Mapping, Quantification and Assessment of Social Values Associated with Ecosystem Management: A GIS based study

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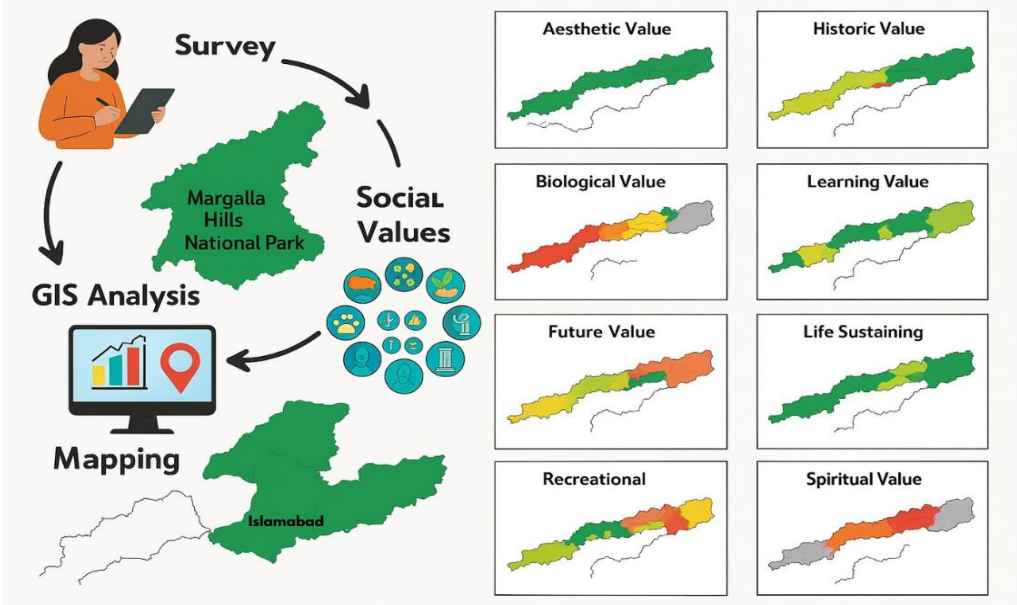
Abstract

Pressure on the use of ecosystem services by humans is increasing day by day. The integration of social value information has become important for designing a framework that supports ecosystem service-based approaches. Research involving the mapping and quantification of social value is required to inform decision makers and stakeholders for the effective management of ecosystems. The present study is based on questionnaire data collected from respondents, acquiring information about public forest use, attitudes regarding those public uses and their associated social values. Geographic Information System (GIS) tools are used to identify the perceived social values from Margalla Hills National Park in Islamabad/Pakistan, mapping and quantifying the relationship between social values and natural resource conditions. Twelve social values are identified by the UN Millennium ecosystem assessment to have a significance of a place. Highly rated social values are: aesthetic, recreational, biodiversity, therapeutic, intrinsic, future and life sustaining, exhibiting clustering R-values as 0.273, 0.347, 0.477, 0.515, 0.564, 0.617, and 0.672, respectively. Among all social values, the aesthetic value has a higher weighted density than the recreational, life sustaining, biological, future, intrinsic and therapeutic

values. The outcome of this study can be used by decision makers and stakeholders to manage the national parks considering the values which have higher substance as well as similar amenities in the country.



Keywords: Ecosystem Services; Geographic Information System (GIS); Margalla Hills National Park; Public Attitudes; Social Values.

1. Introduction

The term "ecosystem services" refers to the benefits that are provided to human beings through the conversion of natural resources such as water, land, air, and vegetation into a stream of essential goods and services, e.g. food, water and clean air (Ahmed et al., 2023; Qi et al 2023). It also includes various elements, processes, and natural conditions supporting concrete and abstract benefits that are integral to continued human existence (Qasim 2022, Shedayi et al., 2022). The Millennium Ecosystem Assessment (MEA) is a comprehensive evaluation of ecosystems which introduces a framework to illustrate the relationship between ecosystem services and human well-being (MEA, 2005; Hassan et al., 2022). This framework identifies four primary categories of ecosystem services-cultural services, provisioning services, regulatory services, and supporting services. Forest ecosystems provide an array of services and benefits to humans such as habitats for different species, biodiversity maintenance, and conservation. (Khalid, Ullah et al. 2019). The amount of carbon stored in forests is quite significant and direct

in financial terms. This aspect creates incentives for the management of forest land, both on a local and global scale. (Shahzad et al., 2019a). Healthy forest ecosystems also promote soil production and conservation, which play a role in controlling stream flows and limiting water runoff, thus preventing land degradation, desertification, and lowering the risks of natural disasters like droughts, floods, and landslides (Fatima et al., 2023; Feng et al., 2025). Forest ecosystem services include the provision of forests resources such as timber, rubber, Brazil nuts, cocoa, bush meat and medicinal plants. This sort of services provision contributes to the eradication of poverty and enhances the (rural) economic development as forests provide fibers, timber and other useful products for subsistence and income generation (Aslam and Yasmeen 2021). In the sense of economic and social developments, services of the forest other than wood production have gained international importance and recognition (Tariq et al., 2021; Chen et al., 2025). Non-wood forest products (NWFPs) include foods and beverages provided by fruits, seeds and nuts, fodder for animals, perfumes and cosmetics ingredients, raw materials for dying and tanning purposes and exudates including gums, resins and latex secreted by plants. Ecological services by the forest also include water quality, water quantity, climate regulation, carbon storage, pollination, seed dispersal, natural pest control, tourism, cultural, aesthetics, recreational and amenity services.

Ecosystem services have been studied mainly in term of environmental economics and ecology. From the perspective of ecology, most researchers have paid great interest on ecosystem processes, function and structure evaluating economic benefits but have mostly failed to estimate social benefits Kayani et al., 2022;Kayani et al., 2022; (Aziz and Anwar 2024). The methods like economic valuation provide tangible values for ecosystem services, facilitating their integration into decision-making processes concerning land and resource management (Hira et al. 2020). However, it has become very important in the valuation of ecosystem services, to incorporate the value perception by stakeholders who get benefits in decision making processes. Especially cultural services are to be considered as non-material, intangible, and these benefits are directly assessed by stakeholders (Shahzad et al., 2019b; Yu et al., 2024) . Human beings sometimes have personal and vital attachments to assets or things like plants. These types of attachments exhibit the values of these things in their lives and are sometimes based on shared (cultural) and individualistic (spiritual) meanings, but there is very little discussion about services of the forest

that are symbolic, cultural and spiritual. These ecosystem services are directly experienced by peoples and also depend on the intrinsic motivation for people to own, manage and protect natural resources (Wasif Ali, Amir et al. 2022). This knowledge not only provides the reasons why individuals feel compelled to admire ecosystem services provided by forests, it also provides a platform to involve peoples in decision-making process in order to manage the environment Hussain et al., 2024).

The current study is based on the perception of social values and forest uses by the public, its attitude and preference as these are the non-market values perceived by stakeholders. These values are, in larger context, related to cultural services such as aesthetic, recreational and therapeutic along with provisioning services such as biodiversity, life sustaining as regulatory services and so on. This study used the extrapolation approach for the identification and mapping of social values perceived by stakeholders.

2. Materials and Methods

2.1 Study Area

The Margalla Hills National Park (MHNP) is located at about 33°44'53.29"N and 73°0'18.97"E in Islamabad capital territory and in Haripur District, Khyber Pakhtunkhwa, Pakistan **(Figure-1).** The park was established in 1980. MHNP covers approximately 17,386 hectares. The most popular picnic spots are Lake View Park and Shakarprian Cultural complex while the most important hill stations are Daman-e-koh and Pir Sohawa. MHNP is rich in biodiversity which includes mammals, birds and reptiles. There is also a great site for birdwatching. The range of MHNP is between 495 and 1528 meters in elevation. The topography is rocky, with several valleys and also steep slopes. Rocks are present from the time of the Jurassic and Triassic era (IWMB, 2018) and limestone is characteristic of this region. Soils of site are enriched with high mineral content, are dark because of this and are capable of supporting tree growth (IWMB, 2018; Li et al., 2021). **Figure 1** is a map showing the boundaries and location of Margalla Hills National Park.

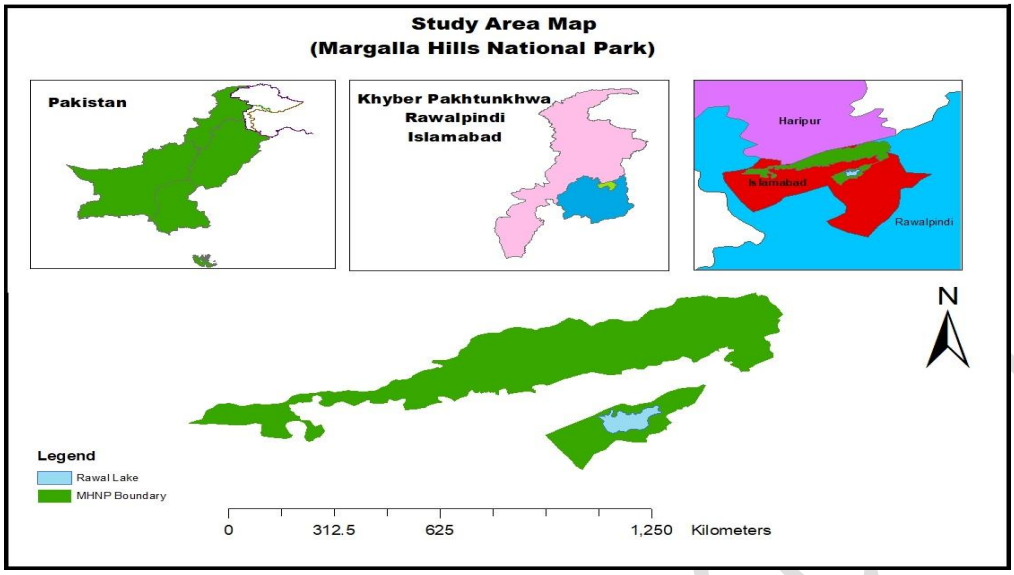


Figure 1. Map showing the boundaries and location of Margalla Hills National Park

2.2 Survey data collection tool

With the help and support of Islamabad wildlife management board (IWMB), a survey was conducted to collect the information in order to quantify the social values of Margalla Hills National Park. It helped to gather data from residents (those who have been living in the area for at least four years) and visitors of the park.

Data collection was primarily conducted along the popular trails of Margalla Hills National Park (MHNP), targeting a broad cross-section of park visitors. A total of approximately 300 respondents participated in the survey. The survey instrument was carefully structured into four distinct sections to comprehensively capture relevant information. The first section gathered detailed demographic and socioeconomic data from respondents, including variables such as age, gender, education level, occupation, and income bracket. The second section assessed respondents' level of awareness and knowledge regarding MHNP, focusing on its ecological significance and conservation status. The third section explored public understanding of the recreational activities and uses permitted within the park, as regulated by the Islamabad Wildlife Management Board. The fourth and final section was divided into two sub-sections: the first sub-section asked respondents to identify and categorize the types of social values they associate with MHNP (e.g., cultural, recreational, aesthetic values), while the second sub-section engaged respondents in spatial mapping by hand-marking the locations of these social value types directly

onto a provided map of the park. This structured approach enabled the collection of both quantitative and spatially explicit qualitative data, offering valuable insights into the public perception and use patterns of MHNP. **Figure 2** illustrates the working methodology in the study area.

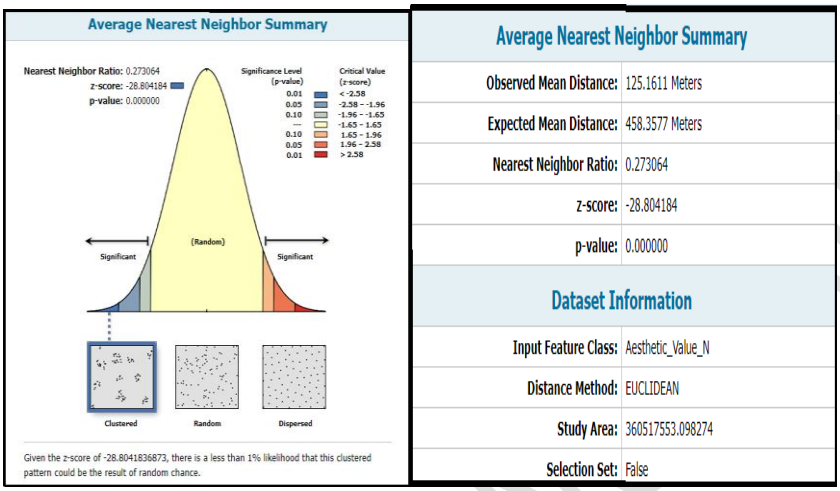


Figure 2. Analytical workflow Completed in ArcGIS.

2.3. Demographic and Socioeconomic status of respondents

The survey included questions regarding demographic and socioeconomic information of respondents; they were asked about their gender, age, marital status, occupation, their income, household expenses, and educational expenses and about their residence time period in Margalla Hills National Park.

2.3.1. Awareness about Margalla Hills National Park (MHNP)

This part contains the information regarding the familiarity of respondents with MHNP like how many times they visited the park, in which season the mostly like to visit, either they earn any income from the products or not, how much they are interested in any happening in park, what should be the public role in planning or policy making, MHNP management allows some forest products to collect, either respondents collect or not or they are not sure about this.

2.3.2. Allowed Public Uses by Islamabad Wildlife Management Board

This part of survey tool has acquired information about the attitudes regarding possible uses of forest as defined by a 5 points Likert scale questions ranging from 1= strongly favor to 5= strongly oppose. These uses include sightseeing, non-motorized recreation which includes hiking

and mountain climbing, logging for the reduction of fuel, educational research opportunities like sampling, observation of wildlife, collection of forest products.

2.3.3. Social value type and marking on map

This part of the survey tool consists of further two subparts, in first, respondents will allocate the amount of that social value type which they consider highly valuable according to them and so on and in other sub part of part 4, respondent will mark the place along with social value type on map.

This part of survey is based upon the concept of willingness to pay (WTP) an imaginary allocation of Rs. 500 among social value types. It was hypothetical amount meaning this was not any real amount, it was only assumed which only shows only the value according to respondents. Money allocated by respondent to any value exhibits the value of that social value type for the respondents. Explanation of all social value types which were included in the survey tool is given in **Table 1.**

Table 1.Description of Social Value Types Used in the Study (Khan, Khayyam et al. 2023).

Social Value Type	Description
Aesthetic value (AV)	I value this park because I enjoy its fragrance, scenery and visual beauty.
Biological Diversity value (BDV)	I value this park because it allows me to observe a wide variety of wildlife and vegetation.
Cultural value (CV)	I value this park because it helps me pass down knowledge, customs, and traditions from my ancestors.
Economic value (EV)	I value this park because it provides resources like wood and minerals, and it is recognized as a prime location for ecotourism.
Future value (FV)	I value this park because it ensures that future generations can experience and appreciate it as it exists today.
Historic value (HV)	I value this park because it contains sites and features of natural and human history that are personally significant.
Intrinsic value (IV)	I value this park regardless of whether people are present; it holds inherent worth.
Learning value (LV)	I value this park because it offers opportunities to gain environmental knowledge through observation and research.
Life Sustaining value (LSV)	I value this park because it supports the production, purification, and renewal of air, water, and soil.
Recreation value (RV)	I value this park because it provides a place for my favorite

	outdoor recreational activities.
Spiritual value (SV)	I value this park because it includes sacred and spiritually meaningful places that inspire deep respect for nature.
Therapeutic value (TV)	I value this park because it improves my physical and mental well-being and enhances my energy.

167

168 2.3.4. **Marking of Social Value Type on map**

169 Study area map was attached with questionnaire and respondents were asked to marked place on
170 map which they want to socially value. These marked places are digitized later.

171 **2.3 Digitization of marked points on Google Earth Pro**

172 Polygon layer of study area drawn in Google Earth Pro and form shape file by using ArcMap.
173 Survey data was collected by using paper maps and it will require Google Earth to digitize the
174 points mapped by survey respondents. After this shape file of each social value type form by
175 using ArcMap for further analysis. **Table 2** shows the average nearest neighbor value for R value
176 represents the clustering, randomness and dispersion of mapped points. Hand-marked social
177 value maps were digitized and georeferenced using ArcGIS. These points were overlaid with
178 DEM, NDVI, and LULC layers extracted from remote sensing data to analyze spatial
179 correlations. GIS tools were used to link social values with elevation, slope, and vegetation
180 indices for clustering analysis.

181 **2.4 GIS ping Table 2. standard value for R Value represents the clustering, randomness**
182 **and dispersion of mapped points**

R value	
<1 (Less than 1)	Clustering
= 1 (equals to 1)	Randomness
>1 (greater than 1)	Dispersion

183

184 **2.4 ArcGIS Mapping**

Average nearest neighbor (ANN) is the spatial statistics which describes the relative clustering, dispersion and randomness of marked points which help by selecting the social value type for analysis. Ann statistic test is applied to every social amenity point data for CSR checking. using the following formula.

$$ANN = \frac{Do}{De}$$

Do, measured by the average actual distance from each feature to the neighborhood, while De is the expected average distance from the feature in a random pattern.

The R-value expresses the ratio of the observed distance between marked points to the expected distance between points. Each R-value is followed by Z-scores that indicate its number of standard deviations, as these are used to statistically identify significant clustering patterns. The R-value quantifies this phenomenon. A value of R below 1 indicates the clustering of points; R equal to 1 suggests randomness; and R greater than 1 indicates dispersion of point (Bokhari, Saqib et al. 2022).

Kernel Density (KD) ArcMap tool

Kernel density (KD) as it calculates density of a features which are in a neighbor, around these features. Density is high on the location of a point and diminishing as far from these points. KD analysis that where clusters in our data exist.

Acquisition of spatial data

Environmental layers which are in the form of 30-metre resolution were needed to identify the characteristics of study site and its relation with selected social values. The layers of LULC, NDVI, DEM, and slope using DEM all are included in current analysis. The selected layers include land use land cover, NDVI, DEM, and slope which are derived from digital elevation model. These layers are all environmental and have been selected for the present study as show in **Table 3.**

Table 3. Environmental layers being included in analysis

Name of the layer	Description of Layer	Source of particular layer
Elevation	Digital elevation model in meters (DEM)	Shuttle Radar topography Mission (SRTM GL1) Global 30m-OpenTopography https://portal.opentopography.org/raster?
LULC	Land use land cover data	Derives from National Land cover Database (NLCD)
NDVI	Normalized difference vegetation index	https://giovanni.gsfc.nasa.gov/giovanni/
Slope	Slope in percent	Derived from digital elevation layer data by using ArcGIS Slope tool

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212 **2.5 Statistical Analysis**

213 Pearson correlation is considered in this study. Correlation is between public uses which
214 Islamabad Wildlife Management board (IWMB) allows in MHNP and social values. It is also
215 conducted between perceived social values and biophysical data of study site.

216 **3. Results**

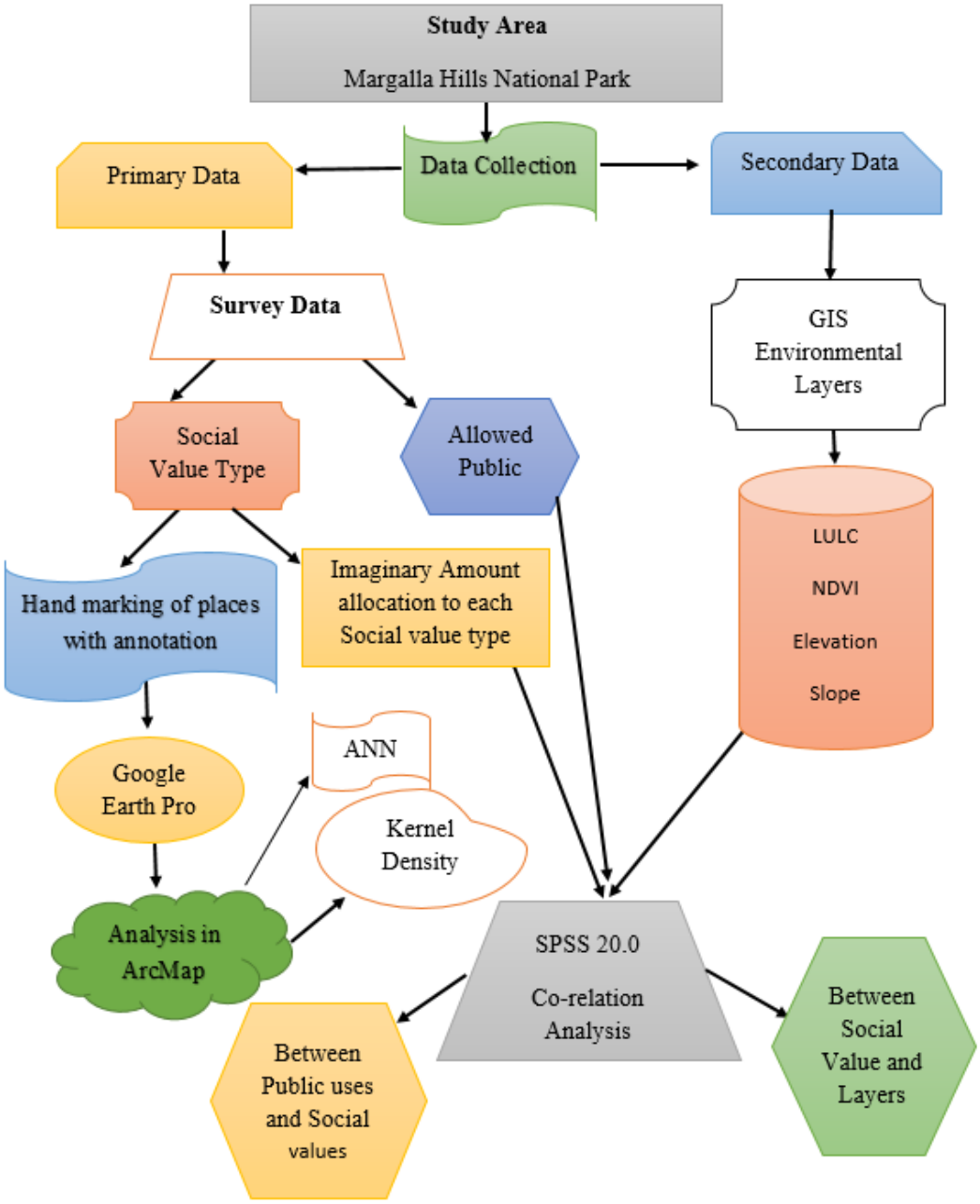
217 Results reveal the use of Geographic Information System (GIS) for the spatial analysis of
218 stakeholder's values, preferences and evaluate the capability of GIS to effectively exhibit
219 information taken from the commonly used methods of social survey data analysis. The current
220 study operated towards the objectives of human uses and values and integration of social and
221 biophysical data into the ecosystem management (Lei et al., 2024).

222 **Amount allocation to each social value type**

223 Imaginary amount, allocated to each social value type by the respondents is explained as; about
224 78.7% respondents allocated 59,700 to aesthetic value, 72.7% allocated 58,480 to recreational
225 value, 26% respondents allocated 8,420 to life sustaining value, 22% allocated 8,030 to
226 biological diversity value, 11.7%, 9.7%, 7%, 5.7%, 5.7%, 5.7% and 5% respondents allocated
227 3320, 2400, 1000, 1500, 1890, 1470 and 1890 to future value, historic value, learning value,
228 economic value, cultural value, therapeutic and spiritual value respectively.

229 **Average Neighbor Statistical tool of ArcGIS**

Average nearest neighbor (ANN) is utilized for analyzing point patterns. The ratio is by comparing the actual average distance to expected mean distance. This method relies on the random distribution of points across the same number of features while encompassing the entire area. When the average nearest neighbor ratio is below 1, it indicates a clustering pattern. Conversely, an index value greater than 1 signifies dispersion. Values below 1 (<1) are denoted by R, which indicates the clustering of point features. R-values are related to Z-scores if R-value is less than 1, Z-scores value will be low by showing negative value. R-value and Z scores are shown in (**Table 1),** in this N-count shows the number of marked points on map by respondents. Average nearest neighbor tool produces html reports of each social value type as shown in **Figure 3.** Seven social value types of aesthetic, cultural, biodiversity, future, intrinsic, life-sustaining, recreational, and therapeutic were finally selected, out of a total of twelve. These seven social value types were selected (Tariq et al. 2023) on the basis of Clément's Complete Randomness (CSR) hypothesis. **Table 4** shows average nearest Neighbor Statistics.



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244 **Figure 3. Html report produce by ANN tool of Aesthetic Value**

245 **Table 4. Average nearest Neighbor Statistics**

Social Value types (SVT)	N_count	R -value	Z- scores
Aesthetic Value	349	0.273064	-28.804184
Biological diversity Value	105	0.477864	-12.274476

Cultural Value	23	1.362046	3.019060
Economic Value	07	2.620926	8.204331
Future value	73	0.617223	-6.256590
Historic Value	16	0.906053	-0.718912
Intrinsic Value	102	0.564590	-15.398262
Learning Value	13	1.940517	6.232874
Life Sustaining Value	71	0.672923	-5.177627
Recreational Value	229	0.347002	-18.821570
Spiritual Value	20	1.243079	2.079666
Therapeutic Value	115	0.515219	-8.449204

Kernel density analysis

Kernel density (KD), it calculates the density of features within a neighborhood around these features. Density is high on the location of a point and diminishing as far from these points. KD analysis that where clusters in our data exist. Seven social values out twelve were selected for mapping, kernel density maps of these values are given below.

Density of aesthetic value (AV)

Among All these social value type highly rated value type is aesthetic value and it was given Bruti top, Talhaar valley, Pir Sohawa, Shahdra valley, Pir sohawa, Shahdra point, Tilla Chorouni, Saidpur Village, Shumber Water Fall. Out of all these places Bruti top attained highest rank as aesthetic value as shown in **Figure 4(a).**

Density of biological diversity value (BDV)

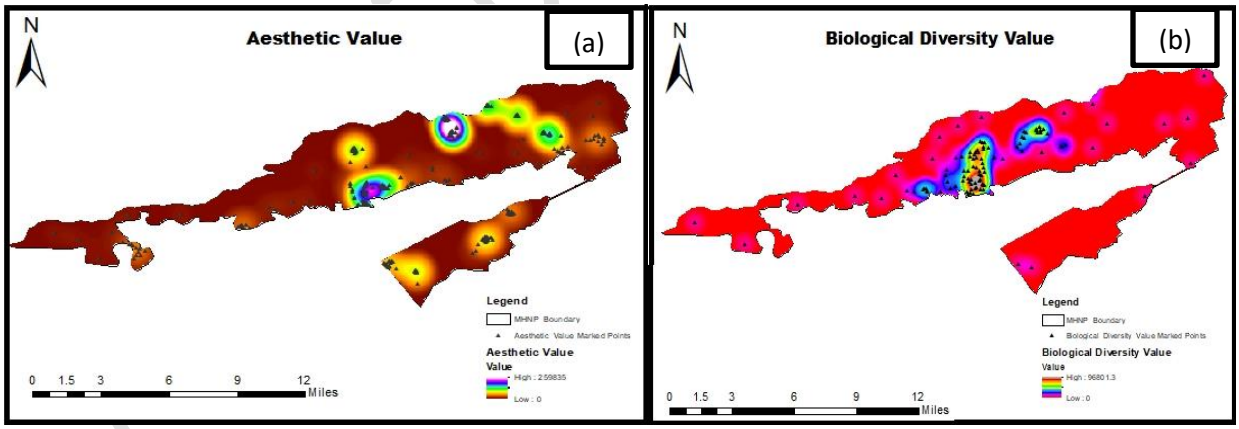
Margalla Hills National Park (MHNP) provides a variety of wildlife, invasive plants species like Lantana (Lantana montevidensis), Common Cocklebur (Xanthium strumariam), Carrot Grass (Parthenium hysterophorus), Castor oil plant (Ricinus communis)**,** Marijuana (Cannibus sativa*),* it includes many trees like Mango tree (Mangifera Indica), Date Palm (Phoenix dactylifera), Kachnaar (Bauhinia variegate), Pine tree (Pinux ruxburgbii)**,** Ber (Ziziphus mauritiana), Amaltas (Cassia Fistula), Sheesham (Dalbergia sisso),many wild flower are present in the boundary of MHNP. **Figure 4(b)** shows the density of biological diversity value on map.

Density of future value (FV)

Respondents marked the future value as they want that their future generation know and experience the forest as they are currently. In protected area most of human activities are prohibited to preserve the beauty and to avoid any damage to forest. Survey respondents mark the future value to the places where vegetation index is high, as shown in **Figure 4(c).**

Density of intrinsic value (IV)

Intrinsic value is directly related to that is present in forest, respondent's value this either people are present in or not, this concept highlights the notion that nature holds intrinsic value, independent of human usage. Intrinsic values suggest that nature can possess worth even without providing direct or indirect benefits to humanity (Ronal, 2012; Rafaqat, Iqbal et al. 2022). Intrinsic value is marked by respondent to various places such as Shumber water fall, Daman-e-koh, Shahdra point, Beetle's nest, Fire track, Trail 5a, Trail 6, Birds watching point at trail 6, Shakarprian, Margalla Valley, Malpur, highest rated density is of in blue and lowest density is in lavender shade as shown in **Figure 4(d)**. Shahdra point and Shakarprian Park are highly marked by respondents.



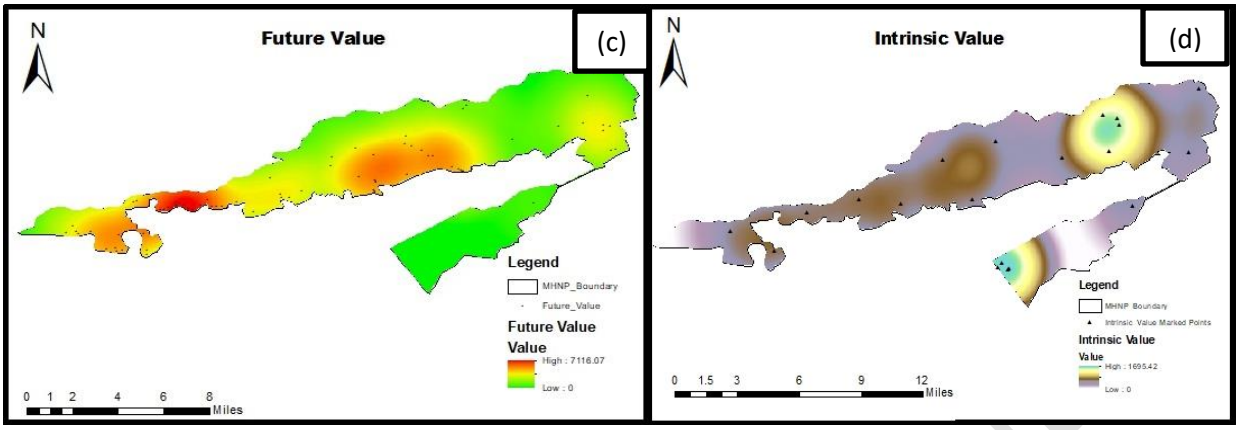


Figure 4: (a) Kernel density map of Aesthetic Value **(b)** Kernel density map Biological Diversity Value **(c)** Kernel density map future value **(d)** Kernel density map intrinsic value.

Density of life sustaining value (LSV)

In response to climate change, reduction of carbon emission has become an important goal worldwide. The largest carbon pool in terrestrial ecosystems is forests as they sequester large amounts of carbon dioxide, they aid to produce, clean and renew air, water and also soil and make better environment for peoples to visit and to live in such an atmosphere. Tilla chrouni, Trail 5, Trail 6, trail 3 and jungle spot are mostly marked by respondents as life sustaining values, dark brown color shows these places and white color exhibits the places which are being less marked by respondents as shown in **Figure 5(a).**

Density of recreational value (RV)

Types of recreational activities which are allowed in the boundary of MHNP are hiking and rock climbing, overnight camping and to some extent swimming. There are eight (8) major trails and so many other small track or trail, comparatively other trails, trail 5, trail 6, and trail 3 are mostly marked by respondents as recreational value. **Figure 5(b)** shows the recreational value map, red color shows the density of recreation value.

Density of therapeutic value

Survey respondents marked therapeutic value on the map because they feel better, physically and also mentally. Many places marked by respondents as therapeutic value such as beetle's nest,

Trail 3, Trail 5, Trail 6, Bruti top, Tilla charouni, Jungle spot, Daman-e-Koh. Trail 5, 3 attained highest value and represented in map as blue color as shown in **Figure 5(c).**

Spatial data output maps

Environmental layers with a resolution of 30 meters were crucial for evaluating the features of the study site and their relationship to the selected social values. These layers encompass land use and land cover (LULC), the normalized difference vegetation index (NDVI), the digital elevation model (DEM), and slope, which is derived from the DEM.

Land use Land cover (LULC)

The land use and land cover (LULC) data, classified into 16 categories, was obtained from the National Land Cover Database (NLCD). This data was processed and categorized using Geographic Information System (GIS) and remote sensing techniques in ArcGIS, as detailed in **Table 5.** The corresponding LULC map is shown in **Figure 5(d).**

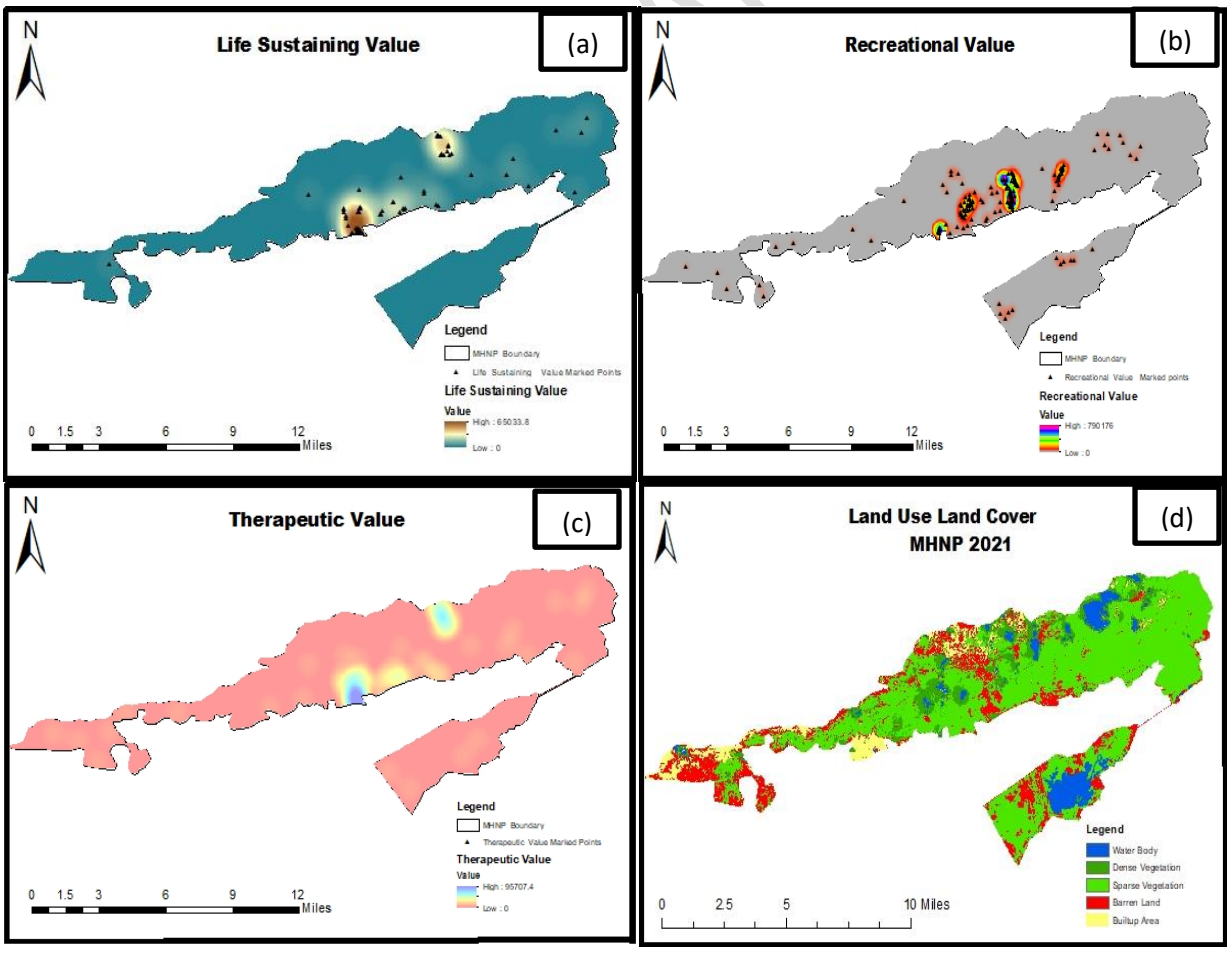


Figure 5. (a) Kernel density map life sustaining value **(b)** Kernel density map recreational values **(c)** Kernel density map therapeutic value **(d)** Classified land use land cover map of study site (2021)**.**

Table 5. Land Use and Land Cover (LULC) Classes with Area Coverage (km²) and Percentage of Total Area

LULC Classes	Sum of total area (sq.km)	% of covered area
Barren Land	29.34	17.4%
Built-up Area	10.24	6.06%
Dense Vegetation	16.60	9.82%
Sparse Vegetation	101.43	60 %
Water Body	11.42	6.7%

Blue color in this map shows the presence of water which covers almost 6.7% of the total area, dense vegetation is represented by dark green color, and it covers only 9.82%. Light green color shows the presence of sparse vegetation and it counts 60% of the total area. 17.4% of the total area is barren land and it is represented by red color and the last class is built up area, it is represented by yellow color, and it covers 6.06 % of the total area.

Normalized difference in vegetation Index (NDVI)

The normalized difference in vegetation index (NDVI) is a widely used remote sensing index. It is defined as the difference between the RED reflectance and NIR (near infrared) reflection divided by their sum. It calculates the surface reflectance and estimates the vegetation growth and biomass in quantitative terms. A dimensionless index which describes the difference in near infrared and visible reflectance of vegetation and it also can be used for the calculation and estimation of the density of greenery on the patch of land (Rafaqat, Iqbal et al. 2022).

The normalized vegetation index ranges between -1.0 and +1.0. Healthy vegetation has low reflectance in the red-light spectrum while showing high reflectance in the near-infrared spectrum, resulting in elevated NDVI values. As noted in **Table 6**, high positive NDVI values correspond to increased levels of green vegetation. In contrast, NDVI values near zero or in negative territory indicate the presence of non-vegetated surfaces, such as bare rocks, water, snow, ice, and clouds.

Table 6. Standard table of NDVI Classes (Giovanni)

Class	NDVI Range
Water	-0.28 – 0.015
Built up area	0.015 – 0.14
Barren land	0.14 – 0.18
Shrub and Grassland	0.18 – 0.27
Sparse Vegetation	0.27 – 0.36
Dense Vegetation	0.36 – 0.74

This map shows the NDVI of Margalla Hills National Park **(Figure 6a).** The range of dense vegetation according to the standard table falls between 0.36 to 0.74, but values of NDVI in study site falls between 0.6 to 0.81. About 30 villages fall under the boundary of MHNP but these are also surrounded by green vegetation. Red color shows the availability of water as Rawal Lake and many other natural water resources like Shumber water fall, ficus spring etc., exist in the boundary of national park.

Digital Elevation Model (DEM)

The digital elevation model, DEM, which is being used for current study analysis is the Shuttle Radar Topography Mission (SRTM GL1) Global 30-m resolution raster elevation data. DEM 30-m is used as an environmental layer correlated with social value type. Data is downloaded and masked by study area boundary as shown in **Figure 6b.**

Red color shows the highest elevated places, orange, yellow, light green and dark green color exhibits decreasing pattern of elevation respectively.

Derivation of slope from DEM

Slope of any area can be calculated by using digital elevation model by the help of ArcGIS slope tool. Green color shows 0^0 to 3^0, yellow 3^0 to 6^0, red 6^0 to 9^0, magenda 9^0 to 12^0, blue color shows highest degree rise about above 12^0 as shown in **Figure 6c and** Location of Margalla Hills Park shows the location **Figure 6d.**

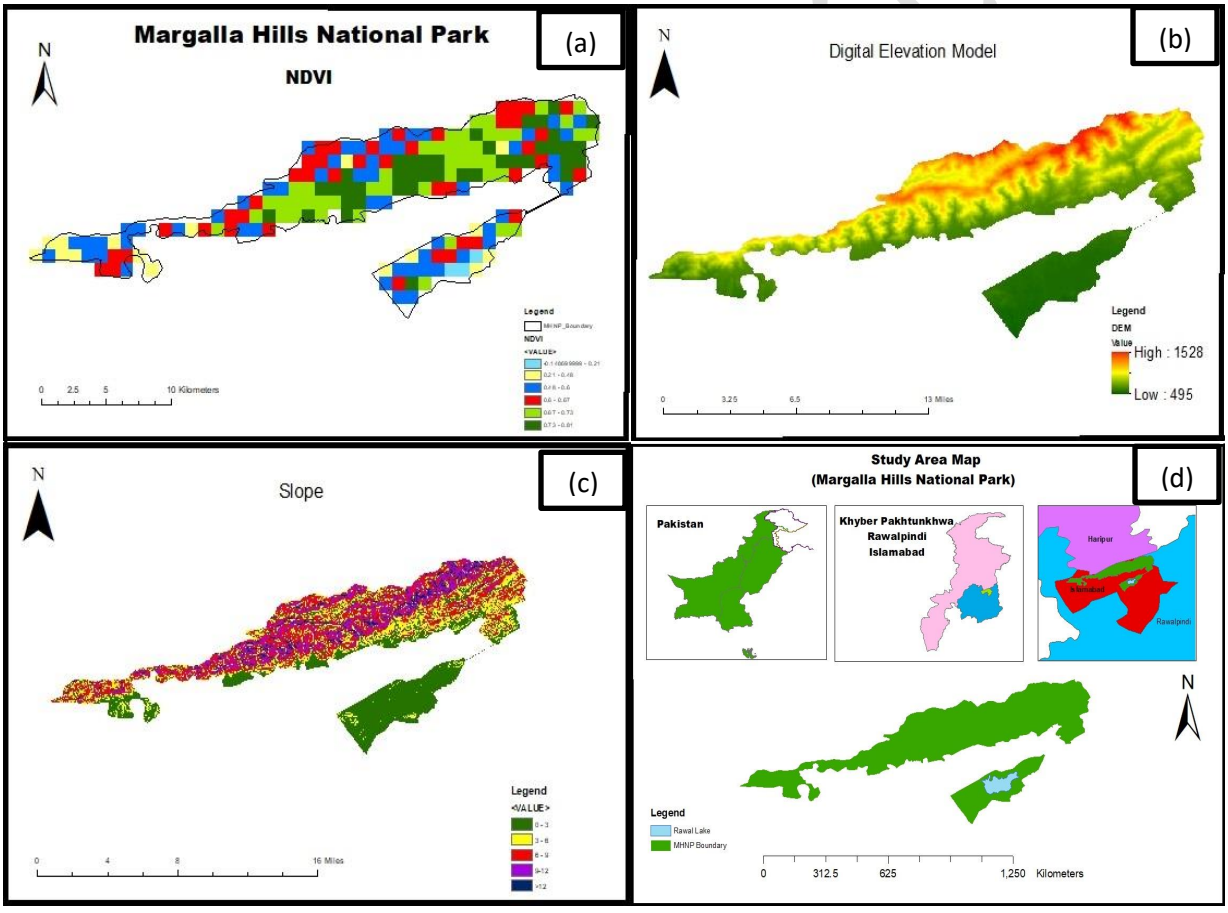


Figure 6: (a) Map of NDVI **(b)** Digital Elevation model (DEM) **(c)** Slope Map **(d)** boundaries and location of Margalla Hills National Park

Statistical Analysis

Correlation study is being conducted between of social value type and public forest use and between social value type and landscape metrics. Aesthetic value has positive significant correlation with all public uses who favor them and it have negative correlation who oppose sightseeing, non-motorized recreation and wildlife watching. Biological diversity value is significantly correlated with all public use who favor except non-motorized recreation, it is negatively correlated with sightseeing who oppose this public use but is positively correlated with motorized recreation because people during these activities destroy the biodiversity. Life sustaining value is significantly correlated who favors outdoor recreation, educational research opportunities with wildlife watching. Recreational value has positive significant correlation with all public uses who favors except logging for fuel reduction which is negatively correlated, it also has negative correlation who oppose educational research opportunities and wildlife observing which is unexpected result and show significant correlation who oppose logging for fuel reduction and collection of forest pro ducts. Therapeutic value has significant correlation with outdoor recreation and wildlife watching who favor these public uses. Result of correlation analysis is shown in Table 7. Correlation analysis is also conducted between social value type and characteristics of landscape. Aesthetic value shows positively significant correlation with digital elevation model (DEM), slope, normalize vegetation index (NDVI), and show no any relation with land use land cover (LULC) which is unexpected results, biological diversity value exhibits negative significant correlation with DEM and slope and positive significant correlation with NDVI and LULC, future and intrinsic have no relation with environmental layers except LULC, which is significantly correlated, life sustaining value is significantly correlated with DEM and NDVI, recreational value as the second highest rated social value shows positive significant correlation with DEM, NDVI and negatively correlated with slope, therapeutic value have significant correlation with NDVI and LULC as shown in below in Table 8.

	Favor or Strongly Favor							**Oppose or Strongly Oppose**						
	Aesthetic Value **(AV)**	Biological diversity Value	Future value **(FV)**	Intrinsic Value **(IV)**	Life Sustaining Value **(LSV)**	Recrea-tional Value	Thera-peutic Value	Aesthetic Value **(AV)**	Biological diversity Value	Future value	Intrinsic Value	Life Sustaining Value	Recrea-tional Value	Th-peu c

		(BDV)				(RV)	(TV)		(BV)	(FV)	(IV)	(LSV)	(RV)	Va (T
htseeing	.158**	.143*	.018	.024	.050	.171**	.013	-.175**	-.145*	.035	.024	.060	.217	.14
n-torized creation	.208**	.049	.229	.025	.246*	.118*	.226**	-.157*	.544	.397	0.164	.175**	.066	.04
gging for l uction	.586**	.141*	-.127	.190	.062	-.224**	.009	.187	.158	.028	-.004	.187**	.140*	.29
ucational search portunitie	.143*	.195**	.056	.051	.118*	.139*	.226	.540	.145	.164	.397*	.084	-.194**	.02
ldlife wing	.208**	.360**	.077	.051	.139*	.158**	.302**	-.060**	.191**	.024	.063	-.056	-.205**	.02
thering ducts	.189**	.410**	.077	0.005	-.076	.118*	-.076	.100**	.544**	.313	-.076	.051	.317**	.06

402 **Table 7. Statistical correlation analysis between public uses and social value type who**
403 **favor or strongly favor and oppose or strongly oppose that particular publicly forest uses.**

404

405 **Table 8. Relationship between the perceived Social Value Type and the Landscape matrix**

Social Value Type	DEM	Slope	NDVI	LULC
Aesthetic Value	0.45**	.41*	0.68**	0.08
Biological Diversity Value	-.062*	-.164**	0.89**	0.46**
Future Value	.051	.066	0.012	0.88**
Intrinsic Value	0.06	.033	.077	0.51**
Life Sustaining Value	0.20*	.077	0.65**	-.009
Recreational Value	0.80**	-.100**	.252*	.028
Therapeutic Value	.005	.009	.653**	0.66**

406

407 **4. Discussion**

408 The assessment of social values in Margalla Hills National Park (MHNP) reveals diverse
409 perspectives. The study examines six publicly permitted park uses, with respondents expressing
410 varying levels of support-some favoring or strongly favoring them, while others opposing or
411 strongly opposing them. Most favored public uses are sightseeing, outdoor recreation activities
412 and educational research opportunities and logging for fuel reduction is strongly opposed by
413 respondents. About twelve social values are allocated by survey respondents with different
414 amount and they marked these social values on provided map along with sample questionnaire.
415 Somehow, similar results present in other studies (Jin et al., 2023; Jin et al., 2023).

416 After that, points obtained on the map are being digitized by Google Earth pro and prepared
417 shapefiles of each social value. Completely Spatially Random (CSR) assumption testing is
418 applied by using ArcGIS statistical tool Average nearest neighbor at the onset and it provides a
419 methodical means for the identification of statistically, significant spatial pattern of social values
420 which direct for further analysis. Seven (7) out of twelve (12) social values are selected for
421 further analysis (Sun et al. 2019). ArcGIS spatial analyst tool kernel density is applied to optimal
422 location of that particular social value on map, similar methodology adopt by Qianget al. (2019)

in study to locate the density of biogas plants. Kernel density map of seven social value type like aesthetic, (BDV) biological diversity, (FV) future, intrinsic, (LSV) life sustaining, recreational and therapeutic (TV) value was formed. Correlation analysis between social value type and public uses show positive and negative significant relationship with each other. Aesthetic values have significant correlation with sightseeing, educational research opportunities, outdoor recreation, wildlife observation and collection of forest products who favor them and they have negative significant (Ahmed et al., 2023). Biological diversity value is significantly correlated with all public use who favor except non-motorized recreation, it is negatively correlated with sightseeing who oppose this public use this is the unexpected result but is positively correlated with recreational activities who oppose this public use as recreational activities has its impact on biodiversity explained by (Lei, 2025) in their research that the most prevalent impact of recreation on biodiversity is the trampling process which harms and destroy the plants which in turn destroy the habitat of animals, it involve in the displacement of organic soil horizons. Hikers and visitors can destroy the fragile soil also responsible for the introduction of invasive species. Life sustaining value is significantly correlated with those who favors outdoor recreation, educational research opportunities and wildlife watching. Respondents value life sustaining as they considered forest involve in the production, preservation, cleaning and renewing of water and air. Forest are being considered the largest carbon pool as they can decrease the atmospheric carbon dioxide via the process of photosynthesis, which in turn transform it into organic carbon via the plant growth and after that store it as a plant biomass Sight view, recreational activities, educational research opportunities, collection of forest products have significant correlation with recreational value who favor them while logging for fuel reduction have negative correlation with recreational value. Respondents enjoy the scenic beauty during hiking or other allowed activities. Educational research opportunities increase during these outdoor activities. It has been seen that learning in experiential perspective is the "process by which knowledge is created through the transformation of experience (Sohail, Muhammad et al. 2023). Non-motorized recreation such as hiking and mountain climbing have significant correlation with recreational value. Along with outdoor recreation forests provide many benefits such as cognitive development, spiritual enrichment. Reactional value is negatively correlated with wildlife watching and educational research opportunities meaning people during these activities try to harm the flora and fauna, they try to hunt them, people of Gokina, Talhaar and Shah Allah Ditta

454 are private landholders they try to do this type of activities (Arif et al. 2023). Therapeutic value
455 has significant correlation with outdoor recreation and wildlife watching who favor these public
456 uses. People feel better mentally and physically when they visit forest or mark, respondents
457 therapeutically value these places people take many advantages from forest as these enhances
458 the stress recovery process at physical, attention and emotional level (Arif et al. 2023) social
459 cohesion and sense of belonging (Arif et al. 2023) Reactional value is negatively correlated with
460 wildlife watching and educational research opportunities meaning people during these activities
461 try to harm the flora and fauna, they try to hunt them, people of Gokina, Talhaar and Shah Allah
462 Ditta are private landholders they try to do this type of activities (IWMB, 2018; Li and Xu,
463 2025).

464 Aesthetic value is significantly correlated with normal difference in vegetation index, elevation,
465 and slope, MHNP exist under the Himalayans mountain range as mountain landscape changes,
466 and these changes are mostly caused by the verticality characteristics and this is mainly happens
467 due to the elevation and ultimately slope, AV is increases with high vegetation index, along with
468 changes in slope and also elevation, the landscape and vegetation categories change and
469 environmental gradient is ultimately formed biological diversity value is negatively correlated
470 with elevation and slope, high altitude effects soil depth and temperature in a way slope gradient
471 alters soil moisture, depth and acidity. Biological diversity value is positive correlated with
472 NDVI and land cover, independent of its small size MHNP is enriched with biodiversity fauna
473 resides where flora is dense. Life sustaining value is positively correlated with land use land
474 cover and NDVI value as forest are involve in cleaning the environment and renew air, plants
475 have positive effect on human health (Arif et al. 2023), MHNP consist of 9.82% dense
476 vegetation and 60% is sparse vegetation, water bodies account for 6.8% of the total land.
477 Recreational value is positively correlated with elevation and negativity correlated slope ,highly
478 rated recreational activities counted in MHNP are mountain climbing, hiking and overnight
479 camping, and it is associated with high elevation and flatter area meaning low slope gradient is
480 accepted by recreationists therapeutic value shows the values of forest as people feel better
481 physically or mentally (Rey-Valette, Mathé et al. 2017) having significant relationship high
482 vegetation level, land use land cover, MHNP is enriched with biodiversity.

483 Common International Classification of Ecosystem Services (CICES) and The Economics of
484 Ecosystems and Biodiversity (TEEB) provided basic framework for the connection of

ecosystems and human well-being. Specifically, the revised CICES classification aims to better capture the contributions of ecosystems to human well-being by identifying ecosystem attributes and behaviors that underpin these services, which inherently reflect social preferences and values (Alfano et al., 2025). Given the increasing frequency of extreme weather events and the ongoing impacts of climate change, future shifts in public perceptions of ecosystem services in MHNP are expected. Climate-induced changes to landscape aesthetics, biodiversity, and recreational opportunities may alter the social values attributed to these services, particularly in terms of public use patterns and conservation priorities (Apostolaki, 2024).

5. Conclusion

This research quantified, assessed, and spatially mapped the social values of cultural ecosystem services within the Margalla Hills National Park (MHNP), providing valuable insights into the relationship between ecological characteristics and societal perceptions in an urban-adjacent ecosystem. Using survey data collected via questionnaires and analyzed through GIS tools, the study identified significant clustering in seven of the twelve assessed social values: aesthetic, recreational, biological diversity, therapeutic, intrinsic, future, and life-sustaining values. These findings highlight the critical role of these values in shaping public perceptions of urban and peri-urban ecosystems. The results revealed significant correlations between social values and environmental variables, including elevation, slope, normalized vegetation index (NDVI), and land use/land cover, except for recreational value, which exhibited a negative correlation with slope. Social values were predominantly distributed in areas with elevations ranging from 527 to 1138 meters, slopes of 60° to 120°, NDVI values between 0.74 and 0.18, and sparse to dense vegetation. These findings underscore the importance of specific ecological and spatial characteristics in fostering cultural ecosystem services. This study demonstrates that GIS tools can effectively integrate non-monetary, spatially explicit social values into the evaluation of cultural ecosystem services, offering a replicable methodology for researchers, stakeholders, and decision-makers engaged in urban ecosystem management and planning. By mapping and correlating social values with environmental variables, this approach advances our understanding of how societal attitudes and preferences are linked to ecological and spatial features, thereby providing a foundation for more informed and inclusive urban ecosystem management strategies.

However, the study faced certain limitations, including an uneven age distribution and the exclusion of elderly individuals who may possess valuable insights based on life experience. Future research could address these limitations by incorporating broader demographic representation and exploring how diverse populations perceive and prioritize social values within urban ecosystems.

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