Brazilian Journal of Biology®

ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

Original Article

Economic valuation of selected ecosystem services in Islamabad Capital Territory (ICT), Pakistan

Avaliação econômica de serviços de ecossistemas selecionados no Território da Capital de Islamabad (ICT), Paquistão

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Abstract

Payment for ecosystem services (PES) is a mechanism where a consumer is able and ready to pay for the protection of the precise ecosystem service and there must be a provider such as local societies receiving an economic resource, who in return, must have the ability to maintain that ecosystem service. Economic valuation provides basis for payment for ecosystem services. Therefore, objective of this study was to evaluate tourism and carbon stock services of the Islamabad Capital Territory (ICT), Pakistan. Two forest zones (Chirpine and Scrub) of Islamabad capital territory (ICT) were selected for estimation of carbon stock and their carbon credits and carbon worth, a questionnaire-based survey was conducted for tourism as a payment for ecosystem services. The method for carbon stock assessment was systematic sampling for Chirpine forest whereas random sampling was done for scrub forest. The size of sampling plot was 17.84 m radius, and a total of 93 plots (49 Scrub zone and 44 Chirpine zone) was taken in the study area. The carbon stock of both zones (Chirpine and Scrub zone) is 22556.75 ton/ha (Chirpine 20105.79, Scrub 2450.96) and total carbon dioxide sequestered by both zone is 82557.72 ton/ha (Chirpine 73587.2, Scrub 8970.52), total carbon credits of both zone is 302160.87 (Chirpine 269328.97, Scrub 32831.9) and the carbon worth of both Chirpine and scrub zone is 4532418.92 $ (Chirpine 4039937.09$, Scrub 492481.83$). Similarly, from tourism point of view, in Shakar Parian, 94% tourists were agreed for PES whereas 6% were disagreed for the PES (the 6% tourist were disagreed to contribute for PES, 40% were agreed for Rs.5 contribution and 54% for Rs.10.). moreover, in Lake view Park, 97% tourists were agreed and 3% are disagreed (In Lake View Park 5% tourists were disagreed for the PES contribution whereas 32% were agreed for Rs.5 and 63% were for Rs.10). In Damen e Koh, around 87% tourist were agreed and 13% were disagreed, (24% were agreed for the contribution of Rs.5 and 63% tourists were agreed for the contribution of Rs.10). In Marghazar Zoo, 93% tourists were agreed (22% were agreed for contribution of Rs.5 and 71% tourist were agreed for contribution of Rs.10) and 7% are disagreed for PES whereas 7% tourists were not agreed for contribution. PES may implement to compensate forest and parks manager to ensure better management of the forests and parks. Due to prime location and scenic beauty of the ICT, it has huge potential for implementation of PES mechanism for sustainable forest management and conservation. Therefore, it is recommended that Capital Development Authority (CDA) Islamabad should devise a plan for implementation of PES in forests and parks of ICT for its sustainable management of recreational and forest resources.

Keywords: ecosystem services, tourism, carbon stock, PES, Islamabad capital territory, Pakistan.

Resumo

O pagamento por serviços ecossistêmicos (PES) é um mecanismo no qual um consumidor é capaz e está pronto para pagar pela proteção do serviço ecossistêmico preciso e deve haver um provedor, como sociedades locais, que recebe um recurso econômico, que, em troca, deve ter capacidade para manter esse serviço ecossistêmico. A avaliação econômica fornece a base para o pagamento de serviços ecossistêmicos. Portanto, o objetivo deste estudo foi avaliar os serviços de turismo e estoque de carbono do território da capital de Islamabad (ICT), Paquistão. Duas zonas florestais (Chirpine e Scrub) do território da capital de Islamabad (ICT) foram selecionadas para estimativa

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Received: February 1, 2022 – Accepted: March 16, 2022

do estoque de carbono e seus créditos de carbono e valor de carbono. Uma pesquisa baseada em questionário foi realizada para turismo como pagamento por serviços ecossistêmicos. O método para avaliação do estoque de carbono foi a amostragem sistemática para a floresta de Chirpine, enquanto a amostragem aleatória foi feita para a floresta de cerrado. O tamanho da parcela de amostragem foi de 17,84 m de raio, e um total de 93 parcelas (49 zona Scrub e 44 zona Chirpine) foi considerado na área de estudo. O estoque de carbono de ambas as zonas (zona Chirpine e Scrub) é de 22.556,75 ton/ha (Chirpine 20.105,79, Scrub 2.450,96), e o dióxido de carbono total sequestrado por ambas as zonas é de 82.557,72 ton/ha (Chirpine 73.587,2, Scrub 8.970,52); créditos totais de carbono de ambas as zonas são 302.160,87 (Chirpine 269.328,97, Scrub 32.831,9), e o valor de carbono tanto do Chirpine quanto da zona de scrub é 4.532.418,92 $ (Chirpine 4.039.937,09 $, Scrub 492481,83 $). Da mesma forma, do ponto de vista do turismo, em Shakar Parian 94% dos turistas concordaram com o PES, enquanto 6% discordaram do PES (6% dos turistas não concordaram em contribuir para o PES, 40% concordaram com a contribuição de R$ 5 e 54% para R$ 10). além disso, no Lake View Park, 97% dos turistas concordaram e 3% discordaram (no Lake View Park, 5% dos turistas discordaram da contribuição do PES, enquanto 32% concordaram em R$ 5 e 63% foram em R$ 10). Em Damen e Koh, cerca de 87% dos turistas concordaram e 13% discordaram (24% concordaram com a contribuição de R$ 5 e 63% dos turistas concordaram com a contribuição de R$ 10). No Jardim Zoológico de Marghazar, 93% dos turistas concordaram (22% aceitaram a contribuição de R$ 5 e 71% dos turistas aceitaram contribuir com R$ 10) e 7% discordaram para PES. enquanto 7% turistas não foram acordados para contribuição. O PSA pode ser implementado para compensar o gestor florestal e de parques para garantir uma melhor gestão de florestas e parques. Devido à localização privilegiada e beleza cênica do ICT, possui enorme potencial para implementação de mecanismo de PSA para manejo e conservação florestal sustentável. Portanto, recomenda-se que a autoridade de desenvolvimento da capital (CDA) de Islamabad elabore um plano para implementação de PES em florestas e parques de ICT para sua gestão sustentável de recursos recreativos e florestais.

Palavras-chave: serviços ecossistêmicos, turismo, estoque de carbono, PSA, território da capital Islamabad, Paquistão.

1. Introduction

A wide range of services are provided by natural ecosystems (Groot et al., 2012). Ecosystems provide numerous goods and services that can maintain sustainable livelihoods. However, global environmental changes coupled with other stressors are affecting the ability of ecosystems to continue providing the same quality and quantity of ecosystem services (ES) (Bhatta et al., 2014). ES is a model that highlights the altruistic impact of nature on mankind (Mitra et al., 2022). Payment for ecosystem services (PES) programs are economic incentives for environmental conservation. PES programs have been applied at the local, regional, and national levels globally (Zhou et al., 2022). They are generally defined as "a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources" (Muradian et al., 2010). It is a product of an ecosystem service where user is able and ready to pay for the protection of the specific ecosystem service, must promise to sustain that ecosystem service (Kasimbazi, 2012). PES is one the mechanisms which is increasingly used to sustain both the natural environment and local livelihoods (Huberman, 2009). PES is the means by which the forest or park managers can receive financial benefit from parks and forest ecosystem services. If a PES scheme allows the owner to produce timber, it can be a source of funds for the implementation of other activities that will help save some other key forest ecosystem services (Apsalyamova et al., 2015).

To alarm the world, the then United nation (UN) Secretary General, Antonio Guterres remarked "climate change is indeed running faster than we are, and we have the risk to see irreversible damage that will not be possible to recover if we do not act very quickly" (Jan et al., 2020). There is solid evidence that forests could play an important and cost effective role in helping to mitigate global climate change (Wise et al., 2009). Forests play a dynamic role in worldwide carbon flux and act as carbon sink by storing huge quantities of carbon for an extended period. More than 40% of the global primary production in forest ecosystem is accomplished by tropical and subtropical forests (Beer et al., 2010). About 7% of the global forest area is under planted forest constituting 264 million hectares. These forests serve multidimensional purposes and carbon stock is one of them (Paquette and Messier, 2010). Forest biomass plays an important role in the global carbon cycle. Existing forests in the world are stocking over 650 billion tones carbon out of which 45% lies in the soil, 44% in the biomass and 11% in the litter and dead wood (Keenan et al., 2015). Forest vegetation sequesters carbon while at the same time deforestation and degradation of standing forests leads to release of stored carbon. The total forest cover has been declining globally 3.95 mha or about 30% of the global land area in 2006. This loss of forest cover and of carbon density per hectare due to degradation leads to significant emissions of greenhouse gases (GHGs), about 95% of which are carbon dioxide (CO2) emissions (Sathaye et al., 2011). The Amazon is the world's largest tropical rain forest and stores approximately 86 Pg of carbon above and below ground, thereby playing a crucial role in global climate regulation (Saatchi et al., 2007). Forest land management practices may result in both positive and negative impacts on ES (Baral et al., 2014). For example, if upstream communities' clear forests, there may be a considerable increase in soil erosion. This in turn may have many consequences downstream, affecting irrigation infrastructure, flood risk, siltation, river navigability and fish reproduction and productivity. On the other hand, if upstream communities maintain vegetation, they may positively influence downstream water availability during the dry season (Ojha et al., 2009). In 2010, total human caused GHG emissions reached 49 (4.5) Pg CO2 eq. yr1, 76% of which consisted of CO2 emissions (Bustamante et al.,

2014). Climate change characterized by global warming has been an international concern for many years. It is commonly accepted that greenhouse gas emissions, especially carbon dioxide (CO_2), are the major cause of global warming (Xu et al., 2022). One of the main contributors of CO2 emissions is transport for tourism. While air transport accounts for only 20% of all tourism trips by EU citizens (domestic and international), it causes 75% of all GHG emissions of all EU tourism transport in 2000 (Gössling and Peeters, 2007). More recently, climate change has emerged as a main issue for the worldwide political and economic agenda, as well as for the tourism industry (Scott and Becken, 2010). In recent decades, Travel and Tourism have become a force with strong impacts on the economy, social phenomena, consumption of resources (Giorgi et al., 2020). To understand the interaction that exists between tourism and the environment, it is required to understand the complexity of tourism. Tourism may look a relatively simple concept. Since the 1950s, the effects of tourism have been experienced more widely, as the numbers of tourists travelling internationally have improved and destinations become more diffuse (Holden, 2016). It has been estimated that there are in excess of 5000 published works on sustainable tourism (Ruhanen et al., 2015).The tourism industry has emerged as a key force for sustainable socioeconomic development worldwide (Wakimin et al., 2018). Yet currently the word 'tourism' has become part of our common language, with over 800 million people per annum travelling internationally (UNWTO, 2006). One of the key aspects of tourism growth is peace and security of the people in the destination economy. Global tourism is greatly reliant on peace and security (Fleischer and Pizam, 2002). The idea of wealth creation through the use of the natural and cultural environments for tourism has received increased international attention since the success of General Franco's policies on tourism development in Spain in the 1950s (Holden, 2016). The global importance of tourism, which, in this year contributed directly to US$2.3 trillion and 109 million jobs worldwide. Moreover, if we also consider the indirect and induced impact, this sector contributed to US $7.6 trillion to the global economy and 292 million jobs, which is equal to 10.2% of the world's Gross domestic product (GDP) and approximately 1 in 10 of all jobs (He et al., 2019). Asia and the Pacific has given the second largest number of tourism arrivals, after Europe, with 28.4% of the world's total. In 2011, 283.9 million arrivals in Asia and the Pacific were recorded, which is a rise of 21.5 million tourism arrivals from 2010. Between 2005 and 2011, the average annual growth in tourism arrivals was 6%. Inbound tourism expenses in 2011 was $362.6 billion, which is $51.8 billion more than in 2010 and equal to 28.9% of the total global inbound expenses (Sajjad et al., 2014). The contribution and support of residents is important (Gursoy et al., 2010).

Pakistan has great attractions in the form of scenic beauty such as sun, ocean, mountains, fauna and flora, lakes and in specific the hospitality of its people that may compel the tourists to visit Pakistan. Pakistan offers much allure in the emerging world. The cultural and historical inheritance is very evident in this ancient region. The country obtains much tourist attraction at Kalam, Swat, Balakot, Malam Jaba, Shangla, Murree, Ayubia, Gilgit, Chitral, Paaras, Sharan, Shinu, Lulusar, Dudipatsar, Shogran, Naran, and Kaghan valleys, Lake Saif ul Muluk, Malika Parbat (highest mountain of Kaghan valley and also called Queen of the Mountains), Supat valley, and other historic mountain ranges in the country (Arshad et al., 2018). The great three mountain ranges, the Hindukush, the Himalayas and Karakoram meet in this land (Malik et al., 2010). These regions of the country depend heavily on tourism income (Hye and Khan, 2013). Islamabad Capital Territory (ICT) has subtropical broad-leaved evergreen, subtropical Chirpine forests and rich in flora and fauna. It is one of the best-protected areas in Pakistan providing medicinal plants, economic, aesthetic and tourism values to surrounding communities and the country. However, in the past three decades, land use change and deforestation have ultimately released considerable amounts of carbon into the atmosphere. This study, therefore, presents tourism as tool for payment for ecosystem services, comparative study of carbon stock of Chirpine and scrub zone of ICT, and proper mechanism/organizational setup of PES for Capital Development Authority (CDA) in ICT, Pakistan.

2. Materials and Methods

2.1. Study area

Islamabad is the capital of Pakistan, and is federally administered as part of the Capital Territory (Shabbir and Ahmad, 2010). The study area (Scrub zone and Chirpine zone Margalla hills national park (MHNP) is located in the Pothohar Plateau in the northeastern part of the country, between Rawalpindi District and the Margalla Hills National Park to the north as shown in Figure 1. Margalla Hills also known as Margalla Mountain Range and simply known as Margalla is a hill-range part of the minor Himalayas located to the north of Islamabad, Pakistan. Margalla Range has an area of 12,605 ha and part of Murree mountains. This range of consists of various valleys as well as high mountains. The hill range lies between an elevation of 685 m at the western end and 1,604 m to the east, with an average height of 1,000 m. The main areas of the Margalla Hills are Daman e Koh, Pir-Sohawa, Gokeena, Mount Happiness, Shah Allah Dita Loh-e-Dandi, Marghazar Zoo, Japanese Park, Nilan Bhoto, Saidpur village and Shahdara village. Lower Margalla Hills are very densely populated and in this area wood is a main source of fuel (Gilani et al., 2020). Among Pakistan's naturally important safe areas, Margalla National Park covers a scrub forest environment related with biodiversity. It is located on the north-eastern part of Islamabad, Punjab and occupies closely 15,883 hectares. This margalla hills extends to the hills of Murree in the east and the Wah Cement Industries Wah in the west. In the west and northwest, it is surrounded by the capital border beyond which the Haripur district Khyber Pakhtunkhwa (KPK) is situated (Khalid et al., 2015). MHNP is a land of 600 plants species, vegetation like (deciduous and evergreen pine and shrub forests), 250 birds species, 24 mammals species and 13 species of reptiles (Sanjrani et al.). The average maximum summer

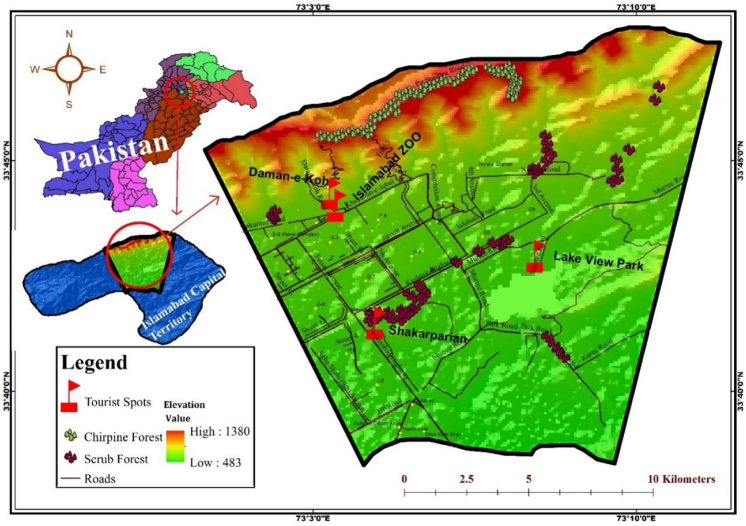

Figure 1. Map of the study area.

temperature of the region is 34.3 °C and the average annual rainfall is 1200 mm per year (Shinwari and Khan, 2000).

2.2. Data collection and sampling design

For the valuation of tourism and carbon stock services, preliminary survey was conducted to find out the variation of tourism and carbon stock in study area. After the survey it was noted that study area has huge potential of tourism and carbon stock. Tourist spots for tourism as tool for PES and Chirpine and scrub forest were taken for carbon stock estimation in study area. Each sampling point was marked on the map and its coordinates were recorded. Global positioning system (GPS) was used to locate these sampling points in the field based on recorded coordinates. After the location of sampling points rope was used for the demarcation of sampling points while Suunto clinometer is for slope measurement. As biomass is available in forest area in two important pools i.e., above ground biomass and below ground biomass, for that diameter and height of all of the trees were measured with the help of vernier caliper and haga altimeter (Muhammad et al., 2023).

2.3. Data collection

Data regarding tourism as tool for ecosystem services were collected from the four selected tourist spots (Marghazar Zoo, Lakeview Park, Daman-e-Koh and Shakar Parian) through questionnaire-based survey. Contingent method of valuation was used as this method involves directly asking peoples in a survey, that how much they would be willing to pay for PES. About four hundred (400) questionnaires, one hundred (100) from each spot were interviewed/filled during the questionnaire survey. The questionnaire contains questions regarding the total expenses that the tourists are willing to pay, and average time of the tourist spent in parks. The collected data was transferred to excel sheet for further analysis. The valuation of ecosystem services was carried out based on willingness of tourist to pay for ecosystem services. In natural forest ecosystems, accumulated biomass is an important parameter for assessing sustainable utilization, productivity, and CO2 sequestration from the atmosphere. For that total 93 sampling points of 17.84-meter radius with 0.1 sampling intensity were taken for the carbon stock estimation, study area has two types of forest Scrub and Chirpine forest, 49 plots were taken in Scrub Forest and the remaining 44 were taken in Chirpine zone of the study area as mentioned in Figure 1. and compare the carbon stock of both Chirpine and Scrub Forest of the study area, for this purpose, random sampling was carried out in Scrub zone due to restricted zones e.g., Red Zones (PM house, supreme court, parliament house etc.) and systematic sampling was carried out in Chirpine zone of the study area.

2.4. Model fitting

Several allometric equations have been developed by investigators to estimate biomass of different tree species using several variables as predictors or independent variables. Diameter meter at breast height (DBH), total height, volume, basal area are the common variables used for assessment of tree biomass (Chave et al., 2014). However, DBH is the most used independent variable for biomass estimation due to ease in measurement and being strongly linked with tree volume and biomass. DBH alone can be used as a single biomass predictor in allometric models. When joint with other variables such as total height and density the estimates could be improved in some cases. The following allometric equation (Equation 1) were used for the biomass estimation of *Pinus roxburghii* (Khan et al., 2021).

$$\text{Pinus.roxburghii.}\left(0.0224\left(D^2H\right)^{0.976}\right. \quad (1)$$

Allometric model developed for mixed forests by Chambers et al. (2001) was used for estimation of aboveground biomass (AGB) of the trees (Equation 2):

$$Y = \exp\_ - 0.37 + 0.33\ln(D) + 0.933\ln(D)2 - 0.122\ln(D)3\_ \quad (2)$$

where, D is the DBH.

Belowground biomass of the different trees was calculated by using the equation (Equation 3) developed by Cairns et al. (1997).

$$Y = \exp[-1.059 + 0.884\ln(AGB)] \quad (3)$$

The carbon content was estimated as 47.4% of the total biomass (Martin and Thomas, 2011).

Worth of store carbon in Chirpine and Scrub Forest of the study area was calculated for the whole carbon stock based on international market price for carbon credit which is 15 US $ as defined by the green climate fund (GCF).

3. Results and Discussion

3.1. Tourists agreed/disagreed for PES

The present study the opinion of the tourists for PES in the study area that how much tourists was agreed and how much was disagreed. In Shakar Parian, 94% tourists were agreed whereas 6% were disagreed for the PES. Similarly, in Lake view Park, 97% tourists were agreed and 3% are disagreed, In Damen e Koh the 87% tourist were agreed and 13% are disagreed and in Marghazar Zoo the 93% tourist were agreed and 7% are disagreed for Payment for Ecosystem services (PES) as shown in Figure 2.

The contribution of the tourists for PES in Shakar Parian the 7% tourist were disagreed for the contribution for PES, 39% were agreed for Rs.5 and 54% for Rs.10. Whereas in Lake View Park the 5% tourist were disagreed for the contribution, 32% were agreed for Rs.5 and 63% are for Rs.10. Similarly in Daman-e-Koh about 13% tourist were not agreed for the contribution for PES, 24% were agreed for the contribution of Rs.5 and the 63% tourist were agreed for the contribution of Rs.10. Marghazar Zoo about 7% of the tourists were not agreed for contribution, 22% were agreed for contribution of Rs.5 and 71% tourist were agreed for contribution of Rs.10 as depicted in Figure 3.

Furthermore, the amount which will be collected for the PES Purpose will be kept in a separate account, and this amount will be used for the conservation and proper management of the particular site as described in flowchart Figure 4.

3.2. Gender, age, and employment valuation

Gender valuation of four selected tourist spots showed that 56% tourists were male and 44% were female in

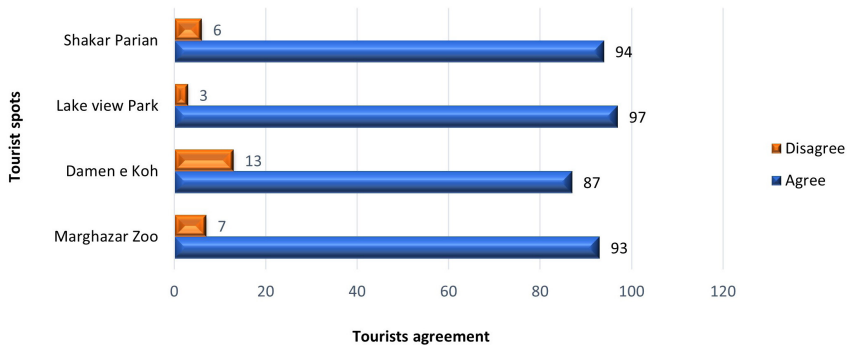

Figure 2. Agreement and disagreement of the tourist for PES mechanism.

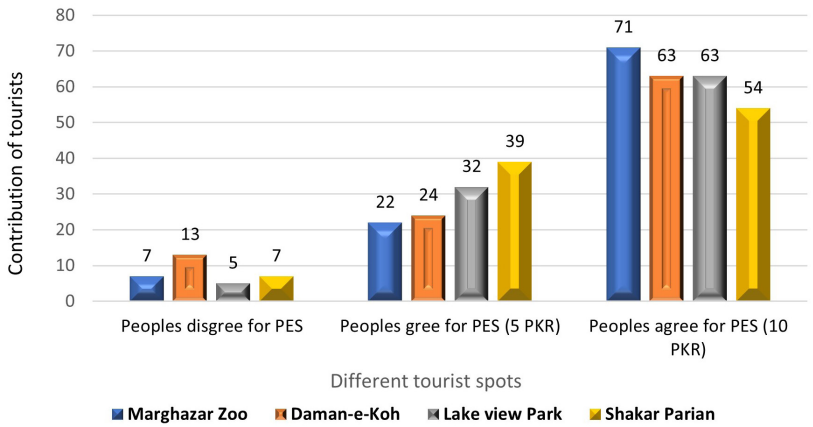

Figure 3. Contribution of tourists for PES mechanism.

which 59% were above 18 years old and 41% were below 18 years old, and in which 50% visitor were jobs holders in different departments and organization (government, nongovernment), 10% jobless and 40% were students of different stages (School, colleges, and university) mentioned in Figure 5.

3.3. Trend and valuation of tourism

ICT serving as the capital of Pakistan since the nineteen Sixty, Islamabad was built according to a carefully organized plan, divided into sectors along a grid of clean, tree-lined streets. The city is sheltered by the Margalla Hills, the foothills of the Himalayas and the home of two forest types Chirpine and scrub forest, rare species of leopard, deer, birds, a. Several hiking paths end at Daman-e-Koh, Shakarparian, a picnic spot with a splendid view of the entire city. The number of tourists increased once again over the past few years due to development of tourism industry again and peace of the area. This trend is till continued and the number of tourists increases with every coming day. In study area the number of visitors from Monday to Friday, were about 24500, whereas the number of tourists on weekend (Saturday, Sunday) were 24000, which showed that the number of the tourists on weekends were double as of working days (Monday, Friday) as documented.

Figure 4. Flow chart of tourism as a PES in ICT, Pakistan.

3.4. Valuation of tourism

Tourism the world's largest industry and for some time now has been its fastest growing industry. The sustainability and development of tourism depends to a large extent on environmental conservation. Sometimes this involves conservation of natural environments but not always. Man-made and natural environments may also be valued for tourism and recreation and there may be a desire to preserve these in their existing state. Furthermore, the tourism industry can have adverse effects on the natural environments on which it depends as a result of pollution created by it or damage caused by tourists as well as degradation or some destruction of tourist assets needed to 'accommodate' the industry, by PES mechanism it may be possible to develop tourism in a way that has little adverse impact on the natural environment, as promoters of ecotourism hope to do. A relevant factor in tourism development is the sustainability of tourism. Given interdependence between tourism and the environment, lack of sustainability of tourism may arise from factors endogenous to the tourism industry as well as exogenous ones. MHNP in study area is one of the best locations for ecotourism in Pakistan. Ecotourism is intended to increase the compatibility of tourism development with environmental conservation thereby sustaining extant environments and promoting the sustainability of tourism. Ecotourism aims to maintain a high environmental standard and, if successful, can avoid many of the problems. Keeping

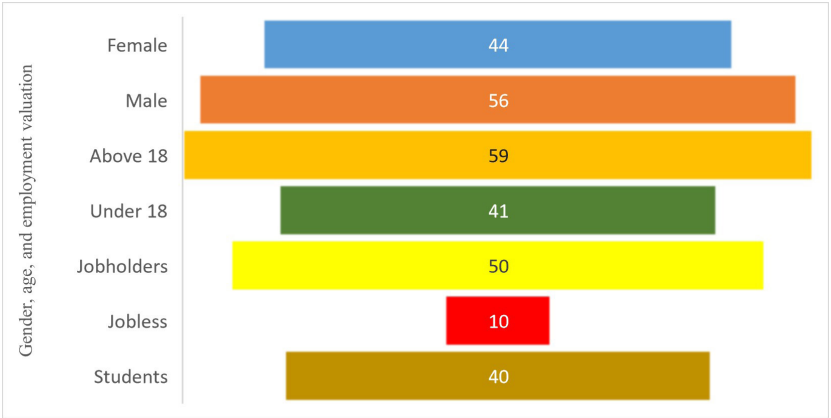

Figure 5. Gender, age, and employment valuation of tourists.

in view the problems PES is the 1st ever mechanism which will be introduced in study area, for this purpose the tourists are agreed to pay for ecosystem services. The total average weekly visitors to study area were 48,489. The total 44,933 out of 48,489 tourists were agreed for PES, the total amount which will be generate annually from tourist for PES mechanism will be US$ 112,871.30 (19,332,040 PKR) as documented in Table 1.

3.5. Tree species for carbon stock

The forest type of the study area is Chirpine and scrub forest, Chirpine forest consist of *Pinus roxburghii*, while scrub forest consists of nine tree species i.e., *Grevillea robusta, Cassia fistula, Albizia lebbeck, Alstonia scholaris, Bauhinia variegata, Broussonetia papyrifera, Acacia modesta, Eucalyptus camaldulensis and Dalbergia sissoo* as shown in Figure 6.

3.6. Diameter at breast height (Dbh) and height of the trees

In present study the mean dbh in Chirpine forest is 30.9 cm and mean height is 17.31 m whereas in scrub forest the mean dbh is 20.9 cm and mean height is 10.7 m, as documented in Table 2 due to best climatic condition and healthy habitat the dbh and height of the Chirpine forest is higher than scrub zone forest.

3.7. Carbon stock calculation

The Current study results indicate the total above ground carbon (AGC), below ground carbon (BGC) and total carbon (TC) and Carbon stock ton per hectare of the scrub and Chirpine zone, total nine selected species of scrub for(est, in which the highest AGC is 512.36 t/h, BGC is 133.21 t/h, TC is 645.57 and total CO_2 is 2362.81 t/h in *Dalbergia sissoo* specie, while the lowest AGC is 52.14, BGC is 13.55, TC is 65.69 and CO_2 is 240.45 t/h in *Grevillea robusta* specie as shown in Table 3.

The mean above ground biomass (AGBM) t/h of the scrub zone is recorded 4138.75 t/h, mean BGBM is 1076.1 t/h, mean total biomass is 4153.9 t/h, mean AGC is 1945.20 t/h, mean BGC is 505.75 t/h, mean TC is 2450.96, mean CO2 is 8970.52, mean carbon credits is 32831.9 and mean total worth is recorded 492481.83, while the mean AGBM t/h of the Chirpine zone is recorded 33951.01 t/h, mean below ground biomass (BGBM) is 8827.26 t/h, mean total biomass is 42778.28 t/h, mean AGC is 15956.97 t/h, mean BGC is

Table 1. Shows trend and valuation of tourists in the study area.

Tourist Spot	Daily visitors (Monday-Friday)	Weekend visitors (Saturday- Sunday)	Average daily visitors	Agreed visitors for PES	Agreed for Rs 10.	Agreed for Rs 5.
Lake view	2000 ×5	5000 ×2	2857	2714	1709 ×10	1005 ×5
Zoo	800 ×5	1750 ×2	1071	995	760 ×10	235 ×5
Shakarparian	1200 ×5	3000 ×2	1714	1593	925 ×10	668 ×5
Daman-e-Koh	900 ×5	2250 ×2	1285	1117	809 ×10	308 ×5
Total	24500	24000	6927 ×7	6419 ×7	4203 ×7 ×10	2216 ×7 ×5
	Total weekly visitors 48500		Weekly total Average visitors 48489	Weekly Total visitors 44933	Total PES amount weekly Rs. 294210+77560= 371770	

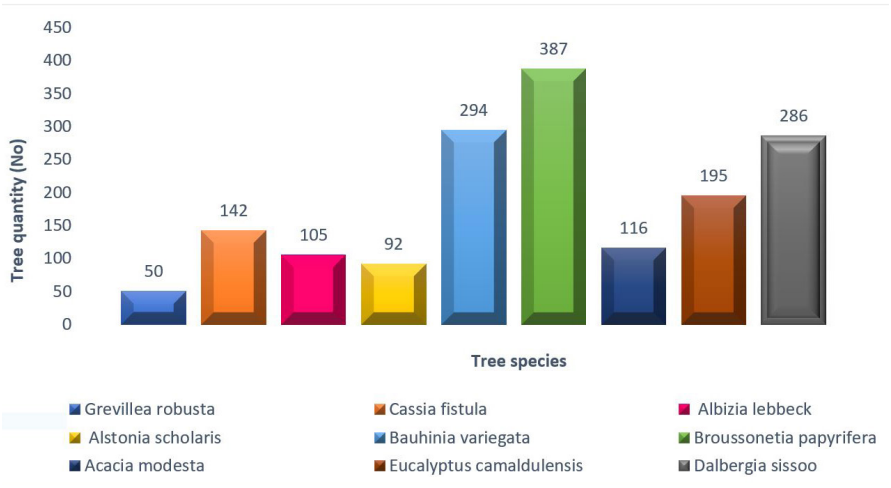

Figure 6. Tree species of scrub forest of the study area for carbon stock estimation.

4148.81 t/h, mean TC is 20105.79, mean CO2 is 73587.2, mean carbon credits is 269328.97 and mean total worth is recorded 4039937.09. The rate of one carbon credit in California USA is 15$. as shown in Table 4.

The derived values of Chirpine zone are higher than scrub zone in all aspects of (mean AGBM t/h, mean BGM t/h, mean total biomass (TBM) t/h, mean AGC t/h, mean BGC t/h, mean TC t/h, mean CO_2, mean carbon credit, mean total worth in US $). The reasons behind more values of the Chirpine as compare to scrub zone is vegetation types Chirpine is coniferous forest while scrub zone are broad leaves deciduous vegetation and some evergreen species, Chirpine zone have higher tree density while scrub have low, the Chirpine zone are undisturbed vegetation because they are located in on top of margalla hills national park and they are protected while scrub zone are in foothills of the margalla hills where lot amount of anthropogenic activities involve, Chirpine zone are fully protected forest where all of the disturbing activities are not allowed. Chir pine zone have proper Forest expert staff due to National Park who concerned with the preservation or improvement of a forest and prevention and control of damage to forest by natural or manmade causes (example - fire, animals, insect, fungi, injurious plants, and adverse climatic conditions). While scrub have lot of disturbance due to roads, vehicles, buildings, parks, hotels, offices, industrialization, and urbanization

Table 2. Shows the mean DBH and mean height of both the forest types/zones.

Mean DBH of Chirpine forest (cm)	Mean height of Chirpine forest (m)	Mean DBH of Scrub forest (cm)	Mean height of Scrub forest (m)
30.90	17.31	20.99	10.79

4. Discussion

Payments for ecosystem services support the maintenance of natural ecosystems through environmentally friendly practices that avoid damage for other users of the natural resources and in addition to conserving the natural resources (Muhammad et al., 2023). A comprehensive study was conducted by Kolahi et al. (2013) in Iran. Iran is a developing country with low income, the average respondents' monthly income and their families' monthly income were US $403 and US $539 respectively, 73% of the visitors were willing to pay money for ecosystem services, which 77% of respondents were willing to pay money less than US$ 1 as payment for ecosystem services. Conversely, 23% were willing to pay money more than US $1 to US $10.35 (Kolahi et al., 2013). At Margala Hill National Park (MHNP) annual benefits from the park were considerable the total annual consumer surplus or economic benefit obtained from recreation in the park was approximately Rs. 23 million. Improvements in the quality of the park

Table 3. Shows species vise AGC, BGC, TC and CO_2 of Scrub zone of study area.

Specie	AGC t/h	BGC t/h	TC t/h	CO_2/h
Dalbergia sissoo	512.36	133.21	645.57	2362.81
Eucalyptus camaldulensis	186.79	48.56	235.36	861.44
Acacia modesta	60.76	15.79	76.56	280.23
Broussonetia papyrifera	75.08	19.52	94.60	346.25
Bauhinia variegata	208.68	54.25	262.94	962.37
Alstonia scholaris	148.79	38.68	187.47	686.16
Albizia lebbeck	113.92	29.61	143.54	525.35
Cassia fistula	129.48	33.66	163.15	597.13
Grevillea robusta	52.14	13.55	65.69	240.45
Pinus roxburghii	453.36	117.87	571.24	2090.75

Table 4. Shows mean calculation of biomass, carbon stock and carbon credits in the study area.

Study area Zones	Mean Above Ground Biomass (AGB)	Mean Below Ground Biomass (BGB)	Mean TBM	Mean AGC	Mean BGC	Mean TC	Mean CO2	Mean Carbon credit	Mean Total worth $
Scrub	4138.7	1076.1	4153.9	1945.2	505.75	2450.9	8970.5	32831.9	492481.8
Chirpine	33951.0	8827.2	42778.2	15956.9	4148.81	20105.7	73587.2	269328.9	4039937.0

are estimated to increase recreational benefits by 39%. The study recommends that a park entrance fee of Rs. 20 per person be introduced, which could be utilized for park management. This would generate nearly Rs. 11 million in revenues annually (Khan, 2006). About 51.5% male and 48.5% female in the study area. In terms of age, 21% of participants were between 20 and 29 years and 30% of participants were between 40 and 49 years. In terms of education, 35 respondents had education of less than high school while 138 participants graduated with a college degree (Hwang et al., 2020).

Our results are also in line with Muhammad et al., 2021 who estimated a total worth of US$ 1,578,458 annually both from hotel-based and daily tourism which directly or indirectly benefit the local community of the study area. Similarly In another study (Lee and Mjelde, 2007) reported the value of tourism of the Korean Demilitarized Zone (DMZ) and Civilian Control Zone (CCZ) between US$ 264 and $ 602 million. As well as in China, the total economic value of parks ecosystem services in Xingshan County is expected to be 582.96 million RMB per year, being a part of actual ecosystem services. These services offer an indirect economic value of 528.73 million RMB per year (RMB: Chinese Currency, 8.3 RMB=US$1(Gurung et al., 2021). Similar study was conducted for carbon stock in 20 trees species by Dr. B.A.M. University, Aurangabad. *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Bauhinia raemosa, Butea monosperma, Cassia fistula, Dalbergia sissoo, Delonix regia, Eucalyptus citriodora, Ficus bengalensis, Ficus religiosa, Hyophorbe amercaulismort, Leucaena latisiliqua, Mangifera indica, Peltaforum pterocarpum, Pithecellobium dulce, Polyalthia longifolia, Pongamia pinnata* (Chavan and Rasal, 2010). Diameter at breast height (dbh) is one of the most important tree variables in forestry. H in the studied forest increased with increasing DBH. Among all species, on average basis *Pinus massoniana* had greater H (18 m) and DBH (33.3 cm) than *Schima superba* with 14.65 m H and 14.70 cm DBH (Ali et al., 2014).

Mean carbon stock in the forests of Khyber Pakhtunkhwa was estimated at 127.72 t/ha which is lower than the carbon stocks in Nepal's forests i.e., 153 t/ha (Oli and Shrestha, 2009). The current study results indicated that the total carbon stock in the forests scrub zone was 8970.52 t/ha while Chirpine zone the total carbon stock was 73587.2 t/ha. The highest carbon stock was found in Chirpine zone (73587.2 t/ha). On the other hand, the largest contributing tree species towards carbon sequestration disregarding the number of trees was *Resak* at 2.36 Mg (C) 0.6 ha^{-1}; whilst, the lowest was *Damar hitam* at 0.23 Mg (C) 0.6 ha^{-1} for the dipterocarp family. Whereas, for the non-dipterocarp family, the largest average share came from *Kedondong* at 2.56 Mg (C) 0.6 ha^{-1}; whilst the lowest was from *Kerdas* at 0.08 Mg (C) 0.6 ha^{-1}. Overall, the total carbon stock amounted to 133 Mg (C) 0.6 ha^{-1} for aboveground, 32 Mg (C) 0.6 ha^{-1} for belowground and 3 Mg (C) 0.6 ha^{-1} for the other components; in total, 169 Mg (C) 0.6 ha^{-1} (Matthew et al., 2018). Moreover, in the Gutianshan National Nature Reserve (GNNR) in Zhejiang province, southeast China Overall, the mean total carbon across all 27 plots was 149.2 Mg C ha^{-1}, with AGC total and BGC total contributing 57.5, 10.5 and 80.7 Mg C ha^{-1} (Liu et al., 2018) whereas, the total carbon stock of the Khyber Pakhtunkhwa forests was estimated at 144.714 million tons Aboveground carbon stock is 68.15 million tons (60 t/ha) making 48% of the total carbon stock (Ali et al., 2020).

5. Conclusions and Recommendations

The current study estimated carbon stock and eco-tourism of the two zones i.e., Scrub and Chirpine zones as a tool for payment for ecosystem services in Islamabad Capital Territory of Pakistan. The study explored the role of tourist as a payment for ecosystem services and carbon sequestration potential of both forests (Chirpine and Scrub) and analyzed them according to potential of carbon sink and forest management and conservation. Fixed area sample plots method was employed to estimate biomass. The plots were circular in shape with radius of 17.84m or one tenth hectare of for plot size. Instruments used for inventory were Suunto clinometer, GPS device, measuring tape, tree caliper and compass. The collected data of forest attributes was converted into growing stock, further it is converted into biomass and carbon stocks. The dry biomass can be converted to carbon stock by multiplying it with 0.47. Questionnaire-based surveys were used for tourism as a tool for payment for ecosystem services. Results showed that the mean AGBM t/h of the scrub zone is recorded 4138.75 t/h, mean BGBM is 1076.1 t/h, mean total biomass is 4153.9 t/h, mean AGC is 1945.20 t/h, mean BGC is 505.75 t/h, mean TC is 2450.96, mean CO2 is 8970.52, mean carbon credits is 32831.9 and mean total worth is recorded 492481.83, while the mean AGBM t/h of the Chirpine zone is recorded 33951.01 t/h, mean BGBM is 8827.26 t/h, mean total biomass is 42778.28 t/h, mean AGC is 15956.97 t/h, mean BGC is 4148.81 t/h, mean TC is 20105.79, mean CO2 is 73587.2, mean carbon credits is 269328.97 and mean total worth is recorded 4039937.09. The derived values of Chirpine zones are higher than scrub zone in all aspects of (Mean AGBM t/h, Mean BGM t/h, Mean TBM t/h, Mean AGC t/h, Mean BGC t/h, Mean TC t/h, Mean CO_2, Mean Carbon credit, Mean Total worth in US $) The rate of one carbon credit in California carbon registry USA is 15$ and based on this rate, this study identified that Chirpine forest is a high carbon stock area in the ICT, Pakistan. Therefore, it is recommended that proper management, improvement, and conservation of these forest is imperative. The study also recommends multi-purpose activities encompassing ecotourism, biodiversity, conservation, sustainable forest management along with carbon management. The carbon stock of the area should be inventoried as baseline for the REDD+ project to claim payment in future on the additional carbon credits in the international markets after completing the required formalities. As the owners have proper share in the proceeding of the forests which they are not receiving due to ban on harvesting, it is recommended to compensate the owners through payment for ecosystem services (PES) to achieve better protection of the resources. To get attention of the policy makers and get proper share in the annual development planning, the worth of ecosystem services and its share in GDP may be highlighted on national level. The owners and tourist may be involved in the protection

of the resources of the area through financial contribution and motivation to ensure sustainability of the tourism area. Payment for ecosystem may be implemented to compensate the owners of the forest, parks and the other resources to ensure better management of the forest and other resources. To facilitate the tourist, tourists' facilitation desk may be established in the study area through contribution of the Parks contractors. Awareness campaign of tourists on the protection of the resource may be initiated in the study area. The government has the motive to create new recreational spots in study area, it is recommended to incorporate the PES scheme for the economic development of the area.

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