The Urban Unit

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

Sahiwal

Regional Development Plan

Environment & Social Safeguard Division

Environment Sector

Sahiwal Regional Development Plan

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01 Setting the Context

Rapid urbanization, population expansion in urban centers and massive economic activities are among certain challenges that Punjab province is facing. To tackle these issues and improve Punjab's population's livability, development and planning at the regional level have been brought to attention.

There is a multifaceted way to express the terminology

"Region"

depending upon the scale of analysis. It could be any land that has common natural and artificial features. It could also be any basic administrative unit that either encompasses an area, division, or district for local government. More distinctively, it could be any administrative or politically/economically/spatially defined area that may cover different states/countries or could be at a national/sub-national/local scale and has a role in a certain level of development.[1]

Punjab Spatial Strategy 2047 outlines division as a good region for achieving larger development goals in harmony with districts and cities as well as for assessing the comparative advantages at a macro scale. **The strategy identifies division as a 'region' which forms the economic units based on a regional vision and development plans that not only enhance competitiveness and productivity of the region but also enable efficient resource allocation and more economic returns.** In an international context, China has successfully achieved its economic transition from an agrarian economy to an industrialized economy by focusing on regional developments and integrated planning frameworks.

The Sahiwal Region, located in the eastern part of Punjab province, encompasses three districts: Sahiwal, Okara and Pakpattan. This region holds significant potential for economic growth and offers ample opportunities for investment. However, it is also endowed with abundant natural resources that face various natural and human-induced threats, including extreme temperature variations, industrialization, urban expansion, deforestation, and dwindling water resources.

This situation thus, demands a number of interventions with a range of amenity green structures and improved environmental quality in order to develop a proportion between grey and green areas of the region. Therefore, a regional development plan of the environment sector is being prepared for the spatial, economic, and environmentally

Figure 1: Divisions of Punjab Province

sustainable development in the region. It also helps in managing the challenges, disparities and competition for development resources between cities in a region as well as keep the goods and resources available to them as per their needs.

02 Sahiwal Regional Profile

The Sahiwal Division occupies a strategic position in east-central Pakistan, with coordinates around 30°39'52" in the North and 73°6'30" in the East. It is nestled within the vibrant Punjab region, serving as a vital link along Pakistan's national highway N-5, conveniently located between the major cities of Lahore and Multan. Surrounded by neighboring divisions, the Sahiwal Division shares its borders with the Faisalabad Division to the west, the Lahore Division to the north, and the Multan Division to the south. The Sahiwal Division comprises following three districts, each with its unique administrative setup and tehsils contributing to the region's development and governance.

- Sahiwal District
- Okara District
- Pakpattan District

The topography of Sahiwal is characterized by a mix of plains and riverine features, making it conducive to agricultural activities and natural beauty. Sahiwal is part of the Bari Doab region, which is a fertile plain formed by sediments deposited by the Ravi River. This means the land is generally flat and low-lying, with an average elevation of around 152 meters above sea level. The Ravi River flows on the western side of Sahiwal, contributing to fertile agricultural lands and adding to the scenic landscape. This river enriches the region with its water resources, supporting irrigation and cultivation of crops. On the eastern side, the Satluj River meanders through the division, further enhancing the area's natural charm and historical significance.[1] Additionally, the region is traversed by the Khushak Bias, a dry riverbed that serves as a distinct boundary between the Sahiwal District and the Pakpattan District. This dry riverbed, while not actively carrying water, plays a significant role in shaping the division's spatial identity and natural features. Furthermore, Sahiwal boasts a considerable forest cover, covering approximately *28,956 acres* of land. This forested area adds to the biodiversity of the region, providing habitats for various flora and fauna species and contributing to environmental conservation efforts.

There a substantial urban-rural population size differences within the Sahiwal Region. According to the 2017, Census of Pakistan, the annual growth rate of the Sahiwal Region is 1.69 with a total population of 7,380,386. Moreover, the regional level analysis shows that the ratio of Urban and Rural populations is 22.1% and 77.8% respectively. The detailed demographic profile of the Sahiwal Region is given below:

Table 1: Demographic Profile of Sahiwal Division [2,3]

Sahiwal Region				
Sr. #	**Particulars**	**Sahiwal District**	**Okara District**	**Pakpattan District**
1.	Location	30.5854° N, 72.9933° E	30.8138° N, 73.4534° E	30.2527° N, 73.1822° E

[1] https://pakistanalmanac.com/punjab-sahiwal/
[2] https://www.pbs.gov.pk/sites/default/files/population/2017/tables/punjab/Table01p.pdf
[3] DISTRICT_WISE_CENSUS_RESULTS_CENSUS_2017.pdf

2.	Area (km²)	3,201	4,377	2,724
3.	Population (2017)	2,517,560	3,039,139	1,823,687
4.	Population Density (per Sq. Km)	781.03	668.47	631.40
5.	Urban Proportion	20.5%	27.4%	15.8
6.	No. of Tehsils	02 (Chichawatni Tehsil and Sahiwal Tehsil)	03 (Okara Tehsil, Depalpur Tehsil and Renala Khurd Tehsil)	02 (Pakpattan Tehsil and Arifwala Tehsil)
7.	Average Household Size (persons/ house)	6.9	6.6	6.43

Table 2: Projected Population[4]

Districts	Growth Rate (1998-2017)	2017	2023	2025	2030
Sahiwal Region	1.69	7,380,386	14,925,537	18,158,503	22,091,750
Sahiwal District	1.65	2,517,560	2,777,309	2,869,716	3,114,410
Okara District	1.63	3,039,139	3,348,745	3,458,804	3,750,037
Pakpattan District	1.85	1,823,687	3,392,476	3,519,159	3,856,950

As the population grows over the next decade, the Sahiwal region may become even greater. Thus, demanding a regional-level development plan where development efforts are focused on the creation of a system of cities that fosters intercity networking, creates more jobs, and increase productivity as well.

2.1. Climate Profile of Sahiwal Region

Sahiwal Region basks in a hot, semi-arid climate, classified as BWh by the Köppen system. Sahiwal's location near the Thar Desert and low altitude contribute to its unique weather patterns. Wet monsoons bring heavy rainfall, while the rest of the year remains dry with little to no precipitation. The average annual rainfall sits around 349 mm.[5] This climate bridges the gap between a scorching desert and a more humid environment. Summers are fiercely hot, with temperatures skyrocketing to 40-50°C in May, June, and July. Winters, however, offer a reprieve, with lows ranging from 5-10°C.[6] Sahiwal's climate is expected to see changes in both rainfall and temperature due to climate change. The annual average rainfall is projected to increase by 3.1% by 2050, though at a slightly lower rate compared to nearby Sialkot. However, this increase won't be evenly distributed throughout the year. The wet months of July and August are likely to experience a more significant rise in rainfall, leading to concerns about increased flooding during

[4] Based on the Statistical Analysis done by the Urban Unit

[5] https://www.myweather2.com/City-Town/Pakistan/Sahiwal/climate-profile.aspx

[6] https://sahiwaldivision.punjab.gov.pk/division_climate.

the monsoon season. Conversely, drier months like January, April, and December might see a decrease in rainfall, raising the risk of drought.[7]

On the temperature front, Sahiwal is expected to experience a rise in annual average mean temperature of around 0.8°C by 2050. This increase is projected to be consistent throughout the year, meaning all months will likely become warmer. This warming trend, coupled with the changing rainfall patterns, presents a complex challenge for Sahiwal. The region may have to contend with both the dangers of increased flooding and the threat of more frequent and severe droughts.[8]

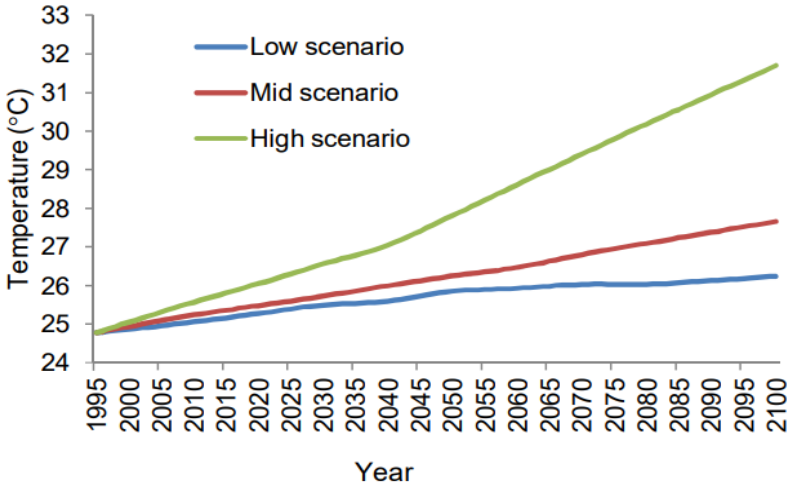


Figure 2: Sahiwal annual mean average temperature projection (^{0}C)

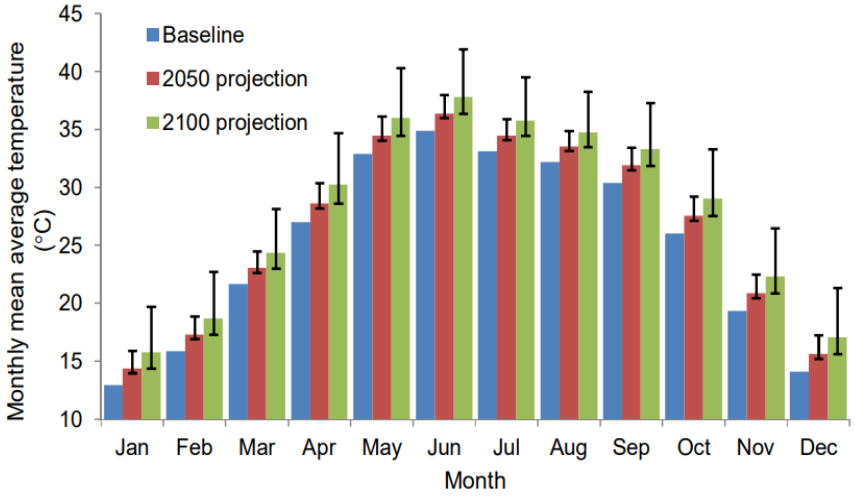


Figure 3: Mean monthly Temperature projection of Sahiwal. Bars indicating uncertainty range

[7] Javaid, K., Ghafoor, G. Z., Sharif, F., Shahid, M. G., Shahzad, L., Ghafoor, N., ... & Farhan, M. (2023). Spatio-temporal analysis of land use land cover change and its impact on land surface temperature of Sialkot City, Pakistan. Scientific Reports, 13(1), 22166.
[8] Ibid at 7.

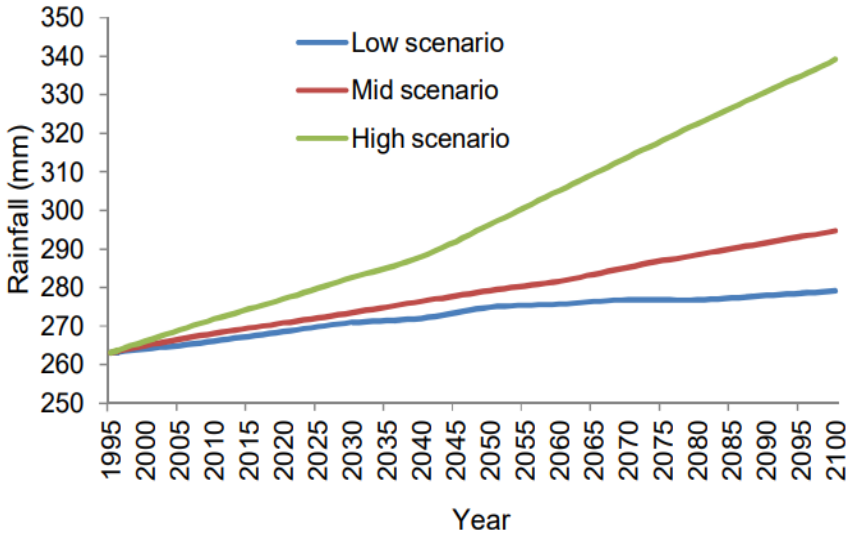


Figure 4: Sahiwal annual mean rainfall projection (mm)

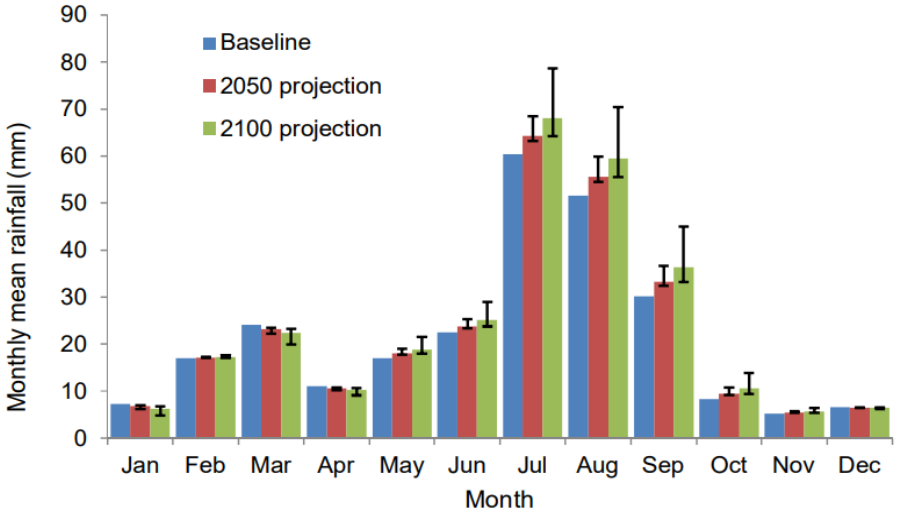


Figure 5: Mean monthly Rainfall projection of Sahiwal. Bars indicating uncertainty range

The Report by the Asian Development Bank on the Climate Profile of Pakistan ranks the three districts of Sahiwal Region based on vulnerability to different climate-related hazards.[9] The ranking is given below in Table 3.

Table 3: Vulnerability of Sahiwal Region to climate-related hazards

Rank	Districts	Flood Risk	Landslide Risk	Earthquake Risk	Drought Risk	Cyclone Risk	Cumulative Risk Level
73	**Sahiwal**	3	1	4	4	2	Medium
95	**Pakpattan**	3	1	3	2	3	Low
82	**Okara**	3	1	4	2	5	Medium
Scoring Key							
Very High		High		Medium	Low	Very Low	
5		**4**		**3**	**2**	**1**	

According to this ranking, Sahiwal district is more vulnerable to climate risks, as compared to other districts of the region[10], particularly, concerning drought and earthquake risk. Whereas, Okara district is at high risk of Cyclone risk. However overall, the Region faces high earthquake risk, followed by cyclone and drought risks. Additionally, wind and dust storms are also common in the Sahiwal Region in the summer season.

2.2. Environmental Profile of Sahiwal Region

Owing to its location in central Punjab, the Sahiwal region enjoys connectivity to various industrial centers and trade routes (i.e., CPEC Corridor) in the Punjab province. Thus, the overall region, particularly Sahiwal city is in the process of transforming into one of the major urban centres of the country. The economic boom along with urbanization in the city has led to a myriad of environmental challenges, including inadequate air & water quality, insufficient access to services including clean water, waste management, recreational spaces, etc.), congestion, and health issues. Moreover, the green cover of the region is also deteriorating.

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

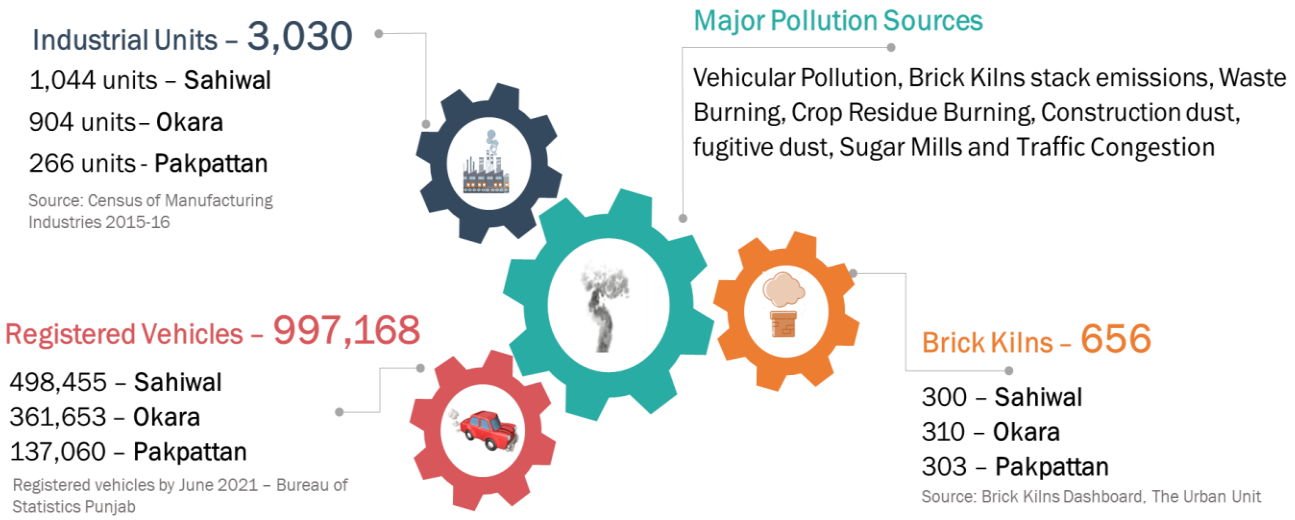


Figure 6: Key Issues affecting Environmental Quality of Sahiwal Region

2.2.1. Air Quality Assessment

The air quality of the Sahiwal Region is largely influenced by industrial emissions, poor traffic management and inadequate transport infrastructure, polluting industries, insufficient availability of clean fuels, outdated technologies, absence of air quality monitoring equipment, open burning of wastes and crop residues, non-availability of resources for enforcement of regulations in emissions control, and ineffective implementation of legislations.

The economy of the Sahiwal Region mainly depends of the services sector followed by the agrarian sector. There are a total of 3,030 industrial units, present in the form of scattered clusters across the region, making industries, the third major economic sector. Sahiwal District hosts 1,044 industrial units, 904 units in District Okara, and 266 units in Pakpattan District. Major industrial sectors in the region include food factories, non-metallic minerals products manufacturing, brick kilns, machinery & equipment manufacturing units, wood and furniture products, and fabricated metal products, etc.[11] The total number and categories of registered industries, in Sahiwal Region, recorded by the Census of Manufacturing Industries 2015-16, are given in Figure 7. Pakistan's first super-critical (high efficiency) coal-fired power plant developed under the CPEC Project is located within the Region. The plant consists of state-of-the-art pollution removal technologies including electrostatic precipitators for dust removals, an ash yard and coal yard to prevent fugitive emissions, the Limestone-Gypsum Flue Gas Desulfurization system to remove SO_2, and a wastewater treatment system based on zero discharge and water reuse systems[12].

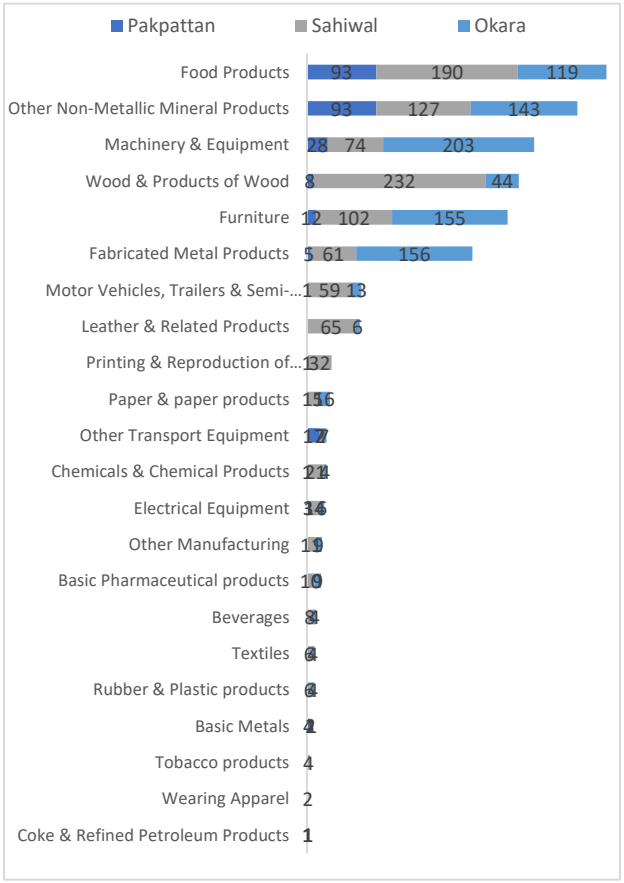


Figure 7: Industries in Sahiwal Region
(Source: Census of Manufacturing Industries 2015-16)

According to the Punjab Brick Kilns Census 2016, there are a total of 913 brick kilns in Sahiwal Region. The fuel source used in brick kilns is coal, mixed with rice husk. The burning of poor-quality coal emits oxides of carbon (CO, CO_2) and sulfur (SO_2), particulate matter (PM_{10}, $PM_{2.5}$), Polycyclic aromatic hydrocarbons (PAHs), and Volatile organic compounds (VOCs)[13]. In addition, solid waste burning, power sector, crop residue burning, and other industrial processes also emit pollutants in the air[14].

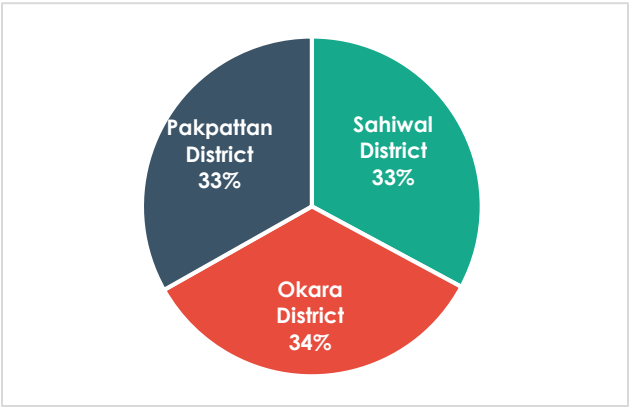


Figure 8: Number of Brick kilns in Sahiwal Region
(Source: Punjab Brick Kilns Census 2016)

[11] Census of Manufacturing Industries 2015-16, the urban unit.
[12] Zia, M.M., Waqar S.S. (2018). Sahiwal Coal Fire Power Plan, An Early Harvest Project by CPEC. Exploring Employment and Environmental Effects. CPEC Center. (Available at: https://cpec-centre.pk/wp-content/uploads/2018/06/Sahiwal-Case-Study.pdf)
[13] Pervaiz, S., Khan, F., Javid, K., Altaf, A., Aslam, F., Tahir, M., ... & Hayat, S. (2022). Development of air quality and brick kilns during the onset of COVID-19: An Analysis. Biological and Clinical Sciences Research Journal, 2022(1).
[14] Tabinda, A. B., Ali, H., Yasar, A., Rasheed, R., Mahmood, A., & Iqbal, A. (2020). Comparative assessment of ambient air quality of major cities of Pakistan. Mapan, 35, 25-32.

The transport sector is reportedly the major contributor to atmospheric emissions in Punjab. It emits CO, CO_2, NO_2, N_2O, SO_2, and PM. About 1.0 million vehicles have been registered in Sahiwal Region, the majority being in the Sahiwal district[15]. Inefficient vehicular engines, use of poor-quality fuel, broken road infrastructure in some places, and construction & other activities leading to traffic congestion are also responsible for traffic-related emissions.

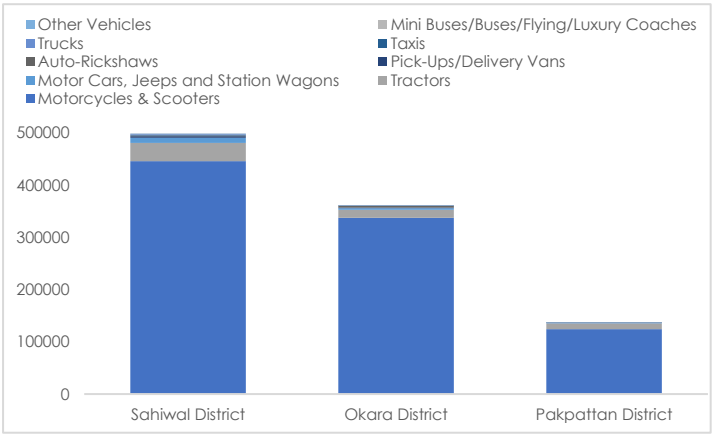


Figure 9: Registered Vehicles in Sahiwal Region
(Source: Punjab Development Statistics 2022)

According to the Air Quality Life Index (AQLI), high particulate matter ($PM_{2.5}$) in the air is shortening the average Pakistani's life expectancy by 3.9 years annually, relative to what it would have been if the World Health Organization (WHO) guideline was met. The average annual concentration of $PM_{2.5}$ in Punjab was recorded to be 52 µg/m³ in 2021, which is higher than the PEQs Limits of 15 µg/m³ and WHO limits of 5 µg/m³ for $PM_{2.5}$ concentration in ambient air. The Life Expectancy Gain (Years) by meeting WHO Guidelines for the residents of Sahiwal Region is 4-5 Years (Figure 10).[16]

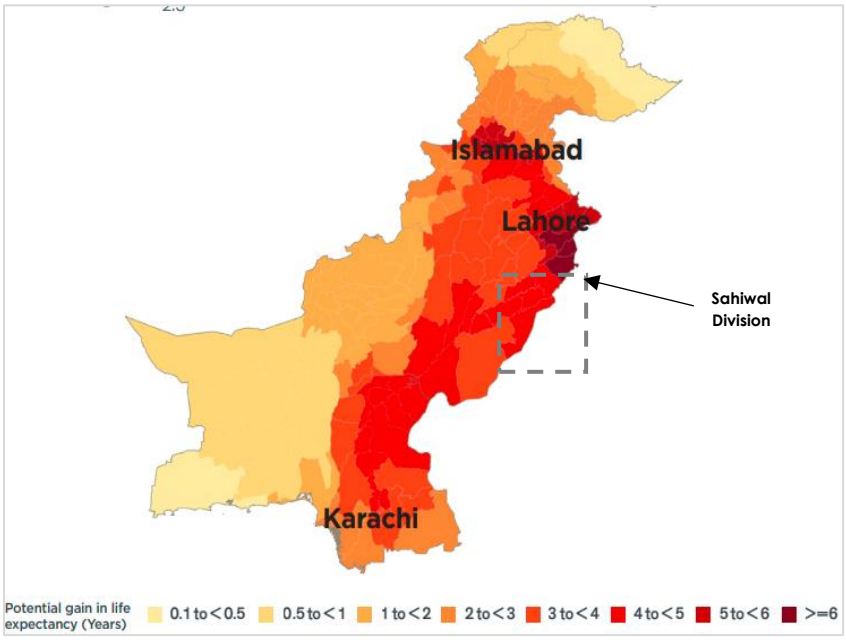
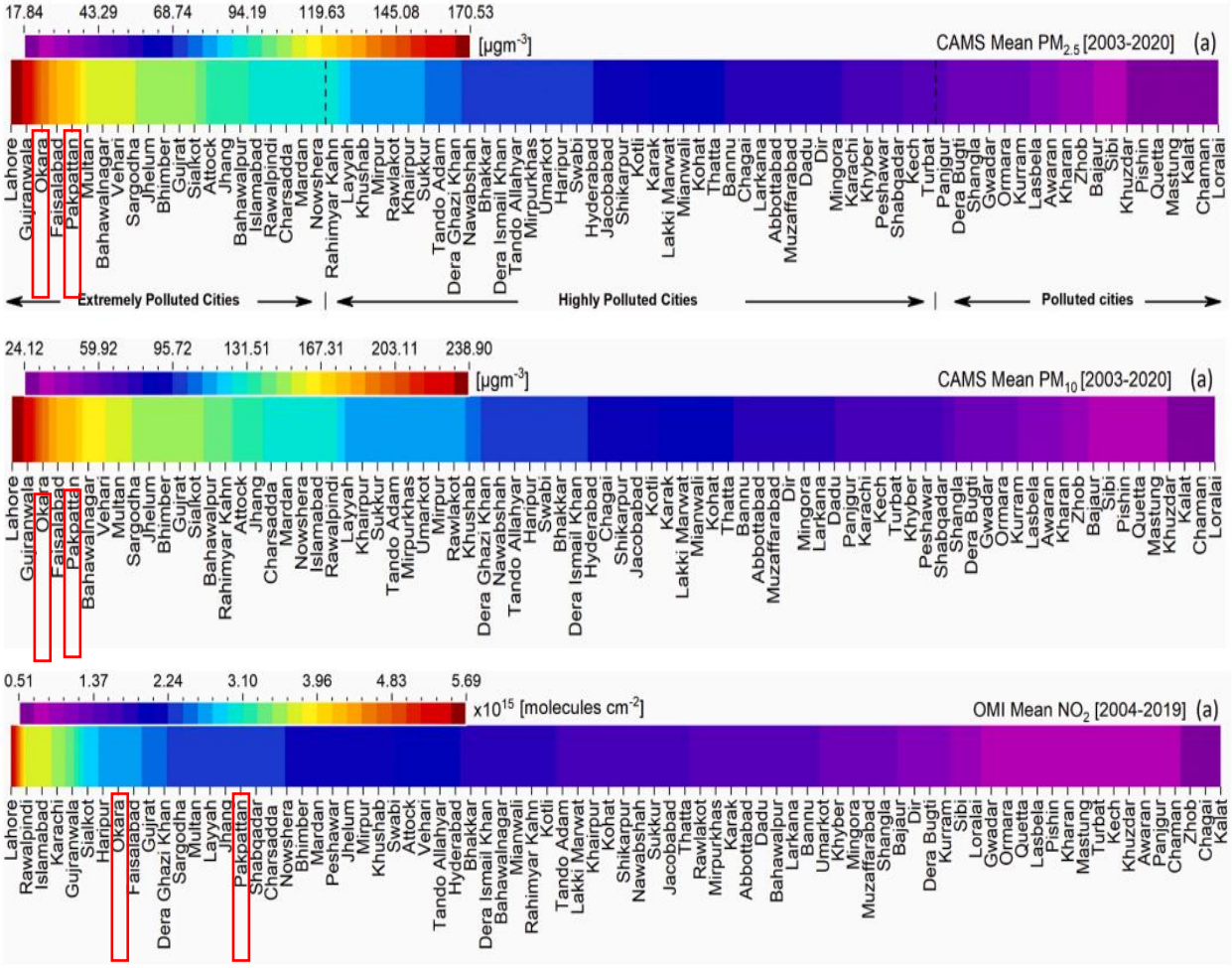


Figure 10: Life Expectancy Gains if WHO Guidelines for Ambient Air Quality are met
(Source: AQLI Pakistan Factsheet 2023)

[15] Bureau of Statistics. Population Development Statistics Report, 2022. Government of Punjab.
[16] Pakistan Fact Sheet, August 2023. Air Quality Life Index. University of Chicago.

Air Quality data for 80 Cities in Pakistan was accessed from CAMS (Copernicus Atmospheric Monitoring System), AERONET (Aerosol Robotic Network, and Merra-2 (Modern-Era Retrospective Analysis for Research and Applications, Version 2) Satellites, in a research study[17]. The results reported that Okara and Pakpattan are the **3rd** and **5th** most polluted cities in Pakistan in terms of $PM_{2.5}$ and PM_{10} concentrations, respectively. Whereas, in terms of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) concentrations, Okara and Pakpattan are among the top 10 and top 15 most polluted cities in the country, respectively. Sahiwal City was not part of this assessment study. The results are presented below;



[17] Bilal, M., Mhawish, A., Nichol, J. E., Qiu, Z., Nazeer, M., Ali, M. A., ... & Ke, S. (2021). Air pollution scenario over Pakistan: Characterization and ranking of extremely polluted cities using long-term concentrations of aerosols and trace gases. Remote Sensing of Environment, 264, 112617.

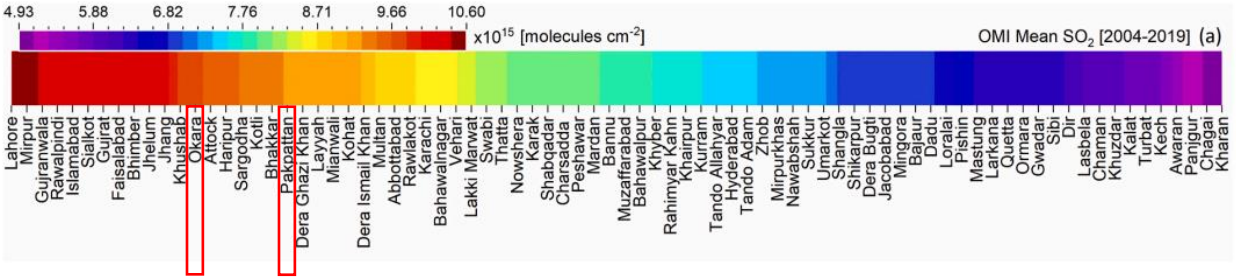


Figure 11: Ranking of Cities in terms of Mean $PM_{2.5}$, PM_{10}, NO_2, and SO_2 concentrations in Pakistan (Source: Bilal et. al, 2021)

The environment team also monitored particulate matter ($PM_{2.5}$ and PM_{10}) in the field with the help of portable air quality monitoring instruments in the Sahiwal Region. The monitoring results showed that the concentrations of $PM_{2.5}$ were recorded above the Punjab Environmental Quality Standards i.e., 35 µg/m^3 in the entire region. The minimum recorded concentration is 90 µg/m^3 and the maximum recorded concentration is 403 µg/m^3. The cities of Okara and Renala Khurd are the most polluted areas, followed by Depalpur, Sahiwal, Arifwala, and Chichawatni. The $PM_{2.5}$ concentrations measured in Pakpattan was <90 µg/m^3. Prominent sources of high $PM_{2.5}$ concentrations in the Region include vehicular emissions, crop residue burning, brick kilns, industrial units, and biomass burning. The results are depicted in Figure 12.

In addition, the monitoring done in the field revealed that the recorded concentrations of PM_{10} are higher than the permissible limit of PEQS i.e., 150µg/m^3 mainly in the western and southern areas of the region. The most polluted cities in terms of PM_{10} are Sahiwal and Chichawatni with concentrations nearing 800 µg/m^3, followed by Pakpattan, Arifwala and Renala Khurd. The concentration was lowest in the Okara and Depalpur cities, (approx. ~ 300 µg/m^3) but still higher than the PEQs limit. Major sources of PM_{10} in the region include roadside dust, biomass burning, brick kilns, and crop residue burning. It is significant to note that the concentrations of particulate matter are also influenced by meteorological conditions, i.e., wind speed, wind direction, temperature, humidity, and precipitation) and seasonal conditions. The results are depicted in below Figure 13.

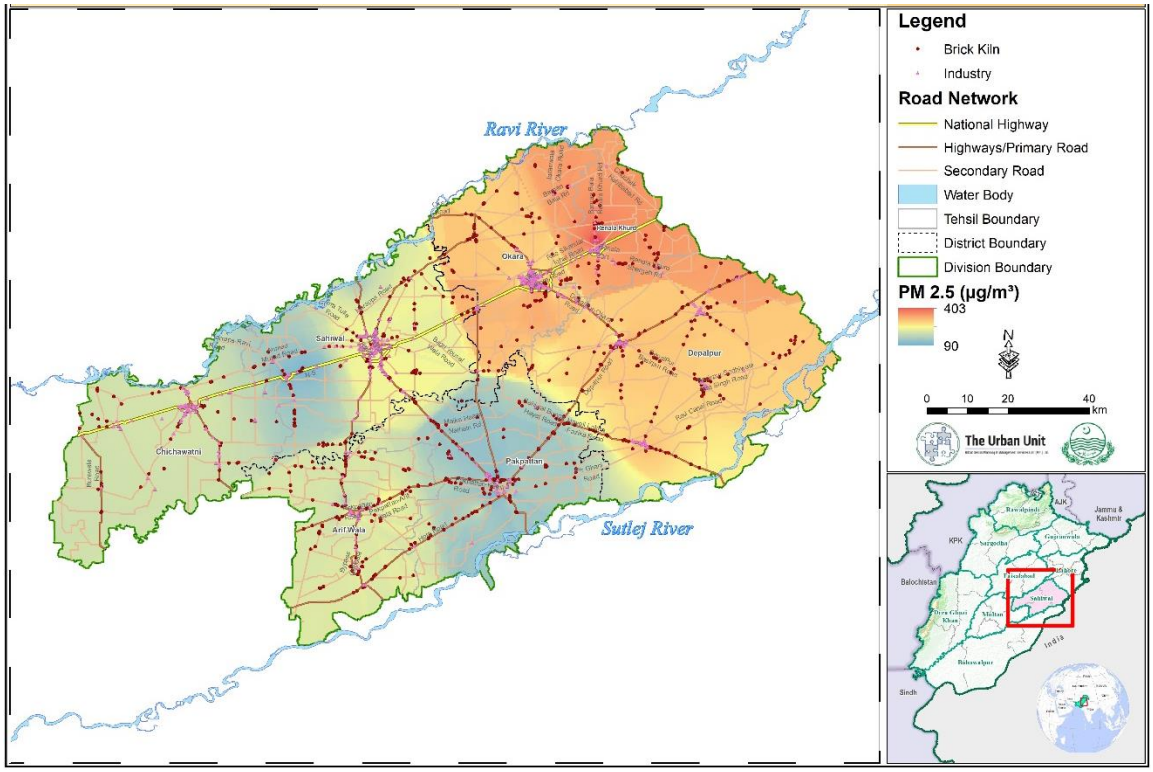


Figure 12: $PM_{2.5}$ Concentration in Sahiwal Region
(Source: Field Survey, The Urban Unit team, 2024)

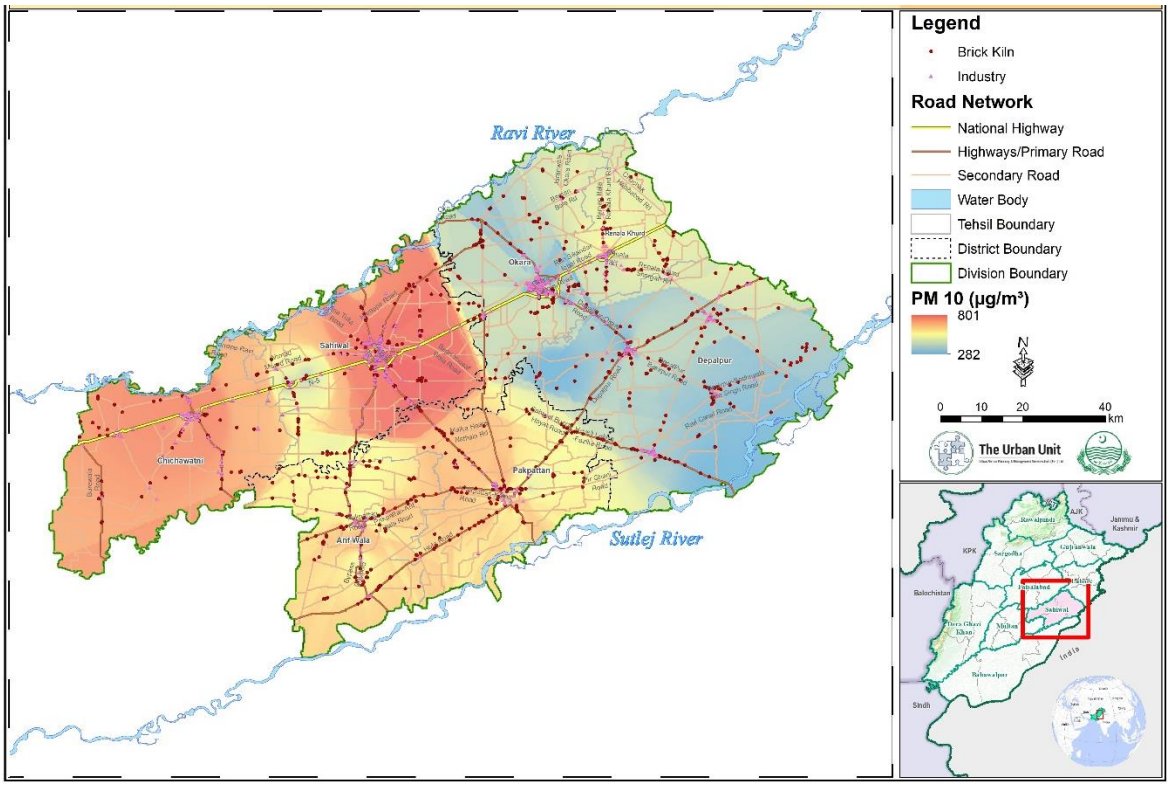


Figure 13: PM_{10} Concentration in Sahiwal Region
(Source: Field Survey, The Urban Unit team, 2024)

To complement air quality monitoring in the field, the research team at the Urban Unit uses remote sensing and satellite data to evaluate the pollution concentrations of Aerosol Index, Sulfur Dioxide and Nitrogen Dioxide in the region. The results of these spatial analyses are represented below. This shows that the major urban centers are the most polluted areas.

- Aerosol Index (AI): Aerosol Index is higher in Chichwatni, Sahiwal, and Attock cities. Major sources include; Emissions from industries & brick kilns, roadside dust, crop residue and biomass burning.
- Carbon Monoxide (CO): Carbon Monoxide (CO) concentration is highest in Attock District. Major sources include industrial units and vehicular emissions.
- Nitrogen Dioxide (NO_2): The concentration of NO_2 is highest in the urban areas of Attock, Renala Khurd, and Sahiwal Cities. Emissions sources include vehicular emissions and any combustion activities.
- Sulfur Dioxide (SO_2): Sulfur Dioxide pollution is distributed throughout the entire Region. Major sources for this high concentration are Biomass burning, Industrial emission, and Traffic congestion.

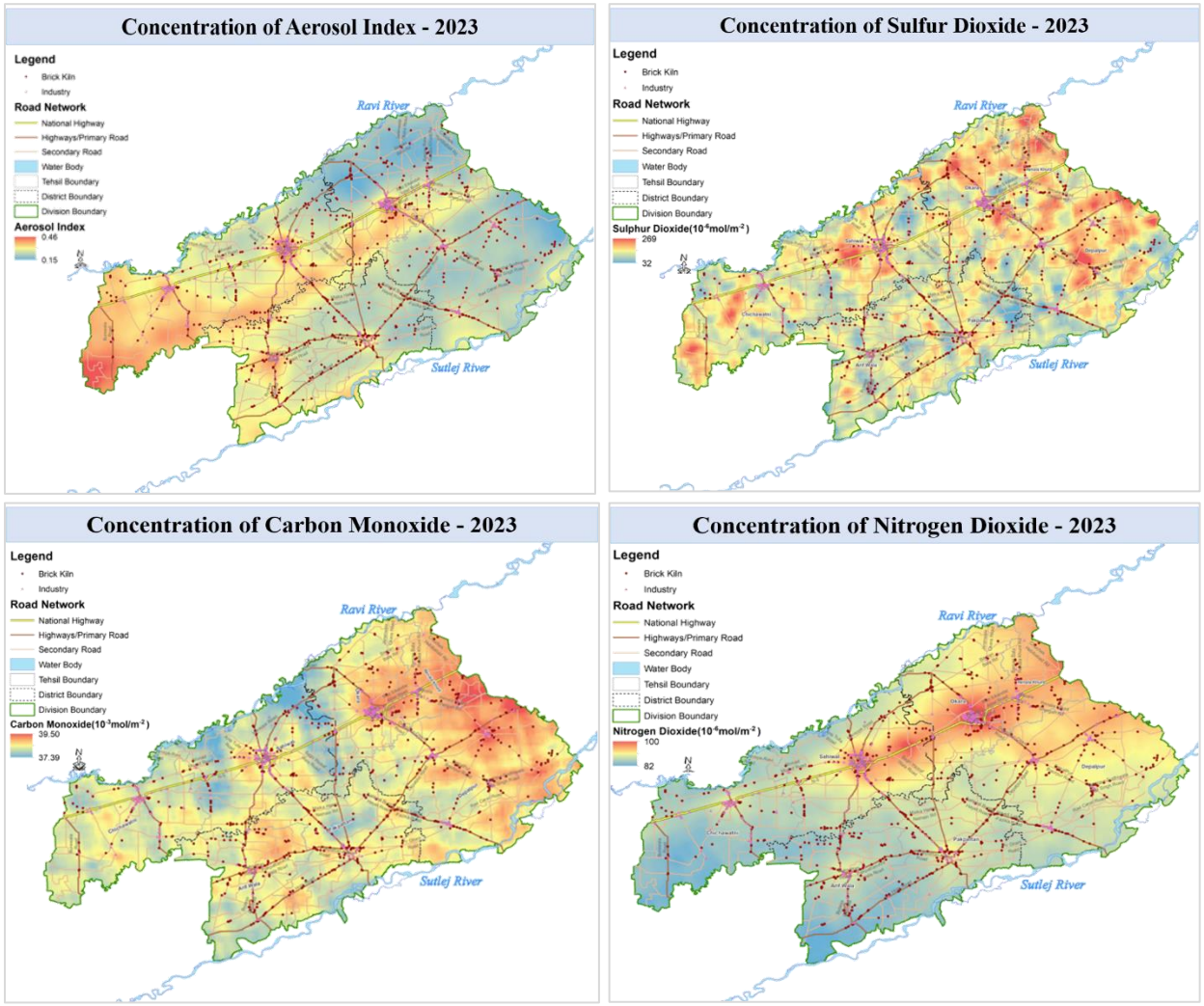


Figure 14: Concentrations of AI, SO_2, CO, and NO_2 in Sahiwal Region (2023)
(Source: Sentinel-5P data)

2.2.2. Water Quality Assessment

Water Quality of Sahiwal Region was also assessed during field visit by obtaining water samples from different sources, including hand pump, motor pump, household connection, irrigation tube well, etc. The samples were then analyzed to determine the concentrations of pH, Electrical Conductivity, Total Dissolved Solids and Arsenic.

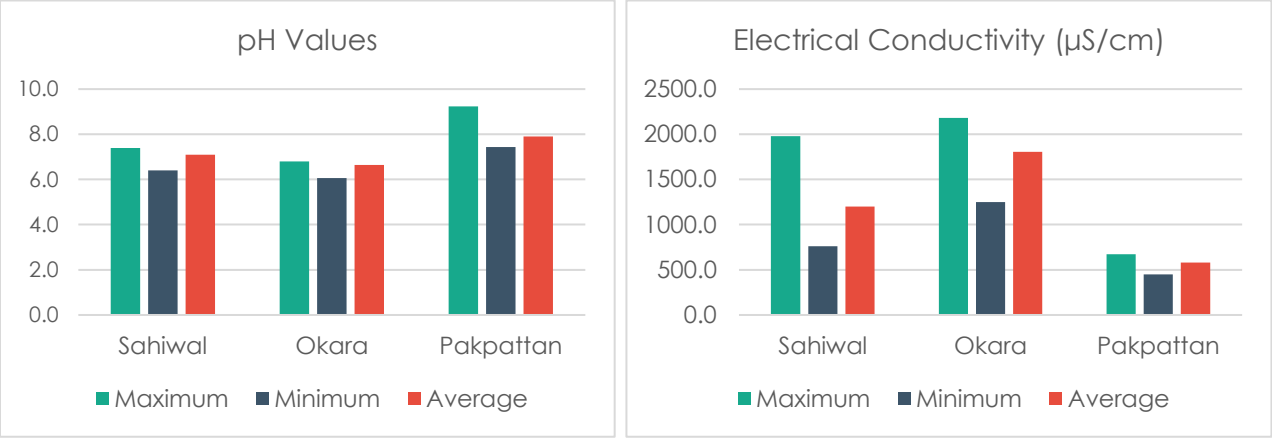


Figure 15: pH and Electrical Conductivity concentration in Groundwater of Sahiwal Region
(Source: Field Visit of Urban Unit Team, 2024)

The permissible limit of TDS for drinking water quality specified by WHO and Punjab Environmental Quality Standards is 1000 mg/l. Figure 16 shows that the concentration of TDS in the obtained water samples from Renala Khurd, Depalpur, Sahiwal and Chichawatni as well as in some pockets of Pakpattan district exceeds the permissible limit because of higher agricultural activity and denser population along with other factors like fertilizers and salts seeping into the water table from agriculture, discharge of untreated wastewater, and depletion of freshwater sources. Conversely, areas on the outskirts of major towns and cities like Sahiwal, Okara, Arifwala and Pakpattan show lower TDS levels, possibly due to deeper aquifers with lower mineral content and less intensive agricultural activity impacting the water table.

World Health Organization (WHO) and Punjab Environmental Quality Standards (PEQs) specify the permissible limits of 10 ppb and 50 ppb, respectively, for Arsenic concentration in drinking water. The results of Arsenic tests revealed that its concentration is below the permissible limits defined by WHO and PEQs within most parts of Sahiwal Region. However, in Pakpattan district, a large pocket showed higher concentration of Arsenic. Particular reason of this higher concentration includes untreated industrial wastewater discharge, leather tanneries effluent discharge, and excessive use of arsenic-based pesticides and fertilizers in fields for crops production. Figure 17 below shows the concentration of Arsenic in the obtained water samples.

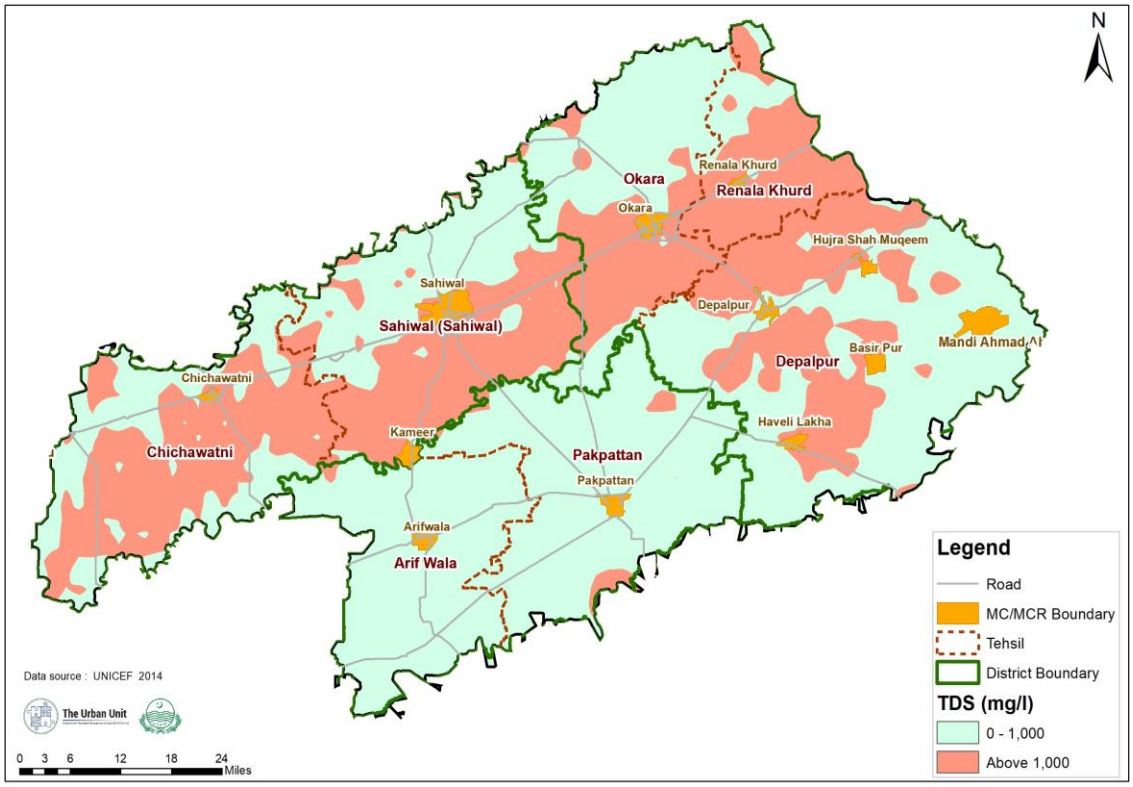


Figure 16: TDS concentration in Groundwater of Sahiwal Region
(Source: UNICEF, 2014)

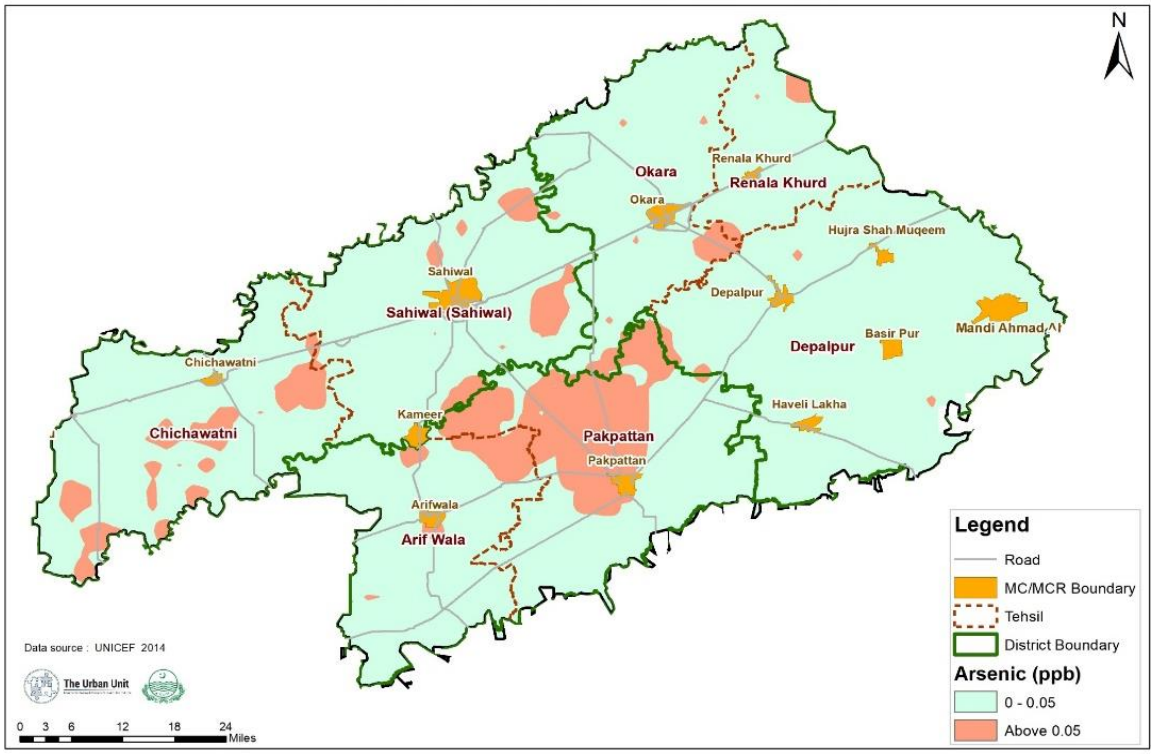


Figure 17: Arsenic concentration in Groundwater of Sahiwal Region
(Source: UNICEF, 2014)

A study conducted in Sahiwal district revealed concerning trends in water quality. Arsenic levels exceeding 10µg/L were detected at 8 locations, indicating that 40% of the studied area's drinking water did not meet the World Health Organization's (WHO) standards. However, all samples remained below the Pak EPA limit of 50 µg/L, ensuring that water across these locations met national standards. On the other hand, chromium (Cr) levels painted a worrisome picture. The mean concentration of Cr was found to be 5.559 mg/L, which is a staggering 111.18 times higher than the WHO and local standard of 0.05 mg/L. This substantial deviation from acceptable levels highlights a significant environmental concern in the region. In contrast, lead (Pb) levels were relatively within acceptable ranges. The Pb concentrations ranged from 2.03 to 20.69 µg/L, with a mean value of 7.037 µg/L. While 15% of samples surpassed WHO's limit of 10 ppb for lead, none exceeded the Pak EPA limit of 50 ppb, indicating adherence to national standards for Pb in drinking water. The study also identified sources contributing to the elevated levels of arsenic and chromium in water.[18] Effluent discharge from leather factories, along with the use of arsenic-containing pesticides and the manufacturing of wood preservatives, were identified as significant contributors to the contamination of groundwater resources. Addressing these sources of pollution is crucial for ensuring safe and sustainable drinking water for the Sahiwal district's residents.

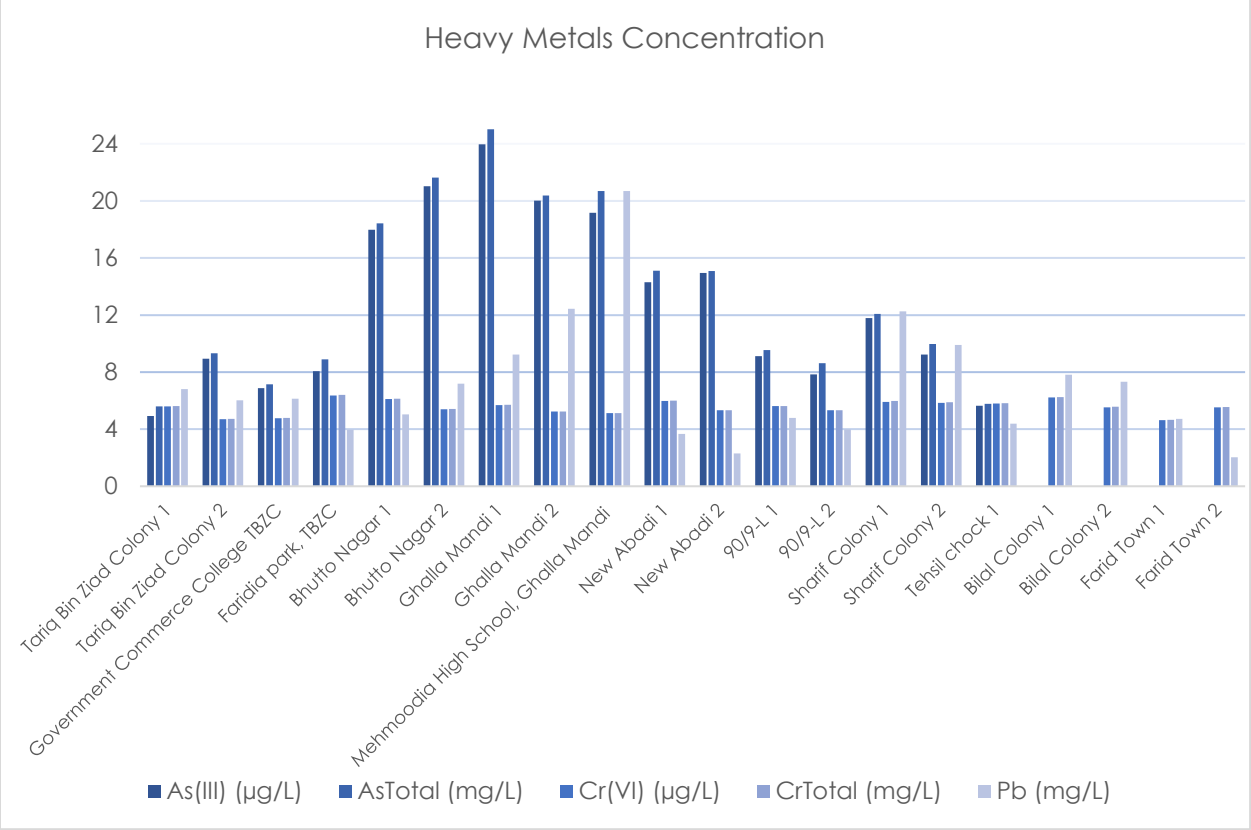


Figure 18: Heavy metals concentration in Sahiwal

[18] Zahira, M., Qureshib, Z., Tufaila, S., Hayat, K., & Hassana, A. (2018). Analysis of Water in the Area of District Sahiwal for Heavy Metals (A Case Study). *AIMS & SCOPE*, 138.

2.3. Green Spaces Assessment

2.3.1. Vegetation Dynamics (NDVI)

Climate is prime significant factor which has influence on soil, vegetation and water resources. A changing climate is anticipated to make agricultural systems and vegetation more vulnerable due to rising temperatures, altered rainfall patterns, and an increase in the frequency of extreme weather events globally. Vegetation plays a crucial role within Earth's ecosystem, in evaluating and overseeing environmental conditions, especially concerning water and atmospheric dynamics, as emphasized in various studies impacting the circulation of energy, carbon, and water across the planet. Vegetation serves as primary indicator which is closely associated with $C0_2$ emissions, holds a profound significance towards achieving the goals of carbon neutrality. The normalized difference vegetation index (NDVI) is an indicator of green vegetation or biomass.

The NDVI (Normalized Difference Vegetation Index) is the difference between near-infrared (NIR) and pigment absorption in red (VIS or visible red). NDVI = (NIR − VIS)/(NIR + VIS). The values of NDVI varies between − 1.0 to 1.0. Positive values 1.0 shows the increasing trend of green vegetation while the negative values exhibit the non-vegetational components e.g., rock, water, snow, clouds and etc.

NDVI has been extensively used to study the climatic impacts on the vegetation including those examining the impact of climate on the productivity of vegetation. Numerous studies have employed vegetation indices taken from remote-sensed data to assess drought and comprehend the dynamics of the vegetation. The Normalised Difference Vegetation Index, or NDVI, has made it possible to evaluate vegetation cover at several scales. It is the most widely used indicator for tracking vegetation greenness and for monitoring vegetation dynamics over wide areas.

The pixels having NDVI values less than 0.1 were excluded to avoid the influence of water content, soil moisture, barren land, etc. displaying the white area (non-vegetation area) in maps. Vegetation cover based on the NDVI values are categorized on the basis of NDVI threshold values: Low vegetation (0.1 -0.2), Moderate vegetation (0.2- 0.4) and High vegetation (<0.4). The spatial vegetation dynamics of the Sahiwal Region, as derived from LANDSAT satellite data (with a 30m spatial resolution) spanning from 2001 to 2023, are illustrated in Figure 19-20. Mean yearly NDVI values are analyzed to understand the variations in vegetation across different years. Additionally, change detection is conducted by examining Google Earth images at specific locations, providing insights into alterations in those areas over time. A notable transformation of barren and non-vegetated lands occurred between 2001 and 2020. Furthermore, the results indicate an enhancement in vegetation across various parts of the Sahiwal division attributed to the Tsunami Billion Tree Plantation initiative from 2015 to 2023. Additionally, several factors may contribute to the overall improvement in regional greenery, including reforestation and afforestation programs, climate and weather conditions, the introduction of drought-resistant plants, and reduced deforestation, among others.

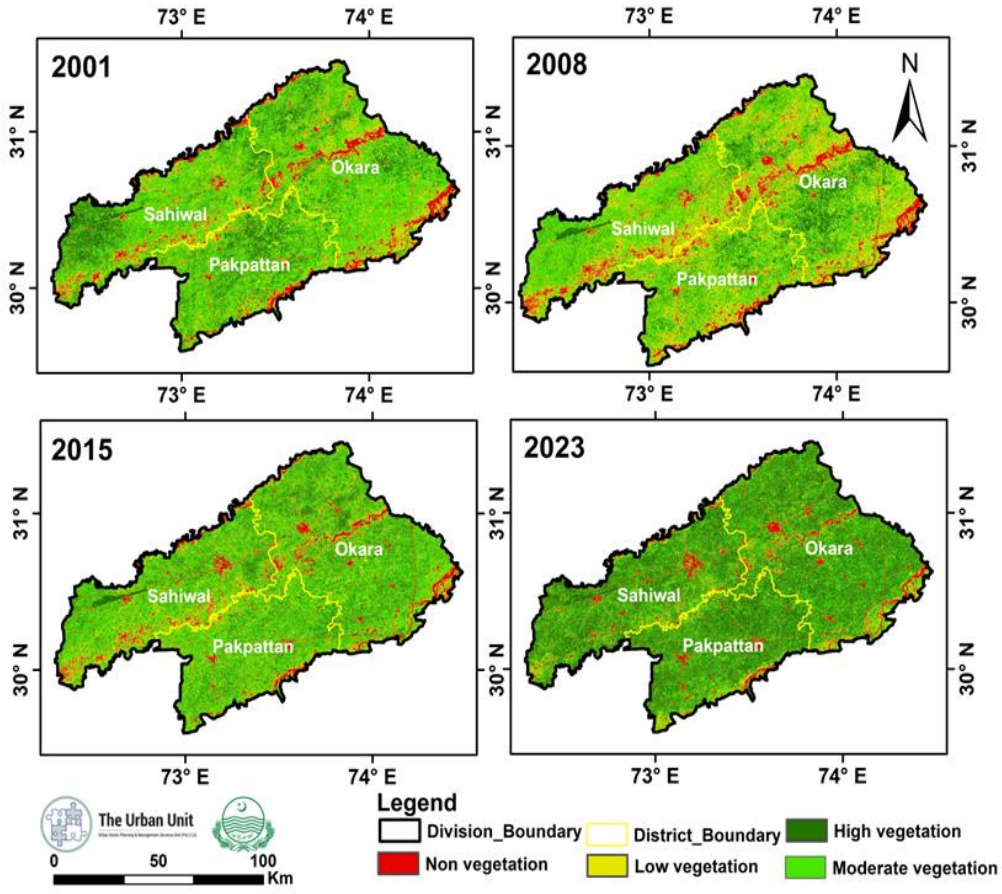


Figure 19: Spatio-temporal trends of vegetation dynamics in the Sahiwal Division during 2001 – 2023

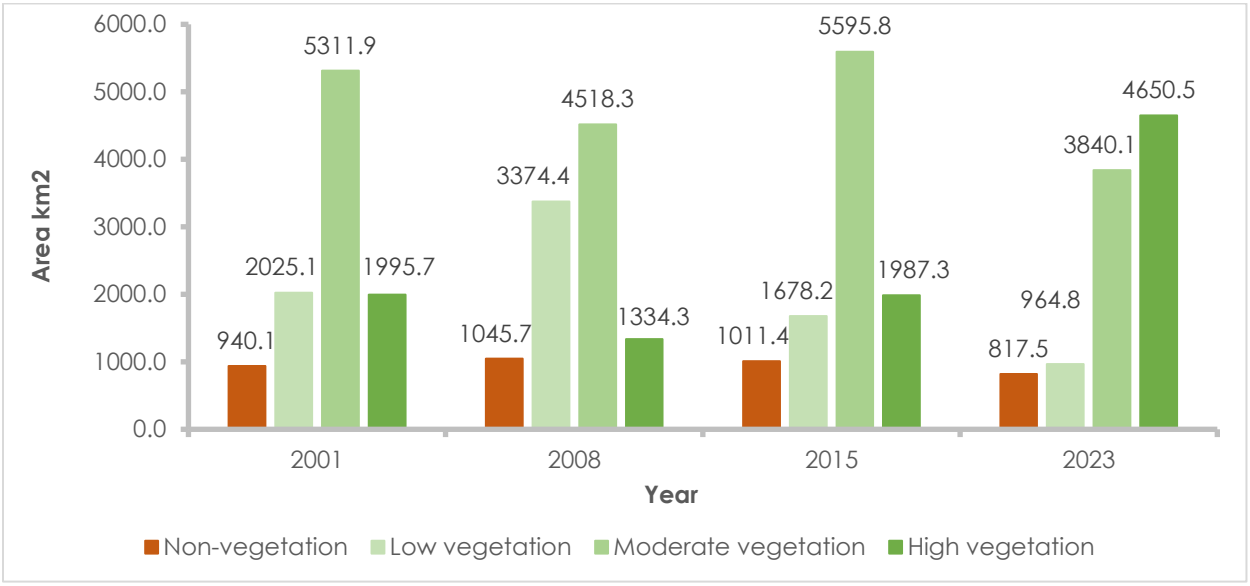


Figure 20: Area statistics of vegetation types during 2001 – 2023

2.3.2. Assessment of Urban Recreational Parks

Urban Recreational parks are a significant component of sustainable development planning and offer a wide range of benefits in terms of revitalization of the natural environment. Briefly, urban recreational parks have the following advantages;

- Recreational Opportunity for all Age-Groups
- Health & Safety Benefits
- Protection of Local Biodiversity and Natural habitat
- Improved provision of ecosystem services such as carbon sequestration, decontamination of water, climate regulation, etc.
- Centers for different community facilities, including zoos, historical sites, educational centers, community well-being and cultural centers, etc.
- Promote economic stability through tourism, creation of jobs, increased real-estate worth, etc.

Urban Recreational parks in Sahiwal were surveyed to assess their sufficiency and accessibility, existing conditions as well as areas for improvement through a survey-based tool. The employed assessment criteria include park ownership, status of maintenance, category of park, and availability of various facilities. A total of **42 Parks** were surveyed in Sahiwal Region.

The majority of the parks in the main cities of Sahiwal and Okara were maintained by the relevant municipal government under the internationally funded PCP (Punjab Cities Program) and PICIIP projects (Punjab Intermediate Cities Improvement Project). However, these parks are not sufficient for these emerging urban centers. Therefore, vacant sites, small open waste dump sites, and less developed parks were surveyed in all cities of the region to increase the green cover in the city. The findings of the survey are given in Figure 21.

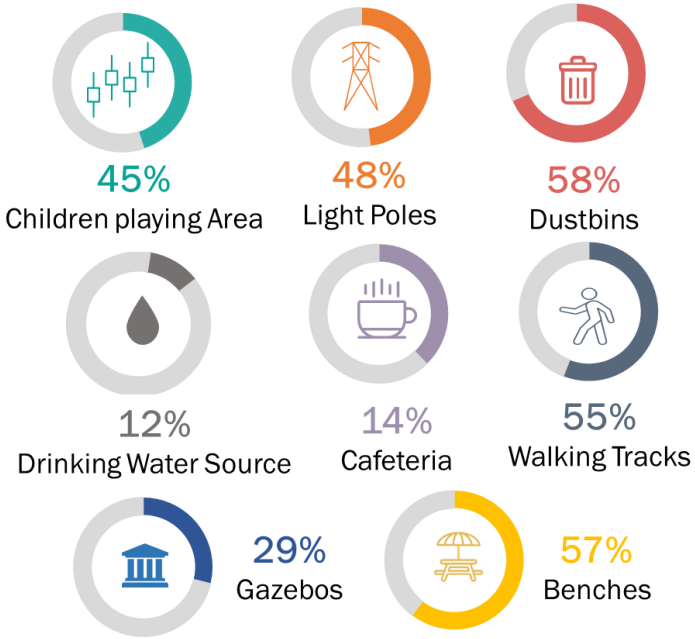
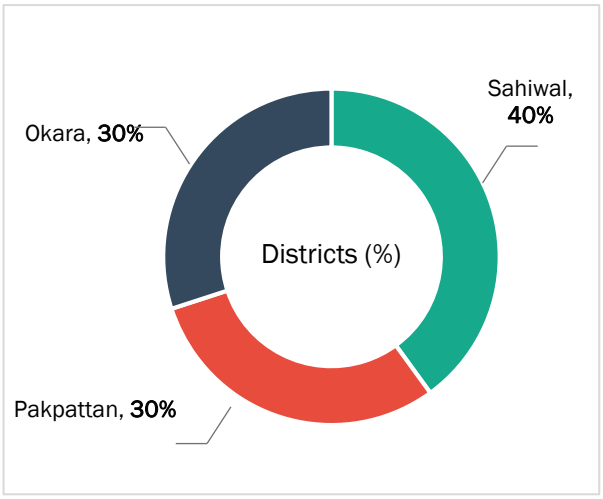


Figure 21: Results of Parks Assessment Survey

2.3.3. Local Community Perception Survey – Green Spaces

To compliment Environment & Social Safeguard's Team survey, a perception survey with local community of Sahiwal Region was also conducted in order to assess the local community perception regarding green spaces of Sahiwal Region.



The planning team thus visited each tehsil of three districts of Sahiwal (Sahiwal, Okara and Pakpattan Districts) in January 2024. A Survey form (Attached as Annexure – A) was formulated to record people's perceptions and attitudes regarding urban green spaces as well as their willingness to pay for these services in their areas. The empirical analysis of the survey helped to conclude the perception and expectations of local community regarding urban green spaces in Sahiwal Region.

The public effectively participated in the survey. The sample size was assigned on the basis of the population of districts of Sahiwal Region; overall **25%** were **females** and **75%** were **male** participants in the perception survey. The data from the perception survey was analyzed and the results were considered in the prioritization of need-based development projects.

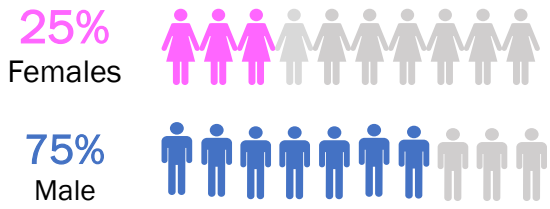


Figure 22: Demographics of Public Perception

Availability of Parks and Green Spaces in the Urban Areas

In Sahiwal Region, the availability of Parks is generally limited and are usually present at a distant apart from residential areas. However, most of the parks are usually crowded all day more particularly in the evening. It is also worth mentioning here that the number of ladies parks is also significantly low in Sahiwal Region to accommodate huge number of female populations. Furthermore, the facilities present in the existing parks are also limited thus required urgent attention and proper management. The most pressing concerns were the lack of drinking water, cafes, washrooms, insufficient lighting, and broken light poles, long distances, inadequate or missing play areas, damaged benches, and other infrastructure.

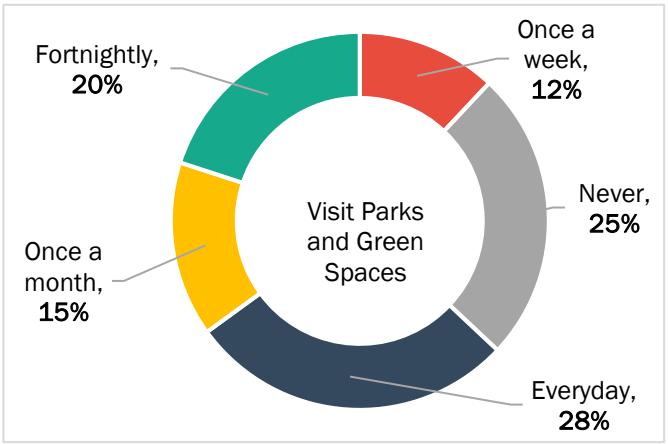


Figure 23: Local Community Visited Parks & Green Spaces

Community Participation and their Willingness to Pay

It is pleasing to comprehend that community of Sahiwal Region know the fact that their active participation is much important to improve the existing condition of green spaces and parks. 81% of the total respondents expressed their opinion that their active participation in maintaining health of green spaces is essential. Moreover, they also suggested that greening of vacant spaces and plantations along the roadsides can enhance the vegetation cover in their cities. It is reported in the study of Riaz *et al*., that the local communities that are involved in the activities to manage the green spaces and plantations are more sustainable communities.[19] Similarly, another study also revealed that public participation is required to improve green spaces.[20]

Another crucial component of the survey is the determination of a hypothetical value to find the respondents' willingness to pay for existing and future environmental resources, such as parks and green spaces. After inquiring and analyzing the survey results, it is affirmed that more than 58% of respondents are willing to pay 50-100 Rs for increasing and improving the green spaces in their area and 10% are willing to pay Rs. 100 - 150/. The survey highlighted that those who are willing to pay can contribute a small share of their income for the enhancement or provision of green spaces which is a dire need in the rapid urbanization of Sahiwal Region.

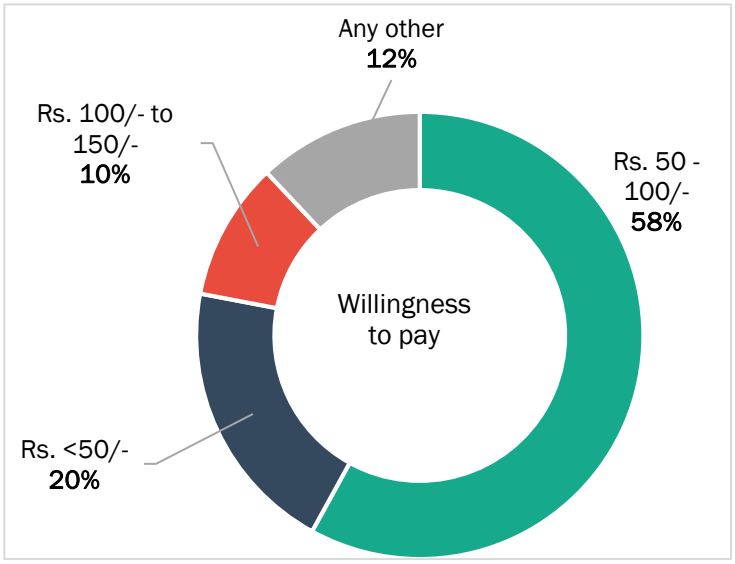


Figure 24: Community's Willingness to Pay for improvement of Parks and Green Spaces

2.4. Key Environmental Challenges – Sahiwal Region

Key Environmental Challenges and Issues that the Sahiwal Region is experiencing are:

[19] Riaz, A., Younis, A., & Naveed, S. (2010, August). Impact analysis of urban and rural landscapes as perceived by respective communities: a case study of Multan city, Pakistan. 954 (pp. 99-107).
[20] Fors, H., Molin, J. F., Murphy, M. A., & van den Bosch, C. K. (2015). User participation in urban green spaces–For the people or the parks? Urban Forestry & Urban Greening, 14(3), 722-734.

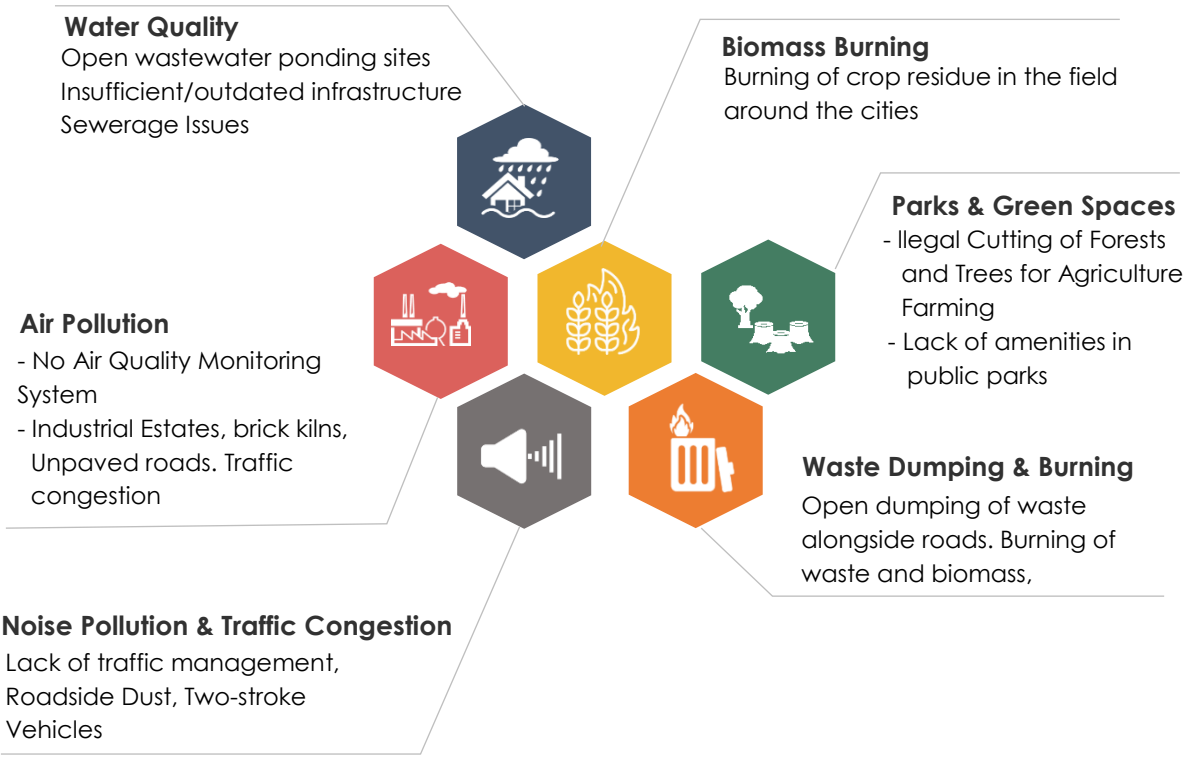


Figure 25: Key Challenges & Issues of Sahiwal Region

To compliment Environment & Social Safeguard's Team findings, the local community of Sahiwal Region is also consulted. Around 100 respondents (75 males; 25 females) from Sahiwal Region were consulted. It is observed that almost 20% of total respondents have reported that air pollution and smog is the major issue in their respective areas. 22% of the respondents claimed that Waste Burning & dumping is the chief environmental challenge they are facing every day. 18% of the total respondents expressed their displeasure towards water quality of their areas. 12% of the total respondents expressing their concerns on Noise pollution while 28% reported that lack of tree shades & green spaces is the highest environmental issues in their respective areas of the Sahiwal Region due to overpopulation and urbanization.

2.5. Biodiversity Conservation Area

The Sahiwal region, encompassing districts such as Sahiwal, Okara and Pakpattan boasts rich forest and wildlife areas under various categories of the forest and protected areas act of Punjab. In the Sahiwal region, forests play a crucial role in preserving biodiversity, maintaining ecological balance, and providing valuable ecosystem services. Moreover, national parks and wildlife sanctuaries also serve as important havens for diverse plant and animal species, safeguarding their habitats and ensuring their long-term survival.

The Urban Unit team visited **05** environmentally sensitive and high conservation value areas during the field visit of Sahiwal Region. These includes:

Sahiwal	Okara	Pakpattan
▸ Chichawatni Plantation (11,500 Acres)	▸ Depalpur Plantation (6870 Acres) ▸ Okara Zoo (25 Acres) ▸ Sulaimanki Wildlife Park (28 Acres)	▸ Dal Waryam Plantation (1576.19 Acres)

Detailed assessments of these visits were conducted which provides a basis to understand the key challenges of biodiversity and its habitat in the region. Details of forest lands in each district, key field observations and threats of these sites are presented in the subsequent sections.

2.5.1. Sahiwal Conservation Site

Sahiwal is the district located in southern Punjab, on the flat plains of Ravi and Sutlej River. The district is home to diversified flora and fauna of the region and producing variety of agricultural crops including cotton, maize, rice, mustard, wheat, and sugarcane. The Sutlej River serves as a wetland and aquatic habitat for regional biodiversity, as well as a wintering grounds for aquatic birds. In Sahiwal district, a total of 11,500 acres land under forest enactment and notified as Chichawatni Wildlife Reserve to protect and conserve the native biodiversity of the district. The faunal biodiversity includes Gray & black partridges, wild hare, wild boar, jackal and porcupines which are inhabitant in varied habitat of Chichawatni forest, whereas Sufaida, kikar, beri, musqat, shahtoot, and neem are the prominent plant species.

Challenges & Issues

- The increasing population of invasive alien species i.e. *Prosopis juliflora* is considered as the major threat to native biodiversity and changing the chemical properties of soil which thus effecting the soil fertility.
- The illegal activities and hunting of key species particularly grey partridges and wild hare threatening the biodiversity of Sahiwal district.
- The illegal tree cutting for wood collection lowering the tree cover in Chichawatni forest.

2.5.2. Okara Conservation Site

The Okara is the agricultural district of Punjab, the rich soil fertility is used to grow a wide variety of key cash crops of Pakistan including cotton, rice, sugarcane, maize, and wheat. The crop variety within district also support variety of faunal diversity inhabitant to forest and agricultural ecosystem of District. The forest land within the district extended over 6,870 acres of land of which 6,151 acres of land planted with different tree species i.e. kikar, sufaida, epple, shehtoot, musqat and beri which support grey partridge, black partridge, wild boar, wild hare porcupine, and goose. In Okara there is 03 biodiversity areas to support the conservation efforts of the distOkara is Punjab's agricultural district, and its fertile soils are utilized to cultivate a wide variety of key cash crops of Pakistan, including cotton, rice, sugarcane, maize, and wheat. Crop diversity within the area supports a range of faunal diversity in the district's forest and agricultural ecosystems. The district's forest land covered 6,870 acres, with 6,151 acres planted using various tree species such as kikar, sufaida, epple, shehtoot, musqat, and beri, which sustain grey partridge, black partridge, wild pig,

wild hare, porcupine, and geese. Okara has three biodiversity zones to help the conservation efforts of the districts, these are the following:

- Depalpur Plantation (6870 Acres)
- Okara Zoo (25 Acres)
- Sulaimanki Wildlife Park (28 Acres)

Figure 26: Forest Habitat of Pipilian Depalpur Plantation and Sulemanki Wildlife Park

Challenges & Issues

The biodiversity of Okara district facing challenges and issues to hinder the conservation efforts within the district, few of these challenges & issues are as follows:

- Illegal poaching and hunting of key species including grey partridges and wild hare.
- Wood theft of native trees due to lack of community awareness.
- Water unavailability for forest plantation in Okara district leads to decline of green cover.
- Missing recreation facilities in sulemanki wildlife park for visitors.
- Limited space for captive animals in sulemanki wildlife park.

2.5.3. Pakpattan Conservation Site

Pakpattan is an agricultural heartland, blessed with fertile soils and favorable climatic conditions. The major crops cultivated here, include wheat, rice, sugarcane, gram, sesame, cotton, and sunflower, sustain livelihoods and contribute to the region's agricultural prosperity. Spanning an area of 2,724 square kilometers, Pakpattan boasts a diverse landscape that includes forests, fertile plains, and water bodies. The district is graced with a total forested area of 1576.19 acres, providing a vital sanctuary for native flora and fauna. Amongst the verdant foliage, a planted area of 1300 acres flourishes with a variety of trees, including Shisham, Mulberry, Kikar, Sufaida, Bakain, Ber, Pipli, and Sambal, creating a tapestry of natural beauty which support grey francolin, Black francolin, Hariyal bird. The Dal waryam forest is the key biodiversity area that need conservation of natural species in their own habitat.

Figure 27: Dal Waryam Forest

Challenges and Issues

- Illegal hunting of key wildlife species such as the Huriyal (Yellow-footed green pigeon), Grey Partridges, and Asian emerald dove.
- Forest wood cutting for various purposes, leading to the depletion of important tree species like Simbal, Kikar, and Shisham.
- Lack of community awareness leading to wood theft of native trees.
- Water unavailability for forest plantation, resulting in a decline in green cover.
- A road crossing the forest, posing a threat to wildlife safety and facilitating illegal activities.
- Illegal hunting of native wildlife species declining their population and thus disturbed the natural equilibrium of the forest.
- Soil erosion as a consequence of the depletion of important tree species that make 275 Acres of forest land unplanted.

2.5.4. Major Threats to Conservation Site in Sahiwal Region

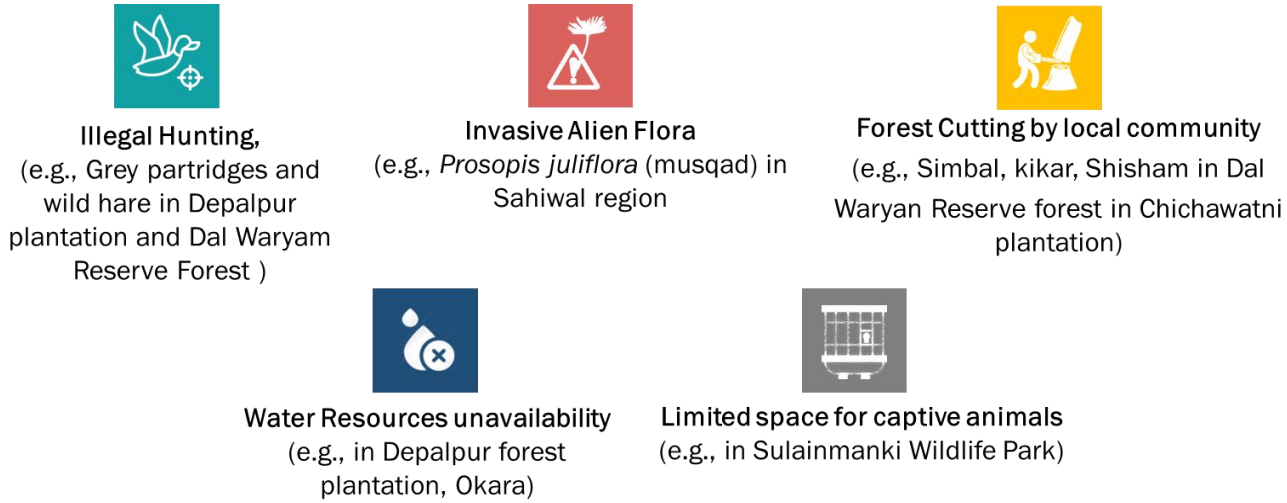


Figure 28: Major Threats to Conservation sites of Sahiwal Region

03 Legal Landscape

The constitution of Pakistan has substantially altered the allocation of legislative powers between the National and Provincial Assemblies, resulting in more Provincial autonomy. Powers have been assigned to provincial Environmental Protection Agencies/Departments (EPAs/EPDs) Some of the key national/provincial regulations that are considered related to the Regional Development Plan of Sahiwal is enlisted below:

National Framework	Provincial Framework
▪ Pakistan Climate Change Act, 2017	▪ Punjab Environment Protection Act, 2017
▪ Forest Act, 1927	▪ Policy on Controlling Smog, 2017
▪ Pakistan Environmental Protection Act, 1997	▪ Punjab Environmental Protection (Delegation of Powers for Environmental Approvals) Rules, 2017
▪ National Climate Change Policy, 2012	▪ Punjab Hospital Waste Management Rules, 2014
▪ Framework for Implementation of Climate Change Policy, 2013	▪ Punjab Environmental Protection Motor Vehicle Rules, 2013
▪ National Sustainable Development Strategy, 2012	▪ Punjab Environmental Protection Administrative Penalty Rules, 2013
▪ National Disaster Risk Reduction Policy, 2013	▪ Regulation of Disclosure of Environmental Information and Citizen Engagement, 2020
▪ National Forest Policy, 2015	▪ Environmental Sampling Rules, 2001
▪ National Rangeland Policy, 2010	▪ Pollution Charge Rules, 2001
▪ Review of IEE / EIA Regulations, 2000	▪ Environmental Tribunal Rules, 2012
▪ National Conservation Strategy, 1992	▪ Punjab Forest Policy, 2019
▪ Biodiversity Action Plan for Pakistan, 2000	▪ Punjab Environmental Quality Standards (municipal and liquid effluents, drinking water, motor vehicles, ambient air, noise, treatment of liquid and disposal of biomedical waste and Industrial gaseous emission), 2016
▪ Guidelines for sensitive and critical areas, 1997	

04 Vision, Goals & Objectives

4.1. Vision

A vibrant and internationally competitive region with sustainable development in a conducive environment whilst protecting and improving biodiversity where ecological resources are proficiently managed and conserved, cleaner environment, climate resilience and recreational facilities may be important indicators of the region's macro-level socio-economics.

4.2. Goals

To protect, conserve and retain the ecological values as well as sustainable development of the region for current and future generations, predominantly as a derivation of glory, inspiration, education, recreation and enhance the local community's livelihood

4.3. Objectives

This plan helps to prioritize development projects at the regional level based on current conditions and future growth needs. Specific objectives of the plan are as follows:

- To identify potential projects & programs that can contribute to sustainable growth, environment protection, conservation, employment opportunities and exploit competitive benefits of the region.
- Improve the overall state of environment in the Rawalpindi Region.
- Project Prioritization and capacity needs to improve livability and competitiveness.
- Such a plan will fulfill a longstanding demand of local officials to have a document that can provide them with a strategic vision for the development of the region and have a voice in the overall planning process in the province.

05 Methodology

Sahiwal Regional Development Plan for the Environment sector was developed to prioritize the most resilient and sustainable solutions for the mitigation of the baseline environmental issues. The plan focuses on adopting a combined approach of data collection from field visits and literature while involving all regional and provincial stakeholders (government organizations and local community) and using modern remote sensing technology for impact assessment on the ground scale. It provides a framework of interventions for environmental improvement, divided into short, medium, and long-term plans spanning from three to ten years. The methodology adopted for the purpose of this plan is given below:

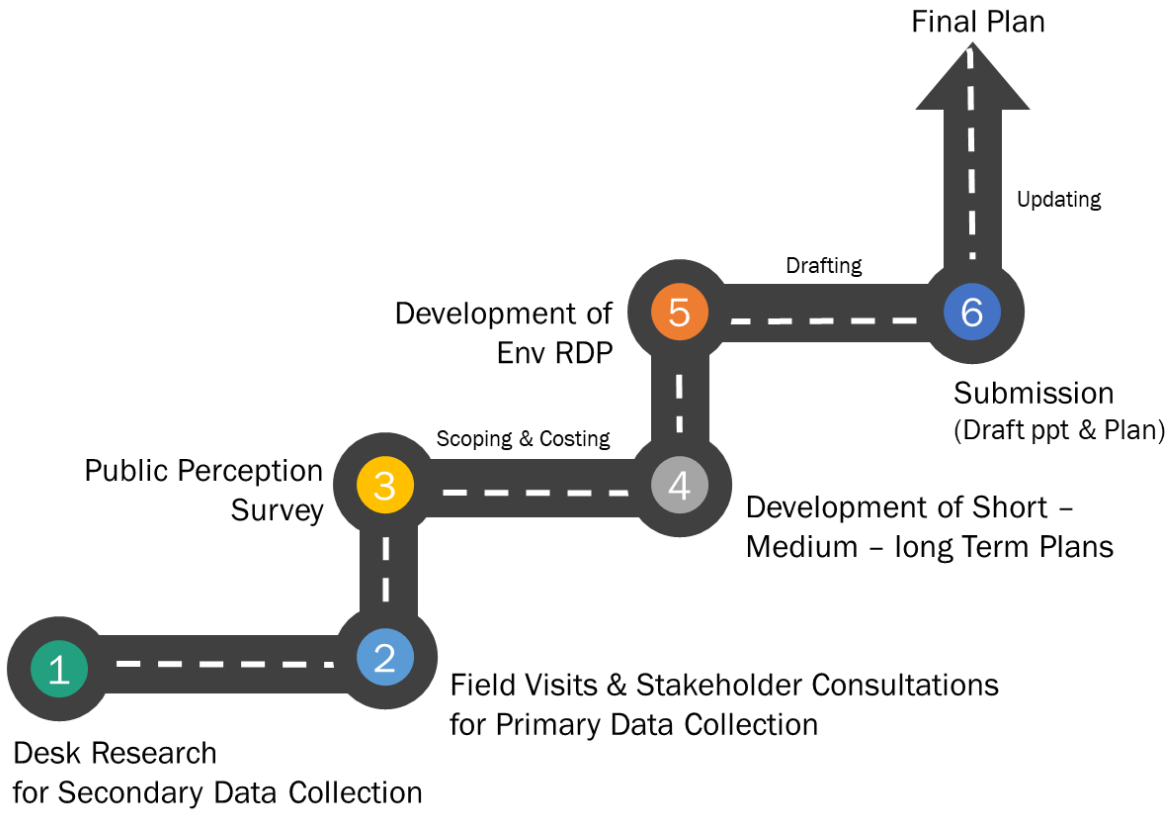


Figure 29: Methodology Map for Sahiwal – RDP

5.1. Desk Research for Secondary Data Collection

A comprehensive desk research was conducted in order to understand the state of environment of the Sahiwal Region during the past decade. Existing legal landscape, administrative and institution set-up, Punjab ADP Schemes, relevant reports and journals as well as similar projects and programs executed in the previous years for the improvement of environmental conditions and green spaces were also assessed.

5.2. Primary Data Collection

Field Visits

For on-ground information, the team of experts consisting of environmental scientists, environmental engineers, biodiversity professionals, and archaeological experts from the Environment and Social Safeguards Division visited the Sahiwal Region. Field Visits were conducted in two phases;

Inception Visit:

The inception visit of Sahiwal region was conducted between December 10th – December 11th, 2023 by the senior officials of the Environment Team. During this visit, meeting with key stakeholders which include; meetings with the Commissioner of Sahiwal Region as well as Deputy Commissioners of Sahiwal, Okara and Pakpattan Districts were conducted.

Rapid Assessment Visit:

After inception visit, a team of experts from the Environment & Social Safeguards Team conducted Rapid Assessment Survey of Sahiwal region from January 02nd – January 07th, 2024. During this course, a series of meeting with various stakeholders as well as Rapid assessment surveys of the major urban centers of Sahiwal, Okara and Pakpattan Districts were conducted.

The institutional hierarchies, inter-linkage of departments, key concerns of the stakeholders, and technical and capacity-building issues were identified during this survey. In addition, air quality and noise quality were monitored, key sources of air and water pollution were identified, and existing biological conditions were also assessed in major urban centers of Sahiwal Region. Apart from that, key areas of interventions for environmental improvement were also identified and documented.

Public Perception Survey/ Community Consultation:

Subsequently, the Environment & Social Safeguards Team also conducted a Public Perception visit focusing on the concerns of local inhabitants in Sahiwal Region. This visit captured community perceptions regarding public and green spaces, existing environmental conditions, changes in environmental quality over time, sources of pollution, and negative environmental impacts from development activities. These insights were instrumental in shaping the regional plan for Sahiwal Division, ensuring community benefits and sustainable environmental improvements.

Stakeholder Consultation:

A total of 16 Consultation Meetings with key government officials in the Sahiwal Region were conducted by the Environment & Social Safeguards team. During these meetings, the key concerns of relevant departments and suggestions for environmental improvements were documented. All key stakeholders provided complete support in the development of a practical and attainable regional development plan.

Figure 30: Stakeholder's Consultations – Sahiwal Region

Figure 31: Field Visits & Public Perception Survey – Sahiwal Region

5.2.2. Environmental Quality Assessment

Air Quality Assessment

Data of four air quality parameters (AI, NO_2, SO_2 and CO) were downloaded from ***Copernicus website*** for year 2022, to analyze their spatial pattern over Sahiwal Region.

Vegetation Cover Assessment

The NDVI dataset for the assessment of vegetation dynamics in the Sahiwal Region is extracted from Landsat satellite data.

Table 4: Satellite data used to assess the vegetation dynamics in Sahiwal Region

Sr. No	Region	Satellite/Sensor	Spatial Resolution	Year of Acquisition
1	Sahiwal	Landsat 5 (ETM)	30m	2001-April
2		Landsat 7 (ETM+)		2009-May
3		Landsat 8 (OLI)		2016-May
4		Landsat 8 (OLI)		2023-April

5.3. Development of Short-Medium-Long term plan

Based on the exercise discussed above, schemes / projects were identified and prioritized for each district. This ten-year plan provides short term (up to 3 years), Medium Term (3 to 6 years) and long term (up to 10 years) projects focusing on improved service delivery, better

environmental quality, enhanced climate resilience along with increased economic growth of the region.

5.4. Development of RDP Sahiwal

Finally, a sectoral plan for Environment component was developed for Sahiwal Region with a comprehensive investment Plan for the period of 10 years (2023-2033). Each project contains its title, cost, category (short/medium/long term) and mode of investment (Government / Donor / PPP).

5.5. Feedback Visit

Consultation is an essential step to engage the multi-stakeholders and get their feedback and ownership in finalizing the project digest for the Sahiwal Region. Therefore, a feedback visit will be conducted for final consent from the relevant department before submitting it to the Planning and Development Board, Government of Punjab.

06 Regional Development Plan

6.1. Framework

Punjab is the most vibrant as well as the populous province of Pakistan. However, from past few decades the province has been facing challenges not only from the economic front but also from the ecological side. The Government of Punjab is well cognizant to the myriad problems that the province is facing. Therefore, in order to tackle these challenges Government of Punjab has taken series of initiatives and drafted various regulation/policies/strategies that address such issues (viz., rapid urbanization, unreliable service provision, low municipal service recovery, high environmental pollution and so forth) and create a regionally equitable economy across the province. As in the province, the public spending is distributed on the basis of administrative jurisdiction i.e., division (region), districts and tehsils, it is desired to consider spatial and socio-economic dimensions for improved service delivery and environmentally sustainable development at a macro scale

Keeping in view of all the facts; such as present challenges, risks, gaps, needs and priorities for future economic development, a Framework for Environment Sector of Regional Development Plan of Sahiwal Region is designed. Each component of this framework is passed through a lens of existing infrastructure, governance and population factor. Comparative advantage is gained by using credible mapping resource and Geographic Information Systems (GIS) for spatial representation of relevant data along with current state of environmental conditions. Consultation is another keystone of the RDP drafting process which is done through meetings, data collection forms, field visits, planning exercises and feedback sessions. Finally, the framework is drafted which enlisting the priority projects at district level which are consolidated as one broader plan/project digest of Sahiwal Region.

6.2. Project Digest/ Investment Plan

Based on the framework of regional development plan, desk review/secondary information, on-ground survey, perception and expectation survey, consultations with local community and meetings with local authorities, a Project digest is developed for Sahiwal Region, which can also call as Investment Plan. These projects are divided based on their urgency / priority for a ten-year span and divided in to short, medium and long term.

The total cost of the environmental sector project digest for Sahiwal Region is **Rs. 2142 million**.

6.3. Proposed Projects

The proposed projects for the improvement of environmental values and biodiversity conservation of Sahiwal Region are as follows:

A. Short – Term Plan (Up To 03 Years) Estimated

Sr. No.	Projects	Estimated Cost (Millions Rs.)
	Short – Term Projects	
1.	Afforestation	
	▪ Sahiwal (400 Acres)	165
	▪ Pakpattan (100 Acres)	41.3
2.	Linear Plantation	
	▪ Sahiwal (40 Av. Kms)	10
3.	Agro-Canopy Forest Okara (20 Av. Kms)	5
4.	Rehabilitation of Forest Irrigation Tube-wells (05 No's)	7.5
5.	Eco-Landscape along Okara Canal (3 Km Length)	34
6.	Aqua Nature Park	
	▪ Fatima Jinnah Park Arifwala (8.5 Acres)	93.6
7.	Community Gardens	
	▪ Al-Abbas Park Depalpur (2 Acres)	55
8.	Pathway Lineage Parks	
	▪ Development of Lineage Park along Canal Renala Khurd, Okara, Sahiwal (40 ft wide and 3kms long track)	34
9.	Restoration and Improvement of Parks	
	▪ 07 Parks – Sahiwal District ▪ 13 Parks – Okara District ▪ 04 Parks – Pakpattan District	443
10.	Installation of Air Quality Monitoring Equipment in Sahiwal district	
	▪ (1 BAM & 25 Low cost equip)	24.6
	▪ Display of big screen	16
	Total	**929**

B. Medium – Term Plan (Up To 05 Years) Estimated

Sr. No.	Projects	Estimated Cost (Millions Rs.)
	Short – Term Projects	
1.	Afforestation	
	▪ Okara (300 Acres)	123.8
2.	Linear Plantation	
	▪ Okara (50 Av. Kms)	12.3
3.	Forest Sprouting Reserve	
	▪ Okara (4.8 Acres)	16.5
4.	Sulemanki Wildlife Park – Extension & Rehabilitation	27.0
5.	Aqua Nature Park	
	▪ Baba Farid Park Pakpattan (3.5 Acres)	43.8
6.	Canal Rejuvenation of Lower Bari Doab Canal Sahiwal	23.6
7.	Community Gardens	
	▪ Quaid-e-Azam Chowk Green Belt (80 ft. long, 15 ft. wide)	1
8.	Forest Park Development	
	Dul Waryam Forest Park, Pakpattan (40 acres)	267
9.	Pathway Lineage Parks	
	▪ Development of Lineage Park along the Railway Track Pakpattan (55 ft Wide and 3 kms long)	17.8
10.	Zero Water Discharge RAS Aquaculture Hatchery	
	▪ Rehabilitation of Fish Hatchery Arifwala, Pakpattan (12 Acres Land) ▪ Development of Sustainable Zero Water Discharge Hatchery in Pakpattan (15 Acres Land)	26
11.	Installation of Air Quality Monitoring Equipment in Okara district	
	▪ (1 BAM & 25 Low cost equip)	24.6
	Total	**583.8**

C. Long – Term Plan (Up To 10 Years) Estimated

Sr. No.	Projects	Estimated Cost (Millions Rs.)
	Short – Term Projects	
1.	Linear Plantation	
	▪ Pakpattan (42 Av. Kms)	10.3
2.	Forest Sprouting Reserve	
	▪ Okara (6.7 Acres)	23.5
3.	Aqua Nature Park	
	▪ Town Park Renala Khurd (5 Acres)	62.6
4.	Development of Parks	
	▪ 05 Parks – Okara District ▪ 02 Parks – Sahiwal District ▪ 03 Parks – Pakpattan District	459.3
5.	Pathway Lineage Parks	
	▪ Development of Track Lineage Park in Canal Colony Pakpattan (60 ft wide and 1.5 km long pathway)	18.1
6.	Installation of Phytoplankton based Floating treatment Wetland (FTW) on wastewater Pond in Arifwala & Depalpur	31.4
7.	Installation of Air Quality Monitoring Equipment in Okara district	
	▪ (1 BAM & 25 Low cost equip)	24
	Total	**629.2**

D. Proposed Interventions Map

- Eco – landscape along Okara Canal
- Development & Rehabilitation of Parks
- Aqua Nature Parks
- Community Gardens
- Sulemanki Wildlife Park – Extension & Rehabilitation
- Forest Sprouting Reserve
- Agro Canopy Forest
- Reforestation – Afforestation
- Linear Plantation
- Pathway Lineage Park
- Zero Water Discharge RAS Aquaculture Hatchery
- Forest Plantation
- Installation of Phytoplankton based Floating treatment Wetland (FTW) on wastewater Pond
- Installation of Air Quality Monitoring Equipment

Figure 32: Proposed Interventions in Sahiwal Region

6.3.1. PROJECT 1: Eco Landscape along Okara Canal

Eco-Landscape involves maintaining the local ecology of a site through the development of green spaces. These landscapes are significant for increasing interaction between humans and local biodiversity creating a sense of awareness and responsibility for the protection of the local environment. It also enables the promotion, restoration, and protection of the indigenous fauna and flora, while regulating the micro-climate of an urban centre.

Exiting Condition of proposed site

Proposed Sites:

- Coordinates: 32.83088181°N; 73.45132284°E
- Gravel Bed Location: 32.769869° N; 72.708337° E

Scope:

- Walkway Pavement
- Gazebo
- Plantation & Trees
- Fencing
- Light Poles

Scope:

- Ecological Corridors are significant for increasing interaction between humans and local biodiversity creating a sense of awareness and responsibility for the protection of the local environment.
- It also enables the promotion, restoration, and protection of the indigenous fauna and flora, while regulating the micro-climate of an urban center.

Estimated Costs:

Sr. No.	Description	Amount in Millions
	Eco-Landscape along Okara Canal (3 Km Length)	
1	Construction of Green Area, Plantation & Trees	11.32
2	Construction Walkway Pavement	9.36
3	Light Poles	8.66
4	Benches & Dustbins	0.24
5	Fencing	1.19
6	Wooden Gazebo	1.05
	Sub- Total Amount R. s	**31.82**
	Add 2% Contingencies	**0.64**
	Add 5% PST	**1.59**
	G-Total Amount R. s	**34.05**

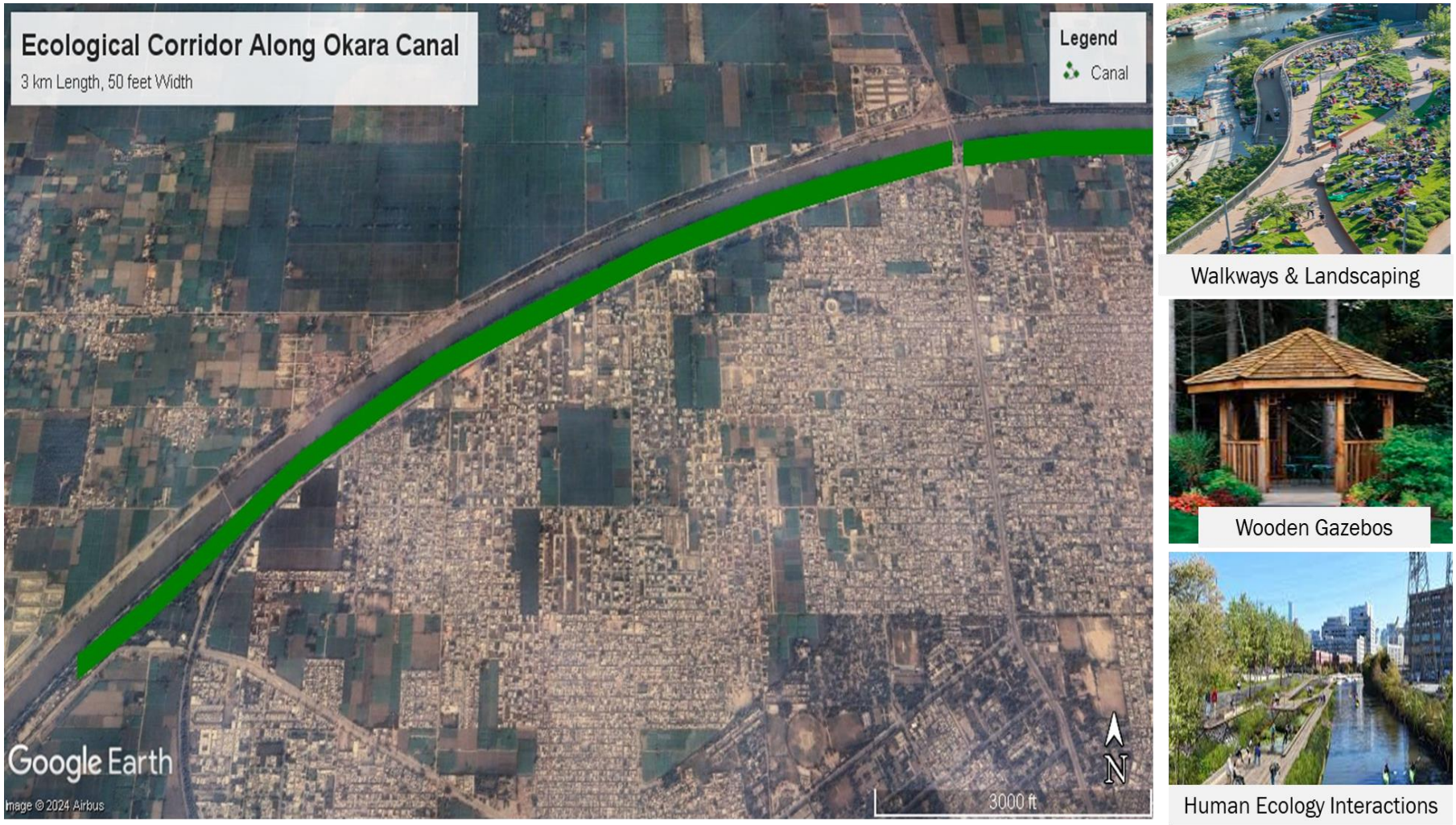


Figure 33: Conceptual Design for Eco-Landscape Along Okara Canal

6.3.2. PROJECT 2: Development & Restoration of Parks

Urban parks are designated open areas, typically characterized by a prevalence of vegetation and water features, and are typically set aside for public use. These parks play a significant role in urban amenity green spaces and serve as crucial yardsticks for assessing the sustainability of cities.

The presence of green spaces within urban areas is instrumental in promoting sustainable urban planning. Conversely, haphazard urban expansion with limited green or open public spaces not only undermines the sustainability of an area but also has adverse effects on human health and well-being.

Prioritizing the establishment of urban green spaces is a major focus in creating cities that are pleasant to live in. The total count of green spaces within a city serves as a pivotal indicator of a city's sustainable urban ecosystem and the overall quality of urban life.

Proposed Sites:

Development of New Parks:

- 02 Parks – Sahiwal District
- 05 Parks – Okara District
- 03 Parks – Pakpattan District

Restoration & Improvement of Parks:

- 07 Parks – Sahiwal District
- 13 Parks – Okara District
- 04 Parks – Pakpattan District

Scope of the Project

The scope of the project aims to provide the following facilities in the parks:

- Children's Play Area
- Gazebos
- Walking Track & Pathways
- Drinking Water faucets Fountain
- Rest areas/washrooms
- Parking area
- Cafeteria
- Benches

Benefits of the Project

- Provision of Improved Ecosystem Services
- Air and Water Purification
- Carbon Sequestration
- Climate Regulation
- Habitat for Local Biodiversity
- Human-Biodiversity Interactions

Estimated Cost

Sr #	Restoration & Improvement of Parks	Cost (M)
1	Ladies Park (30.36338693, 73.38073308) 0.5 Acre	10.512
2	MC Park (30.348331, 73.386551) 2 Acres	27.986
3	Muslim Town Park 1 (30.871828, 73.598441) 1 Acre	21.040
4	Muslim Town Park 2 (30.872919, 73.598516) 2 Acres	27.986
5	Muslim Town Park 3 (30.870876, 73.598442) 0.7 Acre	15.750
6	Fatima Jinnah Park Depalpur (30.67003883, 73.65620313) 0.7 Acre	15.750
7	Garden Town Park Okara (30.80174978, 73.44059838) 1.5 Acres	31.540
8	Abu Bakr Sadiq Park (30.8217938, 73.4535675) 0.28 Acre	5.890
9	Government Colony Park Okara (30.81707219, 73.4658394) 2.3 Acres	38.500
10	Sher-e-Rabbani Town Park (30.8082164, 73.45380232) 0.27 Acre	5.676
11	Faisal Colony Park 2 (30.82202008, 73.45645348) 0.45 Acre	13.245
12	Arooba Park (30.312073, 72.410356) 0.63 Acre	5.676
13	Zainab Park (30.522888, 72.684389) 0.57 Acre	11.984
14	Fatima Jinnah Park Chichawatni (30.403128, 73.071978) 2 Acres	27.986
15	Park Traiq Bin Ziad Colony (30.403128, 73.071978) 1.5 Acres	11.984
16	Hazoori Park (30.39474, 73.079602) 5 Acres	11.984
17	Masjid Sisddiqe Akbar Park (30.402316, 73.052135) 2 Acres	27.986
18	Sher Khan Park, Bilal Colony (30.400138, 73.073414) 3.5 Acres	43.584
19	Baba Fareed Park (30.364288, 73.379079) 3.5 Acres	33.584
20	Canal Park (30.36542211, 73.38446446) 1 Acre	21.040
21	Faisal Colony Park 2 (30.82202008, 73.45645348) 0.45 Acre	9.460
22	Ladies Park (30.312073, 72.410356) 1 Acre	21.040
23	Gulshan-e-Fatima Park (30.80434861, 73.44749735) 0.14 Acre	2.946
	Total Amount Millions	**443.127**

Sr #	Development of new Parks	Cost (M)
1	Bada Faridya Park Arifwala (30.4591966, 73.1503049) 0.5 Acre	14.000
2	DC Office Park (30.360754, 73.380887) 3.2 Acres	63.412
3	Gulshan e Iqbal Park (30.281116, 73.06814833) 1 Acre	27.540
4	Children Park (30.877706, 73.592555) 1 Acre	27.540
5	Fatima Public Park (30.83011997, 73.45158287) 2 Acres	55.080
6	Pakistan Public Park (30.83068694, 73.4517363) 3 Acres	62.750
7	Sher-e-Rabbani Town Park (30.8082164, 73.45380232) 0.27 Acre	7.290
8	Disposal Plant Park Depalpur (30.66340248, 73.65601629) 0.65 Acre	17.550
9	Tainki Wala Park (30.402656, 73.044776) 3.5 Acres	64.521
10	Saleem Akhtar Shaheed Park (30.404943, 73.051463) 3.5 Acres	64.521
11	Disposal Plant Park Renala Khurd (30.87004971, 73.59315228) 2 Acres	55.080
	Total Amount Millions	**459.284**

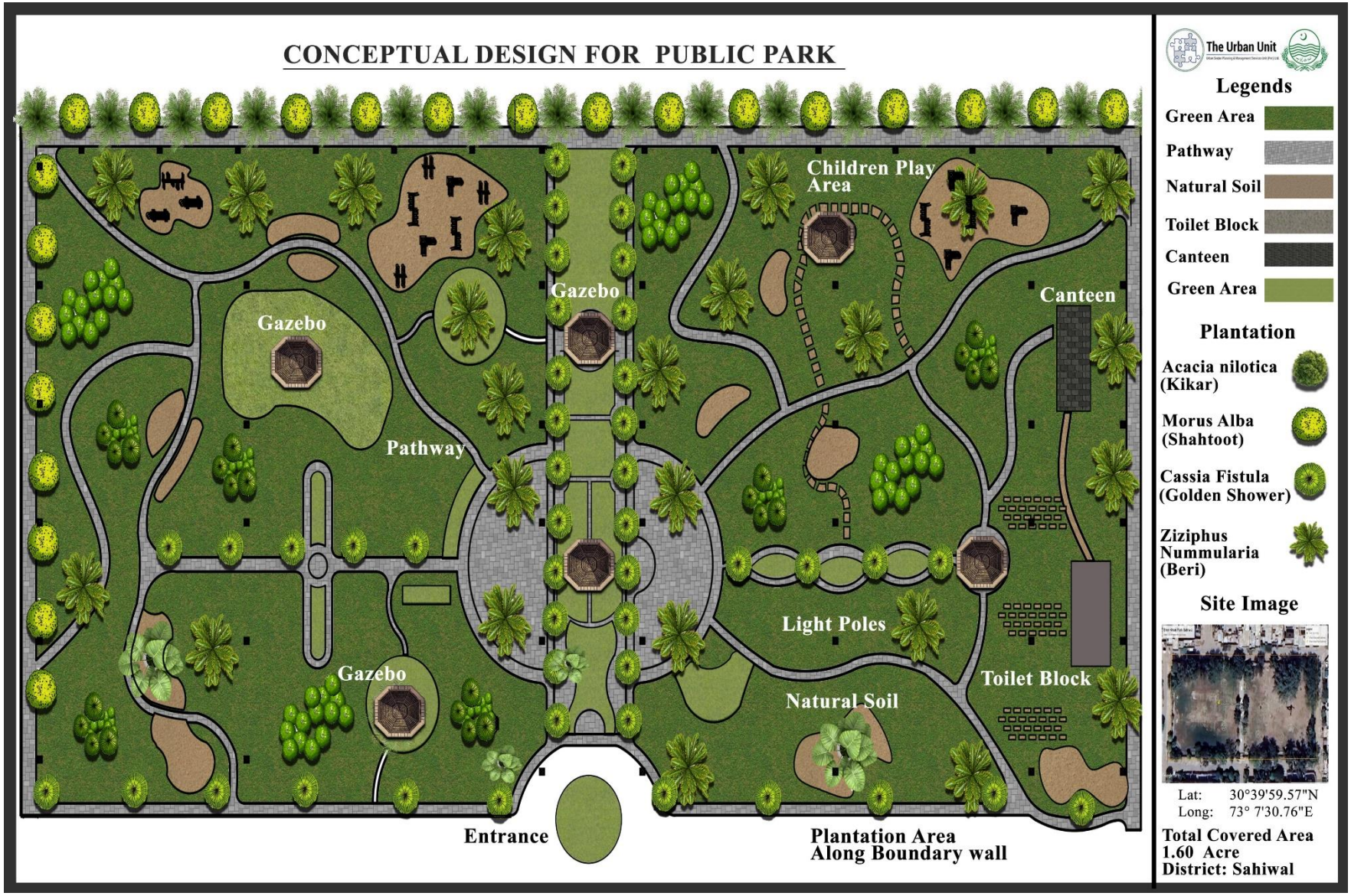


Figure 34: Conceptual Design for Public Parks

Figure 35: Conceptual Design for Ladies Park

6.3.3. PROJECT 2.1: Aqua Nature Parks

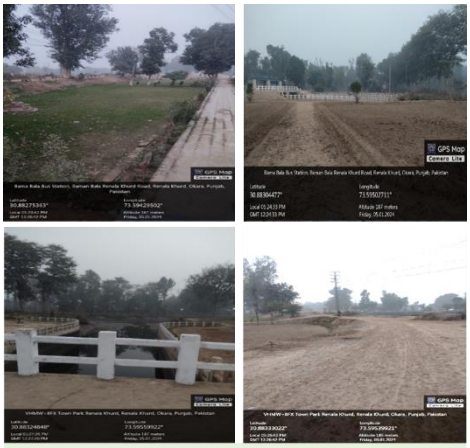
This project focuses on the development of Rain Gardens within parks in urban areas. Rain gardens are the landscaping features which enable the absorption of storm water, improve water conservation, and add to the authenticity of the area. Rain gardens can help protect our natural environment and control the impacts of climate change by reducing the amount of water and pollutants entering the storm water system.

Proposed Sites:

- Fatima Jinnah Park Arifwala (8.5 Acres)
- Baba Farid Park Pakpattan (3.5 Acres)
- Town Park Renala Khurd (5 Acres)

Scope of the Project:

- Rain Garden
- Children's Play Area
- Gazebo
- Walking Track & Pathways
- Drinking Water faucets
- Nursery (Town Park Renala Khurd)
- Fountains
- Rest areas/washrooms
- Parking area
- Cafeteria
- Benches
- Toilets



Exiting Condition of proposed project sites

Benefits:

- Provision of Improved Ecosystem Services
- Air and Water Purification
- Carbon Sequestration
- Climate Regulation
- Habitat for Local Biodiversity
- Storm water Infiltration

Estimated Cost:

Sr #	Aqua Nature Park	Cost (M)
1	Fatima Jinnah Park Arifwala (8.5 Acres) 30.2904604, 73.07478617	93.584
2	Baba Farid Park Pakpattan (3.5 Acres) 30.364288, 73.379079	43.845
3	Town Park Renala Khurd (5 Acres)30.88295777, 73.59504533	62.636

Figure 36: Conceptual Design for Aqua Nature Park (Fatima Jinnah Park, Arifwala and Baba Farid Park, Pakpattan)

Figure 37: Conceptual Design for Aqua Nature Park (Town Park Renala Khurd, Pakpattan)

6.3.4. PROJECT 2.2: Community Gardens

Traditionally, community gardens in urban centers are used by locals for producing fresh vegetables which enables a healthier sense of community and increased community well-being. Under this project, the local government can engage the public for increasing green cover, and improve environmental awareness.

Exiting Condition of proposed project sites

Proposed Sites:

- Al-Abbas Park Depalpur (2 Acres)-
- 30.66355419, 73.66225573
- Quaid-e-Azam Chowk Green Belt (80 ft. long, 15 ft. wide)
- 30.672356, 73.657550

Scope of the Project:

- Gazebo
- Vertical & Horizontal Greening
- Small-sized Plots for plantation
- Vertical greening on side fence and back fence
- Light Poles
- Fencing

Benefits of the Project:

- Provision of Improved Ecosystem Services
- Air Purification
- Carbon Sequestration
- Climate Regulation
- Habitat for Local Biodiversity
- Sense of Community
- Improved local environment

Figure 38: Conceptual Design for Community Gardens

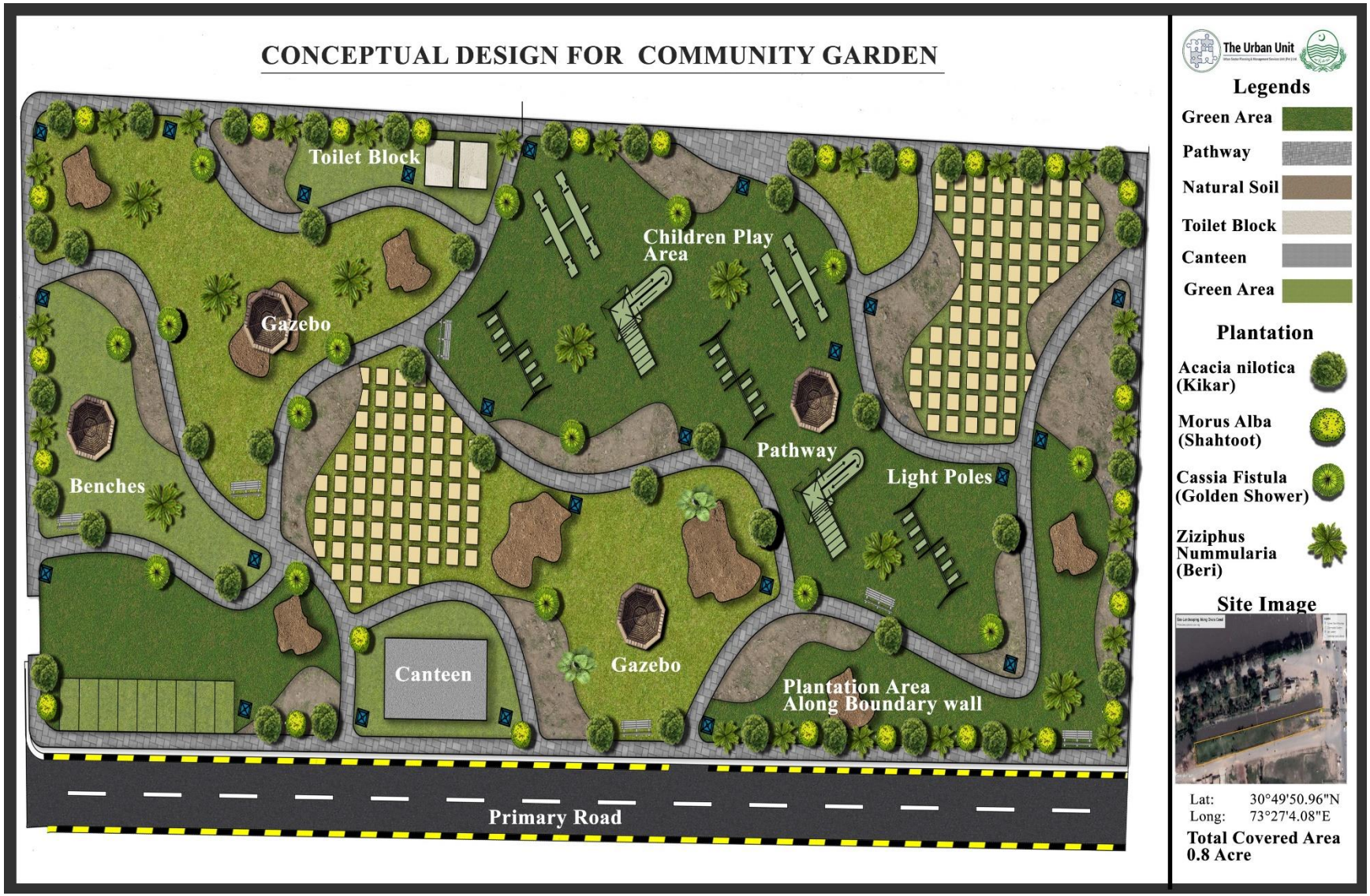


Figure 39: Conceptual Design for Community Gardens

6.3.5. PROJECT 3: Sulemanki Wildlife Park – Extension & Rehabilitation

The Wildlife Park is the ex-situ conservation and protection strategy to conserve the native fauna and provide the breeding ground within suitable habitat. The aim to provide safe and natural habitat for native threatened wildlife species by implementing breeding program and conducting research on behaviour, ecology and genetic diversity of animals. The wildlife park is ground of recreation and educational scientific research opportunity which attract wildlife lovers and researchers, also enhance tourism opportunity for the local residents.

Sulemanki wildlife park is already serving as breeding ground of native wildlife species. The extension & rehabilitation of wildlife park will enhance the scientific research opportunity through collaboration with conservation organizations, universities, and research institutes to advance conservation strategies and help the conservation efforts. This wildlife conservation site will also accommodate the injured and rescued wildlife of the district and provides the rehabilitation facilities. The reintroduction of animals to natural habitat will also be possible through this conservation and breeding program.

Figure 40: Existing Condition of Proposed Project Site

Scope of the Project

- Establishment of veterinary office and admin block to improve institutional capacity and research facilities.
- Establishment of Animal enclosure i.e. Chinkara, Black Buck, Nilgai, and Monkey house.
- Establishment of Information centre and cafeteria to improve ecotourism and research facilities.

- Establishment of Bird aviary and cages i.e. Pheasants, Peacock, Common crane, Ducks, Ostrich, Perret and Partridges.
- Indigenous plantations and Provision of Lawns.
- Establishment of Walking tracks, Admin block and cafeteria facilities.
- Provision of Gazebo, huts and recreational facilities.

Estimated Cost

Sr. No	Description	PKR Millions
1	Construction of Walking Trail	3.26
2	Construction of Brid Cages / Aviary	0.31
3	Construction of Aninmal Enclosure	2.75
4	Construction of Information Center/ Cafeteria	4.24
5	Construction of Toilet Block (Women and Men)	1.56
6	Construction of Admin Office	3.11
7	Construction of Wooden Gazebo / Recreational Facilities	1.29
8	Construction of Rose Garden	0.82
9	Construction of Natural Soil	4.10
10	Construction of Veterinary	2.19
11	Plantation (Arboretum, Fruticetum, Orchidarium & Scatter Plantation)	1.10
	Sub- Total Amount	**24.72**
	Add Contingencies Cost (2.5%)	**0.62**
	Add PST (5%)	**1.24**
	Grand Total Amount with Contingencies and PST	**27**

Figure 41: Conceptual Design of Sulemanki Wildlife Park – Extension & Rehabilitation

6.3.6. PROJECT 4: Forest Sprouting Reserves

The Forest Sprouting Reserve is the ground to raise the seedling and sapling for the reforestation, expansion, and regeneration of forest land and tree cover. Functionally, sprouting reserve is vital for the germination of native species in its natural environment and soil condition, thus the seedling and sapling with stand against the pre and post threats of replantation and sapling relocation. This reserves also act as center for propagation, research, development, and nurturing of diversified tree species.

Proposed Site:

Along Canal Nearby Urban Area, Okara

- Location 1: 73.497996°, 30.836229° (Area:6.7 acres)
- Location 2: 73.424759°, 30.823106° (Area: 4.8 acres)

Objectives of the Project:

The forest sprouting reserve will serve the following objective:

- Improve sapling growth of slow growing Plant Species.
- Produced diseased Free sapling.
- Raised Stock for Reforestation and afforestation.
- Increase vigour and viability by lower competition.
- Improves environment stability.

Conceptual Design:

- The bed and pocket sowing techniques can be used for effective growth of mixed indigenous species.
- The ornamental plant species can be raised through cutting of plants to improve the health of plants and enhanced the aesthetic quality of flowering plants.
- The gradual thinning and removal of weed species for better growth of native seedling species.

Figure 42: Pocket Sowing Technique

Figure 43: Bed Sowing and Planting Technique

Estimated Cost:

Sr. #	Proposed Location	Description	Unit	Qty	Rate (Rs)	Amount (Million)	Amount with 5% PST / 2%Conti
1	Okara Canal (73.497996, 30.836229) – 6.7acres	Earth Work for digging of trenches making of pits and ridges, kacha bands etc. Included cost of collection/ purchase of seeds, cuttings etc. Sowing/ dibbling of seed or cutting. Also cost of dreshi & watering complete in all aspects.	cft	291,852.00	75.00	**21.9**	**23.5**
2	Okara Canal (73.424759, 30.823106) – 4.8acres	Earth Work for digging of trenches making of pits and ridges, kacha bands etc. Included cost of collection/ purchase of seeds, cuttings etc. Sowing/ dibbling of seed or cutting. Also cost of dreshi & watering complete in all aspects.	cft	209,088.00	75.00	**15.7**	**16.5**
						Total Amount	**40.0**

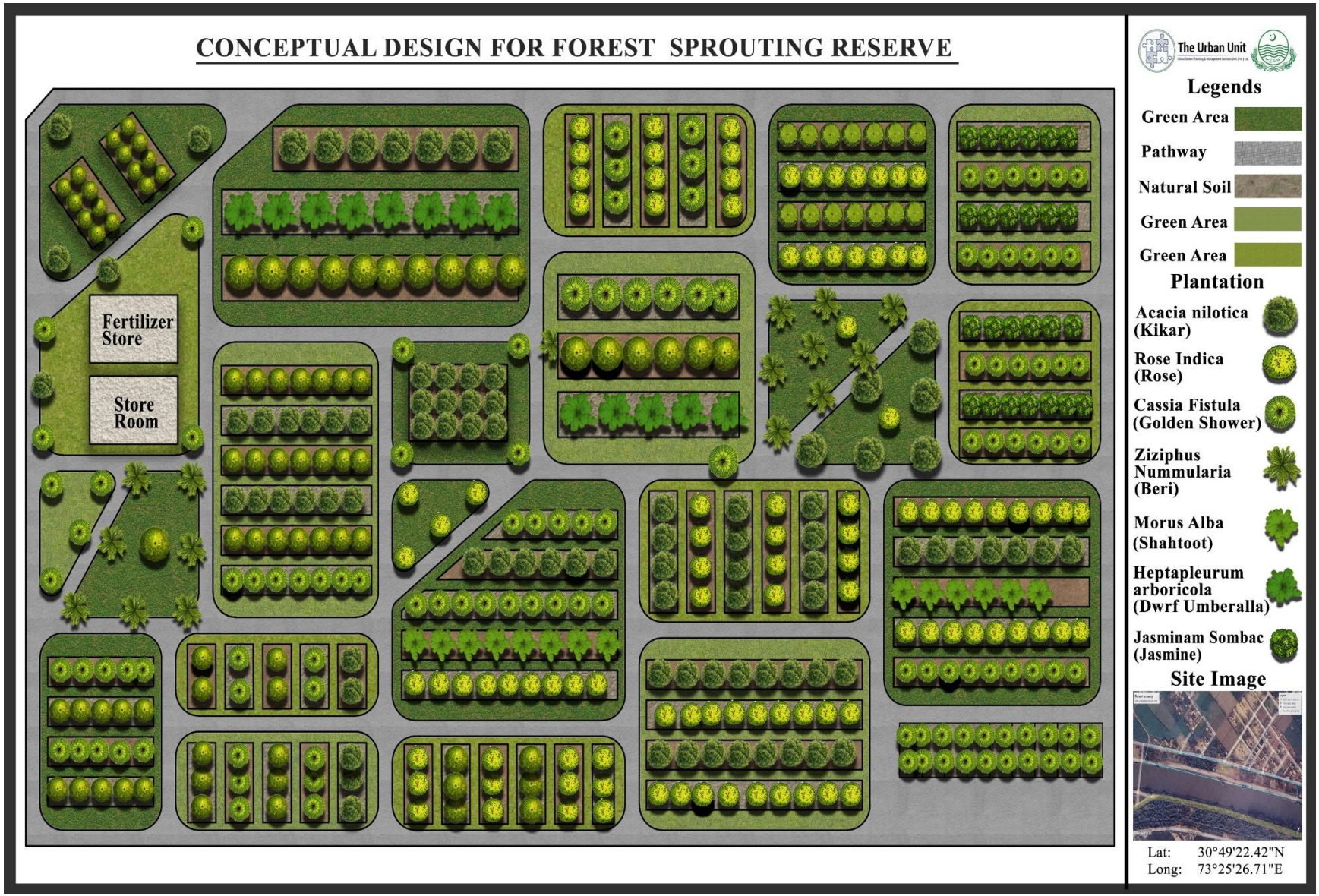


Figure 44: Conceptual Design for Forest Sprouting Reserve

6.3.7. PROJECT 5: Agro-Canopy Forests

Agro Canopy Forest is to socializing the forest bioscape over agricultural land by integration of trees at agricultural and farm land of the area. Agro Canopy Forest is the best practice adopted by the developing countries where forest cover is less than the required statistics. It involves to planting trees alongside crops to provide multiple benefits such as improved soil fertility, enhanced water retention, reduces soil erosion and also diversify the income sources for farmers. Social forestry initiatives aim to involve local communities in tree planting and forest management activities, providing them with direct benefits and promoting their participation in conservation efforts. Agro Canopy Forest also act as wind barrier for weak crops which drop down due to wind flow and cause the great loss of farmers, trees along crops protect ten times larger area's crops than their height from drop down by wind.

Proposed Site:

- Agricultural land Around the Urban Settlement, Okara

Objectives of the Project:

The associated to agro canopy forest are as follows:

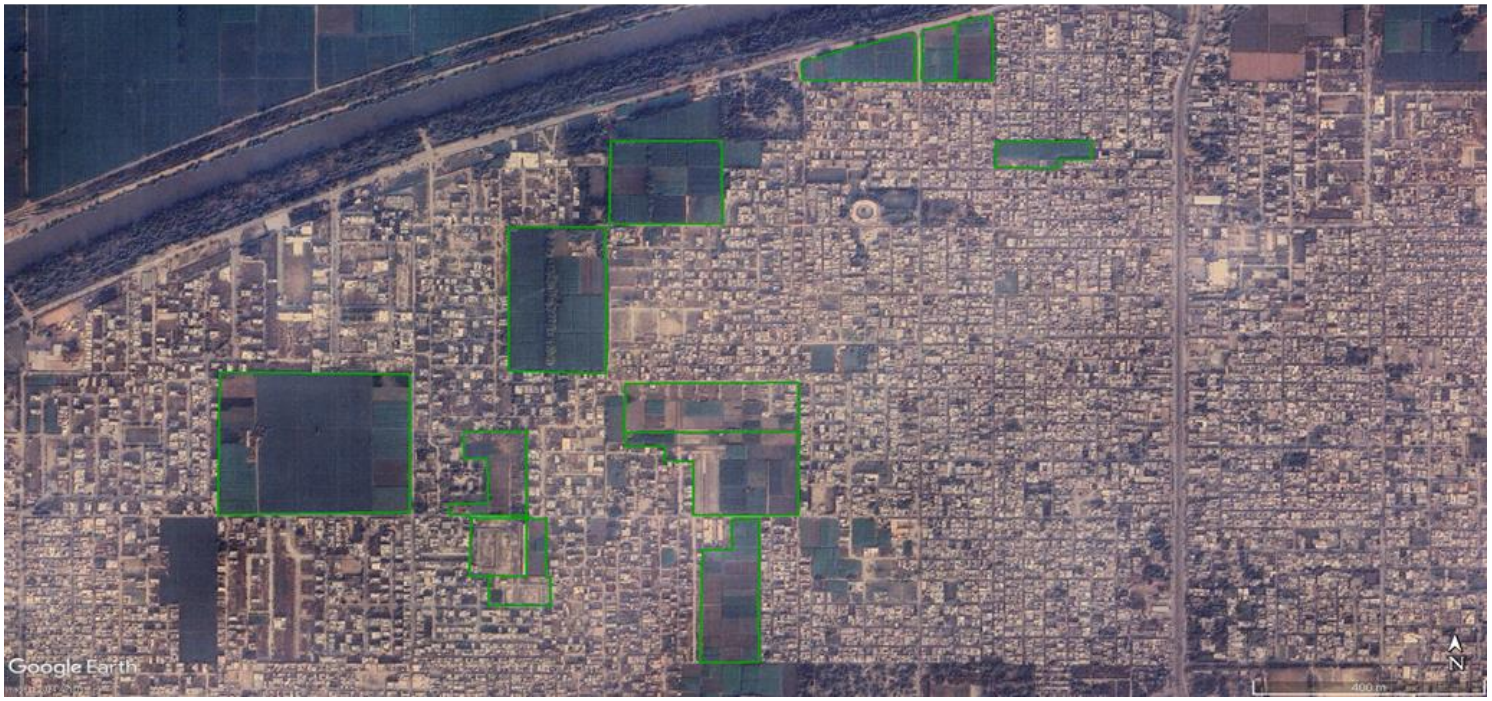
- Increase carbon sink.
- Mitigate climate change issues.
- Promote social forestry.
- Improves environment stability.
- Habitat to urban biodiversity.
- Act as Wind Barrier for field crops

Conceptual Design:

- The mixed indigenous native and fruiting trees plantation.
- The peripheral bed used for plantation to act as wind barrier and avoid crops breakage.

Estimate Cost

Sr. #	Proposed Location	Description	Unit	Qty	Rate (Rs)	Amount (Million)
1	Okara Agricultural Land around the Urban Settlement – 20 Av. Km	Providing and planting of trees including the cost of pitting, digging, fertilizer, watering completes in all respect.	No's of Plants	9,000	550.00	**5.0**
					Total Amount	**5.0**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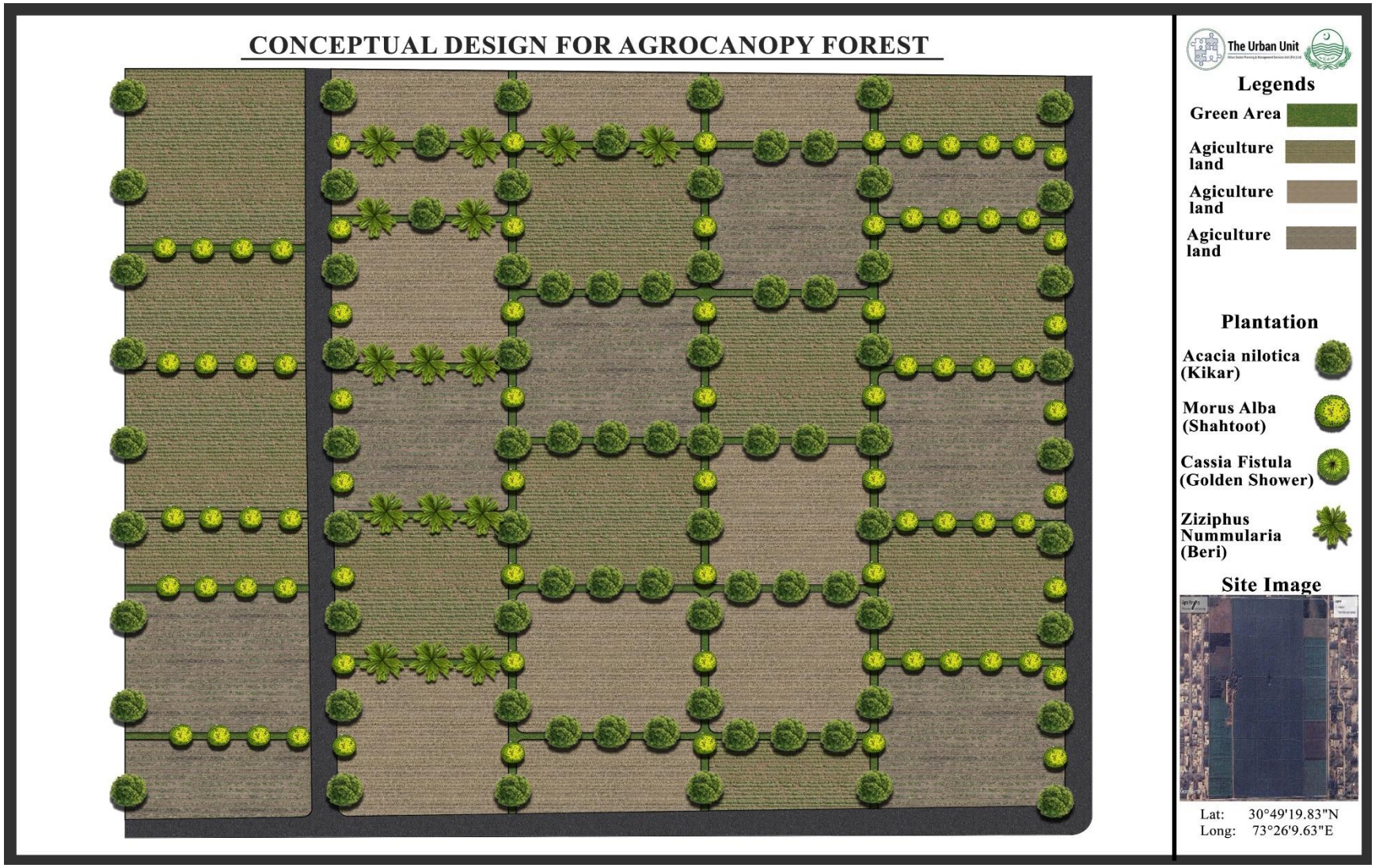


Figure 45: Conceptual Design for Agrocanopy Forest

6.3.8. PROJECT 6: Rehabilitation of Tube Wells at Depalpur Forest Plantation

The Depalpur plantation is the biodiversity and ecological zone within Okara district, which is threatened due to water scarcity. The Rehabilitation of Tube Wells at Depalpur Forest Plantation is aims to improve the irrigation infrastructure, specifically focusing on the rehabilitation and enhancement of tube wells capacity within plantation.

The existing tube wells are facing different infrastructural problems throughout time, such as poor electricity supply, poor maintenance, and civil structure damage. The concern issues are posing crucial threats to the management and conservation of forest ecosystem. Thus, the maintenance and rehabilitation of tube wells are important to achieve the water requirement and improve vitality, growth, and richness of species within the forest.

Source Of Water:

- Tube Wells (21 Nos @3247 acres)
  - Functional Tube Wells (16 Nos @2202.7 acres)
  - Non-Functional Tube Wells (5 Nos)
- Alwardi Minor Canal (15 Outlets)
  - Indented Discharge (58.14 cusecs @5188 acres)
  - Current Discharge (28.90 cusecs 2578.8 acres)

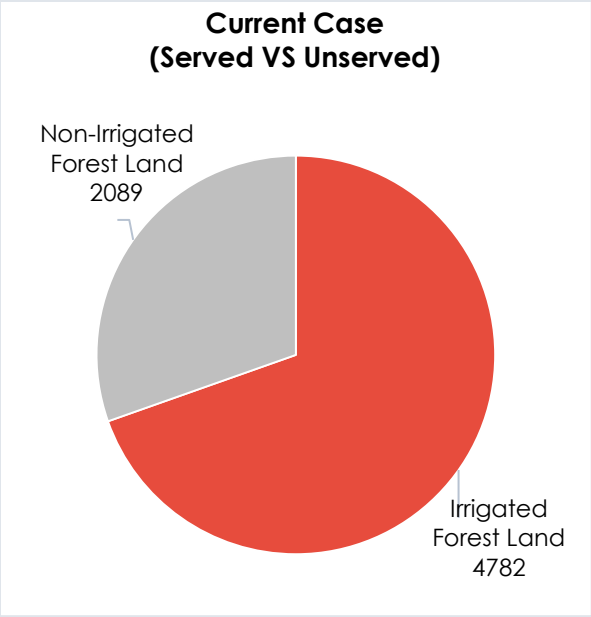
Problematic Area and Key Issues:

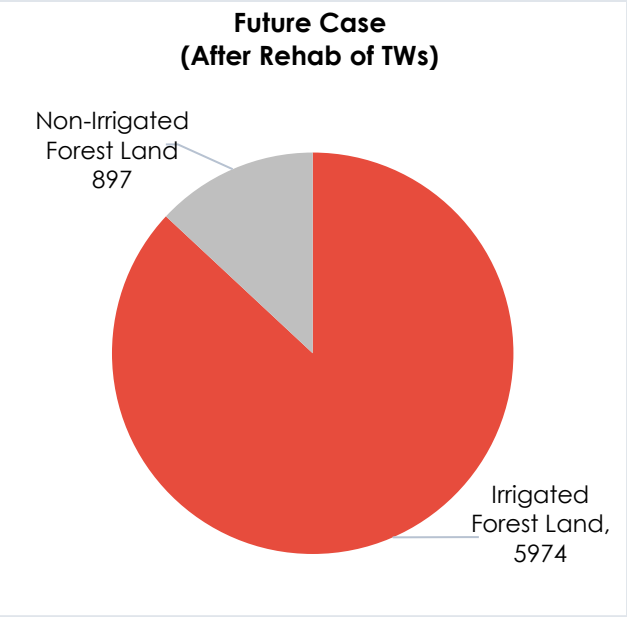
- Non-Irrigated Area = 896.9 acres
- Key Issues include but are not limited to:
  - Annual Canal (Only seasonal flows)
  - Energy related issues for TWs

Figure 46: Existing Solar System and Tube Well in Depalpur Forest Plantation

Suggested Interventions:

- Rehabilitation of non-functional tube-wells
  - Procurement of new solar plates
  - Repairs for electrical works & new panels
  - Civil work as per site requirement





Estimated Cost

Sr. #	Site	Description	Unit	Qty	Rate (Rs)	Amount (Million)
1	Depalpur Forest Plantation	Procurement of new solar plates, Repairs for electrical works & new panels, and Civil work as per site requirement	No's	5	1,492,920.00	**7.5**
					O & M Cost Per Annum @7.5%	**0.6**
					Total Amount	**8.1**

6.3.9. PROJECT 7: Reforestation and Afforestation

Reforestation and afforestation are aimed to increase the forest cover by planting trees on barren lands, degraded areas and other suitable sites of forest land. Afforestation will help to improve native tree species richness that are suitable to the local climate, soil conditions, and ecological requirements. Planting mixed indigenous tree species and improving forest canopies can help to maintain connectivity between natural habitats and support the survival of various plant and animal species. Forest plantation key source to environment stability, which contribute to carbon sequestration and helps to mitigate climate change.

Benefits of the Project:

The proposed project has following significant benefits:

- Improvement of natural habitat for regional biodiversity
- Revival of reginal key biodiversity
- Improved Ecosystem Services
- Climate change mitigation
- Improved human-biodiversity interaction

Conceptual Design:

- The forest plantation design should be based on mix plantation or polyculture design to attract and conserve the wild diversity of the region.
- The species selection based on indigenous plant species which are native to the division like:
  - *Acacia nilotica (Kikar)*
  - *Albizia lebbeck (Siris)*
  - *Acacia modesta (Phulai)*
  - *Dalbergia sissoo (Shisham)*
  - *Morus alba (Shehtoot)*
  - *Ziziphus nummularia (Beri)*
- The gradual thinning of forested land for better growth of plantation and removal of weed like *Prosipis julifora* which is the very common weed in forestry.
- The spacing of line and trees are 10 x 6 feet for the well managed and better growth of plant.

Acacia modesta

Dalbergia sissoo

Ziziphus nummularia

Acacia nilotica

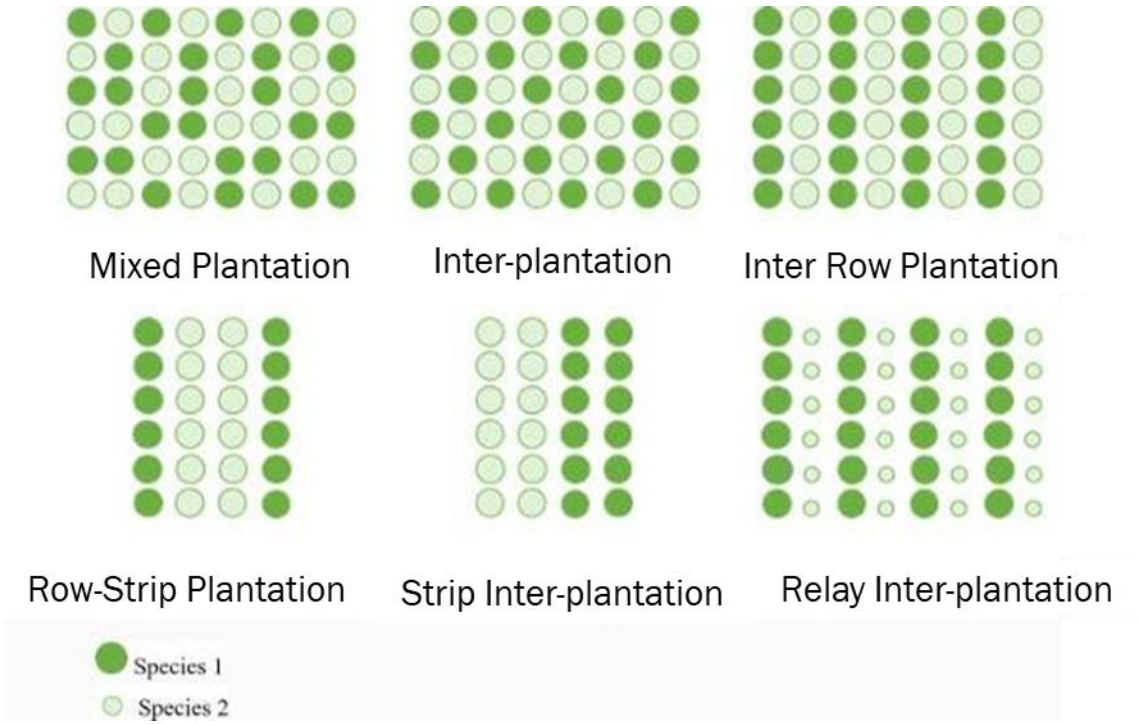


Figure 47: Conceptual Design of Reforestation and Afforestation

Estimated Cost

Sr. #	Site	Description	Unit	Qty	Rate (Rs)	Amount (Million)
1	Depalpur Forest – Okara (300 acres)	Providing and planting of trees including the cost of pitting, digging, fertilizer, watering complete in all respect.	No's of Plants	225,000	550.00	**123.7**
2	Chichawatni Forest – Sahiwal (400 acres)	Providing and planting of trees including the cost of pitting, digging, fertilizer, watering complete in all respect.	No's of Plants	300,000	550.00	**165.0**
3	Dall Waryam – Pakpattan (100 acres)	Providing and planting of trees including the cost of pitting, digging, fertilizer, watering complete in all respect.	No's of Plants	75,000	550.00	**41.3**
					O & M Cost Per Annum @7.5%	**24.75**
					Total Amount	**354.75**

6.3.10. PROJECT 8: Linear Plantation and Green Corridor in Cities

Green corridors, designed as interconnected pathways linking green belts, open spaces, and linear plantations along roads, canals, and tracks, play a vital role in enhancing the environmental quality of a district. These corridors not only contribute to regional biodiversity but also create cooling pathways that help mitigate urban heat and improve air quality. Furthermore, they enhance the visual appeal of highways and provide local communities with recreational spaces. To enhance the environmental values of the division, it is crucial to regularly develop networks of linear green corridors along green belts and expand green infrastructure.

Project Sites:

- Along Pakpattan Railway Line, Sahiwal (4.5kms)
- Along Railway Line Arifwala, Sahiwal (4kms)
- Along Railway Track Okara, Sahiwal (5kms)
- Along Railway Track Renala Khurd, Okara, Sahiwal (3kms)
- Along Canal Renala Khurd, Okara, Sahiwal (3.5kms)
- Along 9L Canal Along Kannan Park, Sahiwal (1km)
- Along Sahiwal Pakpattan Road, Pakpattan, Sahiwal (3.5kms)
- Along Delhi Multan Road, Arifwala, Pakpattan (4kms)
- Along Okara Depalpur Road, Okara (4.5kms)
- Along Kasur Road, Depalpur, Okara (4kms)
- Along Allama Iqbal Road, Chichawatni, Sahiwal (1km)
- Along Rao Ali Stadium Road, Chichawatni, Sahiwal (1km)
- Along Lahore-Multan Road, Sahiwal (6.3km)
- Along Arra Tulla Road, Sahiwal (2.33km)
- Along Noor Shah Road, Sahiwal (2.55km)

Figure 48: Existing condition of the Proposed Project Sites

Benefits of the Project:

- Micro Climatic Modification
- Economic Diversification
- Eco-Friendly environment
- Preventing Soil Erosion
- Carbon Sequestration
- Improved Ecosystem services
- Human-Biodiversity Interactions
- Recreational Point

Conceptual Design:

- The green corridor should be a connected network of green cover and green spaces to achieve the basic aim of the project.
- The plantation along water channel should be planned and based on stratification to enhanced the beauty of the region.
- Number of rows based on the availability of spaces along the planting area.
- The placement of vegetation around developments and the maintenance of larger, interconnected green spaces throughout regions should be done to promote air quality improvement.

Estimated Cost:

SUMMARY OF ROUGH COST ESTIMATE RAILWAY TRACK BEAUTIFICATION			
Sr. No	**Description**	**Amount in PKR (PST 5%)**	**Amount in Millions**
1	Along Pakpattan Railway Line, Sahiwal (4.5kms)	24,101,700.24	24.102
2	Along Railway Line Arifwala, Sahiwal (4kms)	22,147,500.06	22.148
3	Along Railway Track Okara, Sahiwal (5kms)	1,217,789.33	1.218
4	Along Railway Track Renala Khurd, Okara, Sahiwal (3kms)	18,221,040.45	18.221

Roads & Canal Linear Plantation Cost Summary			
Along Sahiwal Pakpattan Road, Pakpattan, Sahiwal (3.5kms)			
Item No.	**Description**	**Amount (Rs.)**	**Amount in Millions**
1	Soil Preparation.	1,530,375	1.5
2	Fertilizer & Pesticides.	2,851,000	2.8
3	Plantation	5,880,260	5.8
	GRAND TOTAL.	10,261,635	10.2

Along Delhi Multan Road, Arifwala, Pakpattan (4kms)			
1	Soil Preparation.	1,804,550	1.8
2	Fertilizer & Pesticides.	2,851,000	2.8
3	Plantation	6,582,148	6.5
	GRAND TOTAL.	11,237,698	11.2
Along Kasur Road, Depalpur, Okara (4kms)			
1	Soil Preparation.	1,804,550	1.8
2	Fertilizer & Pesticides.	2,851,000	2.8
3	Plantation	6,582,148	6.5
	GRAND TOTAL.	11,237,698	11.2
Along Allama Iqbal Road, Chichawatni, Sahiwal (1km)			
1	Soil Preparation.	451,138	0.4
2	Fertilizer & Pesticides.	1,192,000	1.1
3	Plantation	3,117,412	3.1
	GRAND TOTAL.	4,760,550	4.7
Rao Ali Stadium Road, Chichawatni, Sahiwal (1km)			
1	Soil Preparation.	451,138	0.4
2	Fertilizer & Pesticides.	1,192,000	1.1
3	Plantation	3,117,412	3.1
	GRAND TOTAL.	4,760,550	4.7
Along Arra Tulla Road, Sahiwal (2.33km)			
1	Soil Preparation.	1,051,050	1.0
2	Fertilizer & Pesticides.	1,659,000	1.6
3	Plantation	4,653,188	4.6
	GRAND TOTAL.	7,363,238	7.3
Along 9L Canal Along Kannan Park, Sahiwal (1km)			
1	Soil Preparation.	451,138	0.4
2	Fertilizer & Pesticides.	1,192,000	1.1
3	Plantation	3,117,412	3.1
	GRAND TOTAL.	4,760,550	4.7

Along Canal Renala Khurd, Okara, Sahiwal (3.5kms)			
1	Soil Preparation.	1,353,413	1.3
2	Fertilizer & Pesticides.	2,871,000	2.9
3	Plantation	5,427,236	5.4
	GRAND TOTAL.	9,651,649	9.6
Along Okara Depalpur Road, Okara (4.5kms)			
1	Construction of Green Area, Plantation & Trees	12,040,478	12.04
2	Light Poles	8,658,599	8.66
	Sub- Total Amount R. s	20,699,077.00	20.70
	Add 2% Contingencies	413,981.54	0.41
	Add 5% PST	1,034,953.85	1.03
	Grand Total Amount R.s	22,148,012	22.15
Along Lahore-Multan Road, Sahiwal (6.3km)			
1	Construction of Green Area, Plantation & Trees	15,668,465	15.67
2	Light Poles	17,625,300	17.63
	Sub- Total Amount R.s	33,293,765.00	33.29
	Add 2% Contingencies	665,875.30	0.67
	Add 5% PST	1,664,688.25	1.66
	G-Total Amount R.s	35,624,329	35.62
Along Noor Shah Road, Sahiwal (2.55km)			
1	Construction of Green Area, Plantation & Trees	7,716,657	7.72
2	Light Poles	9,135,544	9.14
	Sub- Total Amount R.s	16,852,201.20	16.85
	Add 2% Contingencies	337,044.02	0.34
	Add 5% PST	842,610.06	0.84
	G-Total Amount R.s	18,031,855	18.03

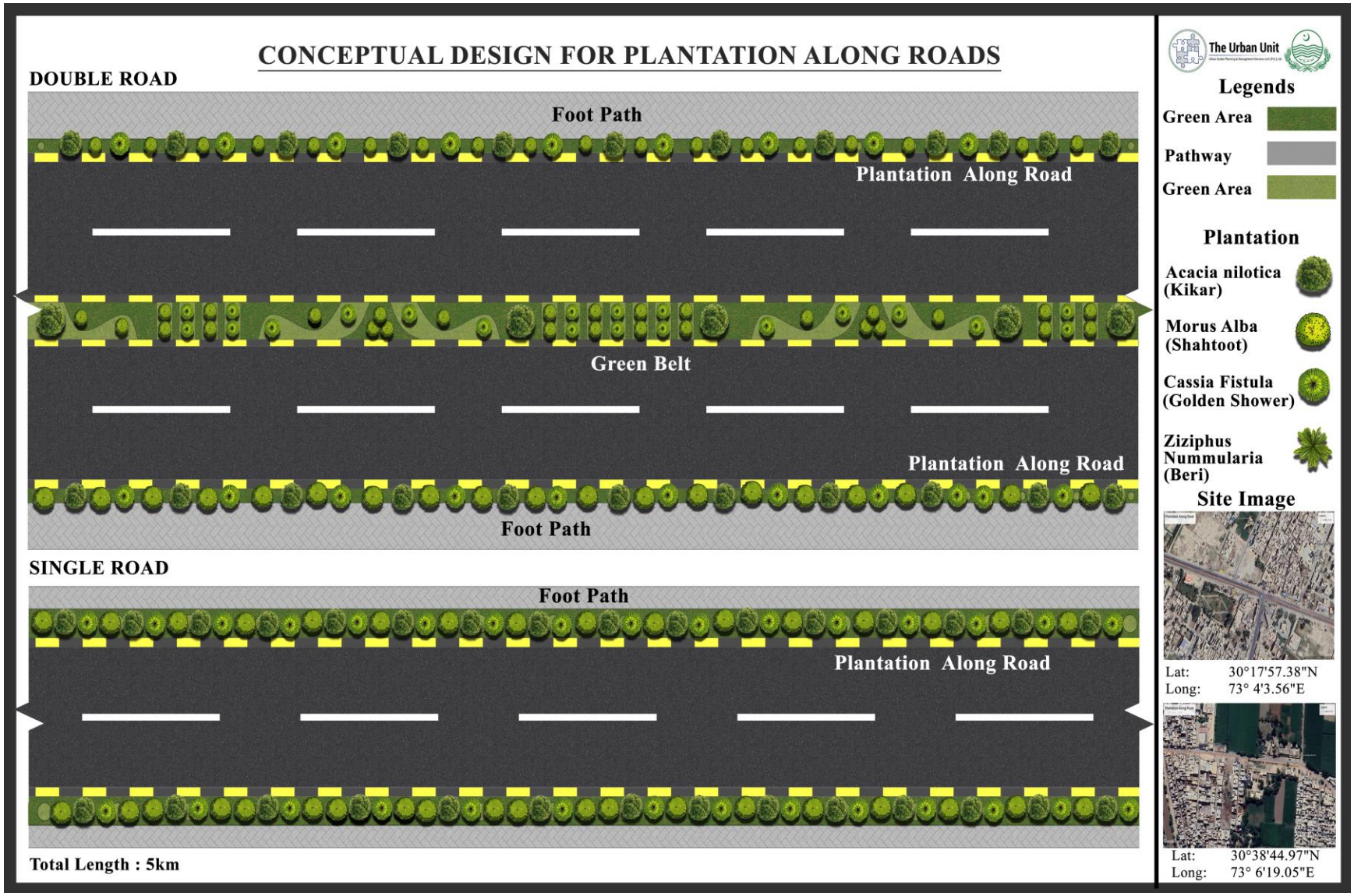


Figure 49: Conceptual Design of Roadside Linear Plantation

6.3.11. PROJECT 9: Pathway Lineage Parks along Railway Line and Canal banks

Pathway lineage parks projects focus on developing green spaces along linear features such as trails, roadsides, or riverbanks. These parks are designed to provide recreational opportunities, promote biodiversity, improve air quality, and enhance the visual appeal of urban or natural environments. They typically feature walking and biking trails, native plantings, water elements, seating areas, and sustainable landscaping practices. Pathway lineage parks offer benefits such as outdoor recreation, active transportation options, mental well-being improvement, wildlife habitats, urban cooling, noise reduction, and community engagement. They contribute to creating healthier, more resilient, and liveable communities.

Project Sites

- Development of Lineage Park along Canal Renala Khurd, Okara, Sahiwal (40 ft wide and 3kms long track)
- Development of Lineage Park along the Railway Track Pakpattan (55 ft Wide and 3 kms long)
- Development of Track Lineage Park in Canal Colony Pakpattan (60 ft wide and 1.5 km long pathway)

Figure 50: Existing condition of Proposed Project Site

Conceptual Design

- The green lineage pathways should form a cohesive network of green cover and spaces, aligning with the project's core objectives.
- These pathways are planned to serve multiple functions, such as pedestrian and cyclist routes, recreational spaces, wildlife corridors, and cultural or historical trails.

- The number of rows of vegetation should be determined based on available space along the pathway.

Estimated Cost

Sr. No	Description	Amount in PKR	Amount in Millions
Development of Lineage Park along Canal Renala Khurd, Okara, Sahiwal (40 ft wide and 3kms long track)			
1	Construction of Green Area, Plantation & Trees	11,324,959	11.32
2	Construction Pathways	9,358,996	9.36
3	Light Poles	8,658,599	8.66
4	Benches & Dustbins	240,645	0.24
5	Fencing	1,188,178	1.19
6	Wooden Gazebo	1,050,000	1.05
	Sub- Total Amount R.s	**31,821,376.63**	**31.82**
	Add 2% Contingencies	636,427.53	**0.64**
	Add 5% PST	1,591,068.83	**1.59**
	G-Total Amount R.s	**34,048,873**	**34.05**
Development of Lineage Park along the Railway Track Pakpattan (55 ft Wide and 3 kms long)			
1	Construction of Pathway	9,242,437	9.242
2	Construction of Stone	978,355	0.978
3	Construction of Green Area And Plantation	1,538,273	1.538
4	Benchs & Dustbin	240,645	0.241
5	Wooden Gazebo	1,050,000	1.050
6	Light Poles	8,658,599	8.659
	Sub- Total Amount	21,708,309	21.708
	Add 2% Contingency Charges	434,166.19	0.434
	Add 5% PST	1,085,415.46	1.085
	G-Total Amount R. s	**23,227,890.91**	**23.228**
Development of Track Lineage Park in Canal Colony Pakpattan (60 ft wide and 1.5 km long pathway)			
1	Construction of Green Area, Plantation & Trees	6,867,229	6.87
2	Construction Pathways	4,679,023	4.68
3	Light Poles	4,329,300	4.33
4	Benches & Dustbins	115,218	0.12
5	Fencing	594,029	0.59
6	Wooden Gazebo	350,000	0.35
	Sub- Total Amount R.s	16,934,798.04	16.93
	Add 2% Contingencies	338,695.96	0.34
	Add 5% PST	846,739.90	0.85
	G-Total Amount R. s	**18,120,234**	**18.12**

Figure 51: Conceptual Design of Lineage Pathway Park

6.3.12. PROJECT 10: Construction of Sustainable Bio-floc Fish Aquaculture System on Zero Liquid Discharge

Bio-floc technology (SBFT) is a transformative approach in aquaculture, known as the "blue revolution," for its sustainable practices and efficient waste management. By utilizing in-situ microorganism production, SBFT minimizes water discharge (0.5 to 1 percent per day), recycles nutrients, and reduces environmental harm compared to traditional methods. The future of aquaculture hinges on responsible practices like super-intensive bio-floc systems, requiring specialized engineering and management for optimal results. This technology's dual role in waste treatment and nutrition provision, coupled with low water discharge rates, makes it a promising solution for regions facing water scarcity or high land costs, fostering sustainable aquaculture development globally.

Existing Traditional Fish Hatchery

Currently, only one Fish Hatchery in Pakpattan district at Arifwala on 12 Acres Land is working on traditional technology which consume large amount of water leading water scarcity and pollution to aquatic ecosystem and contaminating nearby canals. These drawbacks in Sahiwal division requires a more sustainable and advanced aquaculture system which aim to minimize environmental impacts and improve fish production.

Comparison of Traditional & Bio-floc Technologies

Sr.	Parameters	Traditional Fish Aquaculture	Sustainable Bio-floc Aquaculture System
1.	Land Requirement	High	Moderate
2.	Capital Construction Cost	Medium	High
3.	Cost of Aquaculture Feed	High	Low
4.	Power Consumption	High	Moderate
5.	Quantities of Sludge Produced	High	Low
6.	Ease of Operation and Maintenance	No	Yes
7.	Water usage	High	Low
8.	Control over water quality	Limited	High

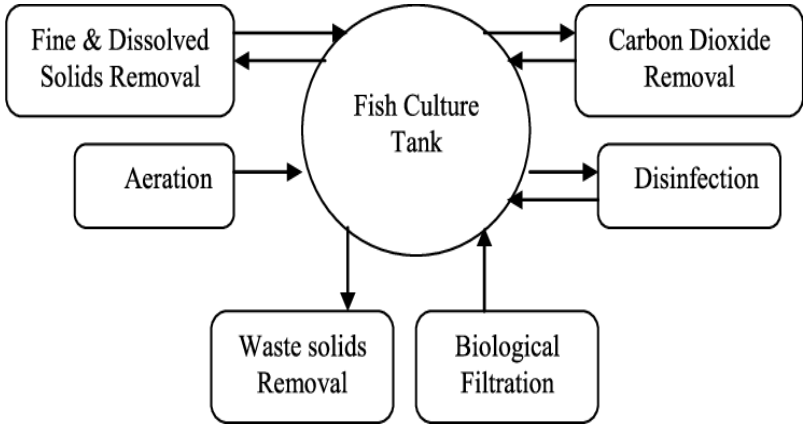
Proposed Sustainable Bio-floc Aquaculture System

On the basis of above comparisons, A Sustainable bio-floc fish aquaculture system on Zero Liquid Discharge technology has been proposed at Pakpattan for improving fish production while minimizing environmental pollution in Sahiwal Division for future planning purpose.

Location of Proposed Project

The location for the proposed fish aquaculture system is chosen by considering the factors including water supply availability, distance from fish farming, and ease of distribution market access, and in proximity to the agriculture land where treated effluent can be discharged easily

for reuse purpose. The tentative area occupied by sustainable fish aquaculture system is 15 Acre Approx.



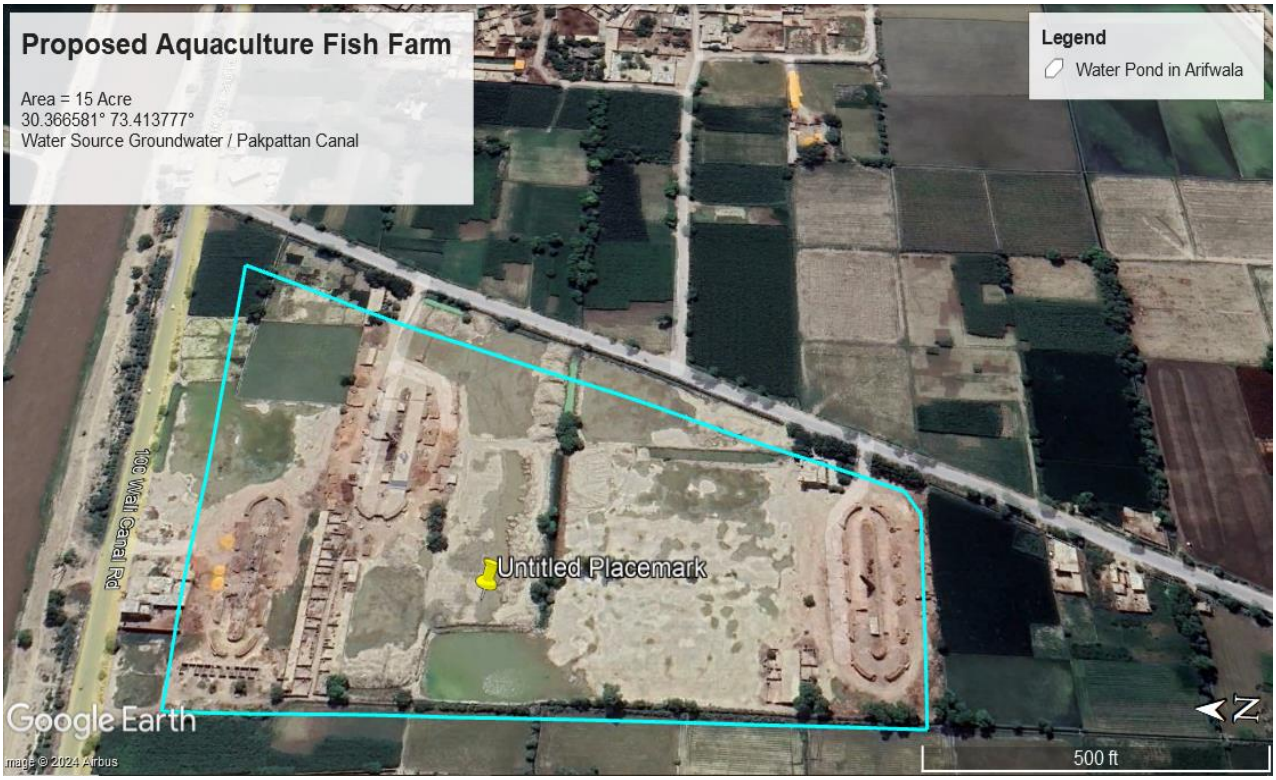


Figure 52: Geographical Location of proposed Fish Aquaculture System

Design Consideration

The sustainable fish aquaculture systems combine the advantages of recirculation and zero-liquid discharge with smart technology. The proposing project for a Sustainable Bio-floc Fish Aquaculture System (SBFA) on Zero Liquid Discharge (ZLD) principles, focusing on environmentally responsible fish production. The project involves site selection, detailed engineering design of ponds or tanks, water circulation systems, aeration tanks, and IoT monitoring for optimal management. Construction will include building lined fish ponds, installing water circulation pumps, aeration

devices, and filtration systems, with a focus on bio-floc management for nutrient recycling and microbial growth.

Components of Proposed Biofloc Fish Aquaculture System

The basic components of SBFA are unique, irrespective of the aquatic species. The capacity of BFA system is decided, based on the biomass and feed rate.

- Filtration screens
- Breeding pond
- UV light for the disinfection of the water
- Fish culture Pond
- Bio filter basin combined with Aeration and Membrane biofiltration
- Gravel filter to trap the sludge particles.
- Water recycling Pond to recycle the overload water
- Sludge basin to gather sludge waste.
- IOT Monitoring System
- The major process involves in Aquaculture are given in the following table

Process/ Technique	Description	Particle Size Removed	Solids Removal Efficiency	Advantages	Drawbacks
Solid Waste Removal	Removal of uneaten feeds and excreta to prevent biofouling, NH3 production, oxygen depletion, and disease occurrence within the system.	Varies	Varies	Prevents system issues, reduces disease risk	Technique specificity based on particle size and type
Sedimentation	Settling tanks or tube settlers used to remove large particles (>100 µm) through gravity settling.	>100 µm	40-60%	Effective for large particles	Low hydraulic loading, moderate solids removal
Granular Media Filters	Rapid sand filter, pressure sand filter, bead filter, etc., used for removing particles (>20	>20 µm	60-90%	Moderate hydraulic loading, high removal	Technique-specific, may require maintenance and cleaning

	µm) through filtration.				
IoT Monitoring System	Smart system equipped with sensors (pH, temperature, dissolved oxygen, turbidity) connected via Wi-Fi for real-time data collection and management.	N/A	N/A	Remote monitoring, data-driven decisions	Initial setup and integration may be complex

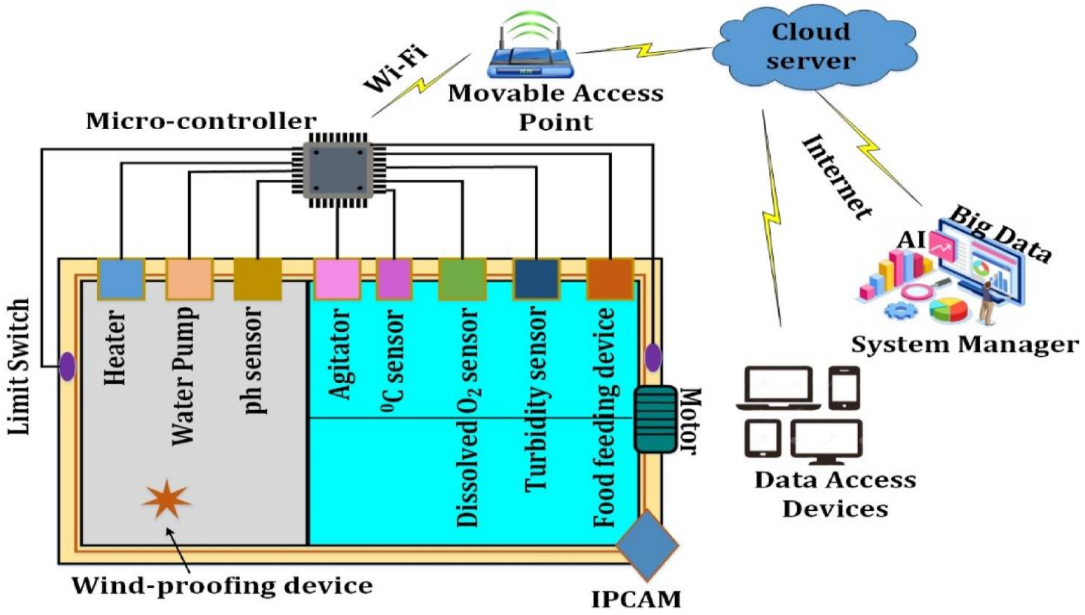


Figure 53: IOT Monitoring System of Biofloc fish Aquaculture System

Advantages of RAS Hatchery

- Eco-friendly culture system.
- It reduces environmental impact.
- Small use of land and water
- Limited or zero water exchange system
- Higher productivity (It enhances survival rate, growth performance, better feed conversion in the culture systems of fish).
- Higher biosecurity.
- Reduces water pollution and mitigate the risk of introduction and spread of pathogens
- It reduces utilization of protein rich feed and cost of standard feed.

Technical Specifications of Biofloc Fish Aquaculture System – Pakpattan

Sr. No	Component	Details
1.	Biofloc pond size	12-meter diameter and 3.5-meter height (3 m water depth)
2.	Area for 10 tanks	1130 m^2
3.	Water holding capacity of each tank	340 m^2 (340,000 Litres) capacity
4.	Water quality parameters	Dissolved Oxygen-5mg/L, Temparature-25-34°C, pH-7.5 to 8, TDS-600ppm, Floc density-25-40 mg/l, Ammonia-0.5 ppm, Nitrite-0.3 ppm, Nitrate-150 ppm, Alkalinity-120-280 ppm
5.	Ponds material	Concrete & HDPE liner
6.	Stocking density	100 nos/m3 (1000 no.s per 340000 litres tank - depending on species)
7.	Survival (%)	Approx. 80% (27000 Nos. per tank)
8.	Type of feed to be used	floating pellet feed
9.	% of feed	2-3% per Average Body weight
10.	Feeding frequency	4 times early stage, later 2 times per day
11.	Duration of culture	6 months
12.	Size/weight of the species(gm)	500 gm average weight
13.	No. of crops per year	2
14.	Production	54 Tonnes per year
15.	Total Fish Production of 10 tanks	54000*10*2 = 1.08 Million/year

Estimated Cost:

Sr. No	Description	Amount (Millions)
	Capital Investment	
1	Construction of Office Building (Area 1650 Sqft Per Cost Unit 3,175)	5.24
2	Fish Hatchery Room (Area 1500 Sq.ft Per Cost Unit 3,175)	4.76
3	Construction of Drain of Hatchery Room	0.32
4	Ten Circular Tank	0.94
5	4 Rectangular Tanks	3.43
6	Two Feed Storage Room (Area 600 Sq.ft Per Cost Unit 3,175)	3.81
7	Chowkidar Hut (Area 400 Sq.ft Per Cost Unit 3,175)	1.27

9	Residence no 01 & 02 (Area 3,340 Sq.ft Per Unit Cost 3,175)	10.60
10	Compound wall around Residence	1.80
11	Construction of Boundary Wall (6600 Rft)	33.00
12	Over Head Reservoir	23.00
13	Installation of Turbine	6.42
14	Installation of Submersible Pump	5.76
15	Thermo Control Fish Wet Lab	6.27
16	Provision of RCC channel	9.71
17	Construction of Gate	0.47
18	Harvesting basins one in each pond	1.89
	Sub- Total Amount	**123.93**
	Add Contingencies Cost (2.5%)	**3.10**
	Add PST (5%)	**6.20**
	Grand Total Amount With Contingencies and PST	**252**

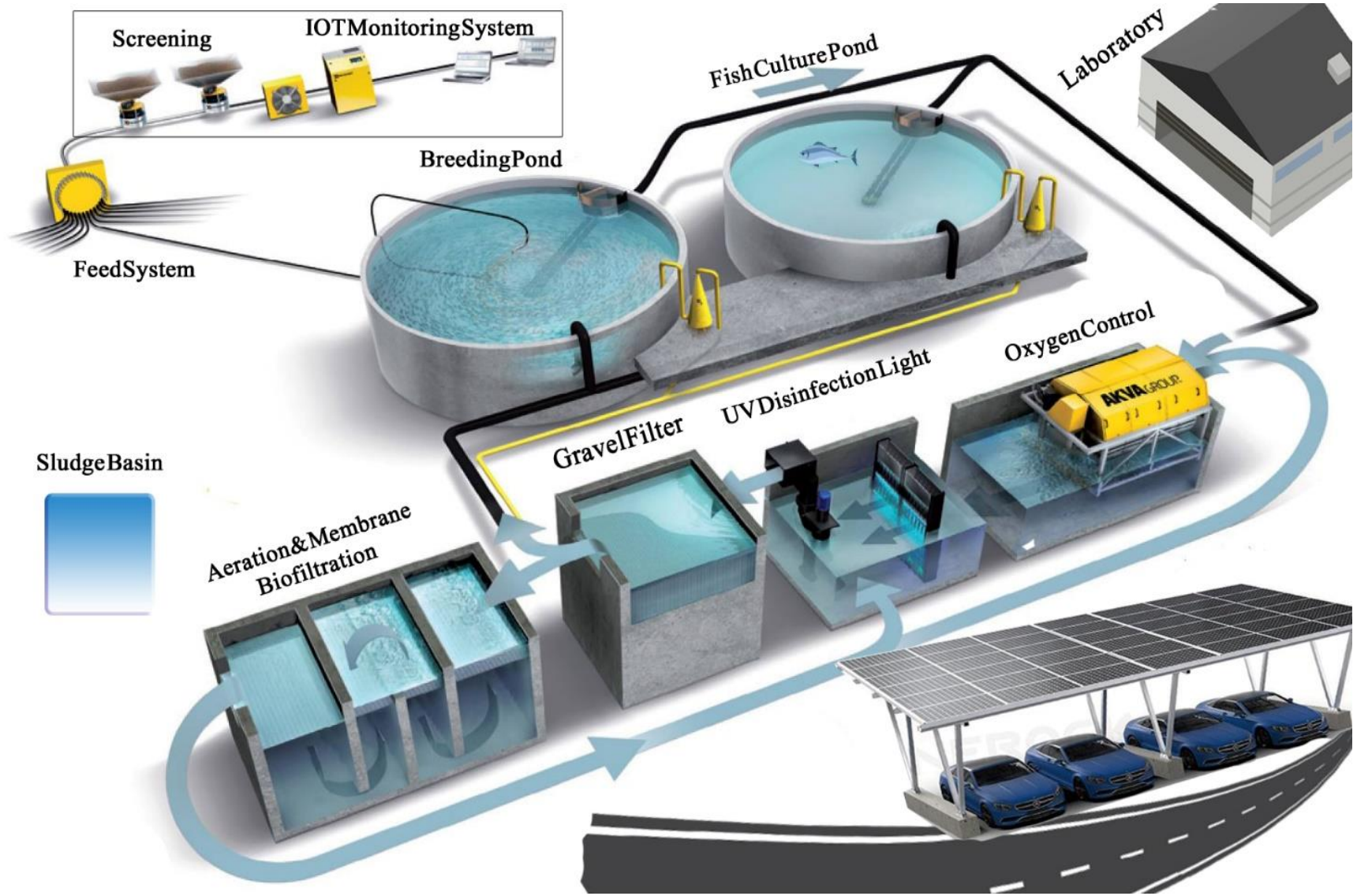


Figure 54: Design Layout of Proposed Sustainable Biofloc Fish Aquaculture System

6.3.13. PROJECT 11: Dal Waryam Forest Park Development

Forest parks play a crucial role in society, the environment, and the economy due to their numerous benefits and contributions. By conserving natural ecosystems, forest parks help maintain healthy populations of native species and protect endangered flora and fauna. Forest parks provide areas for outdoor pursuits such hiking, camping, birding, and photography, as well as chances for tourism. Urban forest parks act as the green lung of the city, giving people access to important green spaces and leisure activities. They contribute to better air quality, a reduction in the urban heat island effect, and an improvement in the general standard of living in crowded places.

With the development of Forest Park Pakpattan, the local people will have access to vital outdoor leisure areas, and the rich biodiversity of the Dal Waryam Reserve Forest will be preserved and highlighted. This 40-acre initiative aims to raise environmental awareness, improve public interaction with nature, and offer educational opportunities to those exploring related fields.

Proposed Project Site:

- **Location:** Dal Waryam Reserve Forest, Pakpattan, Pakistan
- **Forest Park Pakpattan** : 30°27'55N 73°07'50"E
- **Total Area:** 1576.19 Acres
- **Planted Area:** 1300 Acres
- **Vacant Area:** 275 Acres
- **Plantation:** Mixed plantation including Shisham, Mulberry, Kikar, Sufaida, Bakain, Ber, Pipli, Sambal, Arjun tree, Red Pencil Tree, Siris tree (Safed siris), Bottle Brush, Neem, Dodder, Chulai, Khabbal, Chenopodium album, Calotropis procera, Akk plant, Bombax ceiba (Simbhal)
- **Animals:** Grey francolin, Black francolin, Hariyal bird, Jackal, Indian Dove, Dark-bellied marsh snake, Cobra Snake, Wild Hare

Existing Condition:

- **Illegal hunting of wildlife:** Important wildlife species like the Huriyal (Yellow-footed green pigeon), Grey Partridges, and Asian emerald dove are among the many species that illegal hunting threatens to eradicate from the forest park region. The biodiversity of the region is seriously threatened by this activity, which might result in a drop-in population and an upset of the natural equilibrium.
- **Forest Wood Cutting:** The local populations cut forest wood for various uses, such as making furniture. As a result, important tree species including Simbal, Kikar, and Shisham become less abundant, which deteriorates the forest ecology and causes habitat loss and soil erosion.

Figure 55: Existing Condition of Proposed Project site

Proposed Interventions:

- Provision of Recreational Facilities
- Support native wildlife populations.
- Establishment of vacant area to Botanical nursery
- Consider sustainable water management practices for maintaining the lake
- Improved human-biodiversity interaction

Conceptual Design:

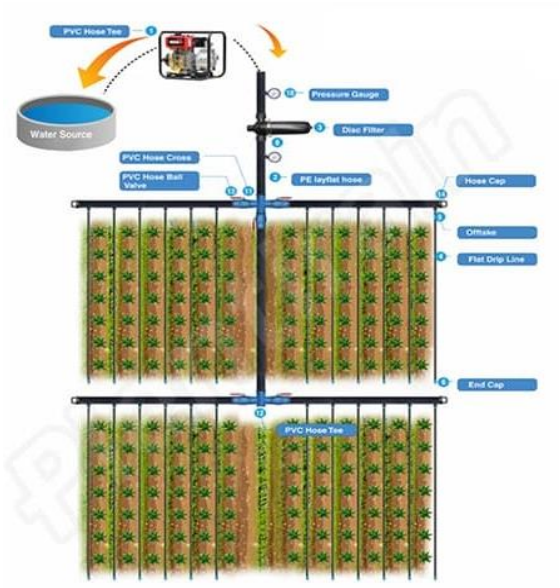
- The Forest Park's conceptual design features a harmonic combination of conservation, educational, and recreational components to create a lively and appealing natural refuge. Its centerpiece is a Bird Aviary, which allows guests to view native bird species in a safe setting and promotes awareness of the region's biodiversity.
- The Botanical Garden, which has a meticulously selected collection of plants, including those endangered by habitat deterioration, encircles this main feature. next to the garden, which offers untouched habitats for local wildlife to flourish in.
- A serene Water Lake acts as a contemplative focal point, drawing in animals and providing tourists with attractive views.
- Comfortable facilities including a cafeteria, rest house, and pavilions are arranged thoughtfully around the park to serve visitors.

Figure 56: Existing Condition of Proposed Project site

Estimated Cost:

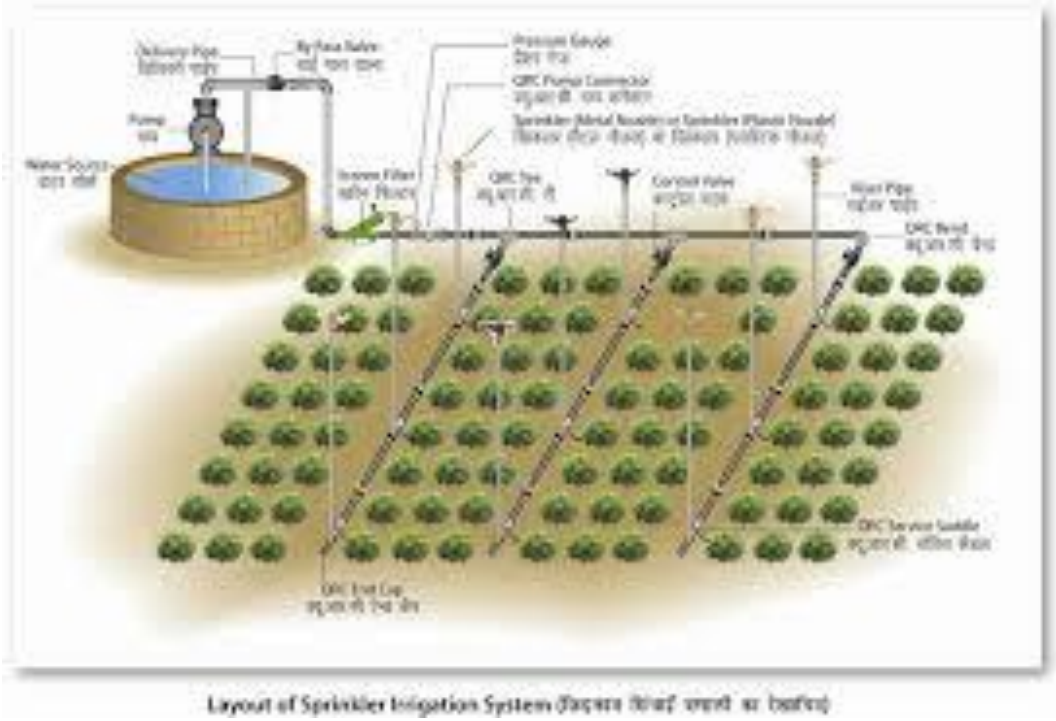
Sr. #	Physical Targets	Target Area	Actual Achievement
1	Development of lawns	6 Acre	5,836,875.00
2	Afforestation of Nursery	5 Acre	7,829,663.17
3	Construction of Rest House	21780 ft²	2,270,000.00
4	Construction of Natural Soil	240 Sqft	30,417,893.13
5	Construction of Lake	0.35 km	54,301,134.78
6	Construction of Admin office	5445 ft²	18,589,180.00
7	Construction of Staff Appartment	21780 ft²	28,589,180.00
8	Construction of car parking	2438 Sqft	24,723,861.14
9	Construction of Wildlife Animals	19 Acre	5,829,663.17
10	Construction of Brid Cages/ Aviary		557,500.00
11	Construction of Bee Fly House		15,440,000.00
11	Construction of Walking Trail	1799 Rft	20,846,889.43
13	Provision of electric Tube Well 1/2 cusec	01	7,900,000.00
14	Provision of Playing area	3 Acre	2,000,000.00
15	Construction of Toilet Block (Women and Men)		1,561,045.19
16	Construction of OHR 20,0000 Gln	1	10,640,000.00
17	Sprinklers	1 acer	9,980,000.00
18	Water Cooler	4-5	377,500.00
19	Wooden Gazebo	5-6	1,065,000.00

Sr.	Description	Amount in Pkr	Millions
	Sub- Total Amount	248,755,385.02	248.76
	Add Contingencies Cost (2.5%)	6,218,884.63	6.22
	Add PST (5%)	12,437,769.25	12.44
	Grand Total Amount with Contingencies and PST	267,412,038.89	267



Drip Irrigation System

Bee Keeping Setup



Layout of Sprinkler Irrigation System

Sprinkler System for **Nursery**

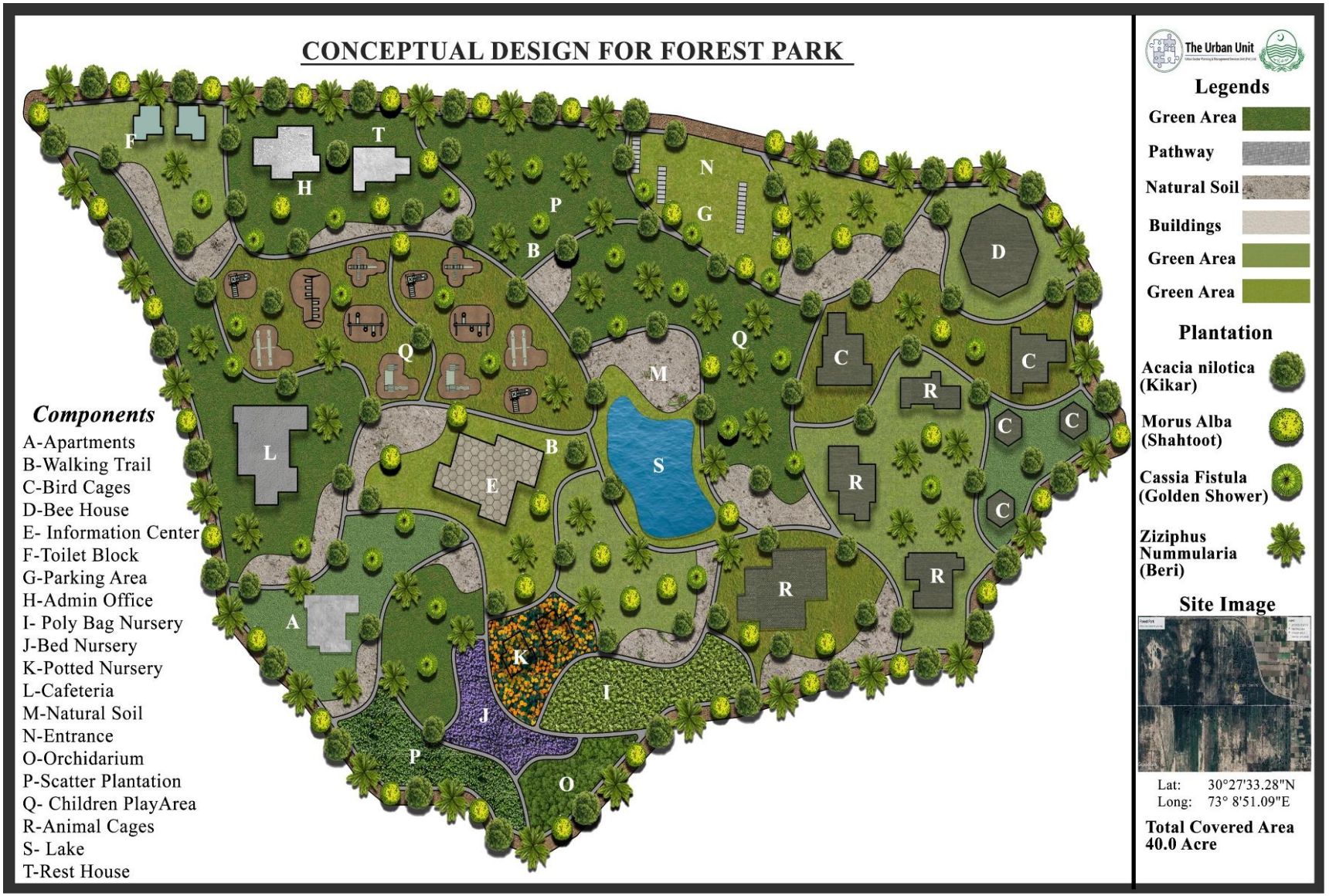


Figure 57: Conceptual design for Forest Park

6.3.14. PROJECT 12: Nature Based Solution - Canal Rejuvenation of Lower Bari Doab Canal Sahiwal

Rapid urbanization, the growth of infrastructure projects and anthropogenic activities have changed the surface and groundwater from what it used to be. Alterations to the natural circulation of the water bodies have a negative impact on the urban ecosystem, resulting imbalance in the blue green spaces within the Urban area ecosystems. The canals in the cities play a significant role in the ecological and socio-cultural sustainability.

Lower Bari Doab canal originates from the Balloki Headworks. LBD canal is receiving water usually form River Ravi and River Jhelum link canals. LBDC receives water from Chenab and Jehlum River via link canal. The LBDC canal irrigates the districts of Kasur, Okara, Sahiwal and Khanewal. The canal is facing disposal of sewage effluent, solid waste in the canal deteriorates the water quality in the Sahiwal City.

Existing condition of the proposed project site

The proposed project aims to rejuvenate the LBDC canal through SWAB (Scientific Wetlands with Active Biodigester) based bioremediation system, restoration of walking trail along the canal. SWAB treatment involves decontamination of water through a combination of layers formed from gravel and plants. The details of the project are discussed below:

Scope of the Project

- Bio-remediation Canal through SWAB Treatment

Proposed Site

- Lower Bari Doab Canal along Kanan Park Length
- Start 30.657923°, 73.107409°
- End: 30.655972°. 73.100533°
- Length: 705m

Conceptual Design

- Reed bed and planting bed prepared for water purification
- Introduction of eco-friendly aquatic plant species having the ability of phytoremediation to treat the water.
- SWAB treatment System

Components of SWAB treatment system

Gravel Bed dimensions

- Length: 25 m, Width: 10.11m, Depth: 2.0 to 2.6m;
- No. of chambers: 5;
- Filler stone aggregate of nominal size of 200 to 300mm over a depth of 77cm, 100mm over a depth of 38cm, 80mm over a depth of 115cm;
- Five manholes for sewage collection;
- 200mm sewage collection pipe;

Proposed Planation

The selective proposed plant species for water resource filtration are as follows: -

- *Pistia stratiotes* (Water Lettuce)
- *Nelumbo nucifera* (Indian Lotus)
- *Lemna minor* (Duckweed)
- *Typha domingensis* (Cat tail)
- *Phragmites australis* (Common Reed)
- *Potamogeton perfolliatus* (Redhead Grass)

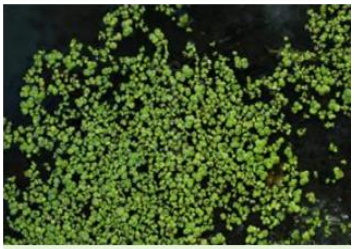
Phragmites karka
(Common Reed)

Typha latifolia
(Cattail)

Potamogeton perfoliatus
(Redhead Grass)

Pistia stratiotes
(Water Lettuce)

Nelumbo nucifera
(Indian Lotus)



Lemna minor
(Duckweed)

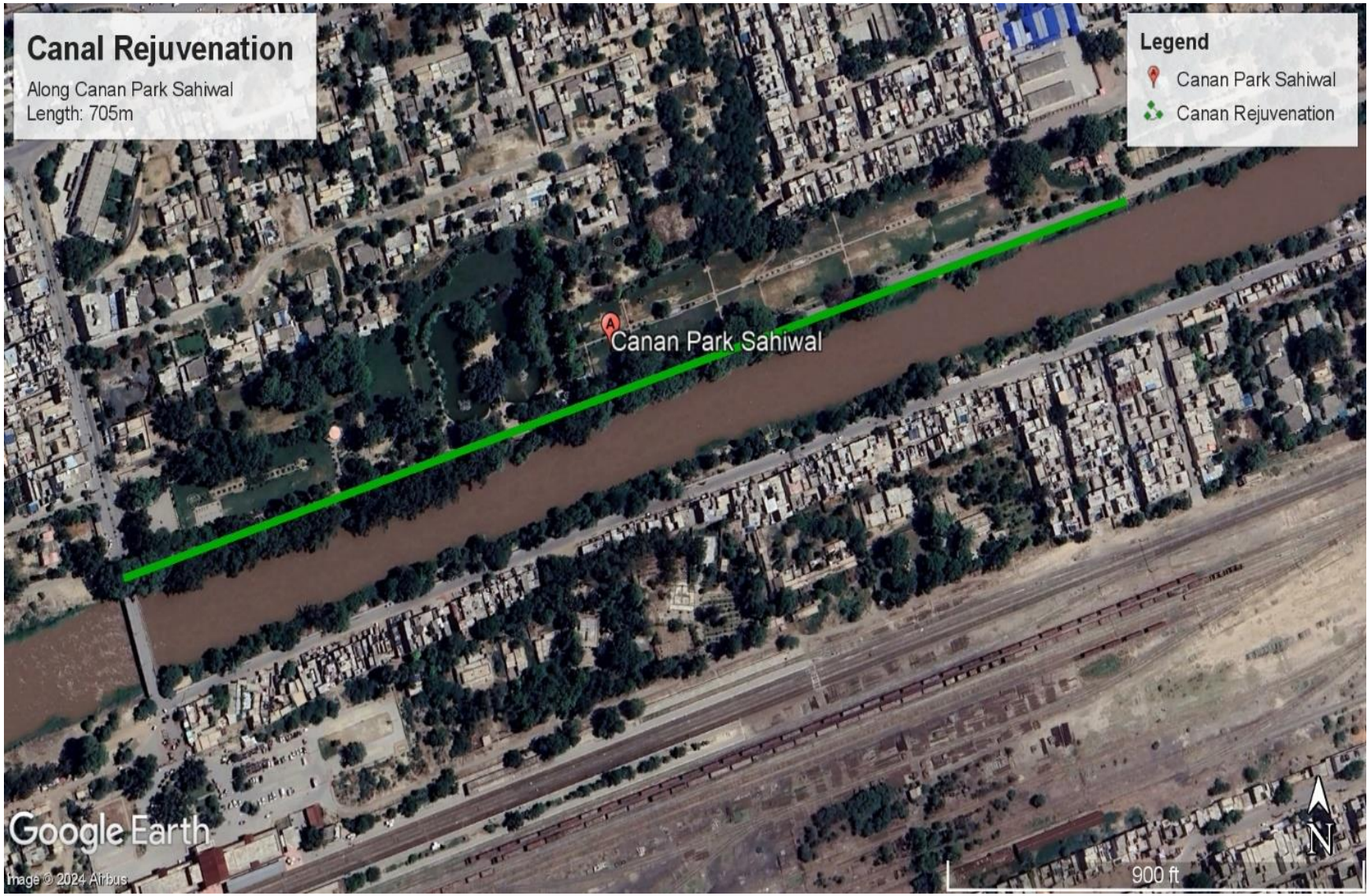
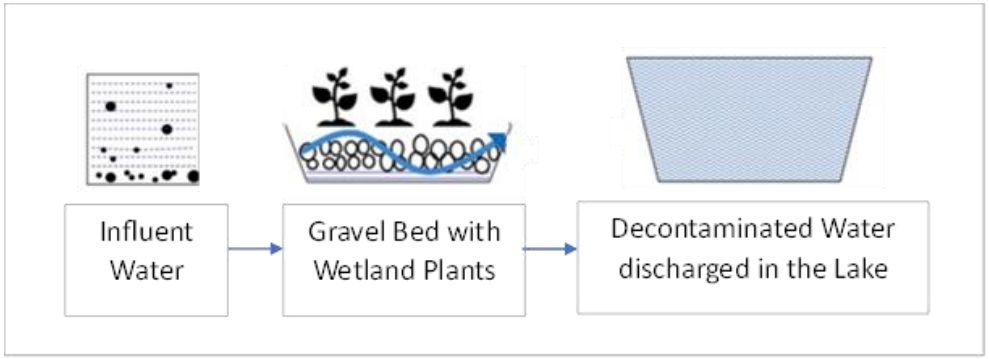


Figure 58: Schematic Diagram of SWAB Treatment

Schematic Diagram of SWAB Treatment

Floating Bed Wetland



6.3.15. PROJECT 13: Installation of Phytoplankton based Floating treatment Wetland (FTW) on wastewater Pond in Arifwala & Deepalpur

Phytoplankton-based floating wetlands are an innovative solution for wastewater ponds, offering a natural and sustainable approach to wastewater treatment. The magnitude of wastewater has been increased due to rapid increase in population and industrialization in Sahiwal division. Wastewater is being discharged directly into fresh water bodies or agricultural lands without proper treatment due to insufficient treatment facilities which give rise to health problems. Wastewater treatment by chemical and thermal techniques is costly because these techniques rely on the use of chemicals and electricity. This project is proposed to replace the chemical and thermal techniques with a floating treatment wetland system which is an environmental protective technique for wastewater treatment.

Construction of Floating Wetlands for Sewage Treatment

Constructed floating wetland is an engineered system which makes use of the aquatic plants and natural processes to remove the contaminants from wastewater. Sewage treatment in floating wetland occurs by physical, chemical and biological process. In physical process, plants hinder the path of water and decrease its velocity which creates a better situation for sedimentation of heavy particles and suspended solids. In chemical process, plants treat the wastewater by killing the pathogens through antibiotic substances which generates from the root of the plants. Biological treatment of wastewater in wetland occurs with six biological processes which are photosynthesis, respiration, fermentation, nitrification, denitrification, and phosphorus removal. Wetland system works on the principle of phytoremediation in which aquatic plants uptake contaminants from wastewater through their roots. Removal rate of contaminants from wastewater depends on numerous biochemical processes in plants. Free floating and submerged plants have capability to remove contaminants from wastewater

Advantages of Floating Wetlands

Floating wetlands are created, covered with plants and phytoplankton, which float on the surface of the wastewater pond. By harnessing the power of phytoplankton, floating wetlands offer a natural, efficient, and sustainable solution for wastewater treatment, improving water quality and supporting ecosystem health

- Phytoplankton, such as algae or cyanobacteria, grow rapidly on the floating wetlands, absorbing nutrients like nitrogen and phosphorus, reduces the risk of harmful algal blooms.
- It improves water quality and reduces contaminants from the wastewater.
- It helps break down organic matter, reducing biochemical oxygen demand (BOD) and chemical oxygen demand (COD).
- It can remove pathogens, such as bacteria and viruses, from the wastewater.
- It produces oxygen through photosynthesis, increasing dissolved oxygen levels in the wastewater, which supports aquatic life.
- It provides a habitat for beneficial microorganisms, insects, and small aquatic animals, enhancing biodiversity.

- Phytoplankton-based floating wetlands require minimal maintenance, as they are self-sustaining ecosystems.
- It can be a cost-effective solution compared to traditional mechanical treatment systems.

Existing Condition of Wastewater Ponds

Currently there is no sewage treatment plant in Sahiwal division, so all the wastewater are largely dumped into agriculture lands, water bodies or gathered in wastewater ponds, during the field visit the team found two vast sewage ponds in the outskirt of city which having high level of pathogens, bacteria, excessive nutrients load leading to algae blooms, uncontrolled mosquitoes breeding, unpleasant odors posing significant health risk and contamination of groundwater. It is essential to mitigate these issues by proposing Phytoplankton based Floating wetlands.

Figure 59: Wastewater Pond in Arifwala, district Pakpattan Wastewater Pond in Deepalpur, district Sahiwal

Projects Need (Sustainable Treatment)

1. Location of Arifwala Sewage Pond

In Arifwala Domestic wastewater from the adjoining semi-urban settlements of were carried out through open drains into the open pond having area 19.3 Acre and depth 25 ft. which became a breeding ground for communicable diseases. Almost 0.4 Cs of domestic sewage discharge from adjoining catchment area of 0.4 km2 into the open pond / agriculture fields causing contamination of water, food chain and several health issues. This problem is moderate due to either the absence of proper treatment and safeguarding water bodies strictly. Pond is 25 ft deep and no safety wall/ barrier placed, caused death of a child by falling into it Design Consideration of Proposed Project.

Figure 60: Geographical Location of Wastewater Pond in Arifwala

2. Deepalpur Sewage Pond Location

In this site an existing Disposal station went out of order so a wastewater pond has been formed at the site of almost 1.3 Acre. Almost 0.15 Cs of domestic sewage discharge from adjoining catchment area of 0.1 km2 into the open pond / agriculture fields leading pollution and health issues.

Figure 61: Geographical Location of Wastewater Pond in Deepalpur

Design Consideration of Proposed Projects

Installing floating treatment wetlands (FTWs) on a wastewater pond involves the following steps:

1. Assessment and Ponds Evaluation:

- Assess the pond's water quality, size, and depth.
- Determine the type and number of pollutants to be removed.
- Design the FTW system, including the size, shape, and layout of the floating islands.

2. Material Selection:

- Choose durable, buoyant materials (e.g., HDPE, PVC) for the floating structure.
- suitable plants and phytoplankton selection according to the local climate and water conditions.

3. Monitoring and Maintenance:

- Regularly monitor water quality, plant growth, and system performance.
- Perform maintenance tasks, such as plant pruning, debris removal, and anchoring adjustments.
- Monitor and adjust the system as needed to optimize performance.

By following these steps, FTWs can effectively treat wastewater, improve water quality, and create a sustainable ecosystem.

Design Criteria for Floating Treatment Wetland (FTW)

The basic design parameters include the area of wetland, loading rate, retention time, plant type, and temperature. Each parameter has its own significance in this system. Wetland temperature is an important design parameter because BOD and various other contaminant removal depend on temperature. Plants are major hyper accumulator for pollutant removal and their growth rate also depends on the temperature. As the plants avail suitable temperature they grow more quickly and absorb more contaminants from wastewater.

Treatment Technology	Design Parameters	Typical Values
Floating Wetland	Thickness	200 mm
	Matrix/media layers	04
	Typical size of module	150 mm
	Area of layers	4 x 2.3 m
	Typical reserve buoyancy	40kg – 50kg per m^2.

Wetland Plants	COD Removal Efficiency %	BOD Removal Efficiency %	TSS Removal Efficiency %
Water Hyacinth	95	96	84
Water lettuce	27	41	85
Typha latifolia	48	31	72

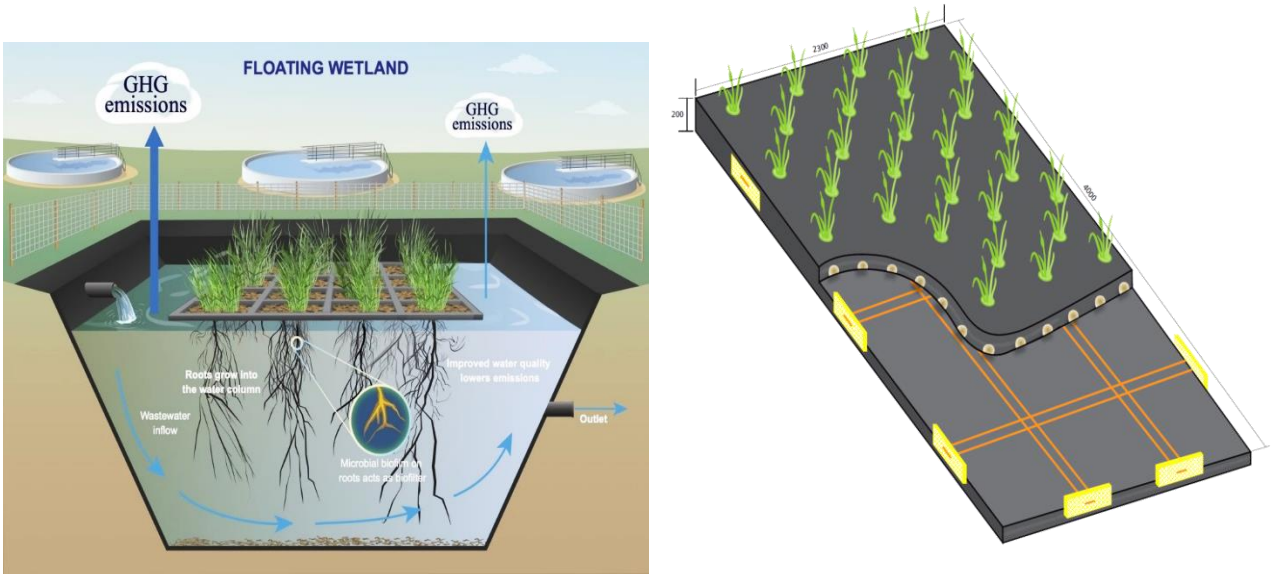


Figure 62: Conceptual Design of floating Treatment Wetland and Floating Beds

Rough Cost Estimation of Proposed Projects

Sr. No	Description	Amount in Millions
1	Construction of Floating Treatment Wetland for wastewater pond in Deepalpur	29.40
2	Construction of Floating Treatment Wetland for wastewater pond in Arifwala	22.1
	Sub- Total Amount	51.5
	Add 2% Contingency Charges	1.03
	Add 5% PST	2.57
	Total Amount R.s	**55.1**

6.3.16. PROJECT 14: Installation of Air Quality Monitoring Equipment

Currently, Sahiwal, like many mega cities globally, is grappling with deteriorating air quality, posing significant risks to ecosystems, human health, and the economy. Factors such as unplanned urbanization, industrial growth, and traffic congestion contribute substantially to air pollution in both developed and developing countries. Effective air quality monitoring is crucial for informed decision-making and addressing these pressing issues.

Recognizing this challenge, the Pakistani government has initiated efforts to tackle air pollution. The proposed project aims to establish an air quality monitoring system in major pollution hotspots within the Sahiwal Division. This system will provide valuable data on pollutant concentrations, enabling authorities to make informed decisions and implement targeted interventions to improve air quality in Sahiwal Division.

Scope of the Project:

This project aims to record particulate matter concentrations ($PM_{2.5}$ and PM_{10}) in Sahiwal, Okara and Pakpattan, district of the Sahiwal Region.

Activities:

Installation of air quality monitoring equipment (US-EPA Approved BAM 1025) and low-cost sensors in hotspot areas of Sahiwal Region.

Low Cost air quality equipment

Display of Air quality indices on screen

Proposed Areas:

- Sahiwal
- Okara
- Pakpattan

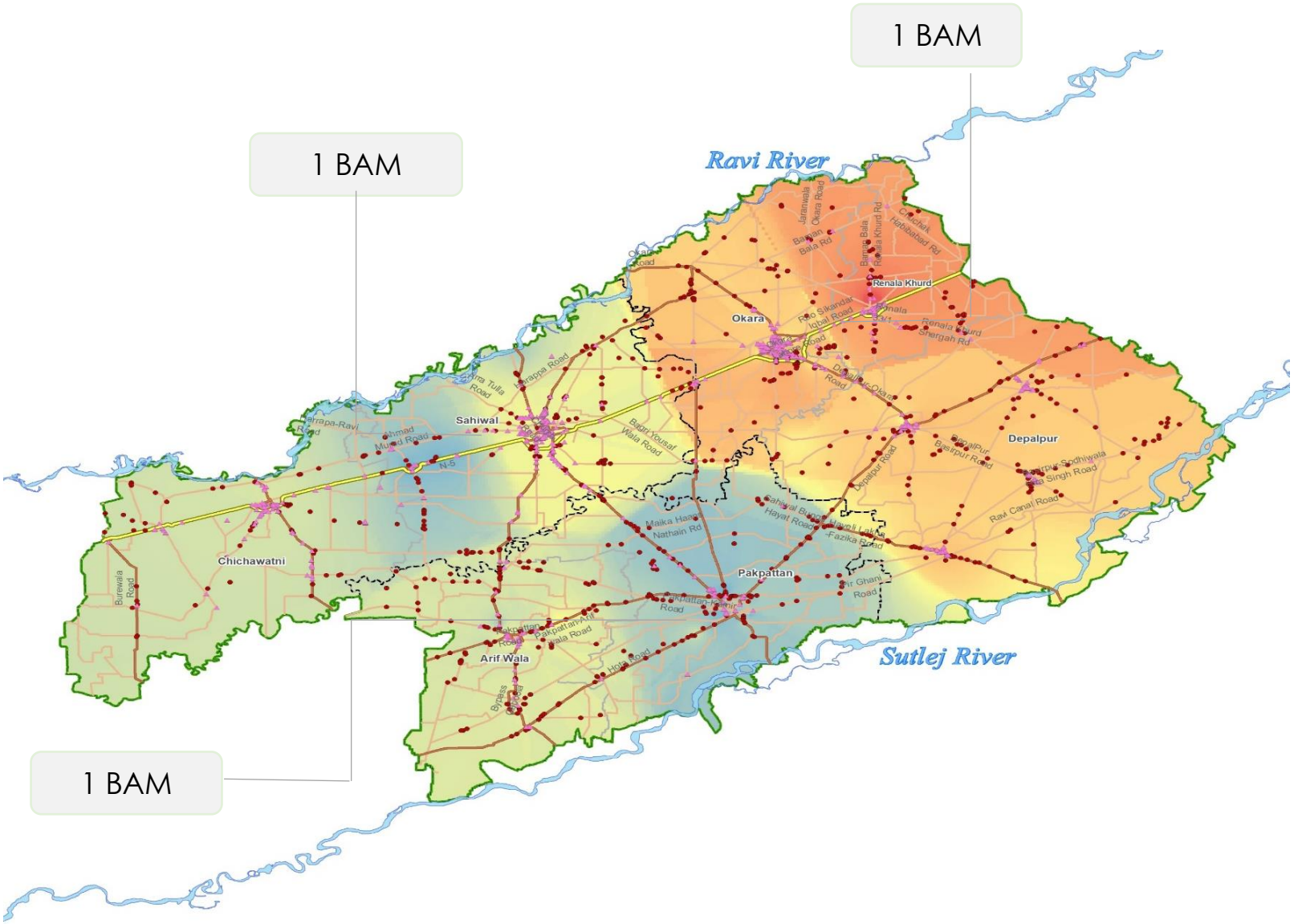


Figure 63: Installation of Air Quality Monitoring Equipment's

Annexures

Annexure – A: Public Perception of Existing Environmental Issues, Green Spaces and Water Supply & Sanitation

DEMOGRAPHIC PROFILE

1.Gender: Male ☐ Female ☐ others_____

2. City/Tehsil Name

Area Name

Location Latitudes _____ Longitudes _____

3.Occupation:

Student ☐ Self Employed ☐

Gov. employee ☐ Private job holder ☐

Retired ☐ Unemployed ☐ Others _____

4. What age bracket do you belong to?

Less than 18yrs ☐ 18yrs - 25yrs ☐

25yrs - 40yrs ☐ 40yrs -60 yrs ☐ > 60yrs ☐

5. What is the latest level of education you have had?

Illiterate ☐ Primary ☐ Secondary Level ☐ High School Level ☐
University Level ☐ Religious Education ☐ Other ☐

6. In which Income Level would you categorize yourself?

☐ Low-Income Group	0-40,000/-
☐ Middle Income Group	40,000-80,000/-
☐ High-Income Group	80,000-120,000
☐ Business Class	>1.5 lac

A. **ISSUES IN THE AREA**

What kind of Issues you are facing in your area?

- Poor Water Quality
- Limited Water Supply
- Sewerage Ponding
- Lack of Green spaces

- Air Pollution
- Broken / Unpaved Roads
- Solid Waste Management
- Any Other

GREEN SPACES AND PARKS

1. Any Park in the Area? Within 1-2km vicinity

☐ Yes ☐ No

Name of Park (If Yes) _____

☐ Public Park

☐ Private Park

☐ Community Park

2. Visit the Parks and Green space?

☐ Everyday
☐ Once a week
☐ Fortnightly
☐ Once a month
☐ Never

3. Distance to nearest Park

☐ ≥ 5 minutes of walk
☐ ≥ 15 minutes of walk
☐ ≥ 30 minutes of walk
☐ More than 30 minutes of walk

4. Please rate the existing condition of Park/ green spaces in your area.

☐ Excellent
☐ Good
☐ Satisfactory
☐ Unsatisfactory

WILLINGNESS TO PAY FOR GREEN SPACES

1. How important is your participation to increase/improve the green space?

☐ Not Important
☐ Important
☐ Highly important

2. How the green spaces/ parks can be increased and improved in your Area?

☐ Development of parks
☐ Greening of rooftops/ buildings
☐ Owned by Public Sector

- ☐ Handover to the Private sector
- ☐ Planting trees at the sides of roads
- ☐ Greening of vacant areas
- ☐ Providing basic infrastructure facilities
- ☐ All of the above

4. How much you are willing to pay per visit for the greenspaces/ parks of the city if implemented by the Government?

- ☐ Rs <50/-
- ☐ Rs 50/- to 100/-
- ☐ Rs 100/- to 150/-
- ☐ Any other

WATER SUPPLY:

How often do you get drinking water?

- ☐ More than once a day
- ☐ Once a day
- ☐ Less than once a day

What is your Drinking Water Source?

- ☐ Piped Water
- ☐ Handpumps
- ☐ Public Tap Water
- ☐ Bottled Water
- ☐ Filtration Plant
- ☐ Other Source_____

"Is the timing of the water supply convenient?"

- ☐ Yes
- ☐ No
- ☐ Not Available

In the past year, have there been instances when the quality of water has been poor?

- ☐ Yes
- ☐ No

IF YES then Ask

If the water is of poor quality, what do you do in these Instances?

- ☐ Go to a well
- ☐ Ask a neighbor
- ☐ Buy Bottle from a shop
- ☐ Other (Please specify_____)

Can you describe the present Taste of Tap Water?

- ☐ Brackish/Bitter (undrinkable)
- ☐ Sweet (drinkable)
- ☐ Saline (undrinkable)
- ☐ Don't know / Haven't noticed

Is Tap water smell acceptable?

- ☐ Yes
- ☐ No
- ☐ Somewhat

Is there any history of your family member getting sick from using tap water?

- ☐ Yes
- ☐ No
- ☐ Somewhat

What is your satisfaction level with existing Water Supply services?

- ☐ Highly Satisfied
- ☐ Satisfied
- ☐ Not Satisfied

SANITATION:

What is a system of sewerage in your area at the user's end i.e. outside the house (tertiary level)?

- ☐ Unlined or Katcha Drains
- ☐ Lined or Pacca Drains
- ☐ Sewers
- ☐ Sump pit
- ☐ Disposal in adjacent areas
- ☐ Others: _____

Have you observed any sewage ponding in the area?

- ☐ Yes
- ☐ No
- ☐ Sometimes

Have you observed any water ponding after a rainfall?

- ☐ Yes
- ☐ No
- ☐ Sometimes

If yes then for How many days it stays on the roads/ areas?

- ☐ <1 day
- ☐ >2 days

- ☐ >3-4 days
- ☐ >one week

Ultimate Disposal of Sewage?

- ☐ Nallah
- ☐ Piped Sewers
- ☐ Open Drains
- ☐ Canal
- ☐ Others

What is your satisfaction level with existing Sewerage services?

- ☐ Highly Satisfied
- ☐ Satisfied
- ☐ Not Satisfied

WILLINGNESS TO PAY FOR WATER SUPPLY & SANITATION:

How important is your participation to improve the Sanitation and Sewerage Services?

- ☐ Not Important
- ☐ Important
- ☐ Highly important

How much Water Supply & Sewerage bill have you received per month?

- ☐ < 100
- ☐ 200-500
- ☐ 500-1000
- ☐ More than 1000
- ☐ No bill

How much you are willing to pay for the improved services of Water Supply & Sewerage services in your area?

- ☐ 100
- ☐ 200-500
- ☐ 500-1000
- ☐ More than 1000

In your opinion, which needs the most attention in your Area to improve the environment? (Select Three)

- ☐ Air Quality Improvement
- ☐ Traffic Management/ Control
- ☐ Development of Recreational Areas/ Stadiums/ Playing Areas
- ☐ Water Supply and Sanitation Services
- ☐ Greening of Area/ Plantation
- ☐ Solid Waste Management

- ☐ Upgradation of Existing Parks
- ☐ Provision/ Upgradation of Sewerage Infrastructure

Any Other please specify_____

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