The Urban Unit

Urban Sector Planning & Management Services Unit (Pvt.) Ltd.

NAMAL LAKE

RESTORATION AND MANAGEMENT PLAN

(2022 – 2027)

Shrinking Lake – Back to Root

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Abbreviations

AQI	Air Quality Index
As	Arsenic
C&W	Communication and Works
CAAP	Communication and Awareness Action Plan
CBOs	Community-based Organizations
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
EROS	Earth Resources Observation and Science
Fe	Ferrous
GLOF	Glacial Lake Outburst Flood
IUCN	International Union for Conservation of Nature
LC	Least Concern
Mn	Manganese
NASA	National Aeronautics and Space Administration
NGOs	Non-Government Organizations
Ni	Nickel
Pb	Lead
PST	Pakistani Sales Tax
Qty	Quantity
Rft	Running Foot
RGB	Red Green Blue
SCOPE	Situation; Core competencies; Obstacles; Prospects and Expectations
SRTM	Shuttle Radar Topography Mission
SWOT	Strengths, Weaknesses, Opportunities, Threats
UHI	Urban Heat Island
USGS	United States Geological Survey
V	Vanadium
VU	Vulnerability
Zn	Zinc

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Executive Summary

Namal lake, a game reserve notified in 1970, is shrinking at an alarming level!

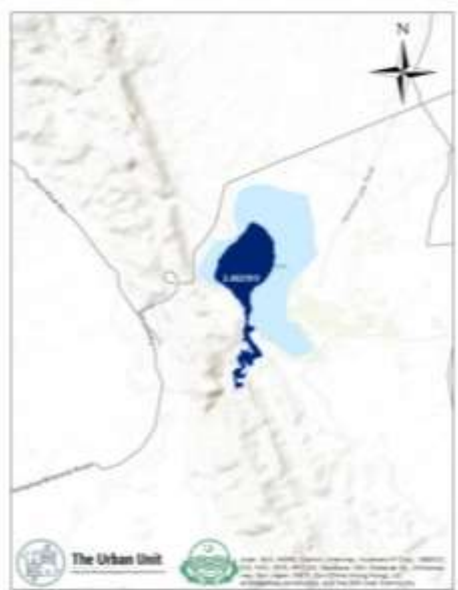
The lake is located in Namal Valley at the eastern border of the Mianwali District of the Sargodha Region. It was formed when British engineers built the Namal Dam in 1913 to address the scarcity of irrigation and drinking water e local residents as well as Mianwali city. Mountains surround the lake on its western and southern sides, and agricultural land is located on its other sides.

The lake's surface area was approximately 5.5 square kilometers at first, but shrinkage in the surface area has been observed over time. The high pace of shrinkage is due to climatic extremes, minimum environment flow and improper channelization. For better comparison and estimation of change in the surface area of Namal Lake, the surface area of the Lake was calculated for the years 1986, 1995, 2000, 2013, 2018, 2020 and 2021 using Landsat versions 4, 5, 7 and 8 datasets.

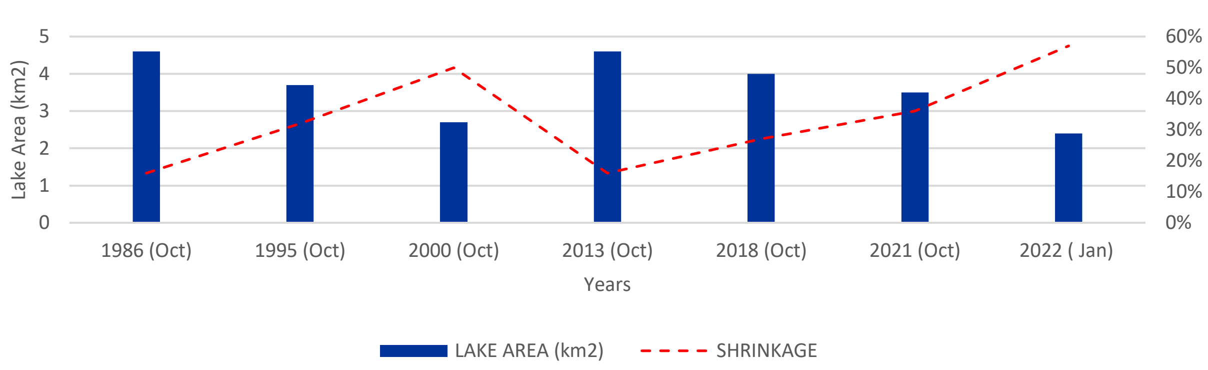
Surface Area of Namal Lake 1986 (Landsat 4-5 Satelitte Data)

Lake Area = 4.6 sq.km

Surface Area of Namal Lake 2022 (Landsat-8)



Lake Area = 2.4 sq.km



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The lake is drying and thus demanding effective conservation and management solutions to sustain the reservoir volume and ecological integrity. Keeping in view the context, an action plan for restoration and management of Namal Lake is proposed which contains various strategies and interventions, as exhibited below;

Proposed interventions for Namal Lake

The proposed interventions and action points include proposals for enhanced discharge through catchment management in Namal lake, provision of the drainage system, control of point and non-point pollution, flood management, plantation, eco-friendly recreational interventions and communication and awareness action plan. The total estimated cost of the project is PKR 317.72 Million.

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Overview

The rapid growth of urbanization, industrialization, and environmental pollution (along with other factors) has lessened the vital role of the natural environment and their associated values in Punjab which covers a wide range of ecosystem services to the citizens.

The overall development in Punjab is highly connected with the natural resources and a range of ecosystems. A substantial number of its population (specifically rural) is highly dependent on natural resources for their subsistence. Lakes are integral part of Punjab's ecosystem. It helps in maintaining the water flow, production of hydel power, acting as water storage/retention facility, regulating the climate (carbon sink), controlling floods, harboring the aquatic ecosystem, enhancing the natural beauty and developing eco-tourism and recreational opportunities. There is a total of 9 lakes[1], natural and artificial, in Punjab which are providing multiple ecosystem services. The Salt Range Wetlands Complex includes 5 significant lakes comprising of Kallar Kahar lake in Chakwal district, Ucchali, Khabeki and Jhalar lakes in Khushab (RAMSAR wetlands) and Namal in Mianwali, whereas other four lakes include Malkana and Kohar Wala lakes near Trimmu Head Works in Jhang, Mangla in Jhelum and Rawal in Rawalpindi. Presently, all these lakes are deteriorating due to natural (e.g., maximum variations in temperature; precipitation) and anthropogenic sources (e.g., Industries, deforestation, urbanization, water abstraction).

Central Punjab is a hub of Salt Range Lakes (natural assets) and considered as the nucleus of Punjab's economic growth and social well-being. The region is comprised of four districts i.e. Sargodha District, Khushab District, Mianwali District and Bhakkar District. Deterioration of these natural assets, mainly due to drop in freshwater flows, habitat destruction, pollution, deforestation, water logging and salinity is an indicative of deprived natural resource management, weak environmental and feeble policy actions.

Namal lake is the prime example of unattended and meager management issue which is shrinking at a high pace and not functioning fully to serve its purpose. Hence, this report is focusing on development of a restoration and management plan for Namal Lake, a game reserve notified in 1970 under Section 18 of the Punjab Wildlife (Protection. Preservation, Conservation & Management) Act, 1974[2].

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[1] *https://dailytimes.com.pk/100089/saving-punjabs-lakes/ JULY 7, 2015*

[2] No.SOP (WL) 12.1/2002.11 In exercise of the powers conferred by Section 18 of the Punjab Wildlife (Protection. Preservation. Conservation & Management) Act, 1974, the Government of the Punjab renotifies the area of Namal Lake specified in the

The lake is located in Namal Valley at the eastern border of Mianwali District of Sargodha Region.

Geographical coordinates: 71 °48°45° E longitude and 32°40°10° N latitude
Total Lake Surface Area: 2.4 km^2 (2022)
Total Project Area: The 2km buffer zone around the Namal lake – 16.035 km^2

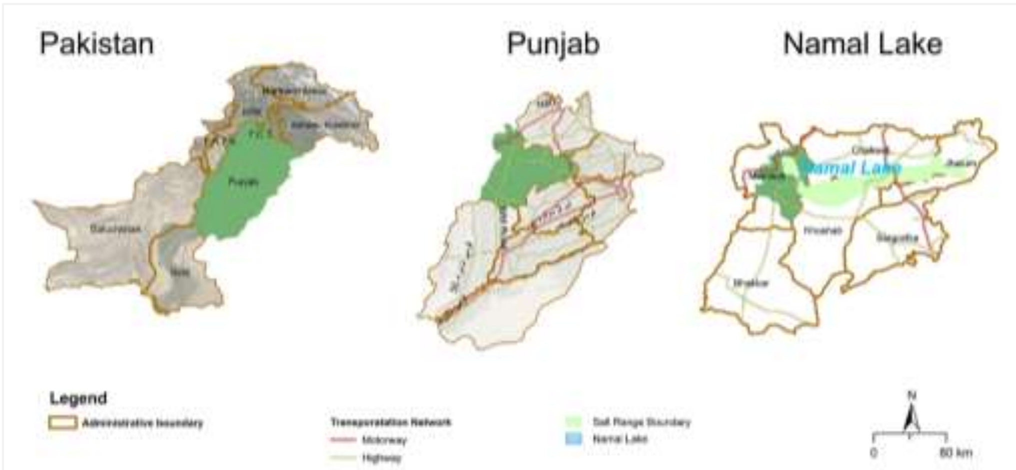

Figure 1: Geographical location of Namal Lake

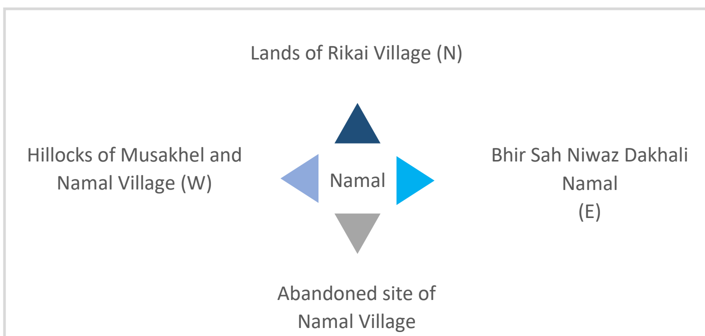

Figure 2: Neighborhood Areas of Namal Lake

> *Box I: Definition of a Game Reserve*
>
> *The Game Reserve, defined under Section 18 of the Punjab Wildlife Act, 1974, states I. The Government may declare any area to be a "Game Reserve". II. No hunting and shooting of a wild animal shall be allowed in the Game Reserve, except under a special permit, which may specify the maximum number of game animal that may be killed or captured, the area and duration for which such permit shall be valid: a. Provided that the number of occasions on which hunting and shooting may be allowed shall not exceed two in a year.*

The Namal Lake is state-owned and the local communities are the main stakeholders. Punjab Wildlife Department is responsible for controlling illegal hunting of wildlife; Punjab Tourism Department is the major stakeholder for enhancing tourism opportunities and facilities in the region; District Government

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schedule given as Notification No. SOFT(EXT)X11-23/73(P), date 22.5.2001 and shall continue to be a Game Reserve for all the wildlife species w.e.f. 13.1.2006. The first notification was issued in 1970.

of Mianwali, who owns the land under water, is responsible to control illegal encroachment surrounding the lake; and Environment Protection Agency, Punjab is the is responsible for combating pollution in the lake.

However, the Namal game reserve is continuously shrinking due to a number of factors in which impacts of climate change and anthropogenic activities are more pronounced[3]. Based on the period from 1850 to 1900, the Earth's surface temperature is likely to increase by 1.5 to 2 °C by the end of the 21st century[4], followed by a projected increase by 0.3 to 0.7 °C over the next 20 years (2016 to 2035). In Punjab and broader swathe of Pakistan, these climatic shifts are more frequent & intense and have direct effects on physical, chemical and biological characteristics of the water bodies including Namal Lake. Rapid rise in temperature is endangering Namal lake life and can wipe it out entirely, if necessary restoration measures are not taken.

> *Box 2: Lake Chad*
>
> *Lake Chad in Africa is a quintessential example of lake shrinkage mainly due to drought, desertification, deforestation, and resource mismanagement in addition to climate change which drastically reduce its size by almost 90 percent in the span of 60 years. Several projects are now being carried out or considered as a part of the Lake Chad Basin to stem the shrinking and degradation, while giving more attention is water-use efficiency.*

1.1 Context

The importance and need of Namal lake restoration and management were arose during the preparation of regional development plan of Sargodha Region, which was also endorsed by District Commissioner Mianwali.

Namal Lake was formed when British engineers built the Namal Dam in 1913 to address the scarcity of irrigation and drinking water for the local residents as well as Mianwali city. Mountains surround the lake on its western and southern sides, and agriculture land is located on its other sides

The lake's surface area was approximately 5.5 square kilometers at first, but shrinkage in surface area has been observed over time. The Thal canal's construction and tube well installation have limited its uses. Hill torrents and rain are the main sources of water for the lake all year, but due to the country's climatic extremes, the surface area has shrunk alarmingly. Lakes have great significance providing freshwater for drinking purposes, preservation of biodiversity and ecosystem as well as recreational values.

In order to understand the changes in the surface area of Namal lake over the time, Landsat satellite data for all versions (4, 5, 7, 8 and 9)[5] were used. October month was selected due to maximum recharge of water bodies after monsoon period. All processing of images and analysis was done using ARC GIS tool.

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[3] MARUM - Center for Marine Environmental Sciences, University of Bremen. (2020, December 23). Climate crisis is causing lakes to shrink. ScienceDaily. (Available on: www.sciencedaily.com/releases/2020/12/201223091540.htm)

[4] IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[5] https://earthexplorer.usgs.gov/

Whereas, surface area of lake was determined by cloud masking and filling, making of polygons and then setting geometry to calculate the surface area.

1.1.1. Surface Area of Namal Lake for the year 1986 and 1995

For better comparison and estimation of change in surface area of Namal Lake, the surface area of the Lake was calculated for the year 1986 and 1995 using Landsat version 4-5 dataset. The estimation is shown in figures below.

In 1986 using Landsat 5 satellite images and after processing the area of the lake is 4.6 square kilometers approximately (dark blue is the current area whereas light blue is the actual area as in the base map) and initially, the actual area is 5.5 square kilometer approximately. The estimated decrease in surface area is 16 % and 32 % for the years 1986 and 1995 respectively.

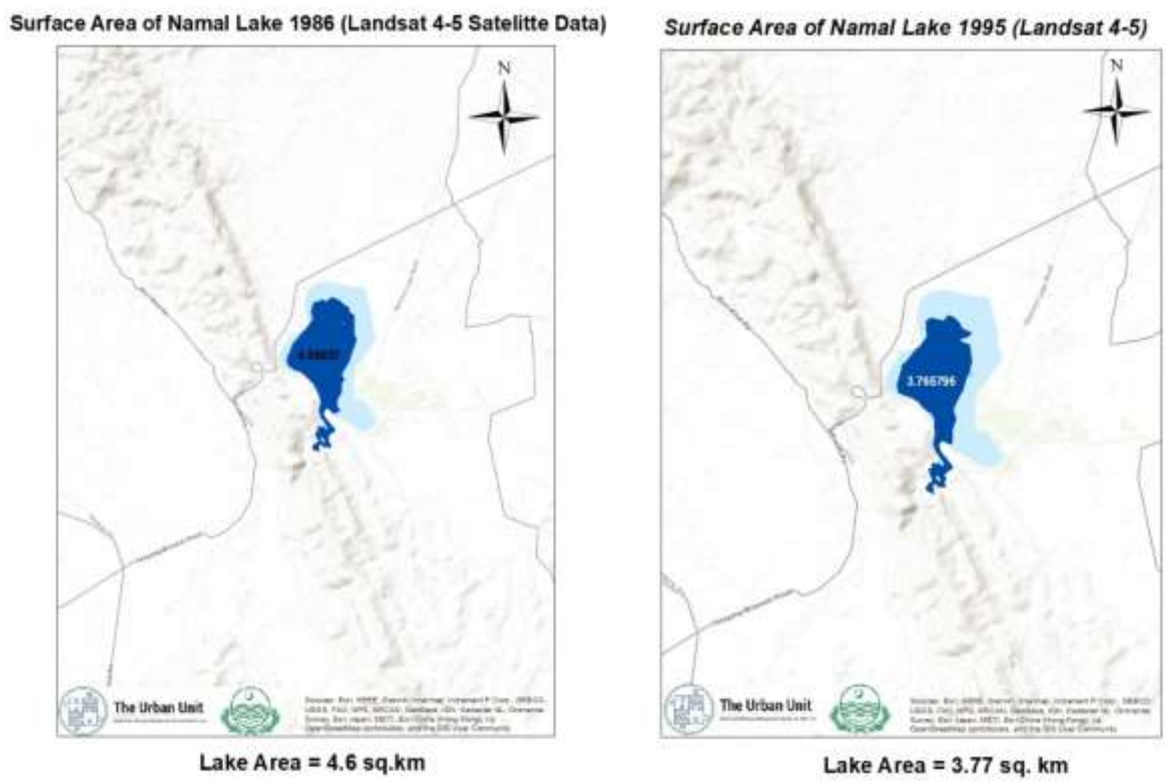

Figure 3: Surface Area of Namal Lake for the years 1986 and 1995

1.1.2. Estimated Surface Area of Namal Lake in 2000 and 2013

For the year 2000, Landsat 7 satellite data is used to find out the surface area of Namal Lake. The estimated area is 2.7 square kilometres showing 50% shrinkage in surface area. The estimated original surface area of the Lake was 5.5 square kilometres. The prolonged drought condition during this period may one reason for this high shrinkage.

Landsat 8 satellite dataset is used to estimate the surface area of the lake in 2013. The estimated surface area in 2013 is 4.6 square kilometres which are larger than in 2000. This increase in area is due to heavy rainfall and flooding conditions in 2010. Despite improving the area, shrinkage is observed as compared to the original area.

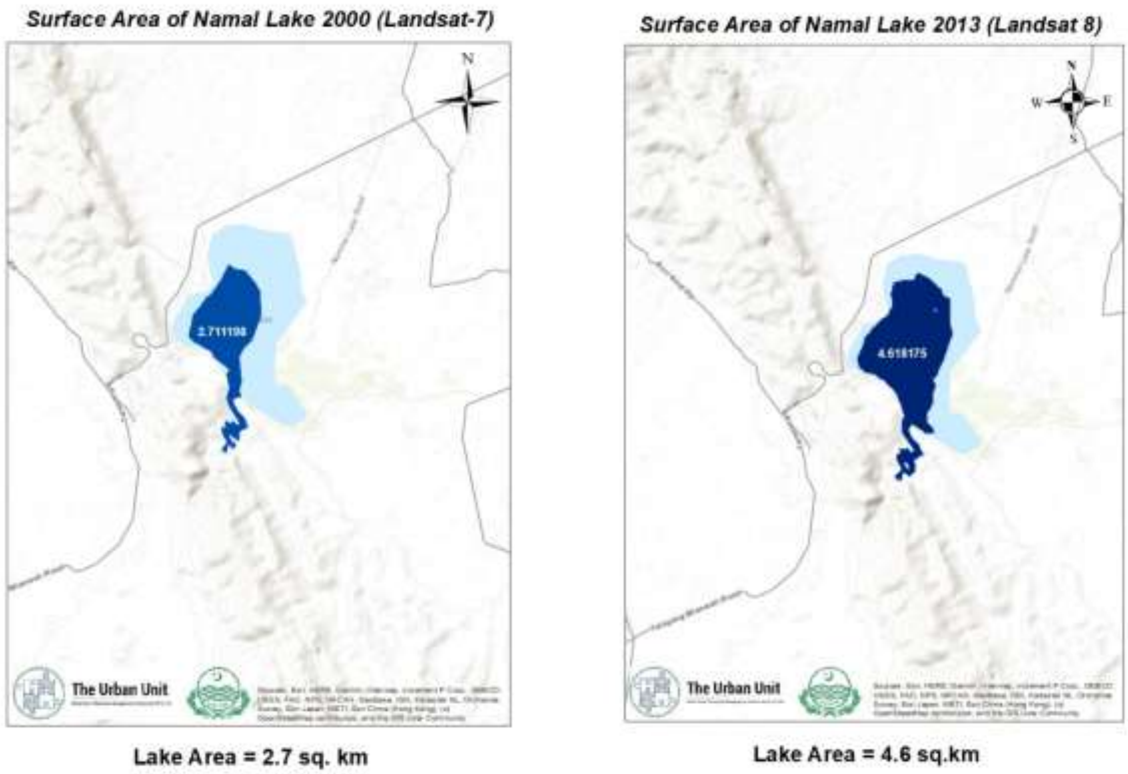

Figure 4: Surface Area of Namal Lake for the years 2000 and 2013

1.1.3. Surface Area of Namal Lake in 2018 and 2021

Landsat 8 dataset is used for the years 2018 and 2021 to calculate the surface area of Namal Lake.

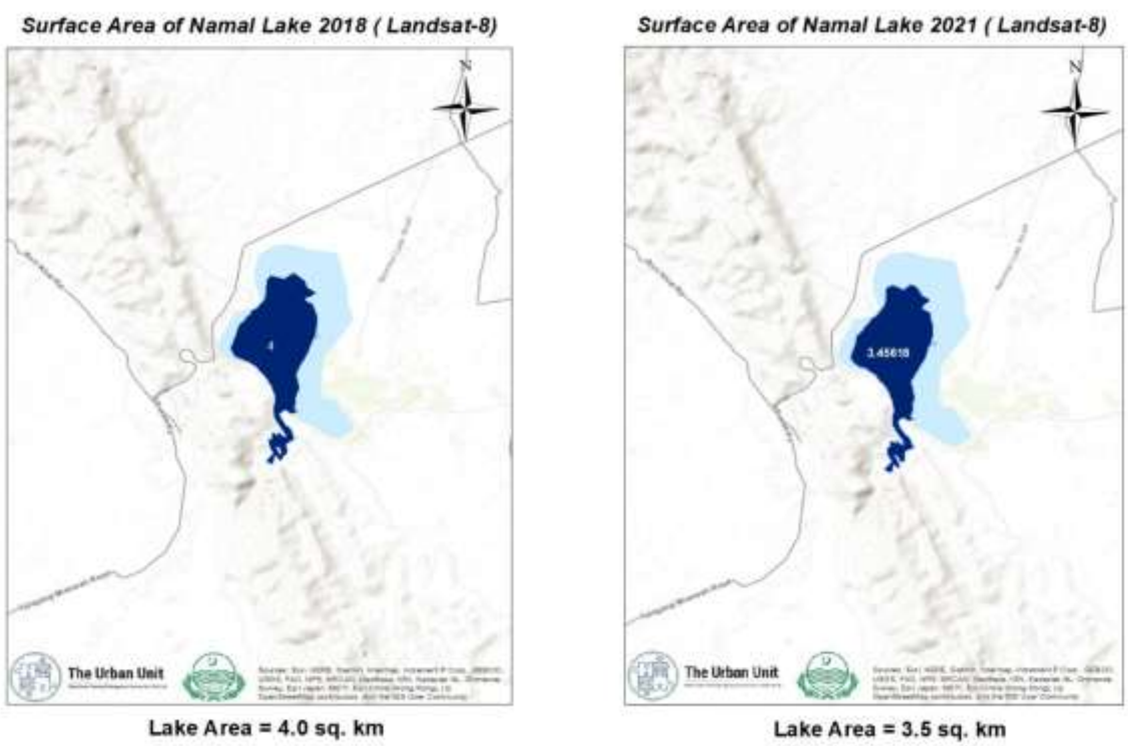

Figure 5: Surface Area of Namal Lake for the years 2018 and 2021

From the figures below, it has been observed that the surface area is gradually decreased which is mainly due to less rain (climatic changes) during this time and causing shrinkage in the area of the lake.

1.1.4. Surface Area of Namal Lake in 2022

Landsat 8 satellite data is used for this year. The figure clearly depicts the prominent decrease in the surface area of the lake.

In 2022, the surface area is 2.2 square kilometres whereas the original surface area of the lake was 5.5 square kilometres. This decrease in surface area is 57% which is the highest shrinkage during this study from 1986-2022.

Table 1: Percentage Change in Namal Lake Surface Area (1986 – 2022)

YEAR	LAKE AREA (km2)	SHRINKAGE
1986 (Oct)	4.6	16%
1995 (Oct)	3.7	32%
2000 (Oct)	2.7	50%
2013 (Oct)	4.6	16%
2018 (Oct)	4	27%
2021 (Oct)	3.5	36%
2022 (Jan)	2.4	57%

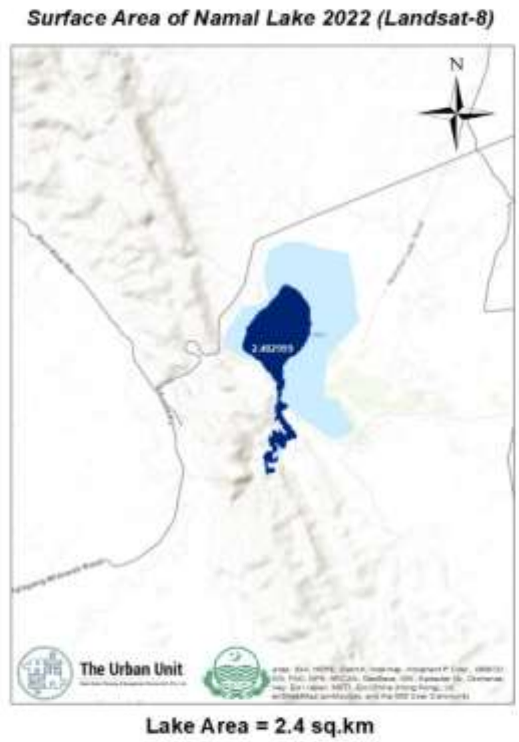

Figure 6: Surface Area of Namal Lake for the years 2022

Hence, the lake is dying and immediately require a restoration and management plan.

1.2 Vision, Goals and Objectives

Namal word is a combination of two Punjabi words "Na" means 'No' and "Mul" means 'price', given by locals in early 1900. Thus, Namal means Priceless 'The most valuable land for which no one can pay the price'.

Recognizing the importance of Namal Lake in providing diversified ecosystem services such as fresh water supply, tourism and recreation, flood & drought protection and so forth, the following section sets the vision, goals and objectives for the conservation of Namal Lake.

1.2.1. Vision

The overall vision of this plan is:

"A healthy ecology of Namal Lake through viable environmental conservation practices which foster sustainable ecotourism in the region and maintain ecological, social, cultural and economic sustainability".

Here, the term Sustainability refers to the environmental, economic and socio-cultural aspects of eco-tourism development and eco-conservation of lake through a suitable balance between these three dimensions to guarantee its long-term sustainability.

1.2.2. Goals and Objective

The intent of this Plan is to provide a comprehensive framework to achieve the overall vision through the following goals and objectives;

Goal: *"Ensure the long-term sustainability of Namal Lake ecosystem by enhancing the water quality, availability and ecological requirements along with opportunities for recreational and educational activities".*

Objectives: The core objectives of the plan include;

- Enhance the natural beauty and pristine state of the lake through conservation and restoration of ecological resources of Namal Lake
- Maintain water level through proper infrastructure planning and physical interventions
- Enhance and encourage eco-friendly tourism to connect nature and human.

1.3 Methodology

Desk study, remote sensing, asset mapping, on-ground field surveys, and stakeholder consultations were the key steps which were followed to assess the current state of Namal lake, along with major issues and challenges.

1.3.1. Preliminary Assessments:

Prior to the detailed site investigations, an extensive desk study was conducted to understand the baseline conditions such as physical environment, surface area, available landscaping, biodiversity and existing facilities at Namal lake etc. In addition to this, the applicable national, provincial and local policies, guidelines, legislation as well as International best practices and case studies were also reviewed.

On-ground field assessment is integral to observe and record existing state of the project area. Two field visits were conducted on 15th January 2022 and from 15-18th June 2022.

Area demarcation, land use survey, baseline assessment, and development planning were the key aspects of the on-ground survey. Whereas, flow data, contour maps and existing challenges of the lake were the prime discussion points with the government officers.

Community surveys and consultations with relevant government officers were also held for better understanding of the issues and challenges of Namal lake as well as to record their vision for the future development in the area.

Figure 7: Field Survey Pictures (January and June 2022)

1.3.2. Landsat Analysis of surface area of Namal Lake

The Landsat satellite dataset Bands 4, 5, 6 were used to estimate the surface area of Namal Lake from 1980 to 2022. October month was selected, due to maximum recharge of water bodies after monsoon period. All processing of images and analysis was done using ARC GIS tool. Surface area of lake has been determined by cloud masking and filling, making of polygons and then setting geometry to calculate the surface area.

1.3.3. DEM-based GIS Analysis of Streams for Namal Lake

In order to analyze the streams of Namal Lake, the STRM - Shuttle Radar Topography Mission elevation data was used. At first, the geographic coordinate system was converted into a projected coordinate system (Universal Transverse Mercator Zone 42N). Then, the condition of the hydrological path was corrected by creating a grid of seamless elevations without any peaks or sinks. Flow direction and accumulation were calculated by using algorithm. The stream was defined using the function of Stream Definition with a threshold value of cells. The threshold value is defined on the basis of the minimum upstream drainage area which can maintain the stream. The threshold value of 1000 cells applied to calculate the stream network. The stream order was derived using the Strahler scheme[6]. The catchments

[6] Strahler, A. N. (1957). Quantitative analysis of watershed geomorphology. Eos, Transactions American Geophysical Union, 38(6), 913-920.

area is defined on the basis of flow direction and stream network using the function of adjoint catchment polygon processing present in Archydro tool.

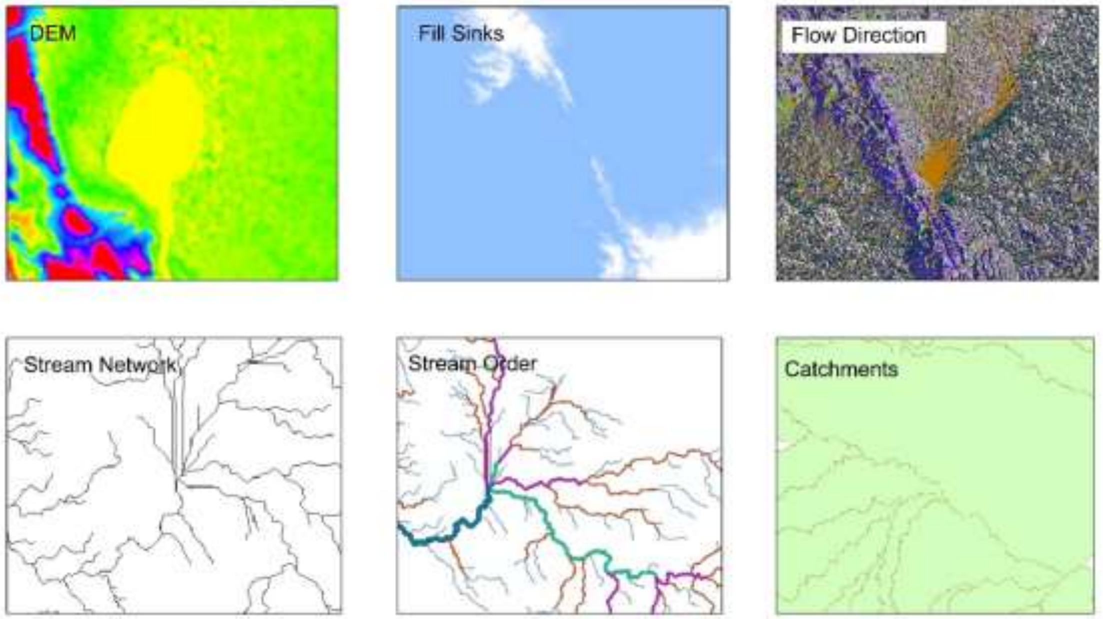

Figure 8: DEM-based GIS Analysis of Streams

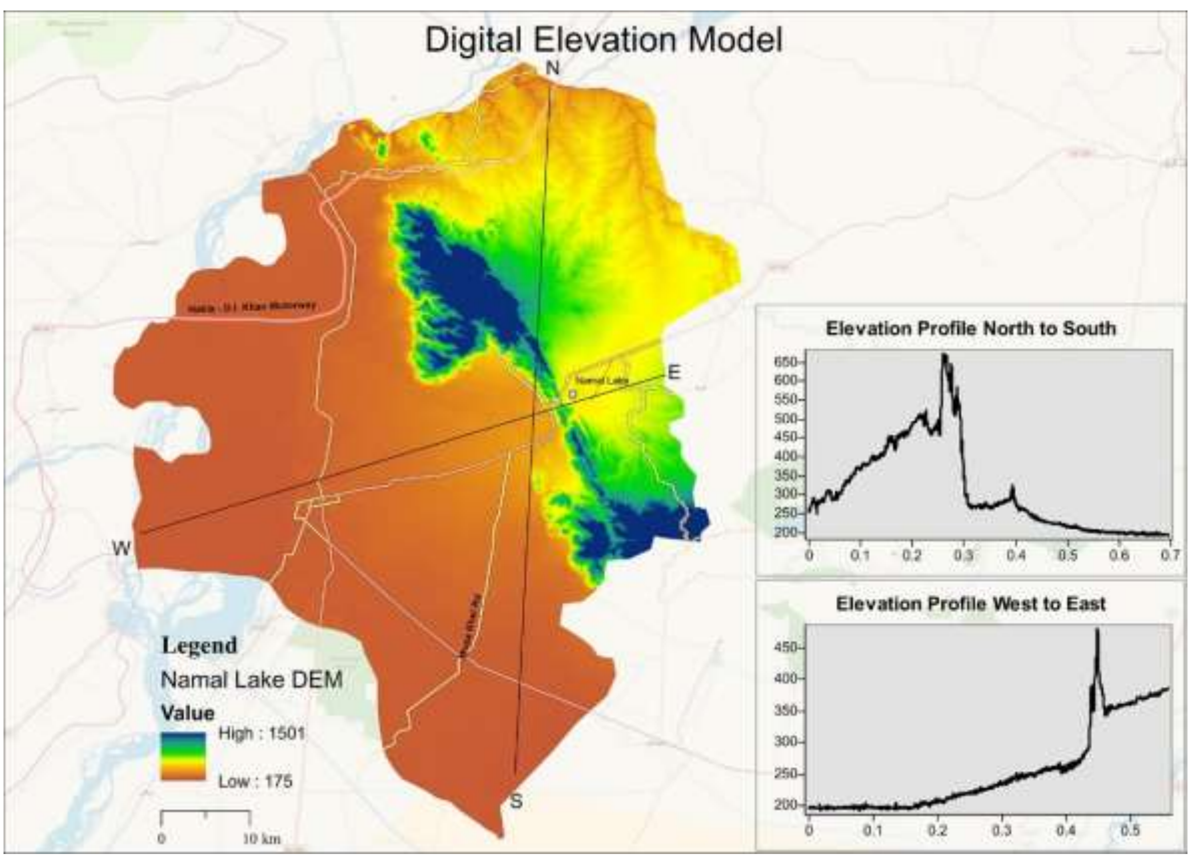

Figure 9: Digital Elevation Model

1.3.4. Flow analysis of Namal lake

In order to assess the flow analysis of Namal lake and to design a drainage system to channel the flow, the following steps were taken;

- Secondary data on rainfall
- Calculation of mean monthly, max. monthly and min monthly rainfall w.r.t month.
- Calculation for annual rainfall
- Selection of Flow coefficient
- Calculation of flow in Namal lake on a monthly basis
- Calculation of annual flow in Namal lake
- Calculation for monsoon flow in Namal lake
- Design of drainage system to channelize the flow in the lake

1.3.5. SWOT Analysis of Namal Lake

To further strengthen the process and gain a better understanding, a SWOT (Strengths, Weaknesses, Opportunities, And Threats) analysis of Namal Lake was performed, allowing key interventions in the project area. Gap analysis of the Namal Lake regarding recharge and siltation was also critical components of restoration and development planning.

1.3.6. Conceptual designing of proposed interventions

Primarily the 2d drawings of the proposed interventions were developed in AutoCAD which includes the plans, elevation, sectional details of Namal lake landscapes, allied facilities such as toilet block, history wall, museum etc. These 2d designs were then imported to 3d modelling software i.e. Sketch-up 2017. Lights and overall environmental settings are developed to conceptualize the proposals for better understanding.

1.3.7. Development of Restoration and Management Plan

On the basis of field surveys, desk studies, stakeholder consultations and multi-analysis through remote sensing, GIS and other softwares, a Restoration and Management Plan of Namal Lake is developed which provides a set of potential interventions and site-specific action plans with costing.

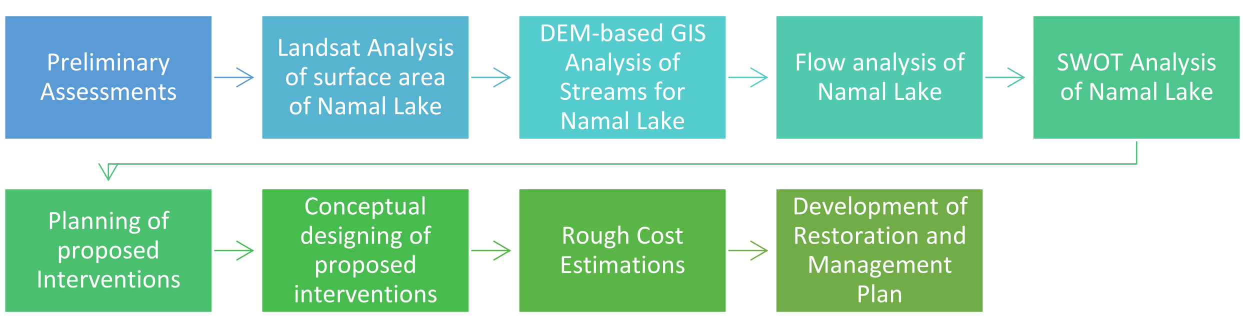

Figure 10: The Overall Methodology

Environmental Situational Analysis

Namal valley is blessed with unique topography in which numerous lakes are bounded by mountainous ranges. Among all the numerous lakes, which speckled in the Namal Valley and stretch up to Soon Sakesar Valley, the Namal Lake is the most visible and at the top of arch. However, the current state assessment of Namal lake through earth observation and ground based assessment, exhibits a gloomy picture and indicating an immediate requirement of restoration and management actions to revive the lake ecology – back to the root.

Figure 11. Namal Lake View

2.1 Climate

The climate of the valley is generally characterized as hot-humid and warm in low lying areas whereas dry and cold at high altitudes. Generally, the project site experienced following distinct climatic variations:

- Hot and dry (when the temperature reaches up to about 45 °C); April - June
- Rainy season (monsoon rainfall); July - September;
- Cool/foggy/mild weather (Temperatures drop to as low as freezing point); October - March
- Yearly Temperature Change Namal

The Mean Yearly Temperature Trend during the year 1979-2021 shows the dashed blue line which represents the linear climate change trends which is increasing from left to right thereby depicting that temperature trend is 'positive' and Namal area is getting warmer over time (in last 40 years) due to Climate change. The lower part of the graph representing the warming stripes; blue stripes for colder and red for warmer years, which clearly depicting the substantial increase in temperature level.[7]

[7] *Meteoblue.com*

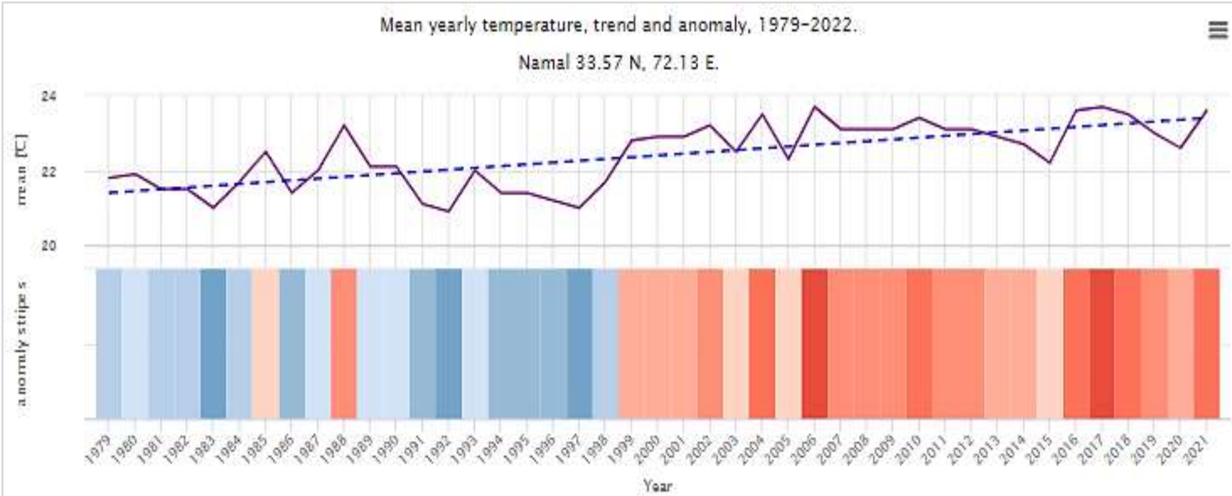

Figure 12: Mean Yearly Temperature, Trend and Anomaly (1979-2022)

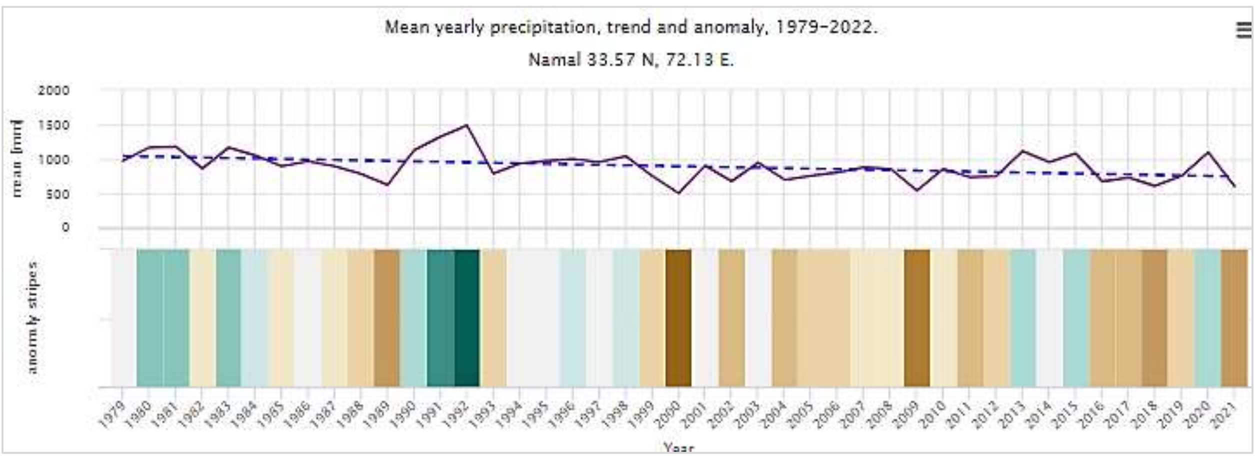

Figure 13: Mean Yearly Temperature, Trend and Anomaly (1979-2022)

The Mean Yearly Precipitation Trend during the year 1979-2021 representing the linear climate change trends which is moving slightly down thereby depicting that precipitation trend of the district is declining and the Namal area is receiving less rainfall rain fall (roughly 200mm less from average line) over time (in last 40 years) due to Climate change. The lower part of the graph representing the precipitation stripes; blue stripes for wetter and brown stripes for drier years. Increase in drier period are quite visible in the last two decades.[8]

2.1.1. Climate Risk and Hazard Assessment:

As per the 5th Assessment Report of the Intergovernmental Panel on Climate Change, the climate change risks are concentrated in urban areas of Punjab. Heat stress/Urban Heat Island (UHI), extreme precipitation, inland flooding, landslides, air pollution, drought, and water scarcity are some of them.

As per the climate risks and hazards classification, the Mianwali district falls in following category;[9]

[8] Ibid at 8
[9] Chaudhry, Q. 2017. *Climate Change Profile of Pakistan*. Asian Development Bank, Philippines. doi.org/10.22617/TCS178761

Table 2: District Level Climate Risk and Hazard Assessment Classification[10]

Rank	District	Flood Risk	Landslide Risk	Earthquake Risk	Tsunami Risk	Cyclone Risk	Drought Risk	Avalanche	GLOF Risk
59	Mianwali	4	4	3	-	2	2	1	1
Scoring Key									
		Very High	High	Medium	Low	Very Low	Non-Hazard		
		5	4	3	2	1	-		

The above table shows that the flood and landslide risk is much higher in Mianwali district. The project area is particularly affected by heavy flooding in the past and are at a high risk of Floods. Frequent hill torrents have severely affected the houses, road network and crops. The 2015 hill torrents hit the residential infrastructure and almost all the main and link roads had been washed away. The main road of the Namal valley i.e. Defense Road (from Ban Hafiz JI, Sakesar connecting Mianwali Airbase to the PAF) was damaged. The Dhok Karsial bridge wiped away and the adjacent roads like Dhok Miana-Pira road, Dhurnaka-Namal, Chah Ugral-Main Road, Bhir Shah Nawaz-Dhok Ali Khan, and Chakda-Dhok Ghazi Khan were also badly affected due to torrents.[11] The floods 2022 due to the unprecedented rains have also badly affected district Mianwali, made thousands of people homeless. Loss of livestock and human lives, damage to the infrastructure and financial losses could not be ignored either.

Earthquakes in the project area are not frequent, however, occasionally shocks having less intensity are recorded in the past.[12] According to the Seismic zoning of Pakistan the area lies in seismic zone 2 B and represents minor damage. Kalabagh fault is a prominent right-lateral strike-slip fault which extends between Kalabagh and Mianwali. It truncates at the western margin of the Salt Range.

2.1.2. Temperature and Precipitation

June is considered as the hottest month with average maximum temperatures is 42°C; whereas, January is considered as the coolest month in which monthly average temperature can be as low as 3 to 4°C. Sunshine hours depend upon the length of days; for example, May, June, & July have long days with more sunshine hours as compared to December & January average annual rainfall of about 250mm – 385mm.

The rainy season usually starts in July and ends in September. More rains are experienced in monsoon season i.e., from July–August. Most of the winter rains are received in the months of January– March.[13] July, August and September are the most humid months, whereas May and June are the least humid months. The average monthly humidity varies from 53% to 62%, fluctuating with the climate variables.

[10] Ibid
[11] https://hapka.info/archive/20150808/169598/namal-valley-hill-torrent-victims-await-relief/
[12] Development of Bhalawal Industrial Estate Sargodha. Environmental Impact Assessment Report, 2018. Punjab Industrial Estate Development and Management Company.
[13] Development of Bhalawal Industrial Estate Sargodha. Environmental Impact Assessment Report, 2018. Punjab Industrial Estate Development and Management Company.

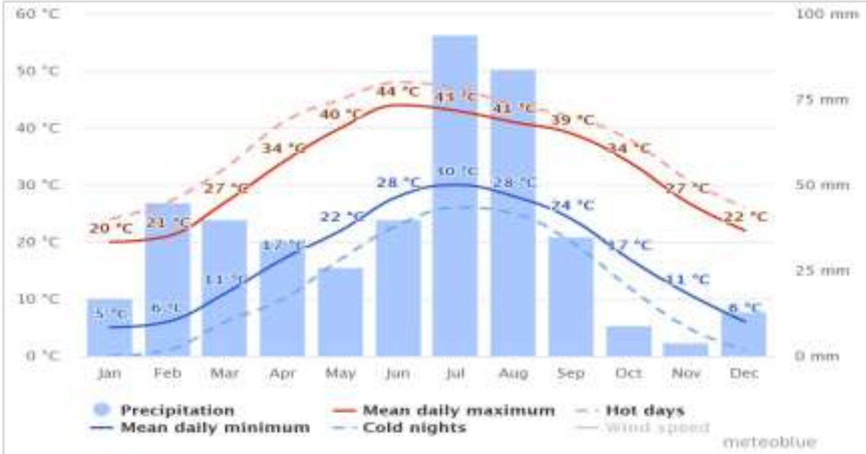

Figure 14: Average Temperature and precipitation pattern of Namal Valley, 2021

2.2 Ambient Air Analysis

No significant sources of air pollution were observed at or near the vicinity of Namal Valley except vehicular emissions. There is one ground-based air monitoring station is available at Musa Khel so the AQI estimations for Namal are based on satellite PM2.5 data i.e. real-time modelled data (air quality index) of a specific time period[14] .

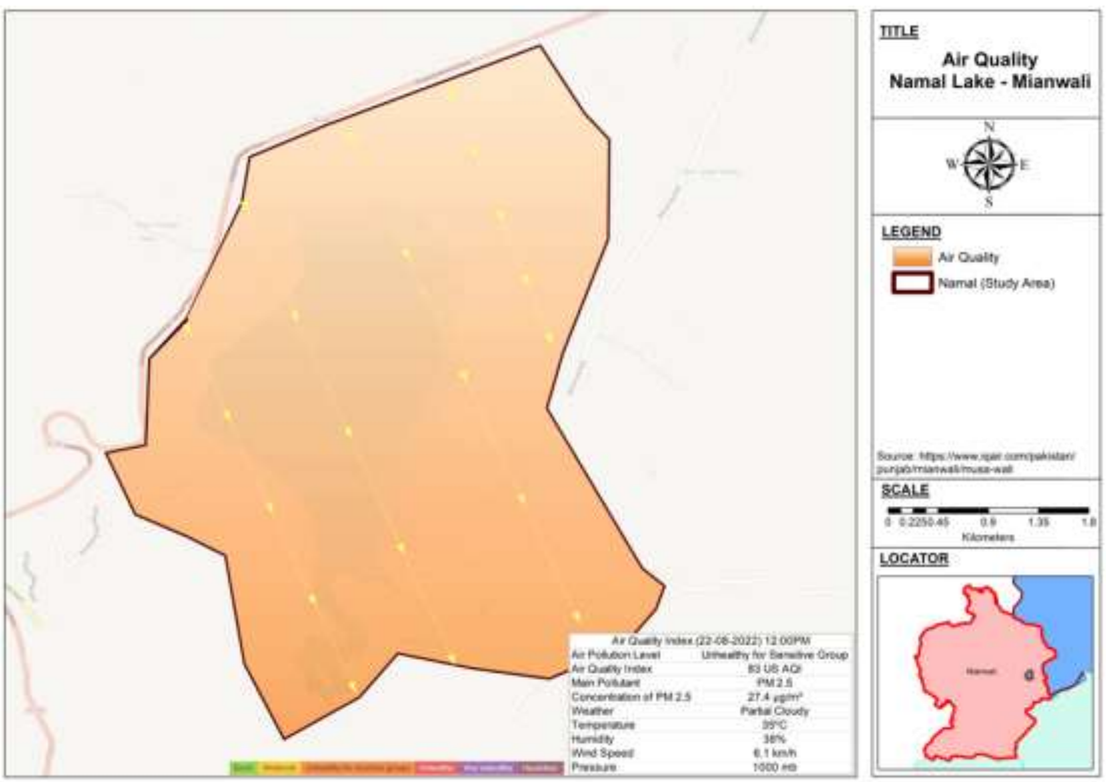

Figure 15: Estimated AQI Index of the Project Area (2022)[15]

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[14] https://www.iqair.com/pakistan/punjab/mianwali retrieved on 20.07.2022 at 10:00 am
[15] Ibid

The overall trend is moderate to unhealthy in the overall district as the AQI can be varied throughout the year based on pollution sources and meteorological parameters.

2.3 Water Quality

The water Quality of Namal Valley is assessed by to determine the pollution load. Anthropogenic inputs and geochemical processes are the more inclined sources for varied concentrations of heavy metals in the Namal Lake.

In 2010, EPA Punjab conducted a water quality testing survey of all 9 lakes of Punjab. The results of Namal lake depicted higher values of TDS, Sulphate (3.5 times) and Sulfide (12 times) exceed the NEQS limits.

Table 3: Water Quality of Namal Lake (EPA, 2010)[16]

Temp. ^{0}C	pH	DO mg/l	BOD mg/l	COD mg/l	TDS mg/l	TSS mg/l	Cl mg/l	Sulphate mg/l	Sulfide mg/l
PEQS	**6-9**	**-**	**80**	**150**	**3500**	**200**	**1000**	**600**	**1.0**
24.3	8.9	8.7	40	90	3780	10	751	2056	12

Another study of 2018 reported higher level of heavy metals As, Fe, Cu, Cd, Co, Cr, Mn, Pb, Ni, V and Zn than the permissible limit.[17]

The study estimated the pollution load index and risk index which exhibited considerable risk to the lake ecology. Further, cluster analysis identified Arsenic and Cadmium occurrence due to the agricultural runoff in catchment areas and combustion of fossil fuels. The higher correlation between Aluminum and Copper reported, which may be to weathering processes, plant decay, and/or domestic waste. In contrast, Cobalt, Ferrous, Manganese and Lead was reported with minor enrichment due to agricultural runoff and discharges from domestic wastes from catchment areas into the Namal lake.[18]

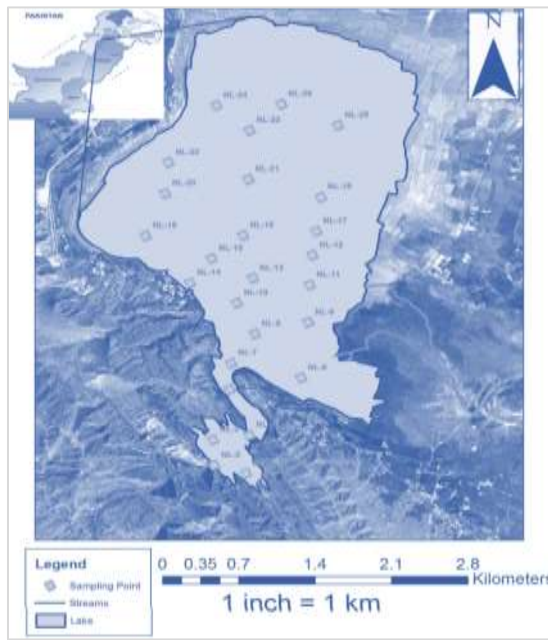

Figure 16: Sampling Locations for heavy metal analysis at Namal Lake

2.4 Over-abstraction

Over-abstraction of Namal lake is another major contributor to the Namal lake shrinkage. Almost 6 weeks a year (October-November), local people extract Namal Lake water for irrigation purposes which has substantially reduced intermittent water flow and lowered lake and groundwater levels. This situation is further deteriorated by reduction of mean annual precipitation in the area resulting in drying up of lake.

[16] EPA Punjab. 2010. *Water Quality of Lakes.* Government of Punjab. Lahore.

[17] Tariq Javed, T., Ahmad, N. and Mashiatullah, A. 2018. *Heavy Metals Contamination and Ecological Risk Assessment in Surface Sediments of Namal Lake*, Pakistan. Political Journal of Environmental Studies. 27(2): 675-688.

[18] Ibid

2.5 Catchment Area, Discharge and Siltation

Namal Lake depends on the rainfall that comes from the catchment area of Golar, Trappi, Rikhi, and Namal. Namal Lake used to augment irrigation needs of the Mianwali district through Namal Canal for 6 weeks in a year. An uninterrupted flow of silt into the catchment area of the lake raised the surface level of the lake by 50 feet in 100 years[19]. Siltation in the lake ceases the working of the gates of Namal Dam. Water is collected into the lake by the gravity flow that causes the meandering of the streams. Siltation also deteriorates the passage of the main streams that are natural discharge channels of the Namal Lake. The meandering of the streams causes loss of a large proportion of discharge.

Table 4: Remote sensing based calculated area of Catchment for Namal Lake

Sr. No.	Name of Catchment	Area of Catchment (Acres)
1	Golar Catchment	37905
2	Trappi Catchment	19125
3	Un-named	25970
4	Un-named	7759
5	Un-named	429
6	Rikhi Catchment	2915
	Total Catchment Area of Namal	96667

Water flowing from the Golar catchment area also shares a major share of silt because water with higher velocity unleashes the erosion downstream of the catchment area. The absence of energy dissipating blocks makes it more vulnerable to erosion. It is very important to dissipate the energy of coming water providing energy dissipating blocks. It will alleviate the risk of damage to the lives and belongings of people who are living in the vicinity of the Namal Lake catchment. In the floods of 2015, the depth of water was 25 feet from the surface level of the lake which causes flooding in the nearly situated Namal University and Government schools. The depth of the water in the dry season decrease to 5 feet.

Climate change is affecting the average annual rainfall badly due to which area of the lake is squeezing by 57 % from its inception. The drastic change in the flow causes problems in the management of the water of Namal Lake. Due to extreme variation in the flow in Namal Canal that is generated by the rainfall, it is not possible to do the water management for agricultural purposes.

It is necessary to monitor variation in the rainfall and discharge. Currently there is no discharge or rainfall measuring devices at the site. It will make it possible to estimate the discharge that may be used to augment agricultural needs.

19

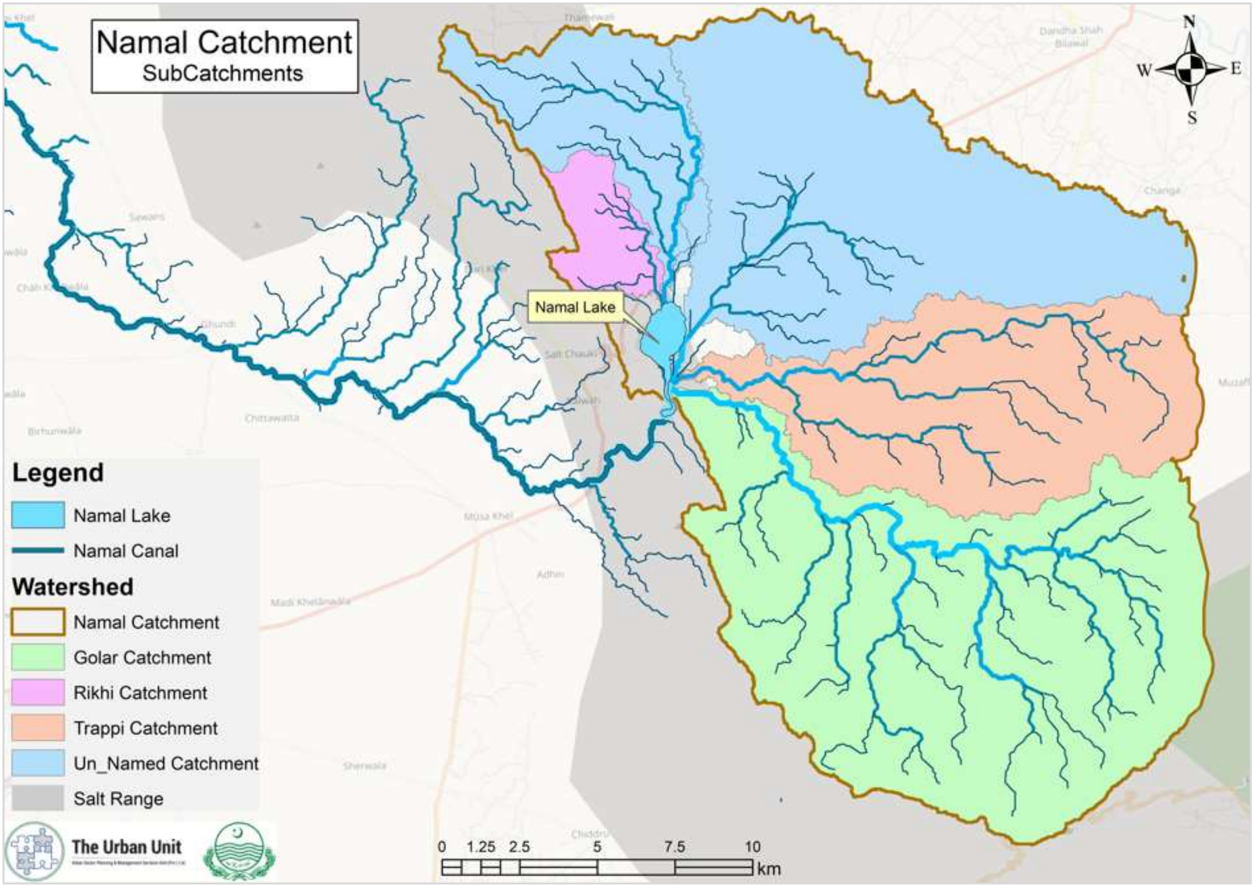

Figure 17: Map of Catchment Area of Namal Lake

2.6 Biological Environment

2.6.1. Flora

Studies have revealed that around 56-68 types of plant species belonging to 34-38 families of kingdom plantae have been found around the Namal Lake vicinity.[20] At lower altitudes, the Namal Valley is carpeted with *Prosopis glandulosa, Tamarix aphylla, Dodonaea viscosa, Withania coagulans, Tephrosia pupurea, Pulicaria glutinosa, P. juliflora, Pluchea arabica, T. dioica,* and *Rhazya stricta* whereas, at higher altitudes *Acacia modest,a* and *Salvadora oleoides* are commonly seen. Apart from that, *Pseudogaillonia hymnostephana* and *Viola cinerea* are also found in the valley but they have rare occurrence.[21] This plant diversity of the region also plays an important role to conserve and attract avifauna of the region and also used for medicinal purposes by the local people of nearby villages. The secondary data and public consultations revealed that major threats to flora and fauna of the region are deforestation, destruction of natural habitat and poaching of birds leading to a reduction in flora and fauna of Namal Lake vicinity as the greater flamingo was the key migratory winter resident of namal lake.

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[20] Khan, A. N., Huda, N., Akram, M., Rasheed, Z. M., Irfan, T., Basit, A. and Hussain, S. A. 2019. Floral diversity of Namal valley Mianwali in Salt range of Pakistan. *International Journal of Biosciences*. 15(5): 610-614.

[21] Shah, A., Poudel, R. C., Ishtiaq, M., Sarvat, R., Shahzad, H., Abbas, A., Shoaib, S., Nuzhat, R., Noor, U. D., Mahmooda, H., Summaya, A., Ifra, A. and Ihsan, U. 2019. Ethnobotanical Study of Medicinal Plants of Namal Valley, Salt Range, Pakistan. *Applied Ecology and Environmental Research*. 17(2):4725-4805.

Table 5: Plant Diversity of Namal Lake

Family	***Species Scientific Name***	**Common Name/ English Name**	**Habit**	**Life Form**
Acanthaceae	*Justicia adhatoda*	Vaheker	Shrub	Perennial
Amaranthaceae	*Achyranthes aspera var. aspera*		Herb	Perennial
	Aerva javanica var. bovei	Bui	Subshrub	Perennial
	Aerva javanica var. javanica	Bui	Subshrub	Perennial
	Amaranthus graecizans	Pigweed	Herb	Annual
	Amaranthus viridis	Green Amaranth	Herb	Annual
	Digera muricata	Tandla	Herb	Annual
Apiaceae	*Foeniculum vulgare*	Sonf	Herb	Perennial
Apocynaceae / Asclepiadaceae	*Calotropis procera*	Ak	Shrub	Perennial
	Rhazya stricta	Vana	Subshurb	Perennial
	Caraliurna tuberculata	Chougan	Herb	Perennial
Asteraceae	*Conyza bonariensis*	Asthmaweed	Herb	Annual
	Echinops echinatus	Unt Katara	Herb	Perennial
	Eclipta alba	Bhangra	Herb	Perennial
	Sonchus asper		Herb	Annual
Boraginaceae	*Trichodesma indicum*		Herb	Annual
	Heliotropium strigosum	Gorakh Pan	Herb	Perennial
Brassicaceae	*Brassica nigra*		Herb	Annual
Canabaceae	*Canabis sativa*	Bhang	Herb	Annual
Capparidaceae	*Capparis decidua*	Karir	Tree	Perennial
	Capparis spinosa	Kari	Shrub	Perennial
	Cleome viscosa		Herb	Annual
Chenopodiaceae	*Chenopodium album*	Bathu	Herb	Annual
Cucurbitaceae	*Citrullus colocynthis*	Kor Tumma	Herb	Perennial
Euphorbiaceae	*Euphorbia helioscopia*	Chatri Dodak	Herb	Annual
Lamiaceae	*Mentha arvensis*	Podina	Herb	Annual
Liliaceae	*Allium ascalonicum*	Jangli podina	Herb	Annual
	Aloe vera	Gandal	Herb	Annual
	Linum usitatissimum	Asli	Herb	Annual
Malvaceae	*Abutilon indicum*	Pataka	Shrub	Perennial
	Malva neglecta	Saunchal	Herb	Annual
	Malvastrum coromendelianum	Sonchal	Herb	Annual
	Salvia moorcroftiana	Lupra	Herb	Annual
Mimosaceae	*Acacia jacquemontii*	Banwali	Tree	Perennial
	Acacia nilotica	Kikar	Tree	Perennial
	Albizia lebbeck	Siris	Tree	Perennial
	Lathyrus aphacea	Dokani	Herb	Annual
	Prosopis cineraria	Jandi	Tree	Perennial
	Prosopis juliflora	Sindhi Kikar	Shrub	Perennial
Moraceae	*Morus alba*	Shahtoot	Tree	Annual
Myrteraceae	*Eucalyptus alba*	Sufaida	Tree	Perennial
	Eucalyptus camaldulensis	Sufaida	Tree	Perennial
Nyctaginaceae	*Boerhavia diffusa*	Punarnava	Herb	Annual
Oleaceae	*Olea ferruginea*	Kau	Tree	Perennial
Oxalidaceae	*Oxalis corniculata*	Khatti Buti	Herb	Annual
Papilionaceae	*Alhagi maurorum*	Jawahan	Shrub	Perennial
	Dalbergia sissoo		Tree	Perennial

Family	*Species Scientific Name*	Common Name/ English Name	Habit	Life Form
	Melilotus alba		Herb	Annual
	Rhynchosia minima		Herb	Annual
Poaceae	*Cyanodon dactylon*	Lawn grass	Herb	Annual
Polygonaceae	*Polygonum plebejum*	Dremak	Herb	Annual
Portulaceae	*Portulaca oleracea*	Lonak	Herb	Annual
	Portulaca quadrifida	Lonak	Herb	Annual
Primulaceae	*Anagallis arvensis*	Chickweed	Herb	Annual
Ranunculaceae	*Ranunculus sceleratus*		Herb	Perennial
Resedaceae	*Oligomeris linifolia*		Herb	Annual
Rhamnaceae	*Ziziphus mauritiana var. spontanea*	Beri	Tree	Perennial
	Zizyphus nummularia	Beri, Ber	Tree	Perennial
	Zizyphus spina-christi	Beri	Tree	Perennial
Rosaceae	*Potentilla heynii*		Herb	Annual
Salvadoraceae	*Salvadora oleoides*	Jal, Pilu, Wan	Tree	Perennial
Scrophulariaceae	*Varbascum thapsus*	Gidhar	Herb	Annual
Solanaceae	*Datura fastuosa*	datoora	Herb	Annual
	Datura innoxia	Datoora	Herb	Annual
	Solanum incanum	Jangli Baigan	Herb	Annual
	Solanum nigrum	Mako	Herb	Perennial
	Solanum surattense	Kandiari	Herb	Perennial
	Withania coagulens	Paneer	Shrub	Perennial
	Withania somnifera	Aksen	Shrub	Perennial
Tamaricaceae	*Tamarix aphylla*	Ukhan, Moora	Tree	Perennial
	Tamarix dioica	Lai	Shrub	Perennial
Urticaceae	*Urtica dioica*	Joomi	Herb	Annual
Verbenaceae	*Phylla nodiflora*		Herb	Annual
Violaceae	*Viola serpens*	Lillio	Herb	Annual
Zygophylaceae	*Tribulus terrestris*	Bhakhra	Herb	Annual
	Zygophyllum simplex	Alethi, Lonak	Herb	Annual


Prosopis juliflora


Salvadora oleoides


Acacia modesta


Pheonix dactylifera


Eucalyptus camaldulensis


Rhazya stricta

Figure 18: Common flora in the project area

Alongside Namal Lake, cluster of trees are present which mostly contains dates, masqad, kikar species. Natural plant vegetation of Namal Valley is exposing to different anthropogenic disturbances such as agriculture activities and harvesting of medicinal plants by uprooting.

Study conducted by Rizwan *et al.* revealed that such disturbances increased the minerals and amino acids content as well as phytochemicals (particularly tannins, alkaloids, saponin, terpenoids, flavonoids and steroids) in the native plant species predominantly in *Grewia tanax, Pu-licaria edmondsonii, Tephrosia purpurea, Pentatropis spiralis*.[22]

2.6.2. Fauna

Namal Lake is an aquatic habitat surrounded by a hilly terrain which is the home of some important avifaunal and mammalian fauna of the region. Previous studies reported around 47 types of birds at Namal Lake and its vicinity which were the main attraction for bird watchers, nature lovers and wildlife conservators, which are now reducing day by day. The fauna diversity of lake is given in table below;

Table 6: Bird Diversity of Namal Lake

Common Name	**Scientific Name**	**Listing**	
		IUCN Status	**CMS Appendix**
Bank Myna	*Acridotheres ginginianus*	LC	-
Barn or Common Swallow	*Hirundo rustica*	LC	-
Bay-Backed Shrike	*Lanius vittatus*	LC	-
Black Kite	*Milvus migrans*	LC	-
Black or Eurasian Coot	*Fulica atra*	LC	-
Black Redstart	*Phoenicurus ochruros*	LC	-
Black-Winged Stilt	*Himantopus himantopus*	LC	-
Blue Rock Pigeon	*Columba livia*	LC	-
Blue-Throat	*Luscinia svecica*	LC	-
Collared Dove	*Streptopelia decaocto*	LC	-
Common Babbler	*Turdoides caudatus*	LC	-
Common Black-Headed Gull	*Larus ridibundus*	LC	-
Common Crow Pheasant	*Centropus sinensis*	LC	-
Common Myna	*Acridotheres tristis*	LC	-
Common Pochard	*Aythya ferina*	VU	-
Eurasian Chiff Chaf	*Phylloscopus collybita*	LC	-
Gadwal	*Anas strepera*	LC	-
Gray River Tern	*Sterna aurantia*	VU	-
Great Egret	*Ardea alba*	LC	I[23]
Great Tit	*Parus major*	LC	-
Grey Heron	*Ardea cinerea*	LC	I
Grey Partridge	*Francolinus pondicerianus*	LC	-
Hoopoe	*Upupa epops*	LC	-
House Crow	*Corvus splendens*	LC	-
House Sparrow	*Passer domesticus*	LC	-

[22] Rizwan, M., Ahmad, K., Khan, I., Ahmed, I., Nazar, S., Bashir, H. 2021. Studies on Nutritional Physicochemical and Functional Composition of Four Selected Plants of Namal Valley (Mianwali) Punjab Pakistan. *Fresenius Environmental Bulletin*. **30**: 4975-4983.

[23] CMS Appendix I comprises migratory species that have been assessed as being in danger of extinction throughout all or a significant portion of their range. *LC - Least Concern; VU - Vulnerable*

Common Name	Scientific Name	Listing	
		IUCN Status	CMS Appendix
Indian Carmorant (Shag)	*Phalacrocorax fuscicollis*	LC	-
Indian Pond Heron	*Ardeola grayii*	LC	-
Indian Tree Pie	*Dendrocitta vagabunda*	LC	-
Jungle Babbler	*Turdoides striata*	LC	-
Lesser Whitethroat	*Sylvia curruca*	LC	-
Little Carmorant	*Phalacrocorax niger*	LC	-
Little Grebe or Dabchick	*Tachybaptus ruficollis*	LC	-
Little White Egret	*Egretta garzetta*	LC	-
Long-Tailed Shrike	*Lanius schach*	LC	-
Mallard	*Anas platyrhynchos*	LC	-
Marsh Harrier	*Circus aeruginosus*	LC	-
Northern Pintail	*Anas acuta*	LC	-
Oriental Turtle Dove	*Streptopelia orientalis*	LC	-
Pied Kingfisher	*Ceryle rudis*	LC	-
Red-Vented Bulbul	*Pycnonotus cafer*	LC	-
Red-Wattled Lapwing	*Hoplopterus indicus*	LC	-
Shoveler	*Anas clypeata*	LC	-
White Browed Wagtail	*Motacilla maderaspatensis*	LC	-
White Eared Bulbul	*Pycnonotus leucotis*	LC	-
White Or Pied Wagtail	*Motacilla alba*	LC	-
White-Breasted Kingfisher	*Halcyon smyrnensis*	LC	II[24]
White-Tailed Lapwing	*Chettusia leucura*	LC	-


Black Winged Stilt


Red Wattle Lapwing


Great Blue Heron


White Browed Wagtail


Little Egret


Common Myna

Figure 19: Key Avifauna in the project area

[24] CMS Appendix II covers migratory species that have an unfavorable conservation status and that require international agreements for their conservation and management.

Purple Heron, Large Egret and small egret are found as local migrant while all other recorded as rare/occasional birds. Among the passage migrant, only Grey Heron is the winter visitor to the project area. Other winter visitors include Common Pochard which is vulnerable and facing decline in population. Rest include Common Coots, Black stilt, red lapwing, Yellow Wagtail and Large-pied Wagtail.

2.6.3. Solid Waste

There is no proper dumping area for solid waste disposal in the project area. Open dumping alongside the roads or open area is common practice.

2.6.4. Management Issues

Following management issues are identified during field survey and consultation meetings with key stakeholders;

- Lack of coordination between various line departments has badly affected the ecological integrity of the lake and its surroundings.
- Weak law enforcement has increased the illegal hunting, over-abstraction of lake water, pollution in the lake from human activities from the adjoining areas, extraction of fuelwood from the catchment area, cutting of vegetation by adjacent communities, excessive livestock grazing in the lake adjacent areas, and so forth.
- Inadequate technical capacities of the field staff is another matter of concern.
- Absence of awareness and knowledge information about the game reserve importance, key species (wild life), legal obligations etc.

2.6.5. SWOT Analysis

The Strength, Weakness, Opportunity and Threat (SWOT) analysis of the project area is given in figure 20.

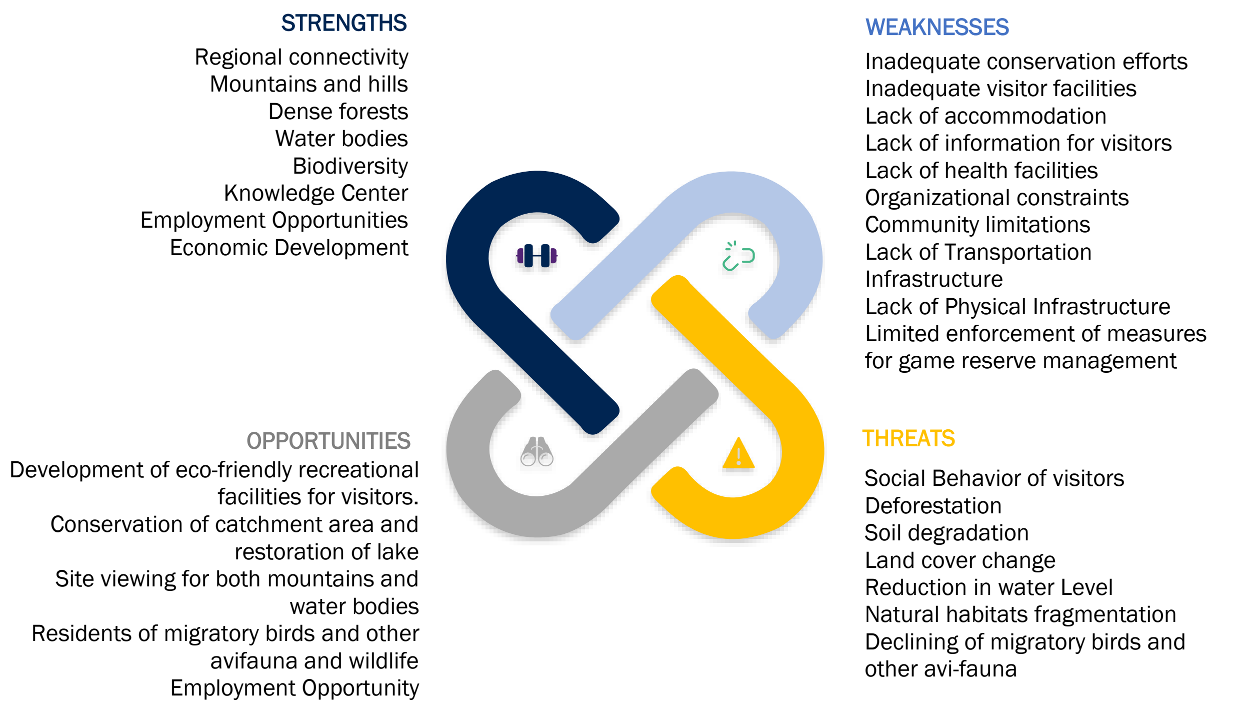


Figure 20: SWOT Analysis

2.6.6. Land cover and land use

The landcover and landuse analysis provided following information;

- The study area witnessed a large number of bushes and sparse vegetation (50 %) on the east and cropland on the west (40%). Water is passed through the southeast along the settlements and the total percentage of water bodies accounts for 5.19%. Dense tree covers 1.84% and settlements 3.35% of the total project area.

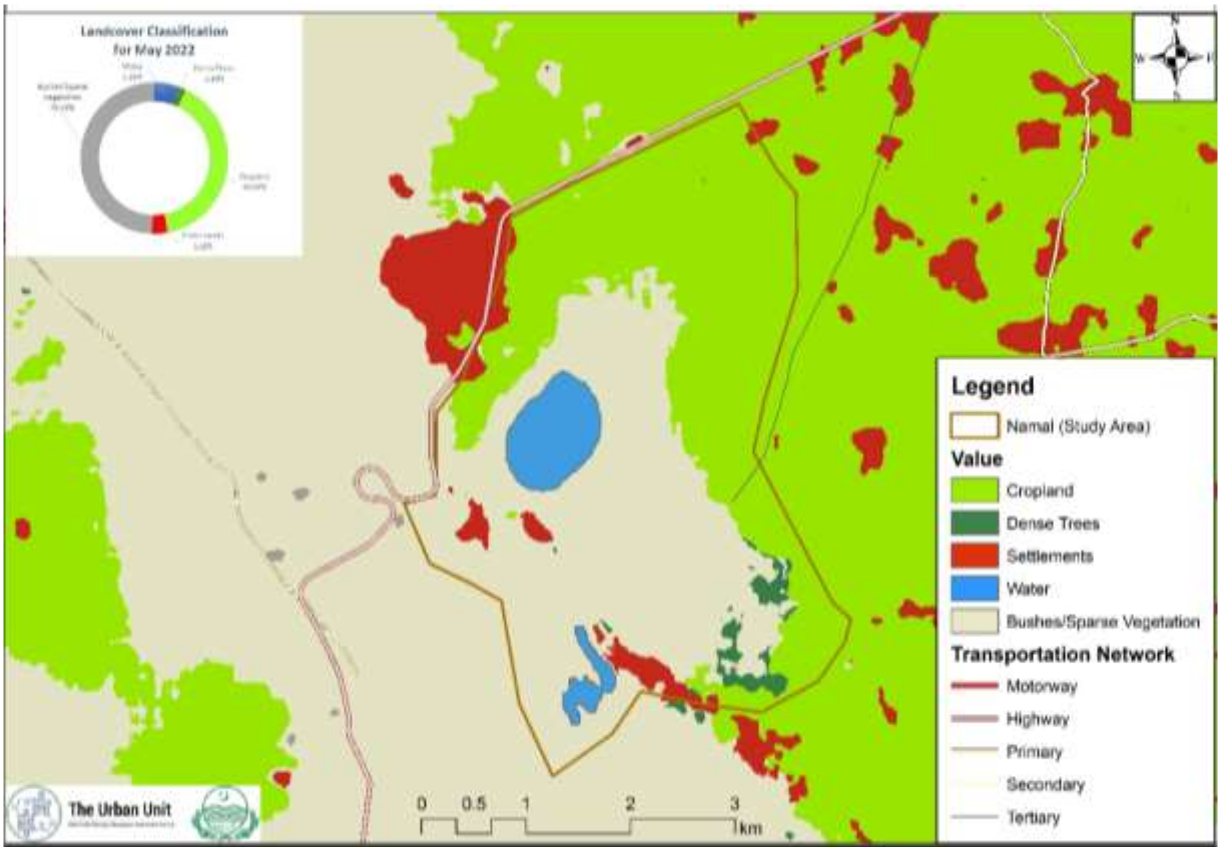


Figure 21: Land Cover Classification for Namal Lake

- Almost 15-20 houses are around the Namal lake (mostly are Semi-pacca houses). Another scattered settlement was observed on the top of the hill near the dam catchment, called Namal Basti, whereas the settlement around Rikhi nullah is known as Rikhi.
- The main water supply in these areas is through water pumping in the area.
- There is a Rest House of Communication and Works Department which also have insufficient facilities. The infrastructure of the Rest house is deteriorated and watermarks of the last flood can be seen on its boundary walls. The cracks on the outer walls of the rest house were quite visible. The rest house does not have facility for food, drinking water and toilets which are considered as the basic amenities.
- A Girls-High school is also located in the project area with a total roll-in of 150-200 students.

- In the Mianwali district, the major crops sown are wheat and gram. Lentils, oilseeds, sugarcane, cotton, guar, mong, bajra, groundnut, jawar, fodder and other pulses and vegetables are also grow. Among fruits, mango, citrus, ber and guava gardens are also found in the district. However, in the project area the major crop is wheat, mainly located at the east, north, and north western side of the lake. The area around lake is comprised of grasses and shrubs. Whereas, sparse vegetation (locally known as "Muskat") observed in the hilly area.
- Further, there is no industry within or near the vicinity of the project area.

The overall analysis is evident that the Namal Lake is experiencing serious threats from multiple fronts and requires a restoration and management plan.

Restoration and Management Plan

A lake's water level is said to be self-sustaining when the inflow and outflow are in balance.

Historical data of the Namal Lake revealed that the water level of the lake usually maintained at minimum specific level thereby attracting large flocks of migratory water birds. However, during the past few years, the lake is drying and thus demanding effective solutions to sustain lake's water level, as well as promote protecting ecological dynamics in the area along with eco-friendly recreational activities.

Keeping in view the context, a plan for restoration and management of Namal Lake is proposed which contains various strategies and interventions, as exhibited below;

Figure 22: Map with proposed interventions for Namal Lake

The proposed interventions and actions are enlisted below;

1. Interventions to increase the discharge in Namal lake
2. Provision of drainage system

3. Control of point and non-point pollution
4. Flood management
5. Plantation
6. Eco-friendly recreational interventions
7. Communication and awareness action plan (CAAP)

3.1 Increase discharge in the Namal Lake

Namal lake has a total 391.2 sq. km catchment area as per the Remote sensing-based analysis of the catchment. Golar catchment is one of the major catchments as it shares a large quantity of discharge with Namal Lake. Water flowing from the Golar catchment area also shares a major share of silt because water with higher velocity unleashes the erosion downstream of the catchment area. The absence of energy dissipating blocks makes it more vulnerable to erosion.

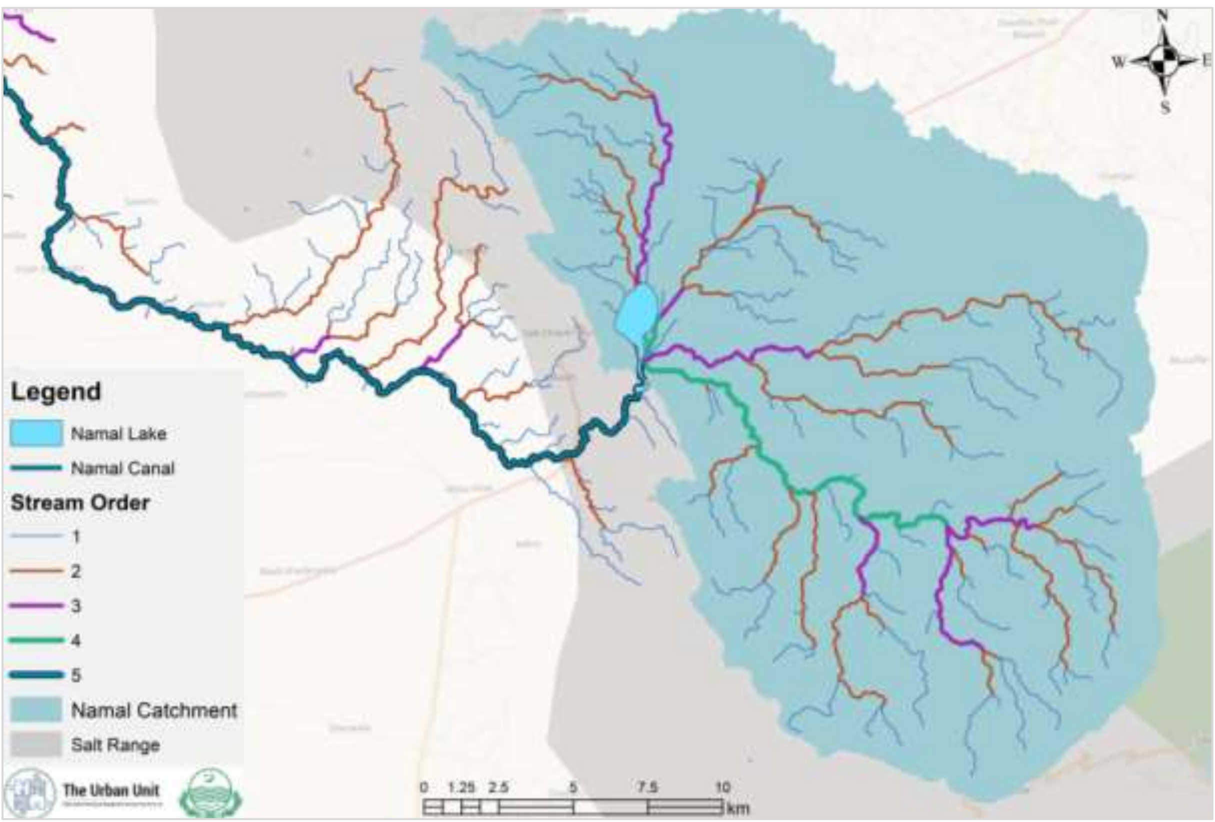


Figure 23: Stream Order Map for the Catchment of Namal Lake

Interventions to increase the discharge of the Namal Lake are identified by remote sensing-based analysis to ensure stream order. Stream order of catchment reflected the streams that share maximum discharge in the lake. Therefore, interventions were suggested for the 3rd, 4th, and 5th order streams to collect the discharge and avoid the choking of the lake due to uninterrupted deposition of silt.

Only source of discharge is the rainwater for the Namal Lake that's why it is important to propose water collection and silt control infrastructures.

4.1.2. Design of Stone Lined Channels

- Selection of 3rd order and 4th order streams from the GIS based map because that streams collect water from other streams
- Marked the patches of stream that need stone lined channelization
- Measure the length patch by using kml file
- Design a channel on the basis of maximum flow (Flow analysis is carried out for the Catchment of Namal Lake)
- Design of channels on the basis of maximum velocity, slope and discharge
- Preparation of sectional drawings for the stone lined channel. Drawing is attached at Annex-A.

4.1.3. Provision of Check Dams:

- Check dams are suggested on the streams that are 3rd and 4th order as larger portion of silt is carried out by that streams due to higher velocity of flow
- Arc-GIS based slope maps of the study area are prepared
- Points where slope is more than acceptable range are selected for the provision of the check dams by using Google Earth Pro
- Dimension of the check dam will be decided on the basis of width of stream or channel provided for that section, discharge, slops, and velocity of the flow. Drawings are attached at Annex-B.

4.1.4. Provision of Ditch-cum-bund:

- Location of the marked recreational area on the Namal Lake is followed up to select the location of the Ditch-cum-bund
- By using kml file surface area of the ditch cum bund will be selected
- Depth of the ditch cum bund will be decided to maintain a natural scenery for the tourists

4.1.5. Provision of Tree Clusters

- Selection of sites where slope of the stream is sharper or where two streams meet
- Identification of sites by using Kml file (Software Google Earth pro).
- The unit area of the trees cluster is proposed 15000 square feet. Almost twenty points (approximate location is marked on the map) are selected for the provision of tree clusters that seemed vulnerable to the high-velocity flow of water and soil erosion. Trees will be provided in three rows to alleviate the velocity of the water. Species of plants that are suitable for the intended purpose are Eucalyptus Camaldulensis (Sufaida), Eucalyptus Alba (Sufaida), Acacia Nilotica (Kikar), Bombax Ceiba (Simbal) and Dalbergia Sissoo (Tahli).

Table 7: Details of tree clusters

Total Number of Trees for Proposed Unit Cluster Area		
Area	Spacing	No. of Trees
500 ft x 30 ft	6ft x 10ft	252 Trees
Total Trees For 20 Proposed areas		252 x 20 = 5040
Total Area of Tree Clusters		15000ft^2 x 20 = 300000 ft^2

4.1.6. Provision of Monitoring System

- Placement of rain gauges to estimate the flow of water in the lake with more accuracy
- Placement of discharge measurement weirs to measure the discharge from all the major streams

3.2 Provision of drainage system

Mianwali district receives approximately 387 mm average annual rainfall most of it in monsoon season. In order to reduce the sedimentation load, stream lining the flow in almost plain area and to make the plain land unflooded near Namal lake, a stormwater drainage channel is need to be constructed.

The proposed drainage system for the project designed to carry the maximum discharge / sheet flow of rainfall during the peak period in the command area.

Design of drain is based on following steps;

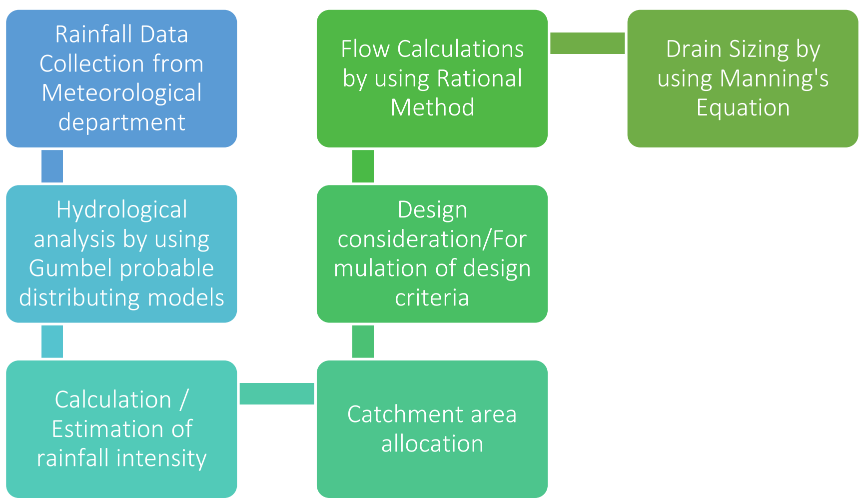


Figure 24: Methodology for drainage system planning

4.2.1. Rainfall Analysis

- The rainfall data is collected from various sources and analysis to estimate the flow in the Namal Lake, as shown in the following tables. Whereas, the rainfall intensity is estimated using the max.
- Discharge of 144 to 168 liter/sec/ha in the region. Detail of monthly rainfall data of Mianwali region is attached in Annexure Q.
- July and August are two months with maximum average rainfall. Major portion of discharge is collected in these two months. Annual rainfall graph reflect abrupt variation in yearly rainfall that makes water management more challenging.

Table 8: Average Monthly Rainfall (On the basis of Data of last 41 years)[25]

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall (mm)	14	34	36	28	17	32	86	70	35	10	6	12

[25] *Average monthly precipitation of past 17 years. (Source: Weatherbase)*

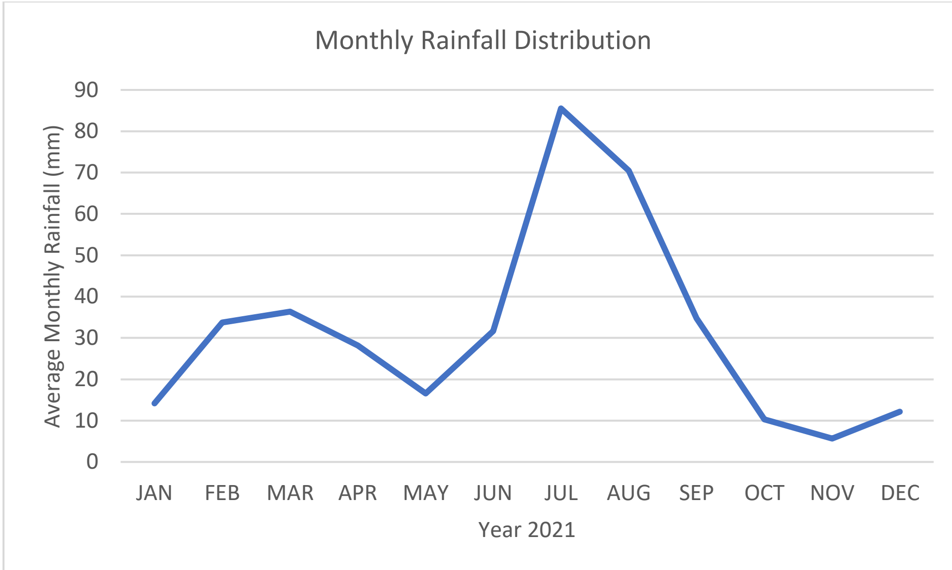


Figure 25: Monthly Rainfall Distribution (Mianwali)[26]

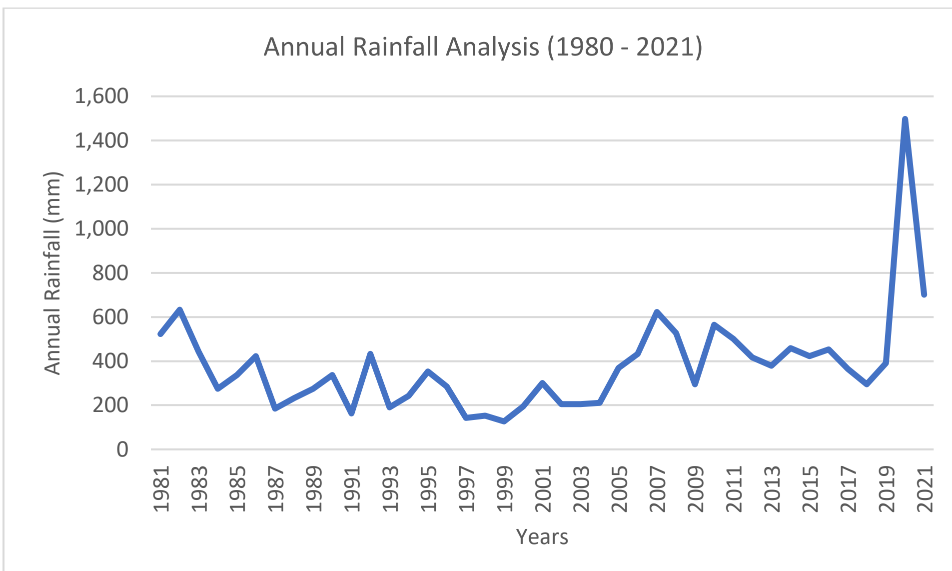


Figure 26: Annual Rainfall Analysis (Mianwali)[27]

4.2.2. Hydrology of Mianwali

Catchment Area Demarcation

The Namal Lake has catchment area of about 391.32 km^2 (96697.5 acres). This rea will be subdivided into smaller sub-catchments based on the degree of slopes and the drainage patterns. The boundaries of catchment areas generated using ArcGIS, ArcHydro Tool. The catchments for Namal Lake are exhibited in figure 16.

[26] Ibid at 26
[27] Ibid

Runoff Estimation

There have been many methodologies developed to estimate the total runoff volume, the peak rate of runoff, and the runoff hydrograph from land surfaces under a variety of conditions. There is also a wide variety of computer models available for this purpose. For this project, basically rational method is adopted for the storm water drainage design.

Rainwater Harvesting Potential of Namal Lake

Namal lake totally rely on rainwater. It has catchment area of about 391.32 km^2 as per the GIS based analysis of DEM of Namal Lake using ArcHydro tool. Golar, Trappi and Rikhi are major contributing nullahs in Namal Lake. Their catchment areas have been tabulated in Table-3. Namal have received an annual rainfall of 379 mm as discussed earlier. By using the catchments and rainfall, the rainwater harvesting potential of major nullahs/streams contributing to the Namal Lake has been calculated on annual, max. Monthly, min. monthly, mean monthly and monsoon rainfall basis. The annual rainwater harvesting potential of Namal Lake is about 22,271,983 (m^3).

Table 9: Harvesting Potential

Annual Potential		**Max. Monthly Potential**		**Minimum Monthly Potential**	
Nullah Name	**Volume (m^3)**	**Nullah Name**	**Volume (m^3)**	**Nullah Name**	**Volume(m^3)**
Golar Nala	8732665	Golar Nala	1968262	Golar Nala	130266
Trappi Nala	4408996	Trappi Nala	993747	Trappi Nala	65769
Rikhi Nala	671943	Rikhi Nala	151450	Rikhi Nala	10023
Overall Flow	**22,271,983**	**Overall Flow**	**5,019,898**	**Overall Flow**	**332,234**

Mean Monthly Potential		**Moonsoon Potential**			
Nullah Name	**Volume (m^3)**	**Nullah Name**	**Volume (m^3)**		
Golar Nala	727722	Golar Nala	4389693		
Trappi Nala	367416	Trappi Nala	2216292		
Rikhi Nala	55995	Rikhi Nala	337769		
Overall Flow	**1,855,999**	**Overall Flow**	**11,195,570**		

Average Flow Velocity

The average velocity of the flow will be calculated on the basis of Manning's equation given below.

$$V = \frac{1.486 R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$$

Where, V=Mean flow velocity, ft / s
R=Hydraulic radius, ft
(R = A/P where, A is the area and P is the wetted perimeter)
S=Slope of the drain ft /ft
n=Manning's coefficient of roughness (0.013 for concrete)
A = B x Y (B = width of drain and Y = hydraulic depth of drain)

Self-Cleansing Velocity

The minimum of 3.0 ft/ sec (0.91 m/sec) self-cleansing flow velocity will be adopted for the purpose of hydraulic calculation to avoid silting/blockage during dry season in all the RCC drains.

Maximum Allowable Velocity

The maximum of 10 ft/sec (3.04 m/sec) allowable flow velocity will be adopted to avoid scouring of drains bed and other structural deformities.

Free Board

A minimum of 6.0 inches (152.4 mm) freeboard will be provided for all drains.

4.2.3. Golar Drain

The Golar drain on Golar nullah has been proposed to reduce the sedimentation load, stream lining the flow in almost plain area and to make the plainland unflooded near Namal lake.

Figure 27: Location of proposed Golar Drain

4.2.4. Drainage Hydraulic Statement

On the basis of above-mentioned parameters of the drainage system, the design of storm water network on Golar Nullah is given in hydraulic statement attached as Annex-D and E. All costing details of Section 3.1 and 3.2 are provided in Annex – F.

The aforementioned interventions would also play a significant role in hill torrents/flood protection. For instance; provision of check dams on the higher order streams will avoid the flooding in downstream of catchment; provision of stone lined channels will direct water of higher order of streams towards the water basin; provision of stone wall or retaining wall will control the flooding in the nearby agricultural lands and energy dissipaters will reduce the probability of flash floods and limit the velocity of water as it would increase the time of traveling of water and flooding in the project area can be avoided.

3.3 Control of Point and Non-Point Pollution

Point or Non-point agriculture pollution sources of Namal Lake needs to be identified through a comprehensive field assessment and laboratory analysis. The pollution prevention plan of such pollution sources would include diversion of channels that take agricultural runoff into the lake, use of alternative or no phosphate fertilizers, capture of agricultural runoff in another source before entering into lake.

Artificial circulation is also a useful management technique to reduce the anoxic condition and stratification of the lake. By using this process, the Dissolved Oxygen Concentration of Namal Lake would be increased, thereby reducing the algal growth and water sediment interface which might be increasing due to increased nutrient supply.

To ensure Namal Lake's sound ecosystem restoration, any development, if carried out, should be planned in accordance with the approval of Environmental Impact Assessment of the project area. As Namal Lake is a game reserve therefore it is stated in Punjab Environmental Protection Act, 2012, that any Environmental sensitive area, falls under Category I: Environmentally Sensitive Areas (1. All projects situated in environmentally sensitive areas) of Schedule II, Regulation 4 of IEE & EIA Regulations, 2000, thereby demanding Environmental study (Environmental Impact Assessment) before any development activity.[28]

3.4 Greening of Namal Lake

4.5.1. Grasses Field:

These grasses field will help to attract the variety of avifauna at Namal Lake to promote the natural beauty of the region for nature lover. This activity will also help to restore and conserve the natural habitat for the diversity of the region.

Activities:

- Selection of Patches for grasses
- Leveling of the land
- Preparation of land/ Grass bed
- Introduction of seasonal grain crops in some patches

4.5.2. Introduction of Flowering and Fruiting Plant Species:

Plantation of flowering and fruiting plant species will help to promote the insect species like Bees, Butterflies and Moths at the site which is food for some insect eater birds to attract and increase the population size of birds at Namal lake.

Activities:

- Selection of sites for plantation
- Plantation Bed preparation

[28] Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations, 2000. https://epd.punjab.gov.pk/system/files/IEE%20and%20EIA%20regulations%202000_11zon%20%282%29_0.pdf

- Introduction of Selective plant species
    - *Ziziphus mauritiana*
    - *Z. nummularia*
    - *Morus alba*
    - *Foeniculum vulgare*
    - *Justicia adhatoda*

4.5.3. Introduction of Native Plant Species:

One of the important interventions that can be used for restoration and conservation proven by the researcher is the introduction of native plant species which helps to restore the natural habitat at a particular place. The introduction of indigenous plant species is also important to conserve the native avifauna of the Namal lake.

Activities:

- Selection of sites for plantation
- Plantation Bed preparation
- Introduction of Selective native plant species
    - *Tamarix aphylla*
    - *Capparis decidua*
    - *Acacia nilotica*
    - *Albizia lebbeck*
    - *Prosopis cineraria*
    - *Olea ferruginea*
    - *Dalbergia sissoo*

Figure 28: Recommended Flowering flora

4.5.4. Introduction of Halophytes:

Salinity is one of the growing issues causing tremendous yield losses in many parts of the world, especially in arid and semiarid regions. Halophytes plant species have the capacity to accumulate and exclude the salt can be an effective method for salt removal including agronomic practices or phytoremediation. Exploiting halophytes for reducing salinity can be good sources for meeting the basic needs of people in salt-affected areas as well.

Activities:

- Halophytes can be introduced in and around Namal Lake
- Sites identification for introduction of halophytes.
- Some of the important halophytes are:
    - *Salvadora oleoides*
    - *Parkisonia sp.*
    - *Acacia spp.*

Figure 29: Recommended Halophyte Flora

4.5.5. Estimated Number of Trees

For the aforementioned interventions, a total of 40 acres area is proposed for natural habitat restoration through afforestation. This will help to promote conservation of endemic species of birds and mammals. The site will be planted as mix cropping of native plant species with tree canopy to ground cover plant species. The estimated number of plant species and their pattern of plantation is given as follow:

Description	Plant Spacing	Estimated No. of Species
Large canopy trees at 40 Acres	10' x 10'	17,640
Middle layer Plants at 40 Acres (1 plant between large canopy)	10' x 10'	17,640
Ground cover Plantation at 40 acres (2 plants between large canopy)	5' x 5'	35,280
Total numbers pf plant species		**70,560**

Other suggestions are as followed;

- The plantation activities in the catchment area will be done in collaboration with Punjab Forest Department and other developmental partners.
- Community involvement in the conservation efforts and plantation should be mandatory.
- Illegal livestock grazing should be allowed on a rotational basis to enhance the growth of natural vegetation.In order to promote conservation of wildlife, especially vulnerable avi-fauna (Common Pochard and Gray River Tern), there is a strong need to depute equipped field staff by the Punjab Wildlife and Parks Department, within the territory of Namal lake for enhanced conservation efforts and prohibit hunting and shooting. A check-post could be established by the department to ensure regular monitoring and enforcement of plan. [29]

[29] WWF. 2011. *Site Management Plan Kallar Kahar Game Reserve.* A part of Salt Range Wetlands Complex. The Ministry of Environment's Pakistan Wetlands Programme. Islamabad. Pp. 1-62.

- Community-based watch and ward mechanism needs to be established. The financial resources can be generated through various eco-tourism ventures in the area. This will not only promote community-based conservation in the area but will also develop a sense of ownership of the resources.
- − Partnerships and linkages with local partners and stakeholders in addition to resident communities also need to be established to discuss harmful environmental concerns (e.g. pollution, illegal hunting, encroachment, illegal cutting of vegetation etc.) at the local level.
- Strengthening knowledge and technical capacity of the field staff deputed by the Punjab Wildlife Department needs to be properly equipped and trained in wildlife identification, data recording and reporting, use of GPS, camera, binoculars and wireless communication devices. Transport facility could also be provided to the field staff for better monitoring and enforcement.

3.5 Ecological Interventions for learning and human interface

The mesmerizing scenery with a vacant space, identified in this plan, that provides for an ideal location given its size, terraced topography and the vistas to the lake it provides for the development of an ecotourism. However, all the recreational activities are designed based on the theme of ecosystem integrity and sustainable development in the project area. An area of around 5.40 acre is selected near Namal Lake for the design of master plan with allied facilities, Namal museum and Natural Landscaping.

Hence, the Lake provides the perfect setting as a recreational point; where through a concentration of different facilities, and planning and design, the Lake will acquire its own an identity and character.

Figure 30: *Proposed Recreational Plan for Namal Lake (2d and 3d)*

Figure 31: *Proposed Plan foe lake front view and sitting area*

4.7.1. Board Walk

On the edge of Namal Lake, a board walk is proposed by using only light interventions such as gazebos, benches, waste bins and kiosks serving only basic food and items. This board walk is developed with eco-friendly materials.

A boating dock that floats over the lake to safeguard the aquatic life. The boats leaving from this dock will all be paddleboats and connect this part of the lake and its visitors to the lake via water. The same boats will be used to take tourists to the abovementioned ecotourism resort.

This board walk will provide the opportunity watch the rare and migratory birds of the area. The boardwalks are proposed to simply give people a nice place to walk along the water and enjoy the view.

4.7.2. Information Center

Visitor information centers are physical locations that provide information regarding an area to the visitors and students. There is a dire need to establish the Conservation and Information Centre of Namal Lake game reserve. The center will have an information desk as well as souvenir merchandise, flyers, maps, and brochures. The Lake visuals will also be used as marketing products, and they can be designed as permanent or temporary structures. Importance of Namal lake, conservation and protection aspects with reference to water level, flow, quality of the lake and the biodiversity, and management directions will also be provided in the information center. Information center is comprised of 3580 sq ft area Proposed drawing is attached at Annex - G

4.7.3. Wild-Life Museum at Namal Museum

Wildlife museums and related institutions such as aquaria, botanical gardens are devoted to study and exploration of biological world. The proposed intervention is to establish a wildlife museum at Namal Lake, Mianwali.

The aim to establish this museum is to collect specimen for research facilities, conservation and preservation of collection, documentation of specimens in museum collection, designing education program for researcher and students, planning for temporary, travelling and mobile exhibition, developing museum publication and learning resource center. The wildlife museum will promote the conservation efforts to protect the existing fauna, specifically migratory birds, of this game reserve. Proposed drawing is attached at Annex - H.

4.7.4. Toilet Block

A Toilet Block will be constructed primarily to provide toilet facilities for the users of a facility or for the general public. Proposed drawing is attached at Annex - I.

4.7.5. History Wall

History Wall is an important monument that can be placed at the entrance gate of the Namal Lake that provides the background and history of the Namal Lake. The history wall provides important information like establishment of Lake, Biosphere Reserve, Area of Lake; type of habitat; important species etc. Such information on History Wall makes an impressive impact on the tourist and shows the grip of management team on the Namal Lake. Proposed drawing is attached at Annex - J.

4.7.6. Light Poles

A provision for light and sound show will be made with its operation/ storage facility, along the Lake area for the illumination of proposed facilities. A total 160 light pole are proposed for Namal Lake. Proposed drawing is attached at Annex - K.

4.7.7. Benches

Some comfortable sitting spaces shall be provided for tired visitors. The provide the opportunity to see the migratory birds, natural landscape of mountains and lake. 30 benches are proposed for Namal Lake master plan. Proposed drawing is attached at Annex - L.

4.7.8. Bird Watch Tower

Namal Lake is gifted with diverse habitats that host variety of important avifaunal species that not only include local species but also a seasonal home for migratory birds. In order to avoid any disturbance to these migratory and native birds, it is proposed to develop Bird watching towers at Namal Lake. Proposed drawing is attached at Annex - M.

4.7.9. Comping Site

A camping site is proposed for tourist at Namal lake. The site area is comprised of 0.9 Kanal. It provides outdoor activity for 6 families that involves spending time in nature, exploring its different aspects, and doing a wide variety of activities such as BBQ. Individuals spend time in various natural settings and enjoy themselves by taking part in physical activities.

Figure 32: *Proposed Comping Site*

4.7.10. Construction Materials:

The following eco-friendly construction material will be used throughout the developments at Namal Lake. These construction materials are beneficial or non-harmful to the environment, and resource; using these materials will not only improve the health of the Valley, its people and tourists. The use of these materials will help support local businesses and helps strengthen the local economy, which in turn will help to build the Valley into a vibrant, prosperous and desirable places to visit.

- Rock or stone
- Clay or mud bricks
- Wood
- Rammed Earth
- Lime or Lime stone
- Bambo

Figure 33: *Proposed Construction Material*

Rough cost estimates of the proposed eco-friendly recreational plan are attached at Annex – N. Summary Cost of the whole project is given at Annex – O. Whereas, Coordinates of proposed Interventions are provided in Annex – P.

3.6 Communication and Awareness Action Plan (CAAP)

Communicating the right information to the targeted audience (key stakeholders) through interactive learning tools and methods is the key to attaining long-term conservation practices in a specified area. This Communication and Awareness Action Plan (CAAP) of Namal lake will provide the specific methods, tools, and activities that are to be employed by the relevant entity for its sound management.

In order to contextualize the CAAP, an analytical tool 'SCOPE - Situation; Core competencies; Obstacles; Prospects and Expectations' is used, as exhibited below;

CURRENT SITUATION

Situation:
- Community participation in conservation efforts is minimal.
- Visitors' social behavior and attitude towards eco-friendly recreational activities are unsatisfactory.
- Inadequate awareness level among the local communities and visitors.
- Insufficient information and guidance facilities for the visitors.
- Non-availability of necessary items/infrastructure to boost environmental protection such as waste bins, public toilets, etc.

Core Competencies:
- Great potential for community engagement.
- Presence of Namal Institute (30 km away from Namal Lake).
- Wild-Life Museum: A potential incubator for education and recreation.
- Green Namal Initiative to establish Namal Knowledge City: a great addition to enhance collaboration & awareness activities.

Obstacles:
- Lack of infrastructure of basic public facilities to support recreational and conservation activities.
- Lack of coordination among different entities (government departments, NGOs, Namal Institute, local people)

FUTURE, IMPLEMENTING THE CAAP

Prospects:
- Engagement of Namal Institute, local NGOs, and government departments for public awareness campaigns.
- Educational and information dissemination facilities such as the establishment of Information Center and Wild-life Museum.

Expectations:
- Enhanced community engagement for conservation efforts.
- Increased awareness among the visitors of the importance of ecological protection of Namal Lake.
- Long-term sustainability of the Namal Lake ecosystem.

The following actions are proposed under CAAP;

4.9.1. Coordination with key stakeholders:

Stakeholders for the environmental conservation of Namal lake can be broadly conceived as;

- Representatives from the Mianwali District Departments and local government
- Political representatives
- Representatives of local NGOs and CBOs

- The Management, Faculty, and Students of the Namal Institute
- Local Community living in Namal Valley (with a special focus on gender aspects and vulnerable populations) including local schools, health care facilities etc.
- Local Shopkeepers, small cart owners, or those involved in the tourism business
- The visitors and the mass general public

All of these groups need to understand both the value of ecological resources and ecosystem services of Namal Lake, existing issues and challenges, the consequences of its degradation and loss, and as well as the need and importance of communication and public awareness activities. Hence, strong coordination is recommended to minimize the environmental impact on Namal Lake and augmented conservation measures through engagement and awareness.

The Management, Faculty, and Students of the Namal Institute can play a significant role in raising awareness campaigns among the local community and visitors. An annual plan can be developed through mutual agreement to raise awareness at a specified timeframe such as during tourism season, important conservation days, before monsoon (to minimize the impacts of hill torrents), and so forth. Moreover, the institute may conduct multiple types of research to conserve lakes and other natural and anthropogenic impacts through nature-based solutions.

Public-private partnerships can also play an important role in effective communication and awareness. On the other hand, an awareness-raising plan for the planners and managers (government representatives) can also be arranged to increase their knowledge and skills regarding the subject.

4.9.2. Develop communication materials and tools;

Develop attractive communication materials, integrating the localized issues and management/conservation measures in local and English Languages, and must be field-tested in consultation with local people.

Ensure availability of awareness-raising material in the information center, wildlife museum, and prominent places around Namal Lake. Use of signage – billboards and visual arts for information dissemination is encouraged. Key awareness messages aimed at local residents are recommended to be relevant to their lifestyle and simple with less scientific terminology. Legal aspects of environmental deterioration and deforestation must be highlighted.

Consider cost-effectiveness while designing the awareness materials and mode of awareness. Use local print media and radio for mass awareness on a frequent basis.

4.9.3. Conduct Outdoor Awareness Campaigns

Conduct community awareness campaigns in Namal Valley and engage them in conservation activities. Namal institute can play a significant role here and can organize outdoor education programs to provide direct, hands-on contact with nature.

Effective school awareness campaigns can also be initiated in the Mianwali district. The campaigns may include establishing conservation clubs, celebration of significant environment days, outdoor activities, solid waste collection and disposal around the game reserve, conservation trips to Namal lake, and so forth.

4.9.4. Strengthening knowledge and technical capacity of the government departments

The relevant staff (including field staff) of Punjab Wildlife and Parks Department, Tourism Department and Irrigation Department needs to be trained so that they are fully quipped and trained in flora and fauna identification, water level restoration and management, data recording and reporting, use of GPS and spatial tools, mathematical and statistical calculations, environmental conservation, etc. The field staff must be equipped with the camera, binoculars, wireless communication, spotting scope, transportation, and other measuring equipments for lake area monitoring and management.

Finally, the effectiveness of the CAAP also needs to be evaluated through continuous monitoring and assessment, and periodic independent evaluations based on measurable performance indicators of the implementing agency.

Box-3: Reviving of Lakes - Examples from other countries

(A) Socio economic activities like festivals and fishing

(B) Awareness sessions through talks and videos

(C) Focus Group Discussions

(D) Youth Engagement through awareness and involvement

Save Naini Lake! India

Due to the campaign, the government has started talking about reviving Delhi's 600 water bodies with Naini lake as a role-model.

People feel a sense of belonging and Naini has become 'our' lake. The term 'ecological revival' was completely new for both the citizens and the government. With people now demanding lake restoration; the vocabulary of the local politicians is also changing. There has been a dramatic drop in the number of people throwing trash and food in the lake as well.[30]

Integrated lake basin management at Indore, India

The participation of local leaders/activists/experts from the local business, academic, research, and professional institutions in several activities have strengthened the social-institutional capital of Indore lake management.

Various socioeconomic activities were involved with the community for lake restoration such as cultural festivals, awareness sessions, focus group discussions, youth/women engagements, etc. This exercise led to the formation of a Lake Conservation Committee (LCC) at each lake neighborhood that now regularly organizes the various socioeconomic activities.[31]

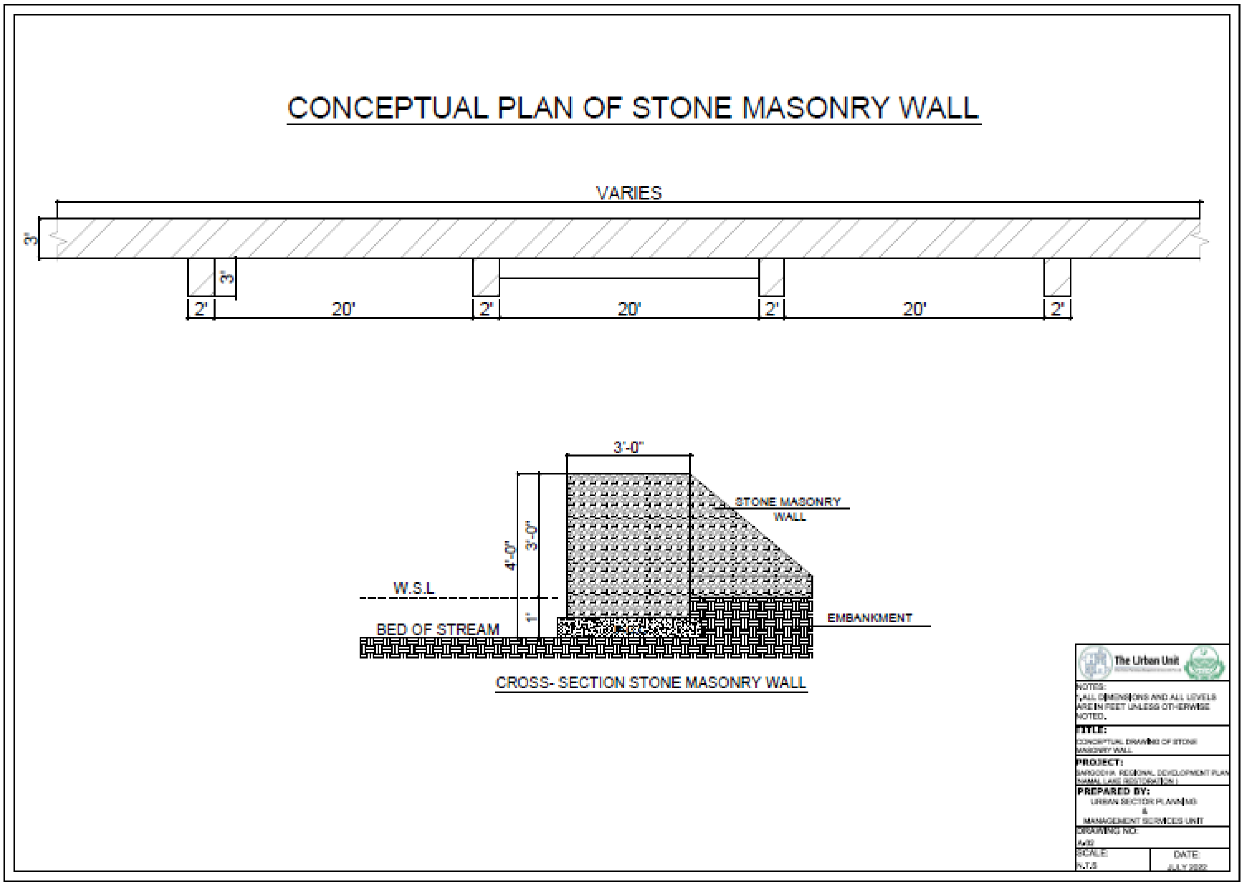
Similar activities can be planned for Namal Lake restoration and management purposes.

[30] https://www.thethirdpole.net/en/pollution/17446/

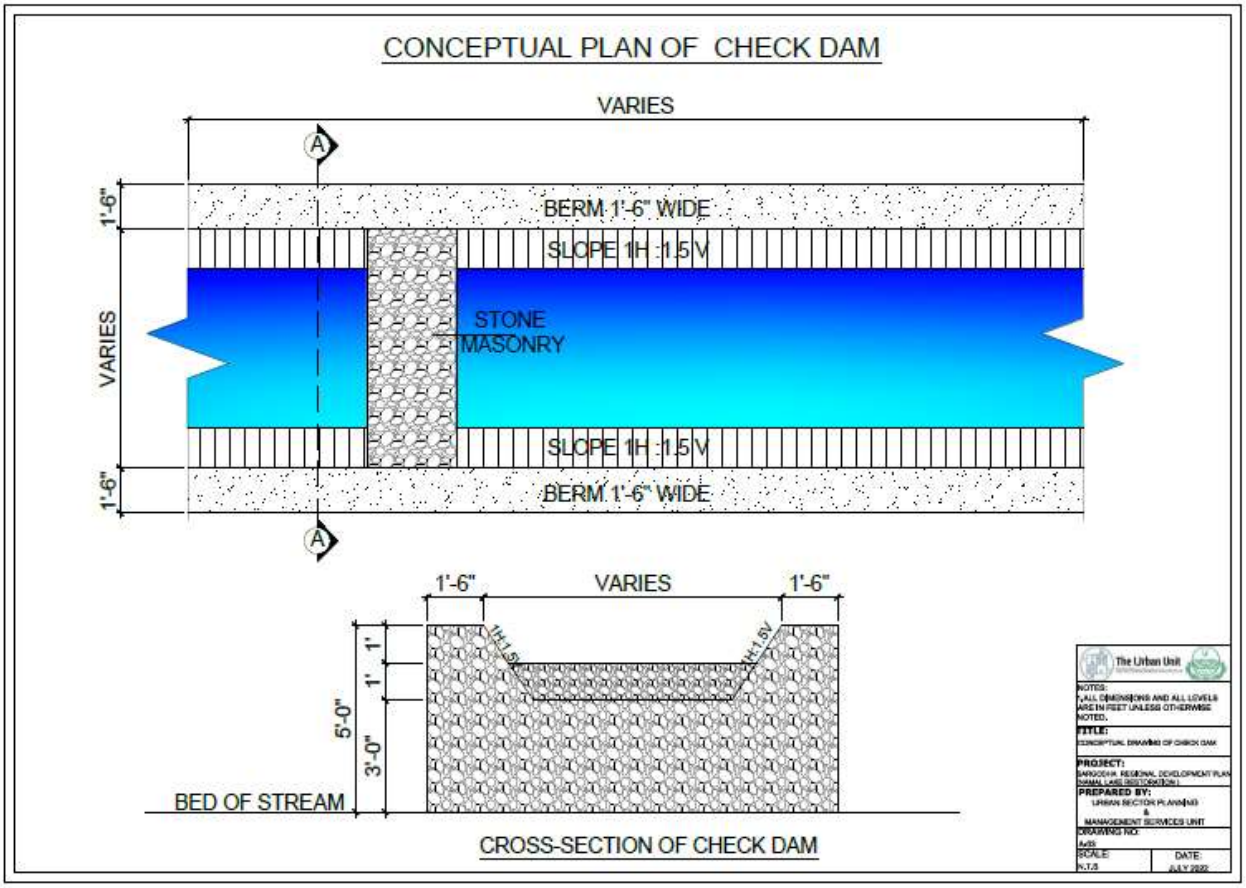
[31] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/lake-conservation

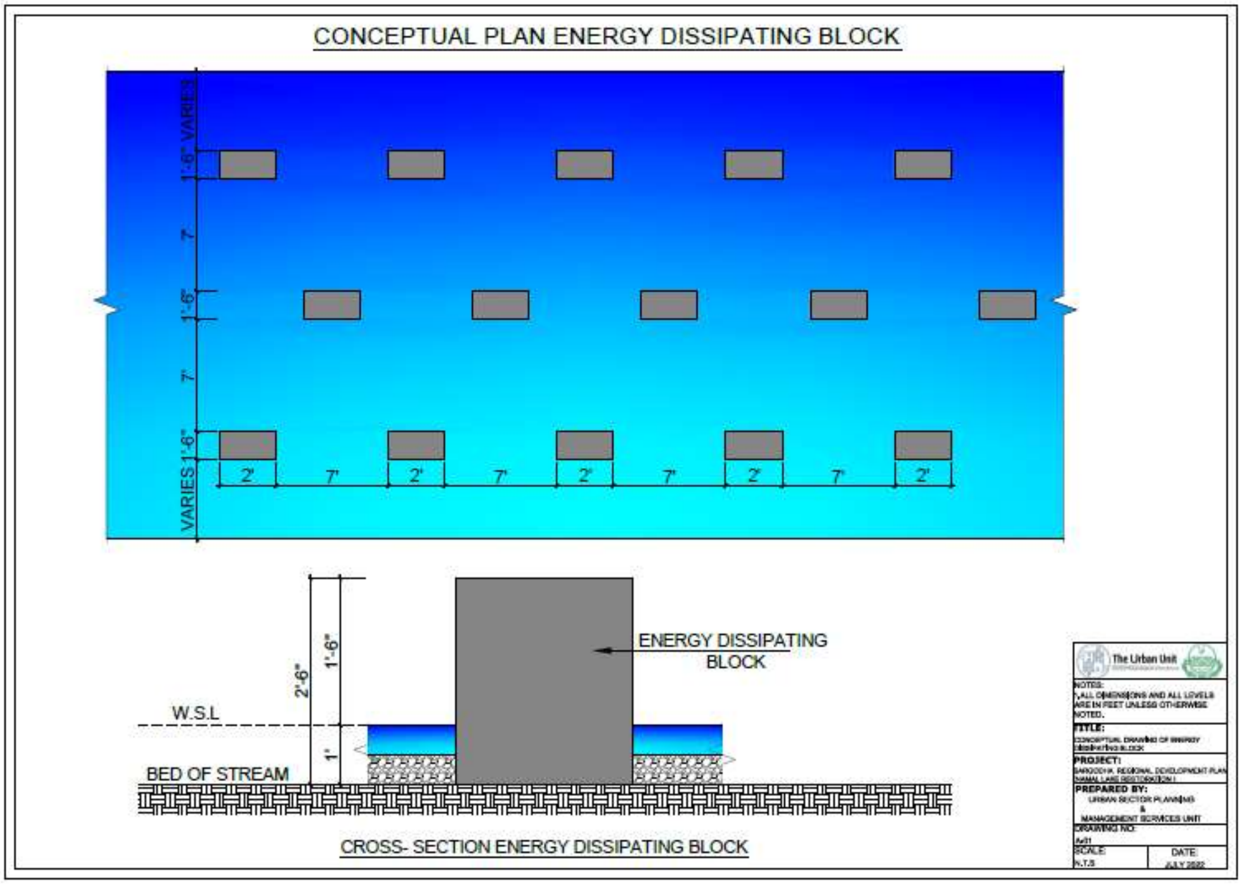
Annexure

Annex – A: Conceptual Drawing of Stone Masonry Wall



Annex – B: Conceptual Plan of Check-Dam and Energy Dissipating Block




CONCEPTUAL PLAN ENERGY DISSIPATING BLOCK
1'-6" VARIES
7'
1'-6"
7'
VARIES 1'-6"
2'
7'
2'
7'
2'
7'
2'
7'
2'
2'-6"
1'-6"
1'
W.S.L
BED OF STREAM
ENERGY DISSIPATING BLOCK
CROSS- SECTION ENERGY DISSIPATING BLOCK
The Urban Unit
NOTES:
1. ALL DIMENSIONS AND ALL LEVELS ARE IN FEET UNLESS OTHERWISE NOTED.
TITLE:
PROJECT:
PREPARED BY:
URBAN SECTOR PLANNING
&
MANAGEMENT SERVICES UNIT
DRAWING NO:
SCALE:
N.T.S
DATE:
JULY 2022

Annex – C: Runoff Coefficient (C) and Manning's Roughness Coefficients

Run-off Coefficient

Description	Runoff Coefficient
Business	
Downtown Areas	0.70 – 0.95
Neighborhood Areas	0.50 – 0.70
Residential	
Single Family	0.30 – 0.50
Multi-Family Detached	0.40 – 0.60
Multi-Family Attached	0.60 – 0.75
Residential Suburban	0.25 – 0.40
Apartments	0.50 – 0.70
Parks, Cemeteries	0.10 – 0.25
Playgrounds	0.20 – 0.35
Railroad yards	0.20 – 0.40
Unimproved Areas	0.10 – 0.30
Drives and Walks	0.75 – 0.85
Roofs	0.75 – 0.95
Streets	
Asphalt	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85
Lawns (Sandy Soils)	
Flat, 2% Slope	0.05 – 0.10
Average, 2-7% Slope	0.10 – 0.15
Steep, >7% Slope	0.15 – 0.20
Lawns (Heavy Soils)	
Flat, 2% Slope	0.13 – 0.17
Average, 2-7% Slope	0.18 – 0.22
Steep, >7% Slope	0.25 – 0.35

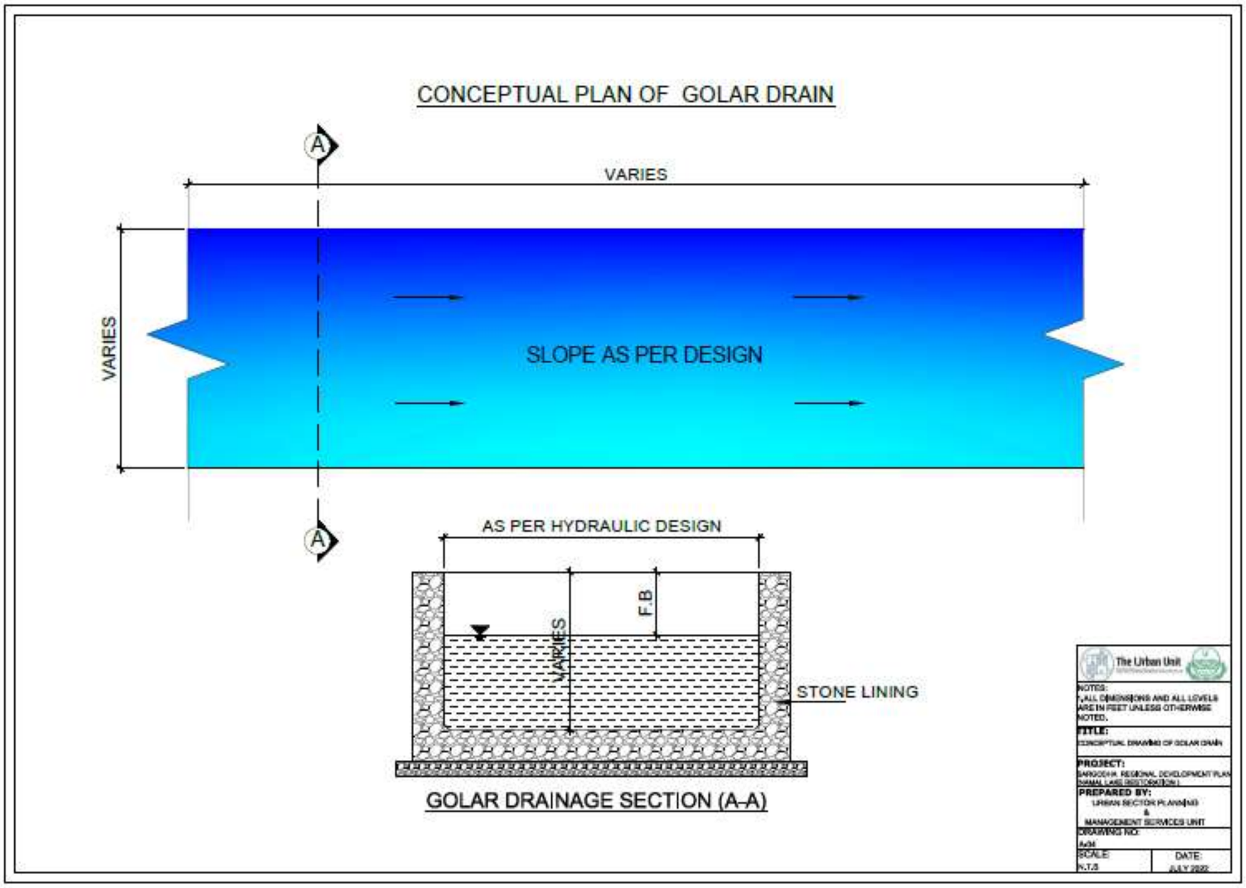
Ref: American Society of Civil Engineers (ASCE), "Design Manual for Storm Drainage", New York, 1960.

Manning's Roughness Coefficients for Overland Flow

Cover or Treatment	Value recommended	Range
Concrete or asphalt	0.011	0.01 – 0.013
Bare sand	0.01	0.010 – 0.016
Graveled surface	0.02	0.012 – 0.03
Bare clay-loam (eroded)	0.02	0.012 – 0.033
Short grass	0.15	0.10 – 0.20
Dense grass	0.24	*– 0.30*

Ref: Woolhiser, D. A.," Simulation of unsteady Overland Flow", Colorado State University, 1975.

Annex – D: Conceptual Plan of Golar Drain



Annex – E: Spreadsheet for the Calculation of Drainage Network for Golar Nala, Namal Lake

Drain ID	Reach		Contributory Area (A)				Coeff. (C)	TOC (t_c)			Intensity (I)	Flow (Q)	Reach Length	Ground Level		Slope		Drain Size (m)		Area	Manning Coeff (n)	Velocity	Capacity		Invert Level		Depth	
								Online	Previous	Total				U/S	D/S	Avail	Adopt	Width	Depth				Avail	Req	U/S	D/S	U/S	D/S
	From	To	online (sq. km)	Prev. (sq. km)	Total (sq. km)	(Acres)		(min)	(min)	(min)	(inch/Hr)	(Cumecs)	(m)	(m)	(m)	(m/m)	(m/m)	(m)	(m)	Sq. m		mps	m^3	m^3	(m)	(m)	(m)	(m)
D-1	**CS-G-1**	**CS-G-2**	0	150	150	37066	0.15	1.36	12.00	13.36	0.28	43.38	100	360	357	0.0300	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.2	356.15	355.89	3.85	1.11
	CS-G-2	**CS-G-3**	0.38	150	150	37160	0.15	0.36	13.36	13.73	0.28	43.49	100	357	357	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.4	355.89	355.63	1.11	1.37
	CS-G-3	**CS-G-4**	0.35	150	151	37246	0.15	0.36	13.73	14.09	0.28	43.59	100	357	357	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.5	355.63	355.36	1.37	1.64
	CS-G-4	**CS-G-5**	0.33	151	151	37328	0.15	0.36	14.09	14.46	0.28	43.69	100	357	357	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.6	355.36	355.10	1.64	1.90
	CS-G-5	**CS-G-6**	0.31	151	151	37404	0.15	0.36	14.46	14.82	0.28	43.78	100	357	356	0.0100	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.7	355.10	354.84	1.90	1.16
	CS-G-6	**CS-G-7**	0.28	151	152	37473	0.15	0.36	14.82	15.19	0.28	43.86	100	356	356	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.8	354.84	354.58	1.16	1.42
	CS-G-7	**CS-G-8**	0.26	152	152	37538	0.15	0.36	15.19	15.55	0.28	43.93	100	356	355	0.0100	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	54.9	353.89	353.63	2.11	1.37
	CS-G-8	**CS-G-9**	0.24	152	152	37597	0.15	0.36	15.55	15.92	0.28	44.00	100	355	355	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.0	353.63	353.37	1.37	1.63
	CS-G-9	**CS-G-10**	0.22	152	152	37651	0.15	0.36	15.92	16.28	0.28	44.07	100	355	355	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.1	353.37	353.11	1.63	1.89
	CS-G-10	**CS-G-11**	0.19	152	153	37698	0.15	0.36	16.28	16.65	0.28	44.12	100	355	354	0.0100	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.2	353.11	352.84	1.89	1.16
	CS-G-11	**CS-G-12**	0.17	153	153	37740	0.15	0.36	16.65	17.01	0.28	44.17	100	354	354	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.2	352.84	352.58	1.16	1.42
	CS-G-12	**CS-G-13**	0.14	153	153	37775	0.15	0.36	17.01	17.37	0.28	44.21	100	354	354	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.3	352.58	352.32	1.42	1.68
	CS-G-13	**CS-G-14**	0.11	153	153	37802	0.15	0.36	17.37	17.74	0.28	44.24	100	354	354	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.3	352.32	352.06	1.68	1.94
	CS-G-14	**CS-G-15**	0.09	153	153	37824	0.15	0.36	17.74	18.10	0.28	44.27	100	354	354	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.3	352.06	351.80	1.94	2.20
	CS-G-15	**CS-G-16**	0.07	153	153	37842	0.15	0.36	18.10	18.47	0.28	44.29	100	354	353	0.0100	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.4	351.04	350.77	2.96	2.23
	CS-G-16	**CS-G-17**	0.06	153	153	37856	0.15	0.36	18.47	18.83	0.28	44.31	100	353	353	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.4	349.86	349.60	3.14	3.40
	CS-G-17	**CS-G-18**	0.06	153	153	37870	0.15	0.36	18.83	19.20	0.28	44.32	100	353	353	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.4	348.68	348.42	4.32	4.58
	CS-G-18	**CS-G-19**	0.05	153	153	37882	0.15	0.36	19.20	19.56	0.28	44.34	100	353	353	0.0000	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.4	347.51	347.24	5.49	5.76
	CS-G-19	**CS-G-20**	0.05	153	153	37894	0.15	0.36	19.56	19.93	0.28	44.35	100	353	348	0.0500	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.4	346.33	346.07	6.67	1.93
	CS-G-20	**OF-1 (Lake)**	0.04	153	153	37903	0.15	0.36	19.93	20.29	0.28	44.36	100	348	347	0.0100	0.0026	5.0	2.5	12.50	0.013	4.572	57.15	55.5	346.07	345.81	1.93	1.19

Annex – F: Rough Cost Estimate for Water Resource Component

ROUGH COST ESTIMATE OF STONE WALL

MRS, 2nd BI-ANNUAL-2022 (01.07.2022 to 31.12.2022) DISTRICT MIANWALI						
Mrs Ref#	**Item No.**	**Description**	**Unit**	**Rate (PKR)***	**As Per Qty**	
					Qty	**Amount (PKR)***
		SCHEDULE ITEMS:				
		STONE MASONRY				
3/21-b-ii	1	Excavation in foundation of building, bridges and other structures, including dagbelling, dressing, refilling around structure with excavated earth, watering and ramming lead upto one chain (30 m) and lift upto 5 ft. (1.5 m) b) By Excavator ii) Ordinary soil	1000 Cft.	8,979.40	4,462.50	40,070.57
6/5	2	Cement concrete plain including placing, compacting, finishing and curing complete (including screening and washing of stone aggregate):				
		(f) Ratio 1: 2: 4	100 Cft	38,178.90	1,785.00	681,493.37
8/4-d-ii	3	Coursed rubble masonry hammer dressed, in ground floor or 20 ft. (6 m) height, building/other than building.)				
		d) in cement, sand mortar ii) ratio 1:4	100 Cft	27,788.45	6,120.00	1,700,653.14
8/4-d-ii	4	Coursed rubble masonry hammer dressed, in ground floor or 20 ft. (6 m) height, building/other than building.)				-
		ii) ratio 1:4	100 Cft	27,788.45	918.00	255,097.97
					Total Amount	**2,677,315.05**

ROUGH COST ESTIMATE OF ENERGY DISSIPATING BLOCK

MRS, 2nd BI-ANNUAL-2022 (01.07.2022 to 31.12.2022) DISTRICT MIANWALI						
Mrs Ref#	**Item No.**	**Description**	**Unit**	**Rate(PKR)***	**As Per Qty**	
					Qty	**Amount (PKR)***
		SCHEDULE ITEMS:				
8/13	1	Providing and fixing stone blocks from 2 Cft.(0.6 cu.m) to 6 Cft (0.17 cu.m). Each including lift upto 20 ft. (6 m)	Per Cft	833.60	1,501.50	1,251,650.40
16/28	2	Providing and laying stone pitching with hammer dressed stones on surface, laid in courses.	100 Cft	9,250.00	6,698.50	619,611.25
					Total Amount R.s	**1,871,261.65**

ROUGH COST ESTIMATE OF CHANNEL

MRS, 2nd BI-ANNUAL-2022 (01.07.2022 to 31.12.2022)						
S. No.	**Item Code**	**Description**	**Unit**	**Quantity**	**Unit Rate (Rs)**	**Total Amount (Rs)**
SCHEDULE ITEMS						
		Abstract of Cost				
1	Chapter No.3 Item 10-i	Earthwork excavation in irrigation channels, drains, etc. to designed section, grades and profiles, excavated material disposed off and dressed within 50 ft. (15 m) lead:-	1000 Cft.	723,951	8,134	5,888,869
2	Chapter No.16-Item No.27	Providing and laying stone pitching/filling, dry hand packed, as filling behind retaining walls or in pitching and aprons.	100Cft.	107,639	14,290	15,381,198
					Total Amount R.s	**21,270,067**

ROUGH COST ESTIMATE OF CHECK DAM

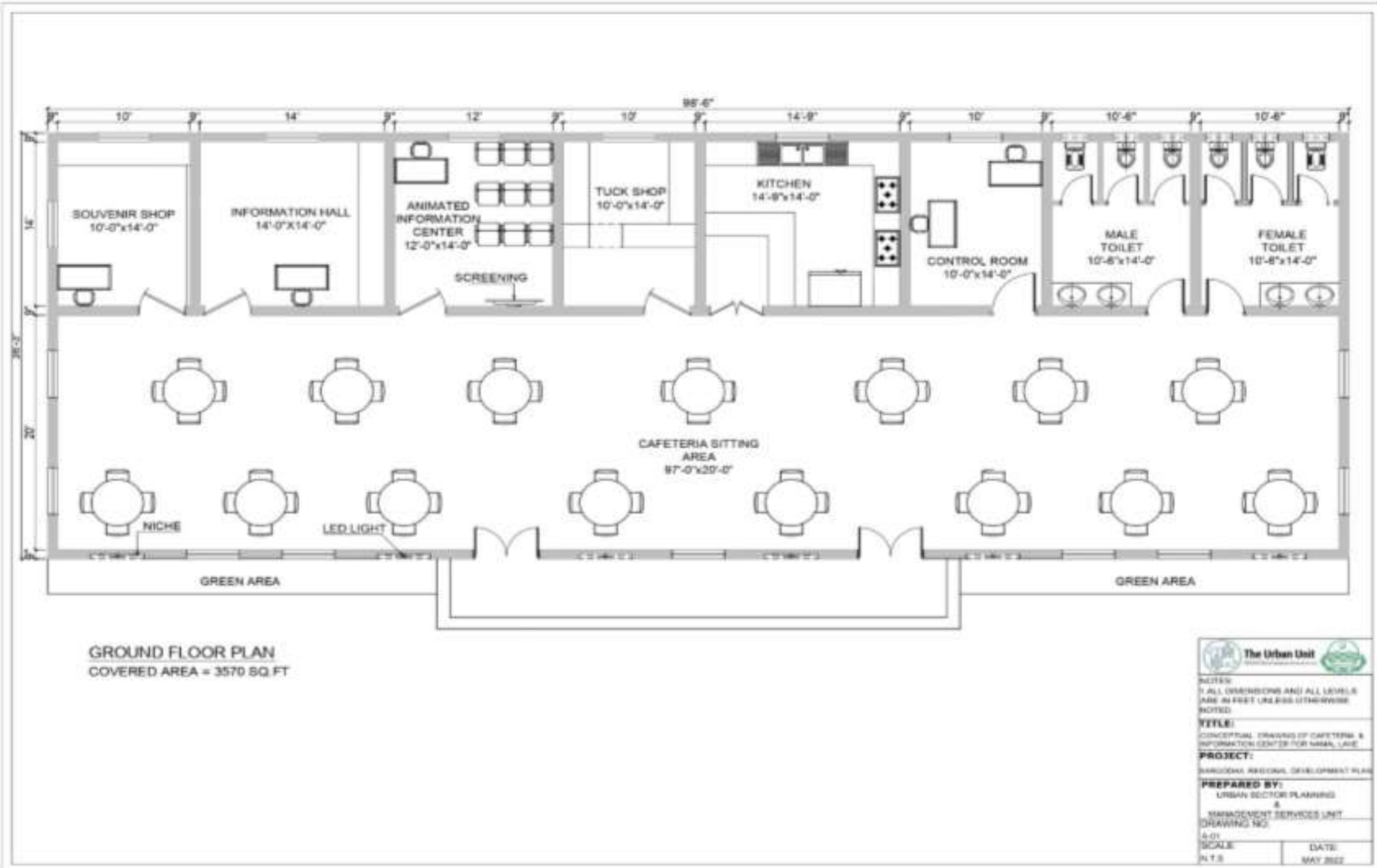
MRS, 2nd BI-ANNUAL-2022 (01.07.2022 to 31.12.2022)

Mrs Ref#	**Item No.**	**Description**	**Unit**	Rate(PKR)*	As Per Qty	
					Qty	**Amount (PKR)***
		SCHEDULE ITEMS:				
		STONE MASONRY				
8/4-d-ii	3	Coursed rubble masonry hammer dressed, in ground floor or 20 ft. (6 m) height, building/other than building.)				
		d) in cement, sand mortar ii) ratio 1:4	100 Cft	27,788.45	133,250.00	37,028,110
					Total Amount	**37,028,110**

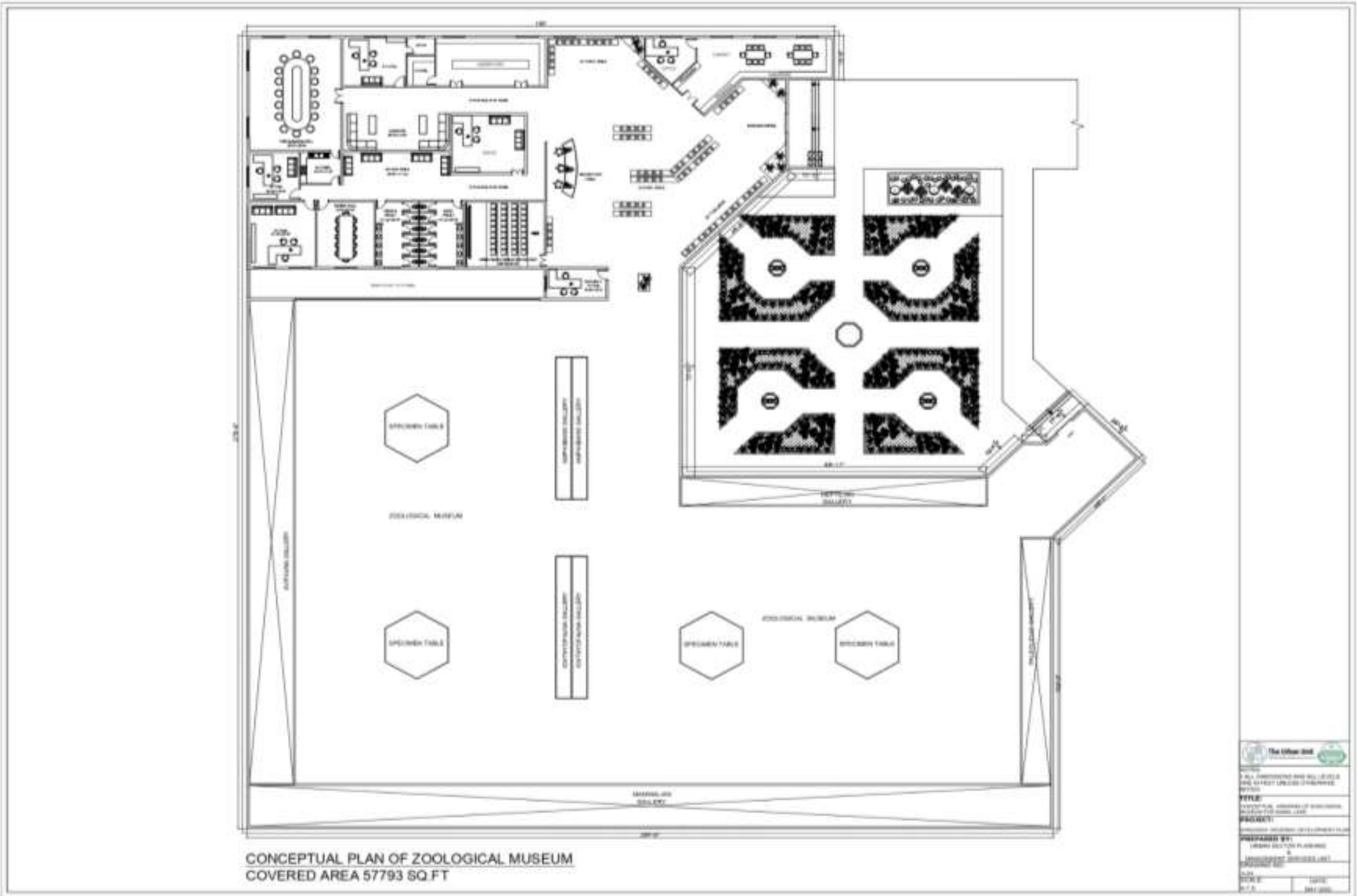
Summary of Rough Cost Estimate

Sr.No	Description	Amount in PKR	Amount in Millions
1	Construction of Stone Wall (190+320 Rft)	2,677,315	2.68
2	Construction of Channel's (9957 Rft)	21,270,067	21.3
3	Construction of Stone Block	1,871,262	1.871
4	Construction of Check Dam	37,028,110	37.028
	Sub-Total Amount	**62,846,753.42**	**62.85**
	Add Contingencies Cost (2.5%)	**1,571,168.84**	**1.57**
	Add PST (5%)	**3,142,337.67**	**3.14**
	Grand Total Amount with Contingencies and PST	**67,560,259.92**	**67.56**

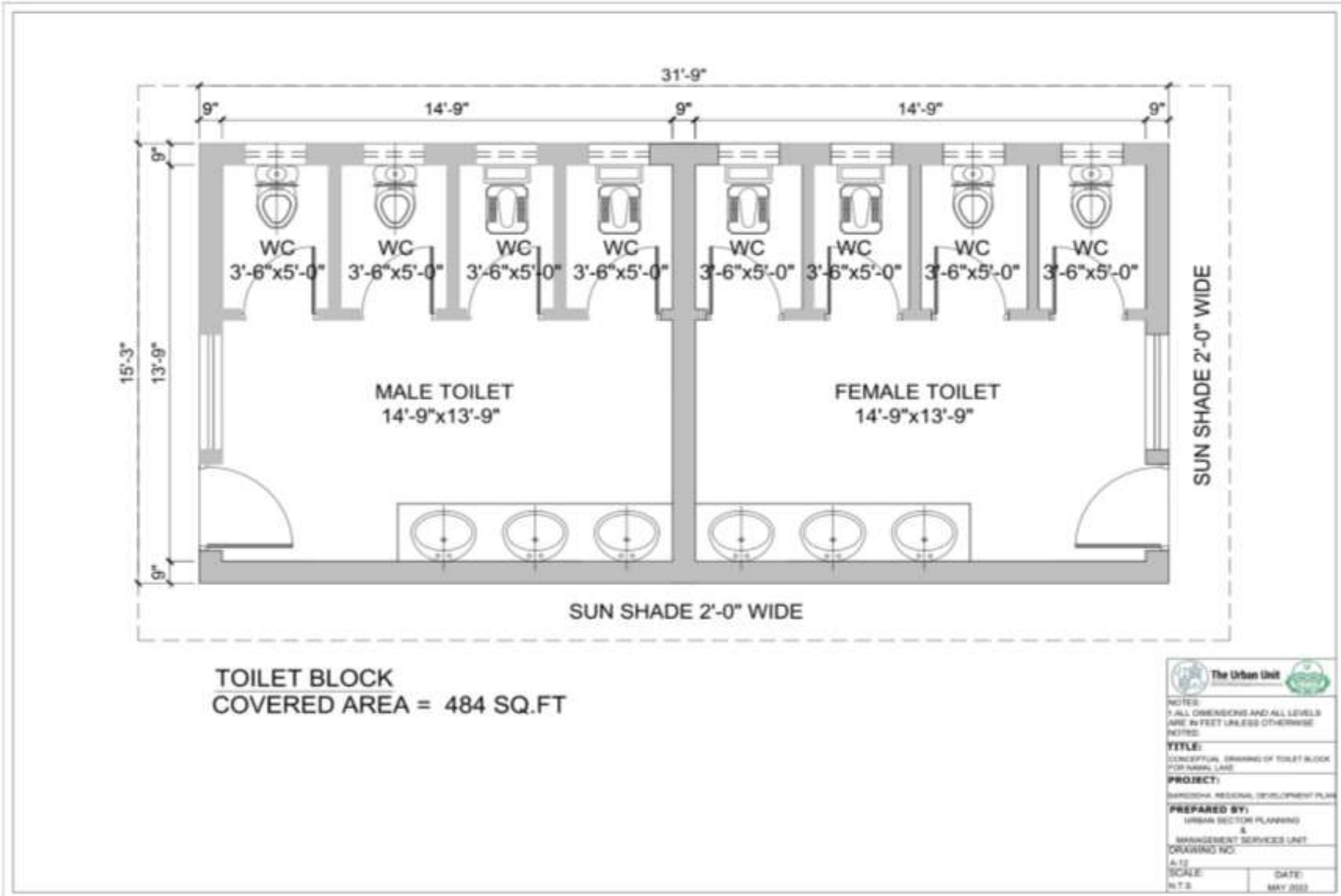
Annex – G: Proposed drawing of Information Center



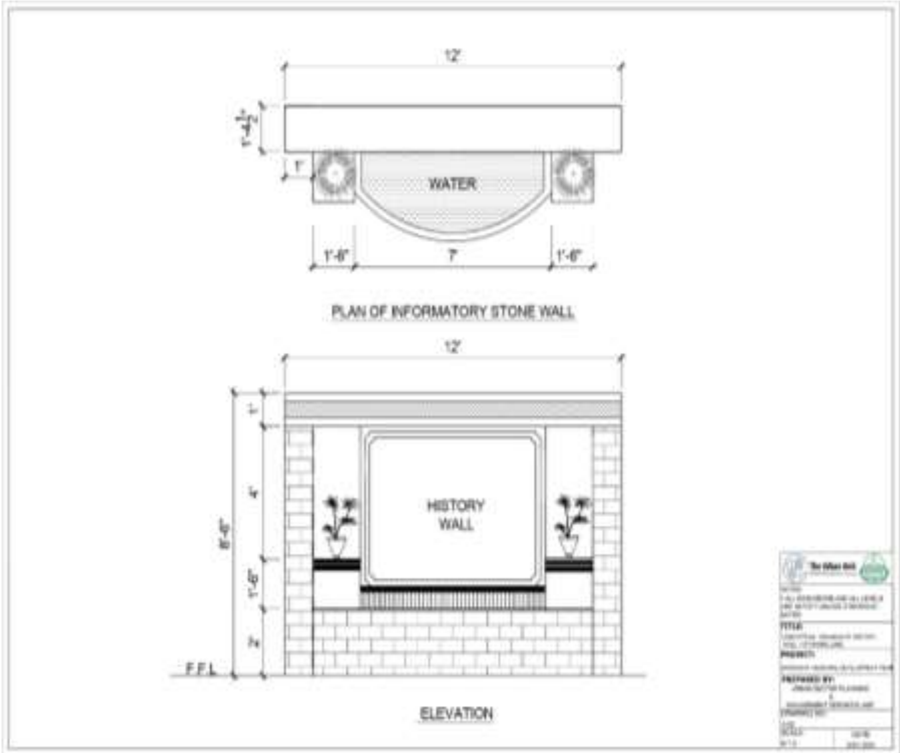
Annex – H: Proposed Drawing of Wildlife/Zoological Museum



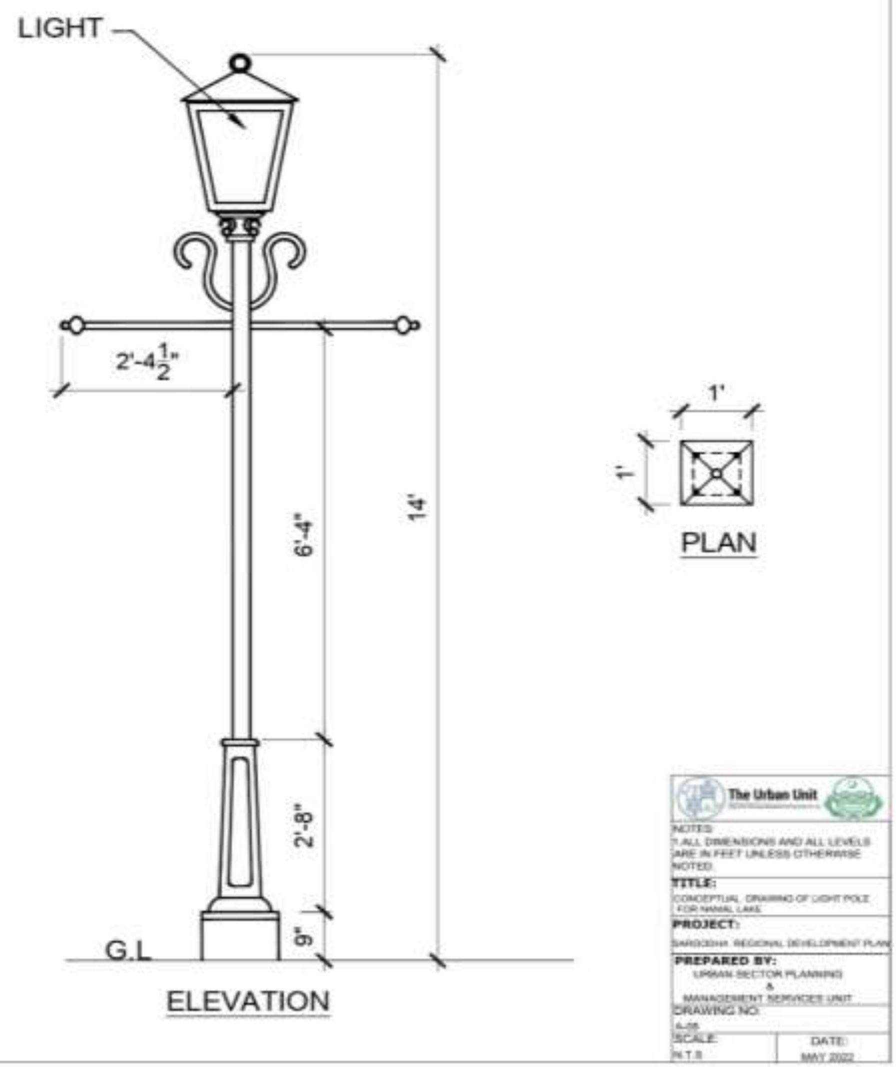
Annex – I: Proposed Drawing of Toilet Block



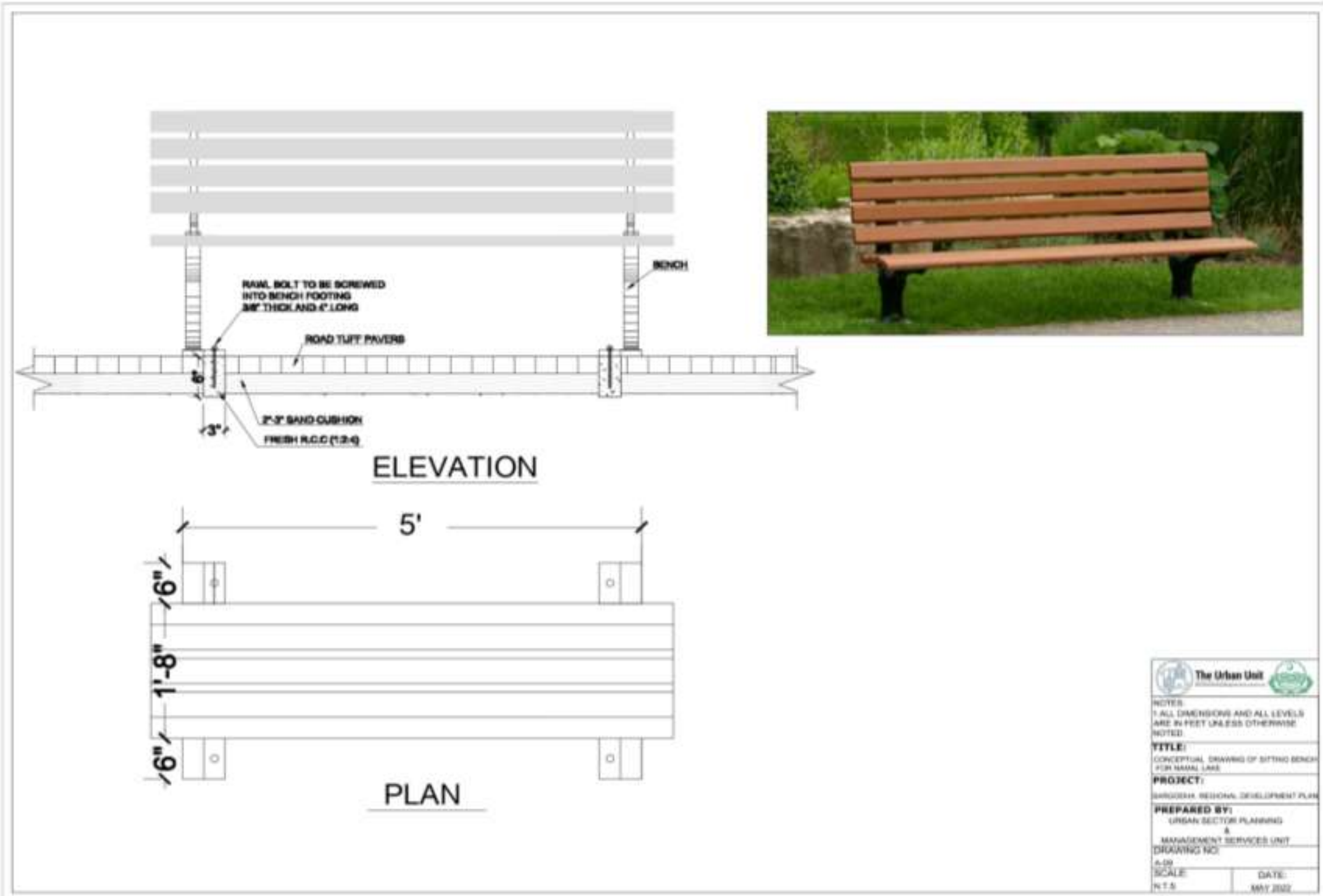
Annex – J: Proposed Design and Drawing of History Wall



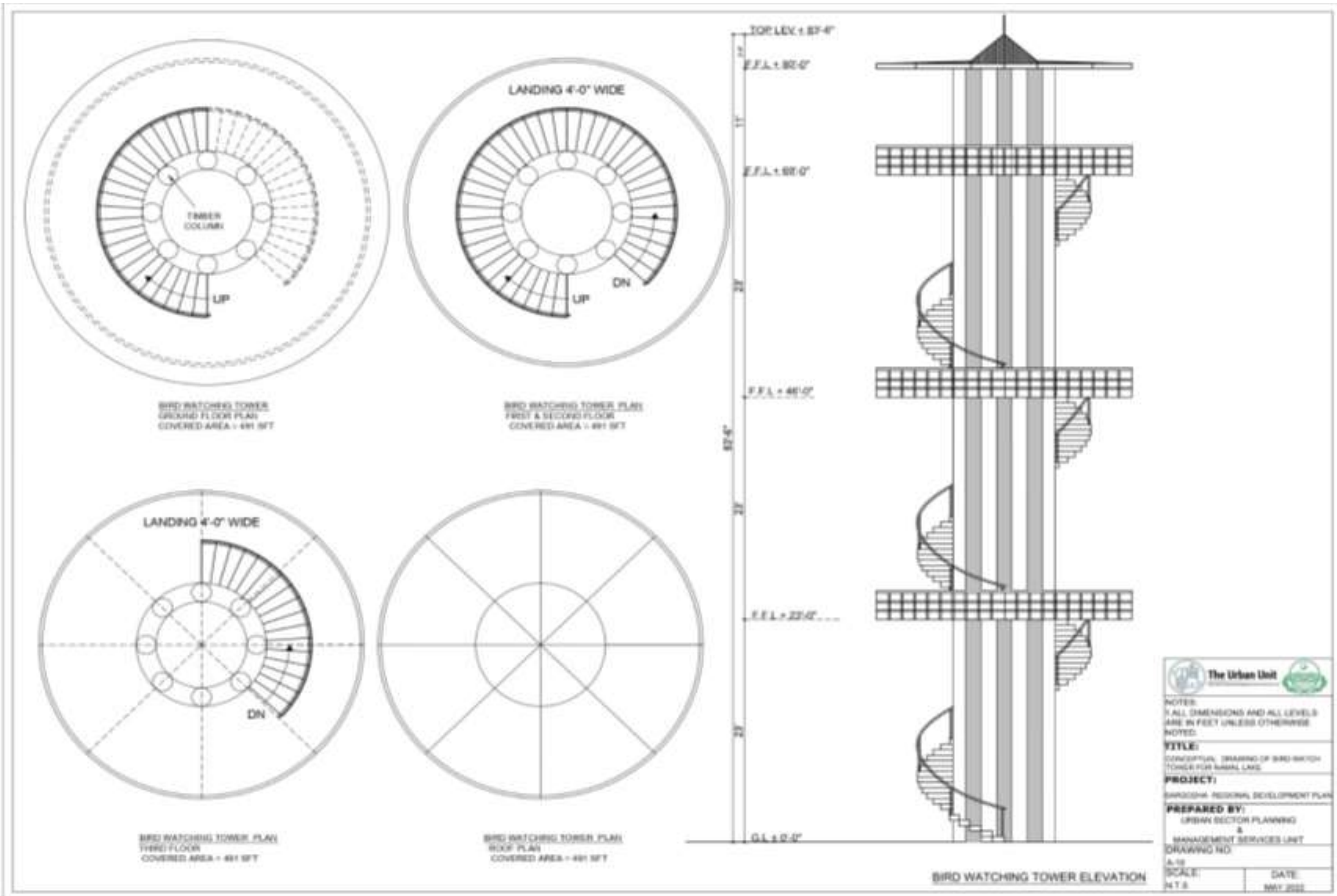
Annex – K: Proposed Design and Drawing of Light Poles



Annex – L: Proposed Design and Drawing of Benches



Annex – M: Proposed Design and Drawing of Bird Watching Tower



Annex – N: Rough Cost Estimation for Proposed Eco-Friendly Recreational Plan

Sr. No	Description	Amount in PKR	Amount in Million
1	Construction of Zoological Museum Building and wildlife Mounting, Preservation and Placementof all Animals Samples	103,528,874.83	103.529
2	Construction of Information Center (Information hall, Souvenir Shop, Tuck Shop, Kitchen,Control Room & Toils)	7,393,811.12	7.394
3	Construction of Cafeteria	6,860,801.02	6.861
4	Construction of Path Way	9,620,423.45	9.620
5	Construction of Parking Area	25,714,241.62	25.714
6	Construction of Landscaping Areas	16,441,798.84	16.442
7	Construction of Natural Areas	2,656,626.48	2.657
8	Construction of Board Walk Area & Cycling Track	13,099,853.41	13.100
9	Construction of Security Watch Tower	2,986,258.94	2.986
10	Construction of Birdwatch Tower	9,345,379.01	9.345
11	Construction of Water channel	3,982,237.73	3.982
12	Construction of Toilets Block	2,119,675.29	2.120
13	Construction of History Wall	1,000,000.00	1.000
14	Construction of Fountain Area	3,283,180.00	3.283
15	Construction of Sign Boards	1,125,000.00	1.125
16	Camping Area	1,497,000.00	1.497
17	Establishment of visitor's facilities (Stting Benches, Light Poles, Swm System, Kiosk, DriningWater, Bonfire, Gazebos, Mini Bazar	11,639,250.00	11.639
18	Solar Pannel System	10,500,000.00	10.500
19	Entrance and Fance	1,000,000.00	1.000
	Sub-Total Amount	**233,794,411.73**	**233.79**
	Add Contingencies Cost (2%)	**4,675,888.23**	**4.68**
	Add PST (5%)	**11,689,720.59**	**11.69**
	Grand Total Amount with Contingencies and PST	**250,160,020.56**	**250.16**

NOTE: *Standardized items (MRs) as notified by the finance department on the basis of current Market for the period of [MRS, 1ST BI-ANNUAL- 2022 (01.01.2022 to 30.06.2022) DISTRICT MIANWALI) have been followed*.

Annex – O: Summary of Rough Cost Estimate of The Namal Lake Restoration and Management Plan

Sr.No	Description	Amount in PKR	Amount in Millions
1	**Component 1: Interventions for Lake Restoration and Management**		
i.	Construction of Stone Wall (190+320 Rft)	2,677,315	2.68
ii.	Construction of Channel's (9957 Rft)	21,270,067	21.3
iii.	Construction of Stone Block	1,871,262	1.871
iv.	Construction of Check Dam	37,028,110	37.028
	Sub-Total Amount	62,846,753.42	62.85
	Add Contingencies Cost (2.5%)	1,571,168.84	1.57
	Add PST (5%)	3,142,337.67	3.14
	Total Amount with Contingencies and PST	**67,560,259.92**	**67.56**
2.	**Component 2: Eco-friendly Recreation Plan**		
	Sub-Total Amount	233,794,411.73	233.79
	Add Contingencies Cost (2%)	4,675,888.23	4.68
	Add PST (5%)	11,689,720.59	11.69
	Total Amount with Contingencies and PST	**250,160,020.56**	**250.16**
	GRAND TOTAL	**317,720,280.48**	**317.72**

Annex – P: Coordinates for location of Interventions

Sr. No.	Type of Intervention	Coordinates
1	Tree Cluster	32°40'30.96"N, 71°49'46.37"E
2	Check Dam	32°41'59.01"N, 71°48'11.77"E
3	Stone Lined Channel	32°41'2.09"N, 71°48'23.17"E
4	Check Dam	32°40'26.90"N, 71°48'26.47"E
5	Energy Dissipating Blocks	32°39'18.71"N, 71°50'32.55"E
6	Energy Dissipating Blocks	32°40'8.41"N, 71°50'0.39"E
7	Energy Dissipating Blocks	32°40'11.54"N, 71°49'37.37"E
8	Check Dam	32°39'52.01"N, 71°48'12.74"E
9	Energy Dissipating Blocks	32°39'42.32"N, 71°48'26.19"E
10	Energy Dissipating Blocks	32°39'52.10"N, 71°48'16.38"E
11	Stone lined channel	32°39'53.58"N, 71°48'11.91"E
12	Stone lined channel	32°39'56.84"N, 71°48'16.09"E
13	Check Dam	32°40'9.70"N, 71°48'8.43"E
14	Tree cluster	32°41'38.03"N, 71°48'50.61"E
15	Tree cluster	32°41'56.10"N, 71°48'48.97"E
16	Check Dam	32°40'21.08"N, 71°48'10.49"E
17	Energy Dissipater Blocks	32°40'13.27"N, 71°49'27.81"E
18	Tree cluster	32°40'24.72"N, 71°49'13.35"E
19	Energy Dissipater Blocks	32°39'32.05"N, 71°50'24.03"E
20	Tree cluster	32°39'48.28"N, 71°50'19.34"E
21	Tree Cluster	32°39'51.23"N, 71°50'17.56"E
22	Stone wall	32°39'53.30"N, 71°50'11.01"E

Annex – Q: Monthly Rainfall data of Mianwali Region

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1981	47.46	36.91	42.19	15.82	10.55	5.27	205.66	126.56	26.37	0	0	5.27	522.07
1982	5.27	84.38	89.65	110.74	63.28	36.91	42.19	126.56	0	5.27	15.82	52.73	632.81
1983	10.55	5.27	26.37	105.47	26.37	5.27	52.73	179.3	26.37	5.27	0	0	442.97
1984	0	15.82	21.09	10.55	0	42.19	68.55	47.46	21.09	0	31.64	15.82	274.22
1985	0	5.27	5.27	26.37	0	5.27	89.65	147.66	0	5.27	0	52.73	337.5
1986	5.27	52.73	63.28	36.91	21.09	21.09	63.28	105.47	10.55	10.55	21.09	10.55	421.88
1987	0	36.91	63.28	0	36.91	10.55	10.55	5.27	15.82	5.27	0	0	184.57
1988	5.27	5.27	42.19	15.82	0	10.55	84.38	21.09	10.55	0	0	36.91	232.03
1989	21.09	0	31.64	0	0	10.55	89.65	94.92	0	0	0	26.37	274.22
1990	10.55	73.83	36.91	15.82	0	5.27	79.1	58.01	36.91	5.27	0	15.82	337.5
1991	0	15.82	5.27	26.37	0	5.27	15.82	84.38	10.55	0	0	0	163.48
1992	36.91	36.91	47.46	15.82	10.55	0	58.01	68.55	137.11	5.27	10.55	5.27	432.42
1993	10.55	15.82	47.46	5.27	0	10.55	68.55	15.82	15.82	0	0	0	189.84
1994	0	21.09	5.27	36.91	5.27	0	89.65	26.37	21.09	15.82	0	21.09	242.58
1995	10.55	15.82	36.91	42.19	10.55	10.55	89.65	100.2	21.09	15.82	0	0	353.32
1996	21.09	42.19	26.37	5.27	5.27	42.19	10.55	73.83	15.82	36.91	5.27	0	284.77
1997	15.82	5.27	5.27	42.19	10.55	5.27	15.82	10.55	0	15.82	15.82	0	142.38
1998	5.27	26.37	5.27	5.27	5.27	15.82	63.28	21.09	0	0	0	5.27	152.93
1999	31.64	10.55	10.55	0	21.09	0	26.37	21.09	5.27	0	0	0	126.56
2000	36.91	15.82	0	0	15.82	15.82	21.09	5.27	31.64	0	5.27	47.46	195.12
2001	0	0	5.27	63.28	10.55	31.64	142.38	21.09	21.09	0	5.27	0	300.59
2002	0	63.28	21.09	5.27	0	26.37	0	10.55	21.09	21.09	10.55	26.37	205.66
2003	5.27	47.46	15.82	0	0	5.27	84.38	10.55	31.64	0	0	5.27	205.66
2004	31.64	5.27	0	10.55	0	21.09	36.91	52.73	36.91	10.55	0	5.27	210.94
2005	26.37	31.64	68.55	15.82	10.55	5.27	121.29	52.73	31.64	5.27	0	0	369.14
2006	15.82	21.09	31.64	5.27	42.19	21.09	79.1	94.92	26.37	15.82	15.82	63.28	432.42
2007	0	94.92	68.55	5.27	10.55	147.66	205.66	42.19	42.19	0	5.27	0	622.27
2008	31.64	0	0	89.65	21.09	68.55	105.47	126.56	58.01	5.27	0	21.09	527.34
2009	21.09	26.37	15.82	36.91	15.82	0	52.73	63.28	26.37	36.91	0	0	295.31
2010	15.82	31.64	21.09	0	5.27	31.64	189.84	216.21	47.46	0	0	5.27	564.26
2011	0	36.91	5.27	21.09	5.27	68.55	163.48	121.29	73.83	5.27	0	0	500.98
2012	10.55	10.55	5.27	36.91	0	5.27	147.66	73.83	94.92	10.55	0	21.09	416.6
2013	0	79.1	36.91	31.64	10.55	68.55	63.28	36.91	26.37	21.09	5.27	0	379.69
2014	0	10.55	31.64	63.28	15.82	10.55	110.74	47.46	89.65	73.83	5.27	0	458.79
2015	15.82	26.37	121.29	26.37	5.27	26.37	79.1	58.01	36.91	15.82	5.27	5.27	421.88
2016	10.55	15.82	63.28	15.82	21.09	36.91	195.12	68.55	26.37	0	0	0	453.52
2017	31.64	15.82	15.82	42.19	5.27	36.91	73.83	84.38	47.46	0	5.27	5.27	363.87
2018	0	21.09	21.09	36.91	21.09	36.91	94.92	26.37	5.27	21.09	5.27	5.27	295.31
2019	31.64	15.82	36.91	31.64	26.37	15.82	84.38	73.83	36.91	15.82	15.82	5.27	390.23
2020	36.91	179.3	263.67	63.28	179.3	316.41	89.65	179.3	121.29	0	47.46	21.09	1497.66
2021	21.09	126.56	31.64	35.36	32.03	56.85	142.02	89.74	115.56	38.76	0.07	11.77	701.46

The Urban Unit

Urban Sector Planning & Management Services Unit (Pvt.) Ltd.