volume		
	c.	Inland water stocks		▪ Regional	
		1. Surface water stocks in artificial reservoirs	Volume		
		2. Surface water stocks in lakes	Volume		
		3. *Surface water stocks in rivers and streams*	Volume		
		4. *Surface water stocks in wetlands*	Volume		
		5. *Surface water stocks in snow, ice and glaciers*	Volume		
		6. Groundwater stocks	Volume		
Biodiversity	a.	Forest biomass		▪ Regional	▪ FAO Global Forest Resources Assessment (FRA)
		1. Total	Volume		
		2. *Carbon storage in living forest biomass*	Mass		

RESULTS AND DISSCUSSION

The Pine forest mixed with other tree species is distributed on over 359,392 Ha, in the four project sites which are shown in graph 2. District Diamer Gilgit Baltistan has the highest (177324 ha) forest area in the region followed by District South Waziristan and District Chitral while District Shirani in the West has the lowest but pure Pine forest area. Besides the distribution of these Pine forests, District Shirani found the leading producer of pine nuts having the annual value of 4553 million Pakistani rupees (28.19 million US dollar) followed by District Diamer Gilgit Baltistan having a net worth of 599 million PKR (3.71 million US$) of producing pine nuts annually. Pine forest in South Waziristan producing pine nuts having a total annual value of 150 million PKR (0.93 million US $) while District Chitral Pine production net worth is 85 million PKR (0.53 million US $). Graph 3 shows district wise the total production of pine nuts.

Figure 2: Forest Area of Four Project sites

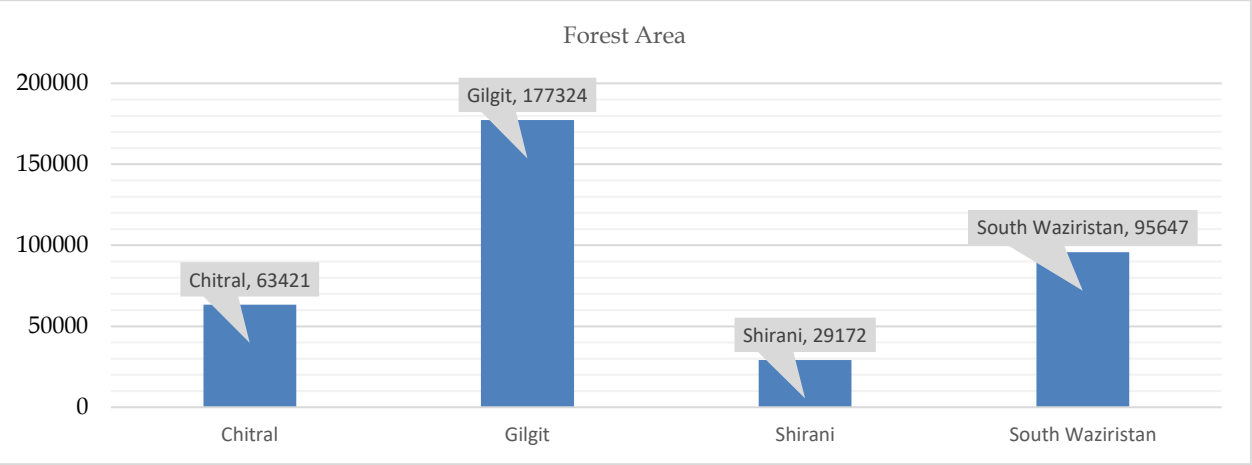
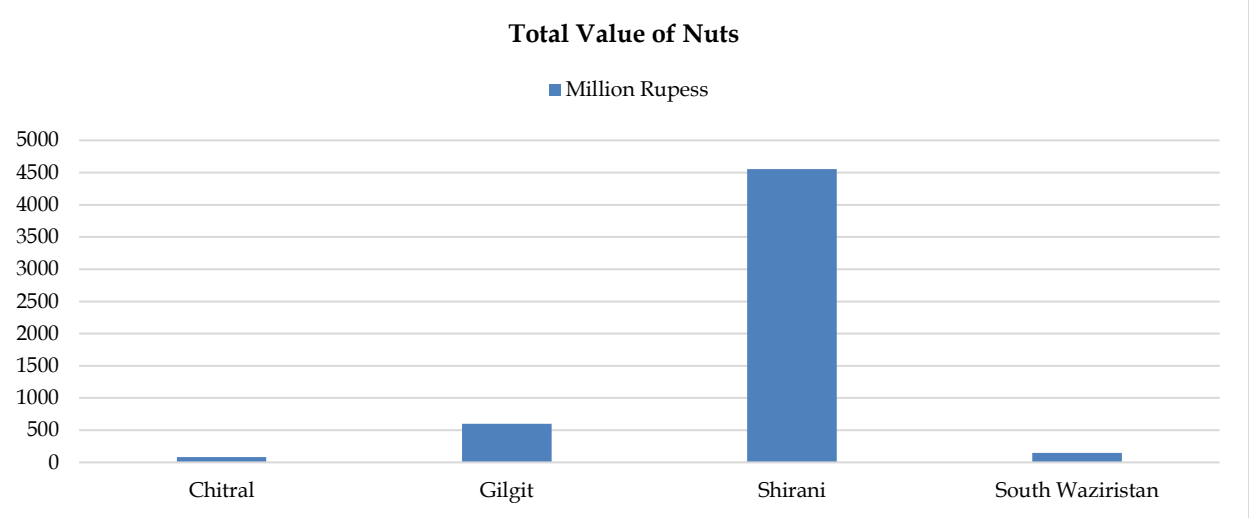


Figure 3: Total Value Nuts in Four Project Sites



Forest Biomass, Carbon Stock, and Value of Carbon Stock

The total biomass and carbon stock were calculated using the biomass expansion factor (BEF) of the Intergovernmental Panel on Climate Change (IPCC, 2004). The total calculated forest biomass stock in the study region was 93.07 Tg (46537670.08Mg), in

which the Diamer Gilgit Baltistan accounts 45.94Tg South Waziristan 24.77 Tg, Chitral 16.42 Tg, and Shirani 5.95 Tg. Similarly, the total carbon stock was calculated for the study region was 46.53 Tg in which the highest carbon stock found in Diamer followed by South Waziristan, Chitral, and Shirani.

Figure 4: Total Biomass and Carbon Stock

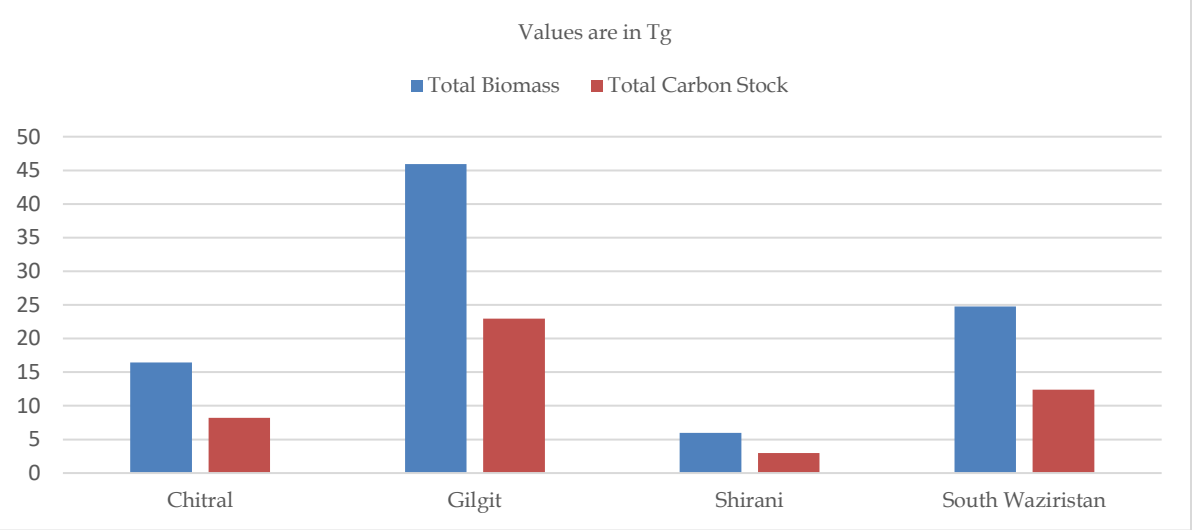
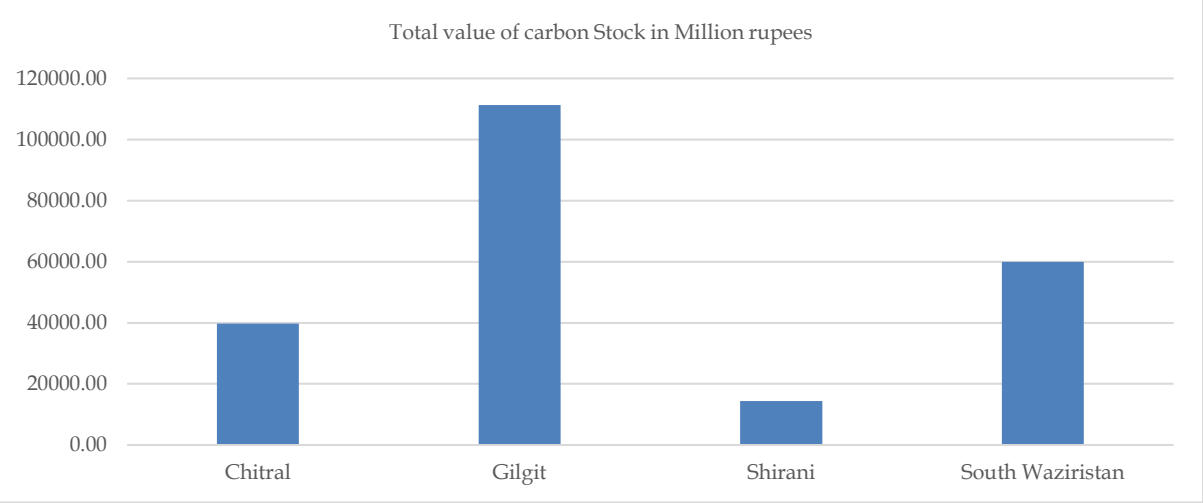


Table 4 shows value of total forest carbon stock assets in each district was calculated by multiplying the forest carbon by the price of carbon derived from the project in Beijing, 2007 (3715 rupees or US$ 23 per ton CO_2). Graph 5 represents the value of forest carbon stock in each district. Diamer Gilgit Baltistan has the highest value of forest carbon stock approximately 111249.36 million rupees (688.85 million US$) followed by South Waziristan which has 60006.92 million PKR (371.56 million US$). The value of total forest carbon stock for Chitral and Shirani was 39789.01 million PKR (246.37 million US$) and 14429.72 million PKR (89.35 million US$) respectively.

Figure 5: Total value of Carbon Stock

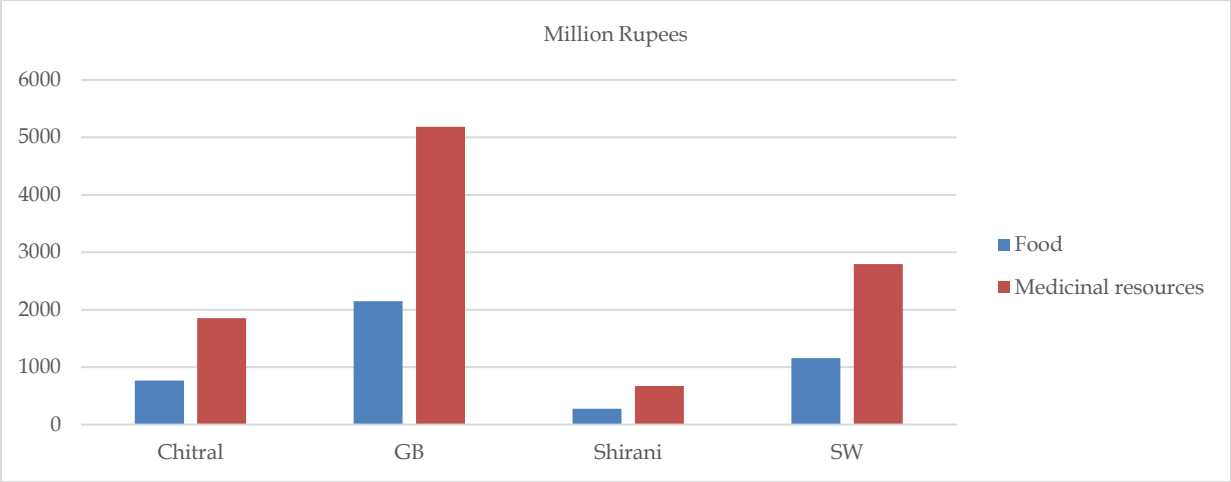


Food, Medicinal Resources, Water, and Climate Regulation

Pine forest annual contribution to food and medicinal resources are given in graph 6. Pine forest contributes a total of 4353.14 million PKR (US$ 27.42 million) in food and 10505.57 million PKR (US$ 66.17 million) in medicinal resources. District-wise

distribution of Pine forest shows that its contribution to Diamer is the highest which is 2147.84 million PKR (US$ 13.29 million) in food and 346875.5 million PKR (US$ 32.10) million in medicinal resources followed by South Waziristan, Chitral, and Shirani.

Figure 6: Valuation of Food and medicinal Resources



Pine forested watersheds include the capacity of capturing and storage of water which contributes to water availability during the dry season and the purification of water through the filtering of contamination and stabilization of soils. These forests contribute a total of 8299.98 million PKR (US$ 52.28 million) in water availability, 10253.40 million PKR (US$ 64.70 million) in water purification, and 78936.85 million PKR (US$ 497.17 million) in water flow regulation to the study region. District wise contribution of Pine forest to water resources is given below.

Figure 7: Contribution of Pine Forest to Water Resources

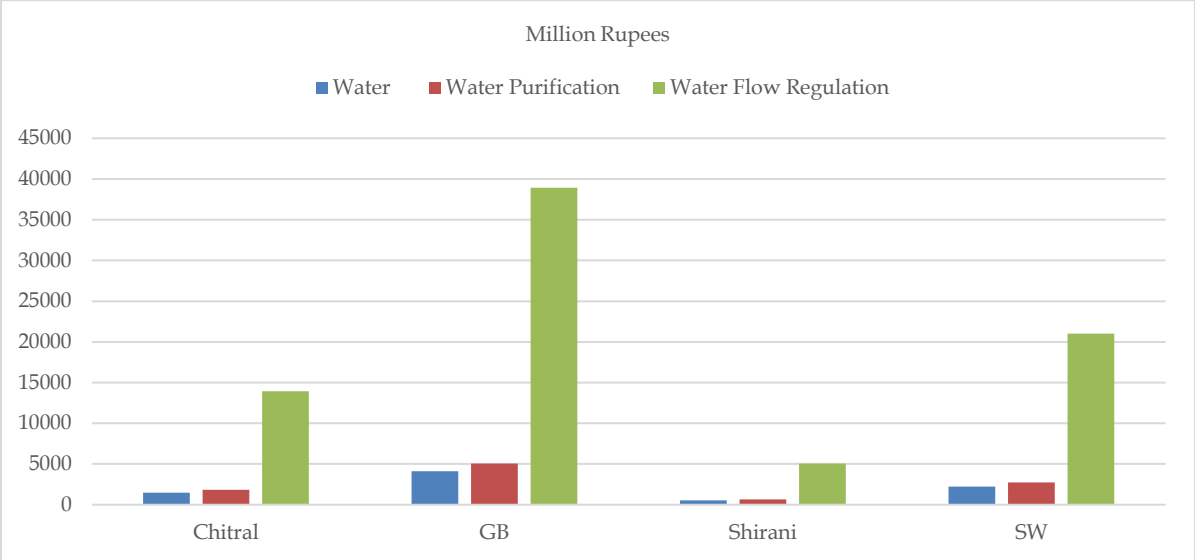
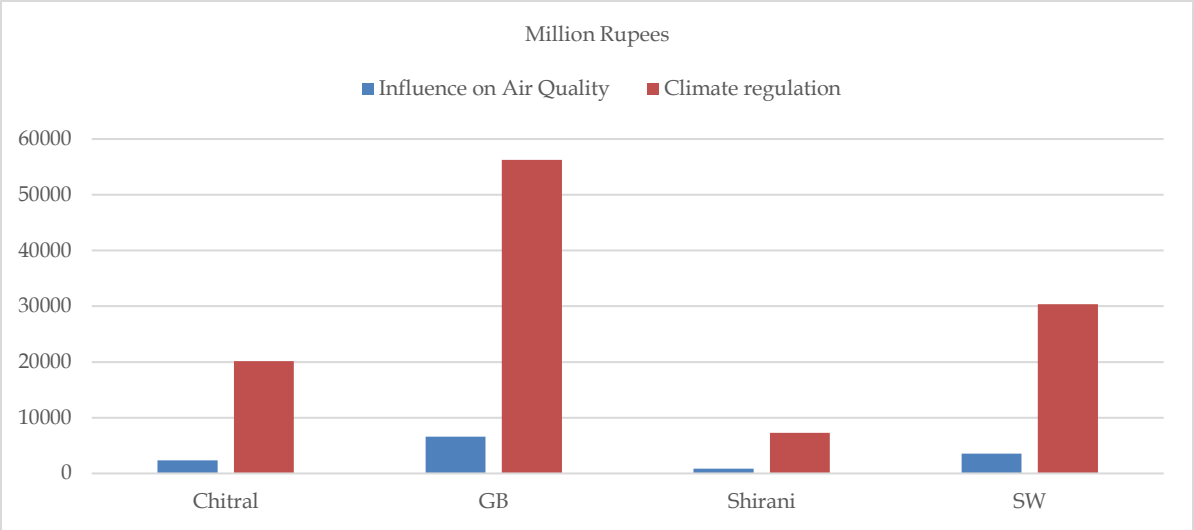


Figure 8: Contribution of Pine Forest to Air Quality and Climate Regulation



Pine forest influence on air quality and climate regulation is given in graph 8, which indicates that the Pine forest has high environmental values. Contributing a total of 13349.62 million rupees (US$ 84.08 million) under the influence on air quality while 114052.15 million rupees (US$ 718.33 million) when climate regulation takes place. The value for air quality and climate regulation is derived using the values from (TEEB Climate Issues Update 2009). District wise contribution of Pine forest for air quality and climate regulation is given in Figure 8.

District wise valuation of Pine Forest

District Chitral

Table 2: Annual Value of Pine Ecosystem District Chitral

Districts Chitral	Marketable		Non-Marketable		Total	
Output	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar
Pine Forest Goods	85.00	0.53			85.00	0.53
Forest Ecosystem Services (a & b)	5899.68	36.53	40314.45	249.63	46214.12	286.16
a Environmental Services	1813.65	11.23	36411.79	225.46	38225.44	236.69
b Sociocultural Benefits	4086.75	25.30	3902.39	24.16	7989.14	49.47
Forest Capital Stock	126842.00	785.40	39789.01	246.37	166631.01	1031.77
Total	***138727.07***	***858.99***	***120417.63***	***745.62***	***259144.71***	***1604.61***

Note: the conversion to the dollar was done using April 2020 exchange rate

The flow value of the annual output of Pine forest ecosystem goods and services of district Chitral is nearly 46299.12 million Pakistani rupees (286.69 million US$). In which Pine goods contribute 85.00 million rupees (US$ 0.53 million) while Pine services contribute 46214.12 million rupees (US$ 286.16 million). The contribution of services further divided into environmental services and sociocultural benefits. Pine forest environmental services output both marketable and non-marketable reach 38225.44

million rupees (US$ 236.69 million). Among the forest environmental services, water conservation and air purification had the most important role. The value of Pine forest capital stock of district Chitral reached 166631.01 million rupees (US$ 1604.61 million). In which marketable resources account for 126842.00 million rupees (US$ 785.40 million) and non-marketable capital stock 39789.01 million rupees (US$ 246.37 million).

District Diamer Gilgit Baltistan

Table 3: Annual Value of Pine Ecosystem District Diamer Gilgit Baltistan

Districts Diamer	**Marketable**		**Non-Marketable**		**Total**	
Output	**Million Rupees**	**Million US Dollar**	**Million Rupees**	**Million US Dollar**	**Million Rupees**	**Million US Dollar**
Pine Forest Goods	599.36	3.71			599.36	3.71
Forest Ecosystem Services (a & b)	16495.39	102.14	112718.48	697.95	129213.87	800.09
a Environmental Services	5068.90	31.39	101807.47	630.39	106876.37	661.77
b Sociocultural Benefits	11426.49	70.75	10911.01	67.56	22337.50	138.31
Forest Capital Stock	354648	2195.96	111249.36	688.85	465897.36	2884.81
Total	***388238.14***	***2403.95***	***336686.33***	***2084.75***	***724924.46***	***4488.70***

Note: the conversion to the dollar was done using April 2020 exchange rate

The annual flow value of the output of Pine forest ecosystem goods accounts for 599.36 million rupees (US$ 3.71 million) and services 129213.87 (US$ 800.09 million) of district Diamer. The contribution of services is further divided into environmental services and sociocultural benefits. Pine forest environmental services marketable values 5068.90 million rupees (US$ 31.39 million) and non-marketable values 101807.47million rupees (US$ 630.39 million). The value of the Pine forest capital stock of district Diamer is 465897.36 million rupees (US$ 2884.81 million). In which marketable resources account for 354648 million rupees (US$ 2195.96 million) and non-marketable capital stock 111249.36 million rupees (US$ 688.85 million).

District Shirani

Table 4: Annual Value of Pine Ecosystem District Sherani Baluchistan

Districts Shirani Output	Marketable		Non-Marketable		Total	
	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar
Pine Forest Goods	4552.50	28.19			599.36	3.71
Forest Ecosystem Services (a & b)	2139.88	13.25	14620.27	90.53	16760.15	103.78
a Environmental Services	657.47	4.07	13205.05	81.77	13862.51	85.84
b Sociocultural Benefits	1482.09	9.18	1415.22	8.76	2897.31	17.94
Forest Capital Stock	46000.00	284.83	111249.36	688.85	157249.36	973.68
Total	***52692.38***	***326.27***	***125869.63***	***779.38***	***174608.87***	***1081.17***

Note: the conversion to the dollar was done using April 2020 exchange rate

The total flow value of the annual output of Pine forest ecosystem goods, services, and standing capital stock of district Shirani is almost 174608.87 million Pakistani rupees (1081.17 million US$). In which Pine goods contribute 4552.50 million rupees (US$ 28.19 million) while Pine services contribute 16760.15 million rupees (US$ 103.78 million). Pine forest environmental services output contributes both marketable and non-marketable value of 13862.51 million rupees (US$ 85.84 million) while sociocultural benefits account for 2897.31 million rupees (US$ 17.94 million) both marketable and non-marketable. The value of the Pine forest capital stock of district Shirani reached 157249.36 million rupees (US$ 973.68 million). In which marketable resources account for 46000.00 million rupees (US$ 284.83 million) and non-marketable capital stock 111249.39 million rupees (US$ 688.85 million).

District South Waziristan

Table 5: Annual Value of Pine Ecosystem District South Waziristan

Districts South Waziristan Output	Marketable		Non-Marketable		Total	
	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar	Million Rupees	Million US Dollar
Pine Forest Goods	150.00	0.93			599.36	3.71
Forest Ecosystem Services (a & b)	8897.47	55.09	60799.35	376.47	69696.82	431.56
a Environmental Services	2734.12	16.93	54914.05	340.03	57648.17	356.95
b Sociocultural Benefits	6163.35	38.16	5885.30	36.44	12048.65	74.60
Forest Capital Stock	191294	1184.48	60006.92	371.56	251300.92	1556.04
Total	***200341.47***	***1240.50***	***120806.28***	***748.03***	***321597.11***	***1991.31***

Note: the conversion to the dollar was done using July 2020 exchange rate

The annual contribution of Pine forest ecosystem goods to the local community of district South Waziristan is nearly 150.00 million rupees (US$ 0.93 million). The contribution of services to local, regional, and global community yearly accounts for 69696.82 million Pakistani rupees (US$ 431.56 million). The contribution of services is further divided into environmental

services and sociocultural benefits. District South Waziristan Pine forest environmental services output both marketable and non-marketable accounts to 57648.17 million rupees (US$ 356.95 million). In which marketable environmental services output reach 2734.12 million rupees and non-marketable environmental services 54914.05 million rupees. The Pine forest's sociocultural contribution to the local community both marketable and non-marketable accounts for 12048.65 million rupees (US$ 74.60 million). The value of Pine forest capital stock of district South Waziristan is almost 251300.92 million rupees (US$ 1556.04 million). In which marketable resources account for 191294.00 million rupees (US$ 1184.48 million) and non-marketable capital stock 60006.92 million rupees (US$ 371.56 million).

CONCLUSION

Unless most forest values are recognized through institutionalized valuation methods, forests as a land use will not get the societal attention needed to make them an integral part of a sustainable global economy. Many attempts in this direction have been made across the globe, but because of the wide differences in concepts and methods, the many estimates of forest ecosystem goods and services made in the past have been inconsistent and not amenable to meaningful comparison across services and periods.

As natural capital and ecosystem services become more stressed in the future, on account of both greater demand and reduced supplies (in part due to changing climate), their value can be expected to increase. Given the huge uncertainties involved, it may never be possible to have a precise estimate of the value of ecosystem services. Nevertheless, even crude estimates provide a useful starting point with implications for decision and policymaking.

To a full evaluation of the Pine forest contribution to local, regional, and global communities the study further recommends a joint approach of a high technological survey (GIS and Remote Sensing) and field survey of the households living in the peripheries of Pine forest. The study has certain limitations ranging from a field visits to funds availability. As the four project sites are very remote and traveling to each site is very time consuming and high costly, therefore based on this report a detailed study by a multi-disciplinary team is proposed

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