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

Drought Management Plan Cholistan

2022 - 2025

Drought Management Plan

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CBOs	Community Based Organizations
CDA	Cholistan Development Authority
DCB	Ditch-cum-Bank
DDMA	District Disaster Management Authority
EPA	Environment Protection Agency
GST	Ground Storage Tank
IOD	Anomalies in the Indian Ocean
IPCC	Intergovernmental Panel on Climate Change
IPS	Intermediate Pumping Station
LLR	Low Level Reservoir
LST	Land Surface Temperature
MODIS	Moderate Resolution Imaging Spectroradiometer
NDMA	National Disaster Management Authority
NDMC	National Drought Monitoring Centre
NDVI	Normalized Different Vegetation Index
NGOs	Non-governmental Organizations
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PMD	Pakistan Meteorological Department
RO Filtration Plant	Reverse Osmosis Filtration Plants
SPI	Standardized Precipitation Index
TCI	Temperature Condition Index
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
VCI	Vegetation Condition Index
VHI	Vegetation Health Index
VIs	Vegetation Indices
WHO	World Health Organizations

ABBREVIATIONS

INTRODUCTION

1.1. Global, Regional and Local Context

"Drought is a 'prolonged absence or marked deficiency of precipitation, which results in water scarcity or a 'period of abnormally dry weather conditions sufficiently prolonged for the lack of rainfall to cause a serious hydrological imbalance," as per the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC).

Every year more than one-half of the terrestrial part of the earth is facing drought conditions. Drought is a recurring condition and for the majority of the world climatic zones, it is typical. Risks from the droughts and the precipitation deficits are likely projected to be high at 2°C as compared to a 1.5°C rise in global warming in some areas [1](IPCC, 2018). Therefore, climate change has serious consequences for water scarcity and food security.

Globally, Asia is extremely vulnerable to droughts because of its arid and semi-arid climatic conditions and high population. South Asia faced several severe and long-lasting drought conditions, which posed critical impacts on the growing economies of this region. From 1981 to 2020, intermittent droughts struck large areas of Southeast Asia and more than 70% of the land area was affected by the moderate drought. Anomalies in the Indian Ocean (IOD) Sea surface temperature is another major reason for drought in this region. In addition, precipitation values on the decadal basis also show fluctuations associated with changes in Pacific Sea surface temperature.

Drought in Pakistan has become a frequent phenomenon due to extreme heat events and low precipitation rates. The sources of winter rainfalls in the Pakistan are western disturbances provide rainfall over western side of the Pakistan and south eastern side of the Pakistan completely goes dry in the winter season. This situation found quite often and it became worst in months of April and May and it goes completely dry and temperature remains very high in these months. From October 2020 to May 2021, the lower precipitation rate has created drought like conditions in southern part of the Pakistan. The limited downpour in the following month couldn't normalized the drought conditions completely. The year 2022 started with limited spell of downpour i.e., -21.6%. The situation again become critical when extreme heatwaves hit the southern Pakistan from mid- march 2022 onwards, and drought-like situation emerged in high-temperature regions of the country.

Cholistan desert, a home to 1.2 million people, is mainly vulnerable to **Meteorological Droughts** because of its arid or hyper arid climate, high temperature, low precipitation rate, less relative humidity, high

[1]IPCC. 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor & T. Waterfield (eds.).

evapotranspiration rate and dry gale winds prevails in Cholistan. These droughts are characterized by a reduction in rainfall over a region for a specified period (day/month/season/year) below a specified amount, usually defined as some proportion (percentage) of the long-term average for the specified time period. Summer rainfalls are caused by the monsoons which creates over Arabian Sea and Bay of Bengal does not reach in Cholistan as they hit from the northern side of Pakistan. In Cholistan, annual loss of moisture through evapotranspiration reaches 200mm and ratio of precipitation to evapotranspiration vary from 1% to 10%. The mean annual rainfall fails to meet 75% to 90% of mean annual evaporation. During this summer, the Cholistan desert is experiencing the worst drought conditions and water scarcity. An intense heatwave episode in March and April devastated the water resources, vegetation, and livestock in the Cholistan region.

Multi-hazard risk assessment of Bahawalpur district identifies Droughts as a major disaster in Cholistan, in comparison to floods and seismic hazards.[2]

Table 1: Elements exposed to drought hazard[3]

Population	Settlements	Land-use and Land-cover Type (Area in Ha)					Drought Prone	Frequently Drought Prone
		Crop Irrigated	Crop in Flood Plain	Crop Rain fed	Crop Marginal	Orchards		
52,190	436	77,425	0	36	35	65	Extreme	Extreme

The building structure in Cholistan is mainly comprise of kacha houses, followed by Pacca and Semi Pacca house, as exhibited in Table 2.

Table 2: Building types in Cholistan

Building Types			**Total Buildings**	**Area (sq. km)**	**Density (Buildings/sq.km)**
Pacca	Semi Pacca	Kacha			
2,264	723	4,469	621	1,726	1

Overall, the integrated risk assessment of Cholistan by hazard types and coping capacity indicate 'Moderate to High Level of Risk', mainly due to meteorological droughts. The details are given in Table 3.

Table 3: Integrated Risk Assessment of Disasters in Cholistan

Hazard			**Exposure**		**Vulnerability**			**Coping Capacity**	**Risk**			**Overall**
Flood YRP 100	**Drought**	**Earthquake YRP 475**	**Flood**	**Drought**	**Flood**	**Drought**	**Earthquake**		**Flood**	**Drought**	**Earthquake**	
0.00	4.00	3.00	2.63	2.00	1.67	1.67	1.00	3	1	5	3	3
Formula: Risk = Hazard x Vulnerability x Exposure / Capacity												
Risk Score: >4.1 Extremely High, 3.1-4.0 High to Very High, 2.1 – 3.0 Moderate to High, 1.1-2.0 Low to Moderate, <1.0 No to very Low												

[2] *Multi Hazard Vulnerability & Risk Assessment (MHVRA Report), 2018, Project Management Unit, National Disaster Management Authority, Islamabad, Pakistan*
[3] *Ibid*

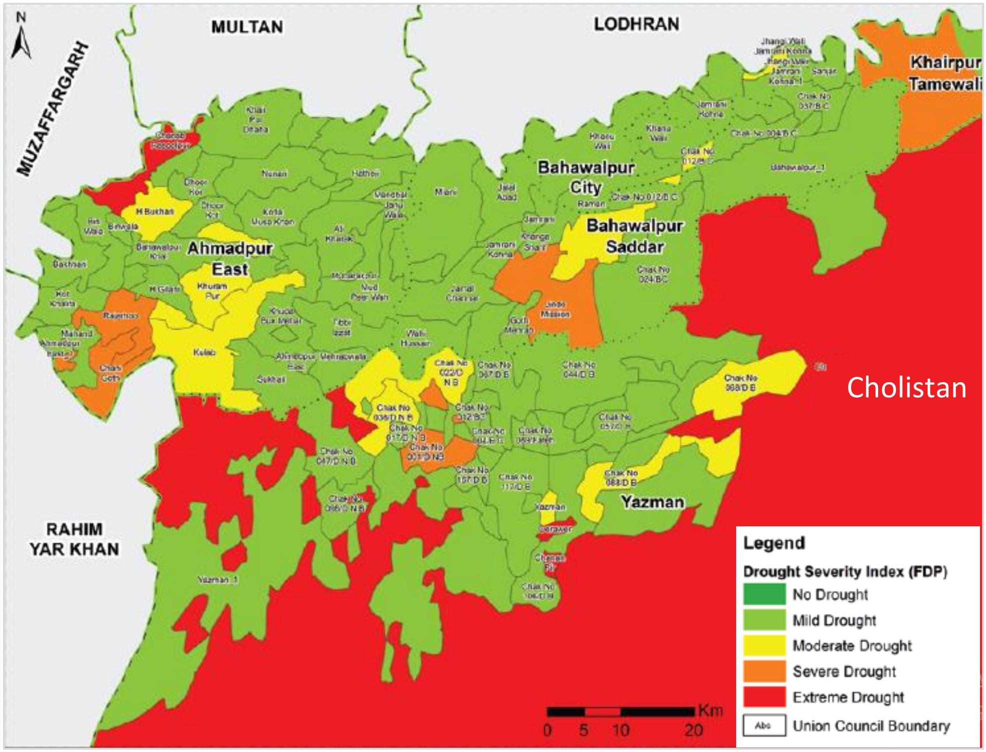


Fig. 1: Drought Severeity Index of Cholistan and other areas of Bahawalpur district

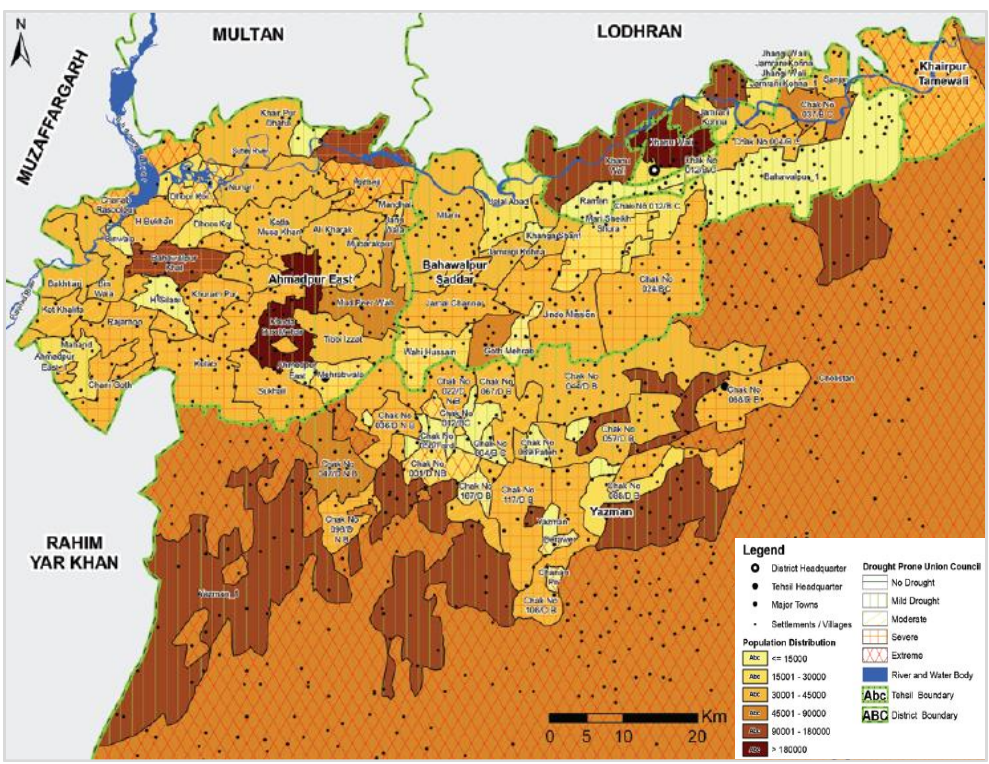


Fig. 2: Settlements, villages, major towns and population exposed to drought

Although, Thal and Cholistan are two deserts in Punjab which are rain fed and get badly affected by droughts, however, the situation of famine and droughts in Thal is way better than Cholistan after the construction of canal network which is being used for drinking as well as irrigation purposes. In addition to that most of the farmers have installed tube wells to irrigate their land for general cropping and fodder cultivation. Contrary, Cholistan is struck by famine every third year[4] which has forced people to migrate to nearby towns and cities. It is not only squeezing in size but also its grazing lands are decreasing every day.

Non-functional assets, outdated conveyance network (water leakages through pipes and joints), inadequate human resource for operation and maintenance, lesser allocation of financial resource for provision of water and emergency services, non-availability of drinking water for both human and livestock, non-availability of improved and good quality seeds, limited awareness level, lack of coordination among the community and government institutions are some of the major gaps identified through inception visit and consultations with the representatives from Cholistan Development Authority.

In addition to this, the existing system of monitoring of droughts and its impacts on various sectors is weak. As per NDMA Act 2010, District Disaster Management Authority (DDMA) are responsible for district planning, coordinating and implementing body for managing disasters in accordance with the guidelines laid down by the NDMA and PDMA. DDMA has developed a 'District Disaster Management Plan 2018' to manage emergencies by putting in place requisite mitigation measures and a well-coordinated and integrated response at district level. However, this plan does not address the major natural disaster of Cholistan i.e., Droughts and mainly focused on floods, epidemics and environmental hazard.

During 2011 to 2020, inter-annual VCI was mapped by calculating monthly minimum and maximum NDVI values for each pixel. VCI was analyzed to understand the drought categories of different levels, as shown in Table. More attention was given to the areas where vegetation was worsening and then drought events were mapped. This was associated with the event of recurrent droughts in the deserted region.

Table 4: Percentage of Drought Categories in Cholistan Desert

Year	Severe Drought (<35) (%)	Moderate Drought (35-50) (%)	Normal (>50) (%)
2011	8.65	39.80	51.56
2012	14.44	45.35	40.21
2013	13.59	40.39	46.03
2014	12.53	35.67	51.80
2015	5.09	34.18	60.73
2016	17.99	44.92	37.10
2017	21.82	33.75	44.43
2018	12.21	36.00	51.79
2019	10.15	33.74	56.11
2020	13.11	30.16	56.73
2021	9.71	39.20	51.09

[4] *https://nation.com.pk/13-Jul-2018/cholistan-future-food-basket*

As displayed in the VCI maps of Fig. 3, the highest severe drought was noticed in 2017 (21.82%) followed by 2016, 2012, 2013, 2020 and 2021 respectively. Fig. 3 shows the Spatio-temporal pattern of pixel based mean VCI on the arid region of Cholistan, which could reveal the agriculturally based drought pattern in the region. This drought pattern could be highly linked with the less precipitation and high temperature and evaporation in the region.

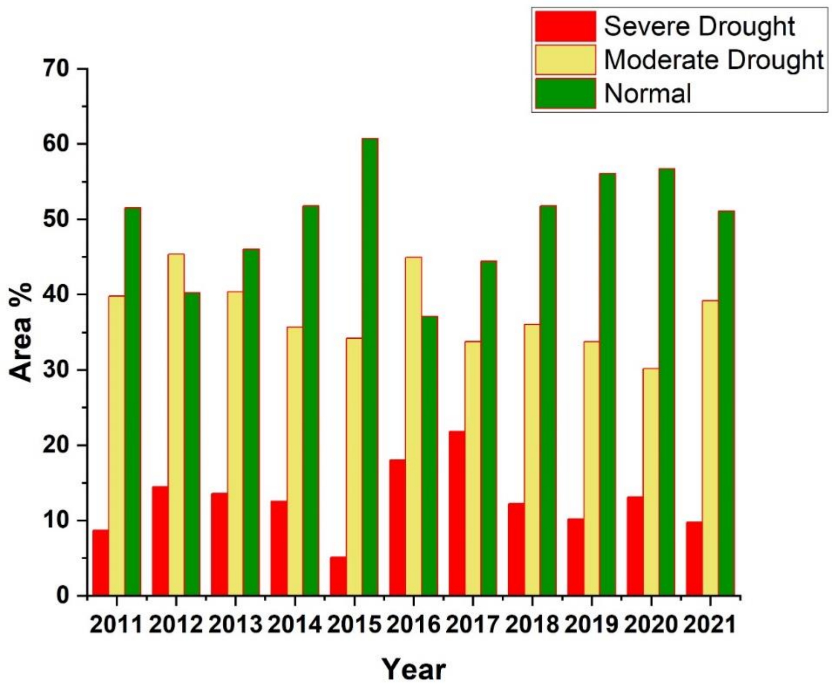


Fig. 3: Percentage area of VCI drought

By using satellite remote sensing data, the spatial distribution of maximum temperature of Cholistan region was mapped. The results revealed that temperature in Rahim yar Khan and Bahawalpur districts showed a declining trend comparatively to the Cholistan deserted area, which experienced severe hot temperatures in the year of 2013, 2015, 2016, 2018, 2020 and 2021 respectively. (Fig. 5)

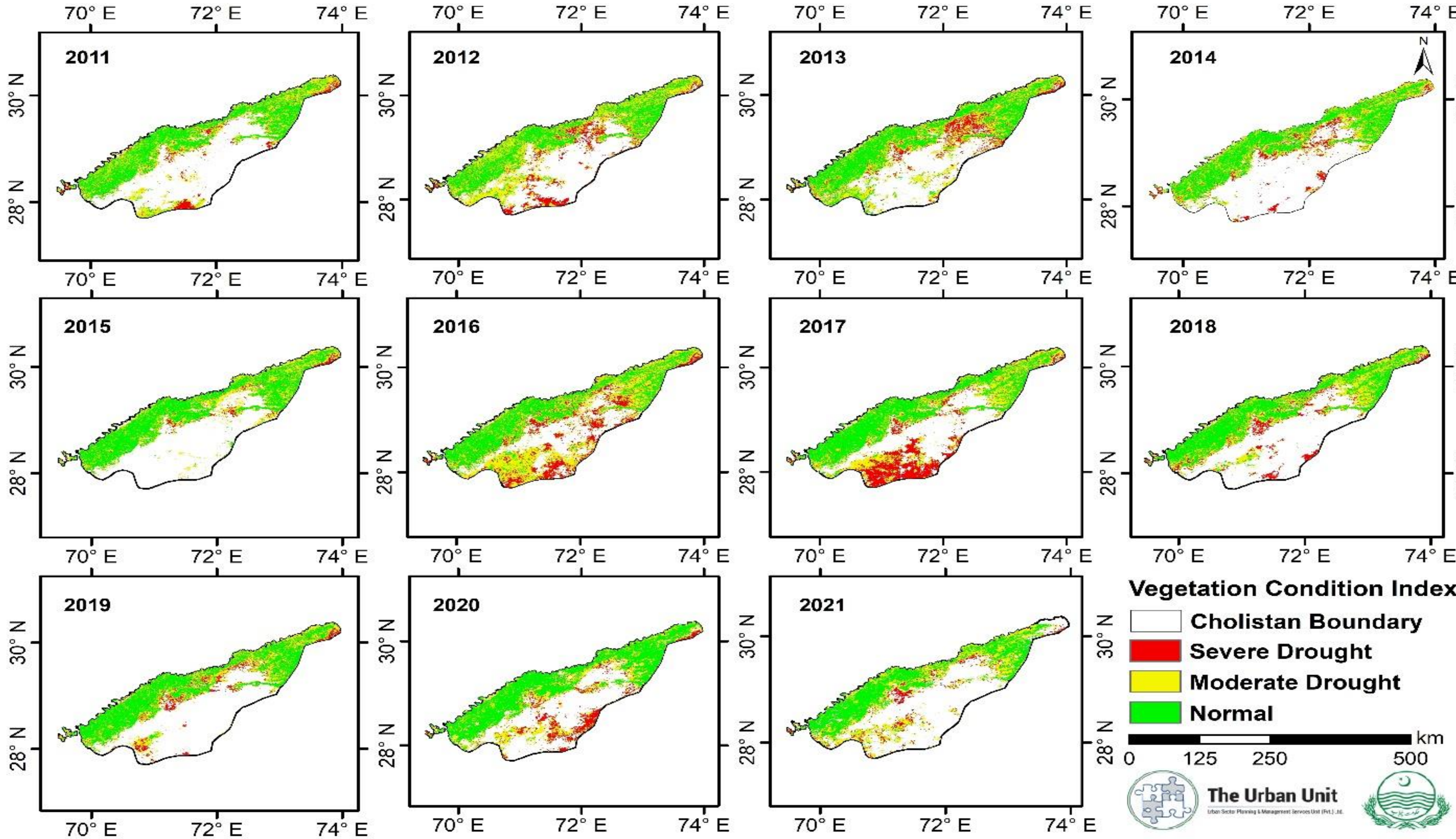


Fig. 4: Spatial Pattern of Vegetation Condition Index

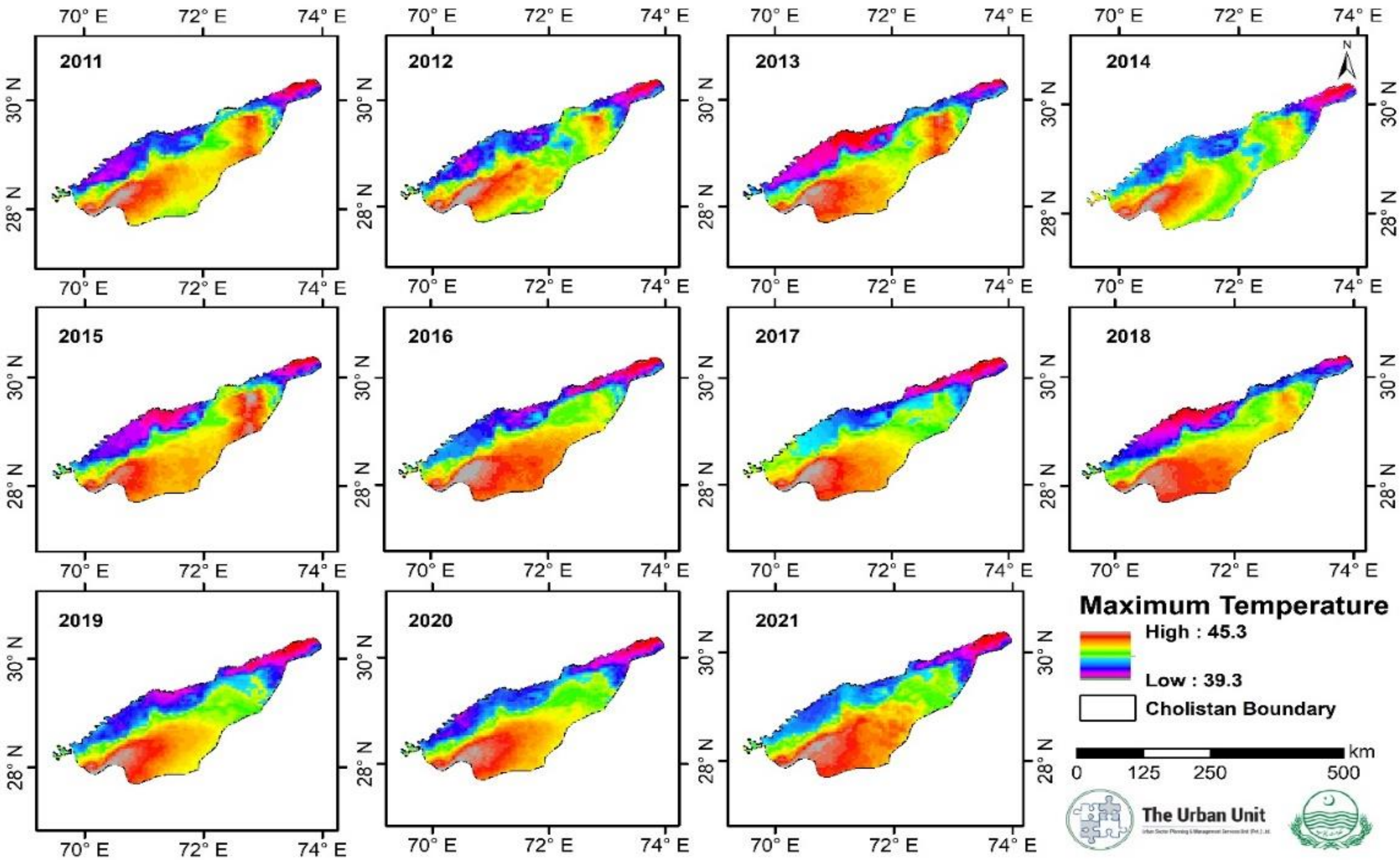


Fig. 5: Spatial Pattern of Maximum Temperature

1.2. Aims and Objectives

This Cholistan drought management plan specifically aims to curtail the drought impacts on the local communities by improving coordination between the respective government departments, enhancing the monitoring process, the capability of early drought warning, preparedness, response, and mitigation activities for local communities, and other entities affected by drought. The plan lays out an integrated, multi-agency approach to manage the drought conditions, with an emphasis on preparedness and response actions, to urgently cope with the adverse effects of global warming on the water resources and assure socioeconomic well-being through sustainable water resources management.

The objectives of the drought management plan are summarized as follows:

- To provide a sustainable and well- coordinated drought management framework by integrating public and private sectors for the mitigation of drought impacts.
- To develop an effective drought early warning and monitoring systems.
- Assessment of drought vulnerability and Implement mitigations to reduce drought impacts.
- To promote appropriate water storage technologies for increased water and food security.

Legal Framework

The constitution of Pakistan does not explicitly grant the right to water (as opposed to States, such as South Africa where the right is enshrined under section 27(b) which allows everyone the right to have access to sufficient water). However, in the landmark Supreme Court judgment of Naimatullah Khan v. Federation of Pakistan (2020 SCMR 622), C.J Gulzar Ahmed held that Art. 9, guaranteeing the right to life, ''… included the provision of drinking water''.

The recognition of a right to 'drinking water' falls short of the recognition under international law that water is necessary for more than just drinking. Although the right to water is not specifically mentioned in articles 11 and 12 of the ICESCR, General Comment No. 15, which was adopted in 2003, provides a coherent right to water. It stipulates that" The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses.'' Pakistan ratified ICESCR in 2008. Further, Pakistan is a State Party to the Convention on the Elimination of All Forms of Discrimination Against Women which stipulates in Art 142(h), ''State Parties shall take all appropriate measures to eliminate discrimination against women in rural areas in order to ensure…the right to enjoy adequate living conditions, particularly in relation to…water supply.'' Additionally, the Convention on the Rights of the Child (ratified by Pakistan in 1990) stipulates in Art 24(2) (c), "States Parties shall pursue full implementation…and, in particular, shall take appropriate measures to combat disease and malnutrition …clean drinking-water…''. The government's ratification of the aforementioned treaties has created long-lasting and legally binding obligations on the State of Pakistan that are enforceable under international law.

In line with these international obligations, Pakistan should recognize a right to water beyond the provision of drinking water. Second, the State should allocate appropriate monetary and other resources to realise the right to water. In particular, it should set a budget – divided between research, development of infrastructure and its continued maintenance.

In addition to this, International agreements and legal frameworks at national and provincial level play crucial role in effective implementation of disaster risk reduction plans and enhanced preparedness which is essential for saving the lives and livelihoods of vulnerable population of Pakistan. The relevant legal framework is discussed below;

The Sendai Framework for Disaster Risk Reduction (2015-2030): Pakistan is signatory to the Sendai Framework which works hand in hand with the other 2030 Agenda agreements, including The Paris Agreement on Climate Change, the New Urban Agenda, and ultimately the Sustainable Development Goals. It advocates substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. The framework sets out seven substantial targets to be achieved by 2030, which includes; (i) reduce global disaster mortality, (ii) reduce the number of affected people, (iii) reduce direct economic loss in relation to GDP, (iv) reduce disaster damage to critical infrastructures and disruption of basic services, (v) increase the number of countries with national and local disaster risk reduction strategies, (vi) substantially enhance international cooperation to developing countries and (vii) increase the availability of and access to multi-hazard early warning systems.

The Calamities Act of Pakistan (1958): This act, at national scale, guide the state's action during emergencies with a focus on response and relief.

National Disaster Management Act (2010): This act covers National, Provincial and District level to lay down a comprehensive framework for DRM, covering all phases of the disaster management cycle (replacing the Disaster Management ordinance of 2009).

National Disaster Risk Management Framework (2007): This framework intended to identify guiding principles and priorities for disaster risk reduction at National, Provincial and Districts Level.

National Disaster Management Plan (2012-2022): This plan also covers National, Provincial and Districts scale to guide and mainstream institutional and technical DRM priorities, in recognition of the needs of pre-disaster phases.

National Disaster Risk Reduction Policy (2013): The policy outlines priorities and directions for risk reduction from a proactive perspective, with a special emphasis on prevention, mitigation and preparedness at all three tiers.

National Disaster Management Plan Implementation Road Map (2016-2030): This road map sets up priority activities for the period of 15 years, with a focus on multi-hazard risk assessments, capacity building, community resilience and raising awareness at federal, provincial and local level.

The National Disaster Response Plan (2019): The plan outlines the framework for disaster response based on identified roles and responsibilities of various stakeholders at all three levels.

Water Crisis: Current State Assessment

3.1. Existing Situation

During last week rainfall in Cholistan has changed daytime temperatures in some areas of Cholistan, but other areas are still experiencing hot and dry conditions. Fig. 8 shows the amount of Precipitation in Cholistan from 18th June to June 2022.

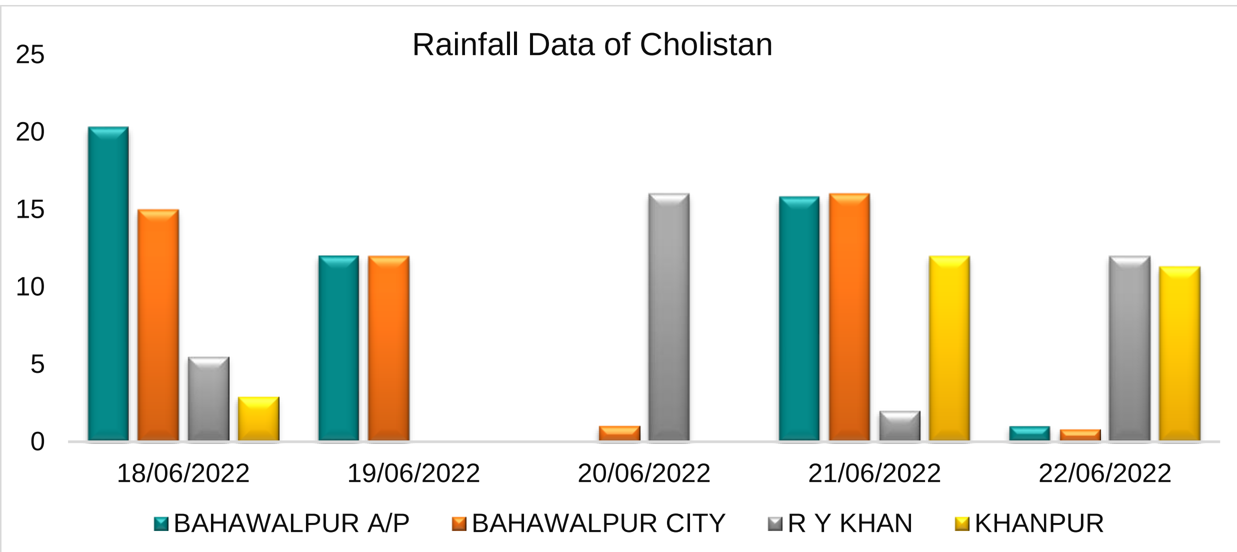


Fig. 6: Rainfall Data of Cholistan

Mild drought has been observed in Cholistan region and its adjacent areas as shown in figure below. While rest of the country show normal conditions[5].

[5] https://ndmc.pmd.gov.pk/new/assets/bulletins/1655435774.pdf

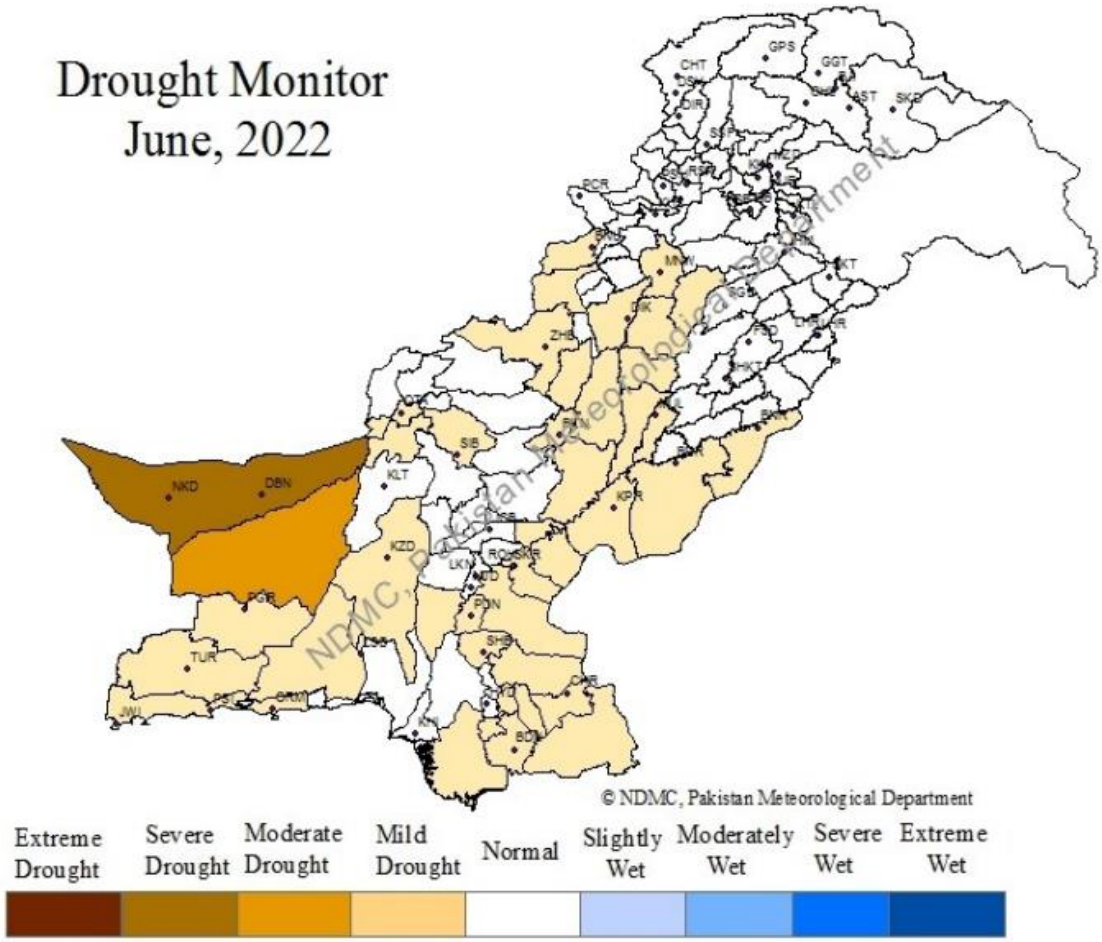


Figure 7: Drought outlook during June 2022 (Source PMD)

Existing water supply system in Cholistan is in miserable condition. The gigantic area of 6.6 million Acres only possesses six (06) public water supply schemes in deep desert areas, these schemes can only carter for ≈40% of the population, when fully functional & operational, however infrastructure of these schemes is in deteriorated and kaput condition with around ≈60% percent of Tube wells malfunctioned causing further cessation of water for the deep desert hamlets.

Imperializing the gap between water demand and supply, water demand outweighs the water production in the area. This gap reduces even further in the future due to high growth rate of livestock in the region. This gap can only be filled with construction of new Tubewells on various schemes and by introducing new schemes for unserved areas. Precipitation data shows water bodies such as Tobas and Kunds aren't reliable for supply of water throughout the year and poses high threat of droughts in the region posing danger to the life of human and their livestock as well as the variety of wildlife residing in the region. These grave issues relating to water can cause severe water scarcity if constructive measures aren't made.

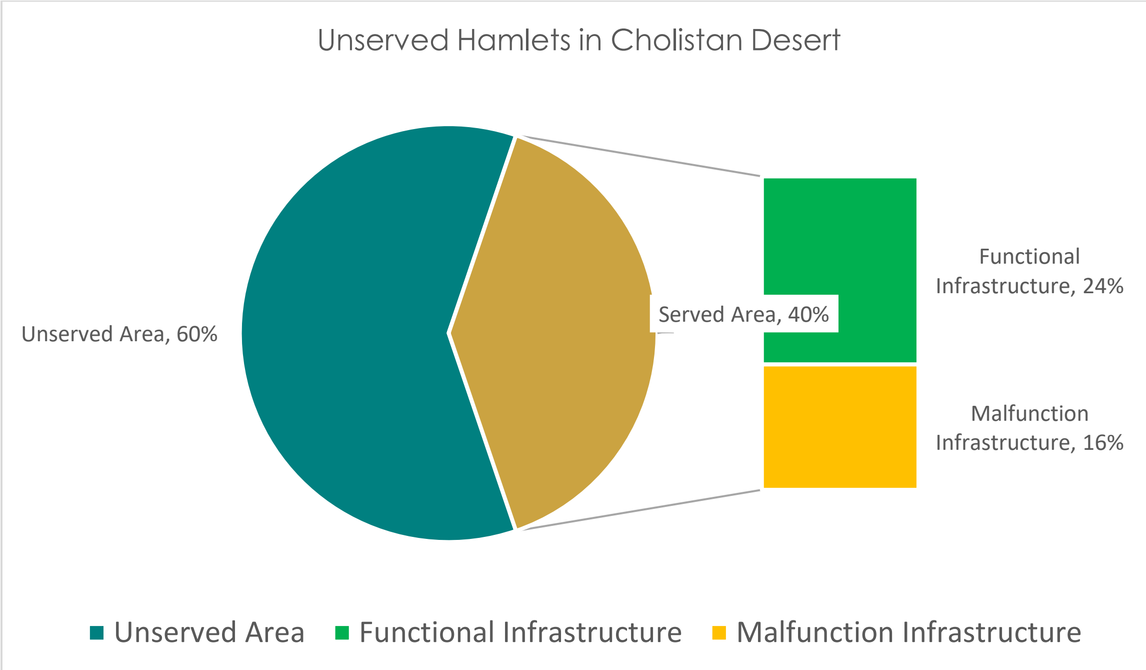


Fig. 8: Existing Water Supply System of Cholistan

These very similar issues instigated drought of 2022 in the month of April & May when precipitation didn't occur and water bodies like Tobas and Kunds dried up while mostly schemes being malfunctional. Since water bodies i.e., Tobas and Kunds failed to provide water due to no precipitation, unserved areas which massive population faced huge drought impact. As per Cholistan Development Authority (CDA), Human population of 15,000 and Livestock figure of 250,000 was at severe risk during this drought. Operational and maintenance fiasco of existing 6 schemes for deep desert areas of Cholistan were also main reason of drought. Failing machinery, outlived pipeline and valves, power outage and unavailability, non-existent water quality control and proper training of staff are among prime issues which in-turn are further fueling decreased supply of water.

3.2. Sources of Water

Broadly water related needs are fulfilled with two genre of sources, rain water carrying bodies such as Tobas and Kunds and piped water supply with Low Level Reservoirs serving as delivery points. Both comes with pros and cons and following has been established after detailed study during Master Planning exercise of the Cholistan region.

Table 5: Reliability of Water Supply Practices

Water Source Type	Features	Reliability
Toba	▪ 2,200 with more than 50% silted / partially silted ▪ Storage Capacity ≈ 132,000 Gallons ▪ Just enough to fulfil demand of 550 Human and 2,800 Livestock of a single day ▪ Currently 1 Toba fulfils water demand for 3-4 month (with reduced demand) ▪ Economical method of construction ▪ Source is precipitation hence more susceptible to early cessation ▪ In few regions' preference is given to Toba water due to orthodoxical practices	Highly unreliable as precipitation cannot be controlled, is unhygienic and very limited storage capacity is offered
Kund	▪ ≈200 in numbers ▪ Storage capacity of ≈ 85,000 gallons ▪ Just enough to fulfil demand of 300 Human and 1,550 Livestock of a single day ▪ Dia. 8 – 15m & Depth 3 – 5m ▪ Source is precipitation making it more susceptible to cessation Tobas	Highly unreliable as precipitation cannot be controlled and very limited storage capacity is offered
Water Supply Schemes	▪ Total 6 schemes ▪ Seepage Tubewells (on 5 schemes) and Direct Pumping (Sourian Scheme), from Irrigation Canal and Old Hakra River Bed ▪ Around Total spread of 649km undersized & outlived pipeline ▪ 20/49 Malfunction Tube wells ▪ Underground water with 500-5000 ppm TDS hence seepage from Canals prompting High construction and operating Cost	Highly reliable as water demands may be meet with proper operation & maintenance

3.2.1. Tobas

One of the key sources of water in the Cholistan desert is the rainwater, which is collected in depressed area (usually man-made) locally known as Toba during rainy season. Since Tobas are not engineered, they result in wastage of water by seepage and evaporation. Desilting of Tobas is also not done regularly, which further reduces its water storing capacity. The size and storage capacity of each Toba varies depending on length, width and depth. Furthermore, the filling of these Tobas with rainwater also varies due to size of catchment. The water storage capacity of these Tobas ranges between 400 and 800 cubic meters. Ponds samples are reported to have TDS of 250-700 ppm by Pakistan Council of Research in Water Resources

(PCRWR). Tobas do not meet drinking water standards due to high turbidity & no disinfection process. It must be mentioned here that due unavailability and primitive rituals, humans and animals use same water of Toba which is a very common practice in Cholistan. A total of 1,748 Tobas are reported however more than half of them are silted. Since Tobas are dependent upon precipitation, they can only provide water for 3-4 months. Average Rainfall value in Cholistan is calculated to be 33-121 mm with Maximum annual rainfall to be 688mm (2020) and 43mm (2014). The rainfall departure of around -16.3 % and increased temperature of as high as 50-55^{o}C in April 2022 further elaborated the unreliability of dependence on water bodies such as Tobas.

Fig. 9: Tobas in Smaller Cholistan

3.2.2. Kunds

Kund is a man-made structure which is used to store rainwater in the Cholistan, for drinking purpose in addition to the ponds. Kunds are constructed by using pucca material like bricks, cement etcetera in the shape of well above the level of ground water depth to store rainwater for longer period in order for humans to use for drinking purpose when there is no water in the Tobas. Along the water supply schemes, around 200 Kunds are constructed by locals and CDA on different catchment areas to store rain water. Kunds are capable of storing water for long period but its storage capacity is small with high cost of construction. The diameter of Kund ranges between 8 and 15 meters while depth ranges between 3 and 5 meters with a storage capacity of 50,000 to 120,000 gallons. Kunds can store rainwater for longer period than Tobas because seepage from the bottom and sides is stopped totally due to concrete material and evaporation is also stopped totally by the concrete lid which is placed on mouth of the structure. Like Tobas, precipitation is the only source to recharge its storage tank making them highly unreliable.

Katcha Kund with concrete top

Concrete Lined Kund

Fig. 10: Kunds in Cholistan Desert

3.2.3. Existing Water Supply Schemes

Cholistan Development Authority (CDA) is currently operating six (06) water supply schemes for general public. Since the ground water in Cholistan is mostly saline, water is abstracted from recharged aquifers (by seepage from canal) and sweet water pockets along river bed of old Hakra River bed with the help of tube wells and direct pumping. There are total of 49 tube wells on different locations along canals on the outskirts are being used for water abstraction. The tube wells, despite connected to electricity, have back-up generators installed due to low voltage & power outrage problems which further contribute towards lessen water production. The extracted water is supplied to the Low-Level Reservoirs which are located at long distances where drinking water stations are provided for human beings and animals separately. Owing to long conveyance network of the schemes, several intermediate pumping stations (IPS) are constructed on the networks to facilitate the transference of water. These pumping stations have tanks of varying capacity (70,000 Gallons to 200,000 Gallons) to store the incoming water and then further transfer to the connected low-level reservoirs & successive intermediate pumping station. The reason of these intermediate pumping station is high head losses due to long distanced schemes and elevation difference.

Table 6: Summary of 06 Existing Water Supply Schemes

Sr. No.	Name of Scheme	Total Length (km)	Installed Tube Wells/ Pumps	Functional Tube Wells	IPS	LLR
1.	Mirgarh to Choori Source: Seepage water from Hakra Right Canal	54	7	2	1	8
2.	Khutri Dahr to Tufana Source: Seepage water from Old Hakra River Bed	45	3	2	1	7
3.	Kudwala to Banna Post Source: Seepage water from Desert Canal Br.	75	14	4	3	11
4.	108 DB to Bhijnot Source: Seepage water from Desert Canal Br.	120	14	3	5	15
5.	111 DNB to Gurara Source: Seepage water from Dera Nawab Br.	155	12	5	3	10
6.	WS Scheme Surian (Ongoing, 80% Completed) Source: Directly from 1L Canal	200	4	4	7	15
Summation		**649 kms**	**53**	**20**	**20**	**66**

During the various detailed field visits it was observed that around 70% area of the Cholistan Desert is Brackish. Underground Water Quality samples are reported to very high (+1000ppm) which makes water undrinkable for Humans and their Livestock. There are some sweet water pockets on/near to Old Hakra River Bed but prolong yielding rate, underground water with high TDS mixes-up with the sweet water and these are also unsustainable since these pockets are not imperialized yet with proper testing. As such, it is established that water supplying schemes are the only reliable source of water supply to the locals of Cholistan

3.3. Water Deficiency & Unserved Areas

It is for sure that the region of Cholistan lacks the proper water supply. In detail study during Sectoral Master Planning following can be extracted in-term of shortage both in water production and in coverage area. There are many unserved pockets. Almost 60% of the region lacks the facility of clean water supply infrastructure. Rate of water production is also too small when compared with the water demand of the region. Around 60% of the area is unserved which implies that water supply infrastructure doesn't even exists. Most of the areas where droughts occur i.e., in 2022, are also one of these areas. Presently Tobas and Kunds are the main source of water in these areas. A permanent solution is needed in order to enhance stability and livelihood in unserved Pockets. Following are the areas reported by CDA which were severely affected by droughts in 2022. The total affectee of these areas are around 15,000 human population and 250,000 Livestock.

Table 7: Drought Areas reported by CDA

Sr. #	Settlement Name	Human Population	Livestock Population
1.	Bijnot – 1	2000	12000
2.	Bijnot – 2	2000	12000
3.	Ahmed Wala	400	9000
4.	Bitryan	850	15000
5.	Kheer Sar	1050	15000
6.	Nawan Khu	200	6000
7.	Laraan Wali	250	6000
8.	Saan	400	8000
9.	Misri Wala	300	7000
10.	Chillan	500	8000
11.	Lakhmali	300	10000
12.	Janay Wala	250	6000
13.	Hansi	400	7000
14.	Khan garh	150	3000
15.	Din Garh	1600	20000

16.	Wanjohar	1000	12000
17.	Saans	200	8000
18.	Rukan Pur	600	12000
19.	Kurai Wala	200	8000
20.	Lakhu Wala	150	6000
21.	Kaki	100	5000
22.	Jogi Das	200	3500
23.	14. Khoi	100	3000
24.	Sarwar Chowk	200	6000
25.	Toba Kandaira	150	4000
26.	Dadi Karam Khatoon	300	7000
27.	Tamachi Wala	100	3000
28.	Sokhera Wala Khu	250	4500
29.	Bachay Wala	100	3000
30.	Toba Bairseen Wala	150	4000
31.	Laraan Wali	200	6000
32.	Modi	150	4000
33.	Palwanian Wala	100	3000
34.	Ludhar Wala	100	4000
Total		**15,000**	**250,000**

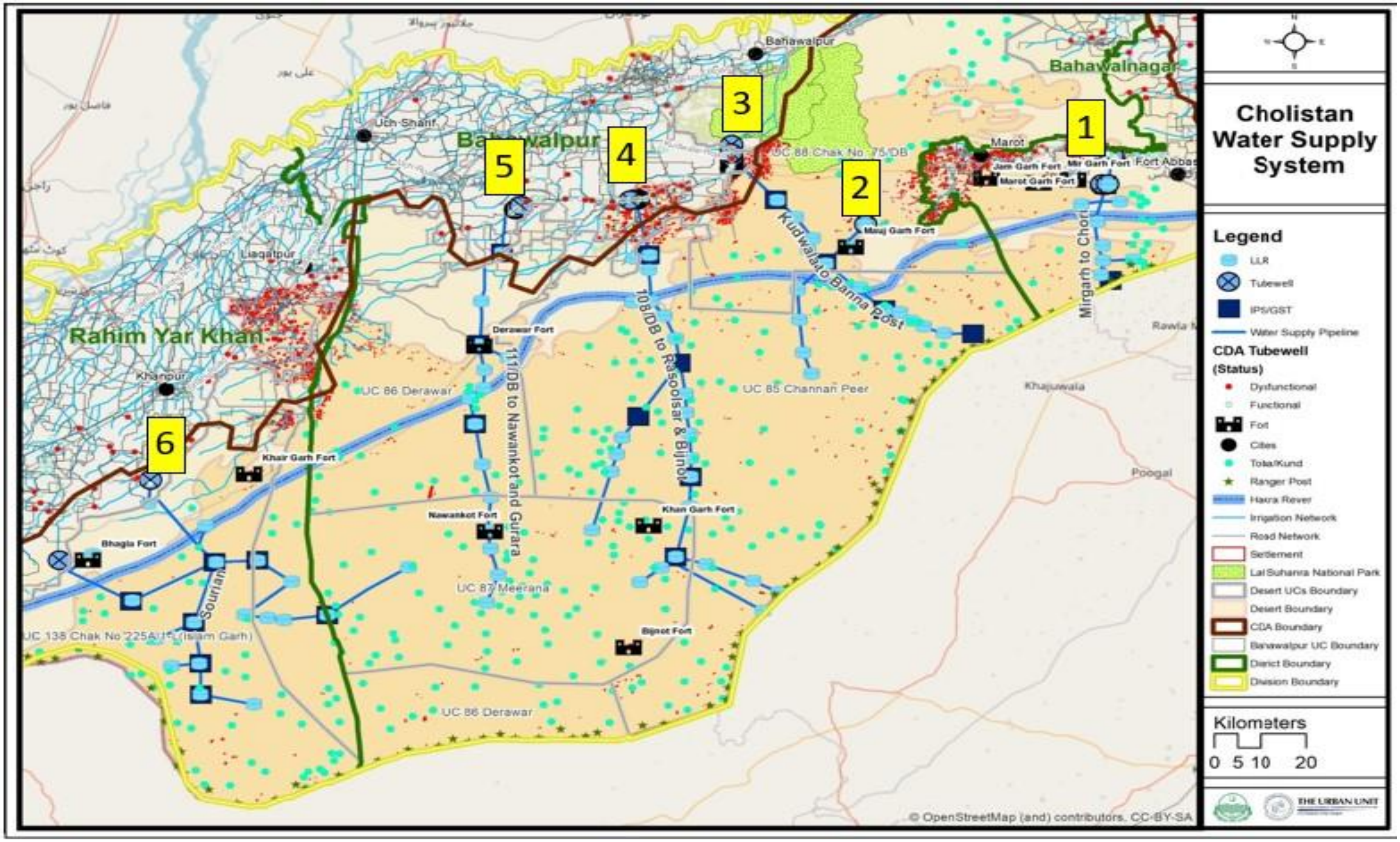


Fig. 11: CDA Existing schemes Infrastructure detail

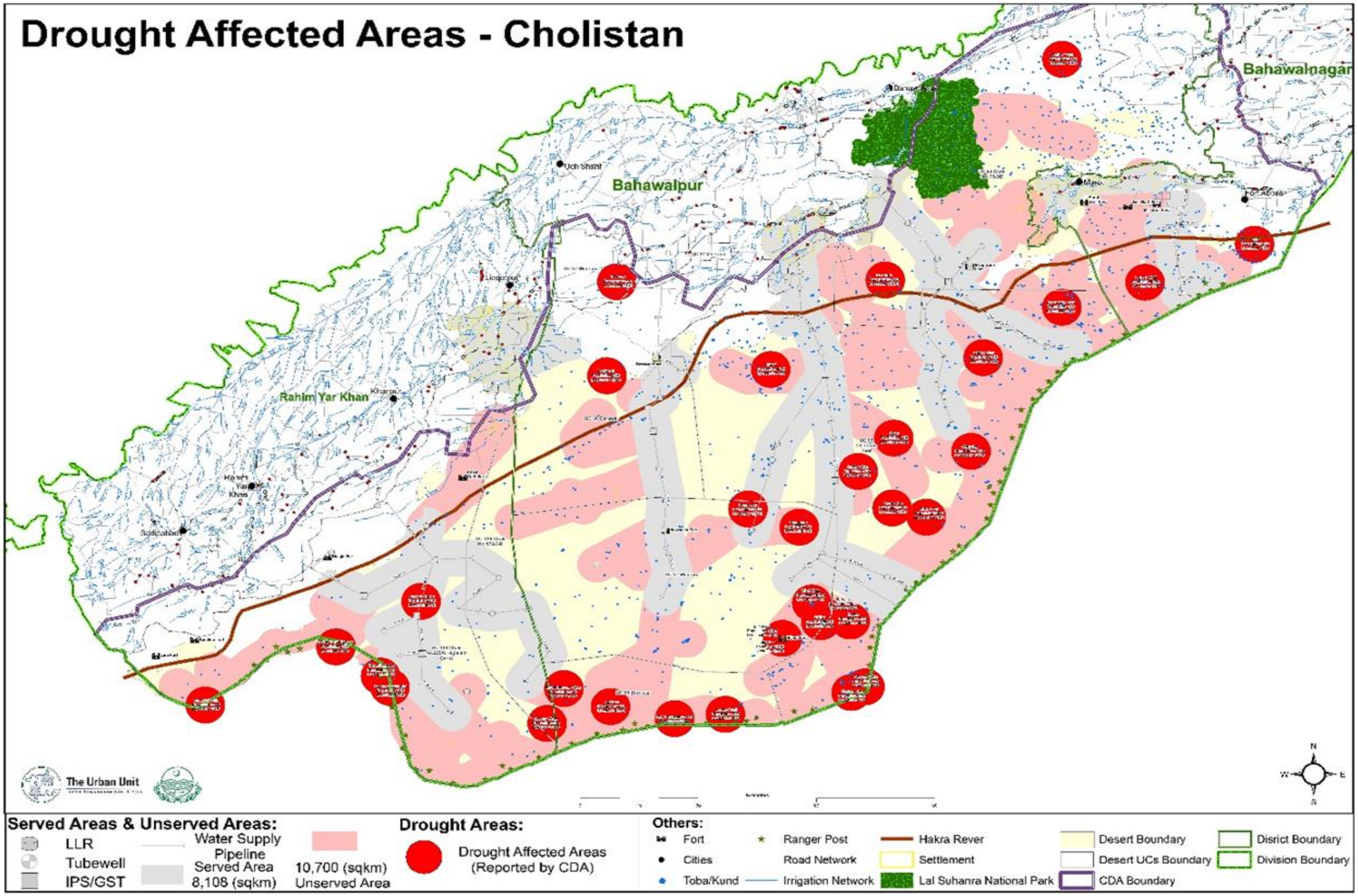


Fig. 12: Map showing Unserved areas

Drought Management Plan

This Drought Management Plan is designed to facilitate the management of drought situation in planned and structured manner with the optimum utilization of the time, to minimize the adverse impact of drought on the community. This drought management plan will help in delineating the roles and responsibilities of Government departments involved in the drought monitoring, vulnerability assessment, mitigation, preparedness and response.

Disaster management in any region generally requires the participation of all sectors of society. Although the State Government takes the lead, success is more likely when everyone, especially those at the grassroots, believes in the initiatives. Furthermore, it must be aware that the Drought Management Plan must address the competing interests of all subsectors fairly and equitably based on the limited water availability.

4.1. Establishment of Drought Monitoring cell

The Drought Monitoring Cell (DMC) will be established in CDA for field level assessment and implementation of drought management plan. The DMC will provide support to the relevant departments i.e. Agriculture and Livestock department, Water Resources department, Irrigation Departments, PDMA, and PMD for timely and predictive assessment and interventions. This monitoring cell being familiar with local environment and remote areas of Cholistan will identify drought-hit areas and affected communities, assesses damage, including impacts on agricultural production, depletion of water resources, impacts on livestock, land degradation, deforestation, and human health. Drought monitoring of meteorological and hydrological variables will be carried out by Pakistan Meteorological Department.

4.2. Establishment of Central Coordination Committee of Drought at Commissioner Office

Central Coordination Committee for drought assessment and relief works will be established in Commissioner's Office Bahawalpur that will have a representation from Cholistan Development Authority (CDA), Agriculture and Livestock department, Water Resources department, Irrigation Departments, Provincial Disaster Management Authority (PDMA), and Pakistan Metrological Department (PMD). The Committee will be responsible for effective coordination with the relevant departments so that joint efforts will be done by these departments under the Chairmanship of Commissioner Bahawalpur.

4.3. Components of Drought Management Plan

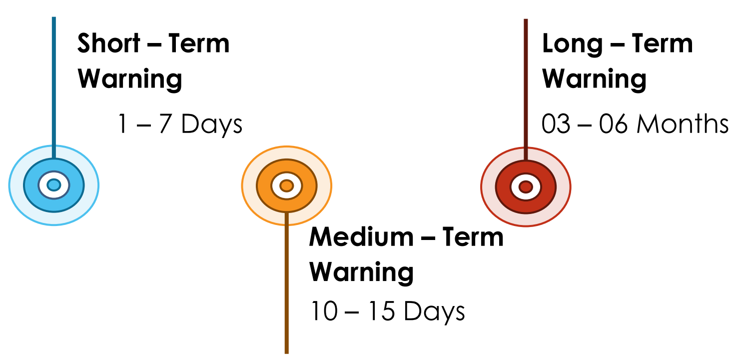
4.3.1. Monitoring, Early Warning and Information System

Drought indicators are based on climate data and remote sensing products are at present the best available tools to monitor drought over large regions and periods. Considering the trends of droughts, drought early warning systems on global, regional, and levels are necessary because these systems provide the timely and reliable information necessary to make decisions regarding the management of water and other natural resources. Early warning systems of droughts aim to track, analyze and deliver pertinent information concerning trends of hydrologic, climatic, and water supply conditions. Ideally, they have both monitoring (including impacts) component and a forecasting component. A drought early warning system is an integrated system of information that consists of five significant key components i.e.

- Observation & Monitoring,
- Prediction & Forecasting,
- Planning & Preparedness,
- Communication & Outreach, and Interdisciplinary Research
- Capacity Building

These key components are the basis of the drought early warning system and act as a baseline for proactive and effective drought management and policies. The drought early warning system categorizes water supply and, climate trends erects the probability of incidence and the severity of drought and its impacts on regional climate.

Early warnings about droughts must be provided according to the following time span[6] (can be adjusted according to the stakeholder requirements):



To acquire timely information and a sufficient amount of spatial data about the current drought situation, an analysis of the existing monitoring network for drought indicators is required for an early warning system. The analysis of drought indicators may focus on examining the number of monitoring stations and

[6] guidelines-preparation-drought (europa.eu)

frequency of measurements. An effective warning system must provide real-time information that is updated at least on weekly basis. Usually, an upgrading of the existing monitoring system is needed, to increase the frequency of measuring the chosen indicators.

Fig. 13: Key Components of Drought Early Warning System

4.3.1.1. Observations & Monitoring

Drought's monitoring is a complex process and depends on several atmospheric, vegetative and hydrologic, and anthropogenic factors, which are challenging to monitor droughts accurately and consistently in this region. A drought monitoring system must be developed in the Cholistan by Pakistan Meteorological Department. Precipitation measurements, meteorological conditions, and soil moisture are crucial for use in many areas of drought planning and response. The drought monitoring process will use a percentile ranking methodology, in which different indicators would be analyzed weekly, by comparing current values to the historical data values for all variables.

4.3.1.2. Prediction & Forecasting

Early warning of droughts depends on the drought forecast products of the concerned area. Various methods are available globally, to forecast droughts. Uncertainty in drought prediction and short-term to seasonal forecasts present a major challenge to climatologists and hydrologists as well as decision and policymakers.

Highly complex models that incorporate important physical processes across the atmosphere, ocean, and land surfaces are used for seasonal predictions of temperature, precipitation, and ultimately drought. Forecasts of precipitation, temperature, and many other weather variables from these models are used by the NWS (Climate Prediction Center, River Forecast Centers, and National Water Center) and the NRCS Water Supply Forecast. In addition, the USACE and USBR produce important reservoir level forecasts.

The reliability and usefulness of official drought forecasts and outlooks (and the prediction tools and models that inform them) are vital to any DEWS. These efforts focus on improving the current monthly, sub-seasonal, and seasonal drought outlooks with consideration for extending the forecast service to longer lead times. These activities leverage advancements in drought research and expand current work to include operational drought prediction systems where possible.

Drought Indices

The generalized method for the assessment of drought is based on the drought indices, which are the most frequently worldwide used tool for the drought analysis spatially and temporally7. Due to the various facets of drought from region to region, there is no single drought index that is ideal for all regions. Drought always starts with a lack of precipitation but can be exacerbated with warmer temperatures that contribute to dryness and impact soil moisture, groundwater, streamflow, ecosystems, and human systems Drought indices can be categorized as meteorological, hydrological, agricultural, socioeconomic, dependent on the analytical approach and input variables, such as soil moisture, precipitation, and runoff. Amongst them, due to the availability and simplicity of meteorological drought indices, the standardized precipitation index (SPI), vegetation condition index, and Standardized Precipitation Evapotranspiration Index (SPEI) are most commonly used. Compared to the SPIE, the SPI is frequently used for measuring droughts and is suggested as standard drought-monitoring indices. The degree of vegetation greenness also can be a signal of drought, such as analyzing the probability of Normalized Different Vegetation Index (NDVI) deviation from normal. The Land Surface Temperature (LST) products and Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Indices (VIs) are widely used tools for the derivation of vegetative and thermal-based drought indices, for the detection and monitoring of meteorological droughts globally and regionally (WMO and GWP, 2016).

Standardized Precipitation Index (SPI)

The Standardized Precipitation Index, introduced by Mckee et al.8 is developed from the notion that droughts are started by a reduction in the precipitation resulting from a scarcity of water relative to the water demand. Since the Standardized Precipitation Index is based only upon the precipitation in each period, compared with the averaged or normal values, it is closely related to the variability of the hydrological cycle specifically in monsoon climatic zones.

Vegetation Condition Index (VCI)

Vegetation Indices (VI) derived from remote sensing datasets have been extensively used to monitor vegetation health and drought conditions. Remote sensing derived drought indices mainly include Vegetation Health Index (VHI), Temperature Condition Index (TCI) and Vegetation Condition Index (VCI). These indices have been widely applied in many regional studies under different environmental conditions around the world. The VCI was one of the earliest remote sensing drought indices mainly applied to

[7] Guo, Y.; Huang, S.; Huang, Q.; Wang, H.; Fang, W.; Yanga, Y.; Wang, L. Assessing socioeconomic drought based on an improved Multivariate Standardized Reliability and Resilience Index. J. Hydrol. 2019, 568, 904–918

[8] Mckee, T.B.; Doesken, N.J.; Kleist, J. The relationship of drought frequency and duration to time scales. In Proceedings of the AMS 8th Conference on Applied Climatology, American Meteorological Society, Anaheim, CA, USA, 17–22 January 1993; pp. 179–184

comprehend agricultural drought. Spatio-temporal pattern of VCI can be easily calculated by using NDVI dataset.[9],[10]

- **Web-Based Drought Early warning systems**

- ***National Drought Monitoring Centre, Islamabad (Pakistan Meteorological Department)***

NDMC (National Drought Monitoring Centre) serves as a hub for the consolidation of all drought-related data on a regional basis. NDMC also prepares, and issues all bulletins based on the indices throughout Pakistan, and advises all Government Agencies.[11]

4.3.1.3. Planning & Preparedness

The monitoring, planning, and reducing drought risk must be integrated. These initiatives aim to increase drought resilience through networking, engagement, and collaboration.

The critical component of planning for drought is the provision of reliable climatic indicators information, including seasonal forecasts, which helps decision-makers while critical management decisions. If properly applied, this information leads to reducing the extreme climate events and other impacts of droughts. Various organizations and entities are responsible for the drought preparedness and planning process, including Cholistan Development Authority, PDMA, Pakistan Council of Research in Water Resources, Agriculture and Live Stock etc. Identification of drought stages and appropriate response actions are the key characteristics of drought management plan.

4.3.1.4. Outreach and Communication

Outreach and communication are critical for an effective drought early warning system, planning, and preparedness, raising awareness, informing and warning, sharing key actions that must be taken, understanding impacts, and evaluating actions to improve resilience moving forward.

Capitalize on social media networks as a tool for drought preparedness and response and to better understand impacts geographically. There is a need for capacity building and facilitation on drought training tools and adaptation of strategies to mitigate the drought conditions.

4.3.1.5. Interdisciplinary Research and Applications

There is urgent need to identify scientific research programs which can help to improve understanding of drought, its effects, and mitigation strategies. The development of research program must be connected with processes with identified gaps, and challenges, by considering related issues monitoring methods based on remote sensing data, impacts of climate change etc. Accurate seasonal forecasts help in better

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[9] Rojas, O.; Vrieling, A.; Rembold, F. Assessing drought probability for agricultural areas in Africa with coarse resolution remote sensing imagery. *Remote. Sens. Environ.* **2011**, *115*, 343–352. [Google Scholar] [CrossRef]
[10] Kogan, F.N. Remote sensing of weather impacts on vegetation in non-homogeneous areas. *Int. J. Remote Sens.* **1990**, *11*, 1405–1419. [Google Scholar] [CrossRef]
[11] https://ndmc.pmd.gov.pk/new/#

understanding of triggers which are used in decision making more practicable. Based on the current situation of Cholistan the key proposed research themes could be following:

- Improvement process in drought management plan (drought indicators, historical evaluation, and drought forecast)
- Methodology for risk assessment including the development of hazard and risk maps
- Water scarcity and storage of water
- Climate change modelling of droughts (Future Projections)

Road map for monitoring, early warning and information system

This comprehensive Drought Monitoring encompasses the following activities:

- Continuous monitoring and Forecasting of Drought Indices (Standardized precipitation Index, Vegetation condition Index and Maximum Temperature)
- The institutional assessment of drought impacts and risks.

This monitoring, early warning and information system will analyze climate, water supply trends and detects probability of occurrence of droughts by categorizing severity of climatic extreme event. Pakistan Meteorological Department will provide weekly and monthly updates on climatic parameters, as the drought progresses and prior to any formal drought measures being implemented. The responsibility to collect, analyze and disseminate the data will be Pakistan Meteorological Department.

- The responsibility to issue early warning system will be of Provincial Disaster Management Authority. The website of Pakistan Meteorological Department's National Drought Monitoring Centre will be updated with information on the status of drought conditions and impacts, as well as other drought-related information. The Focal Person for receiving early warning from the Provisional Office will be the Deputy Commissioner, and the Focal Person for the provision of Health Services in the affected areas will be the Chief Executive Officer (Health)[12].
- For the Public dissemination, Early warning will be communicated through any available and possible resources such as announcements via mobile messages teams in the mosques, patwaris, SMS, print & electronic media etc.
- Adopt the color-coded system, which is based on traffic lights colors for the identification of the severity of drought and help to make it understandable and easy for implementation of the implications. The following figure identifies the drought conditions, from normal to the unprecedented drought, along with actions to be implemented and level of services to be expected.

[12] Disaster Management Plan Bahawalpur, 2020;

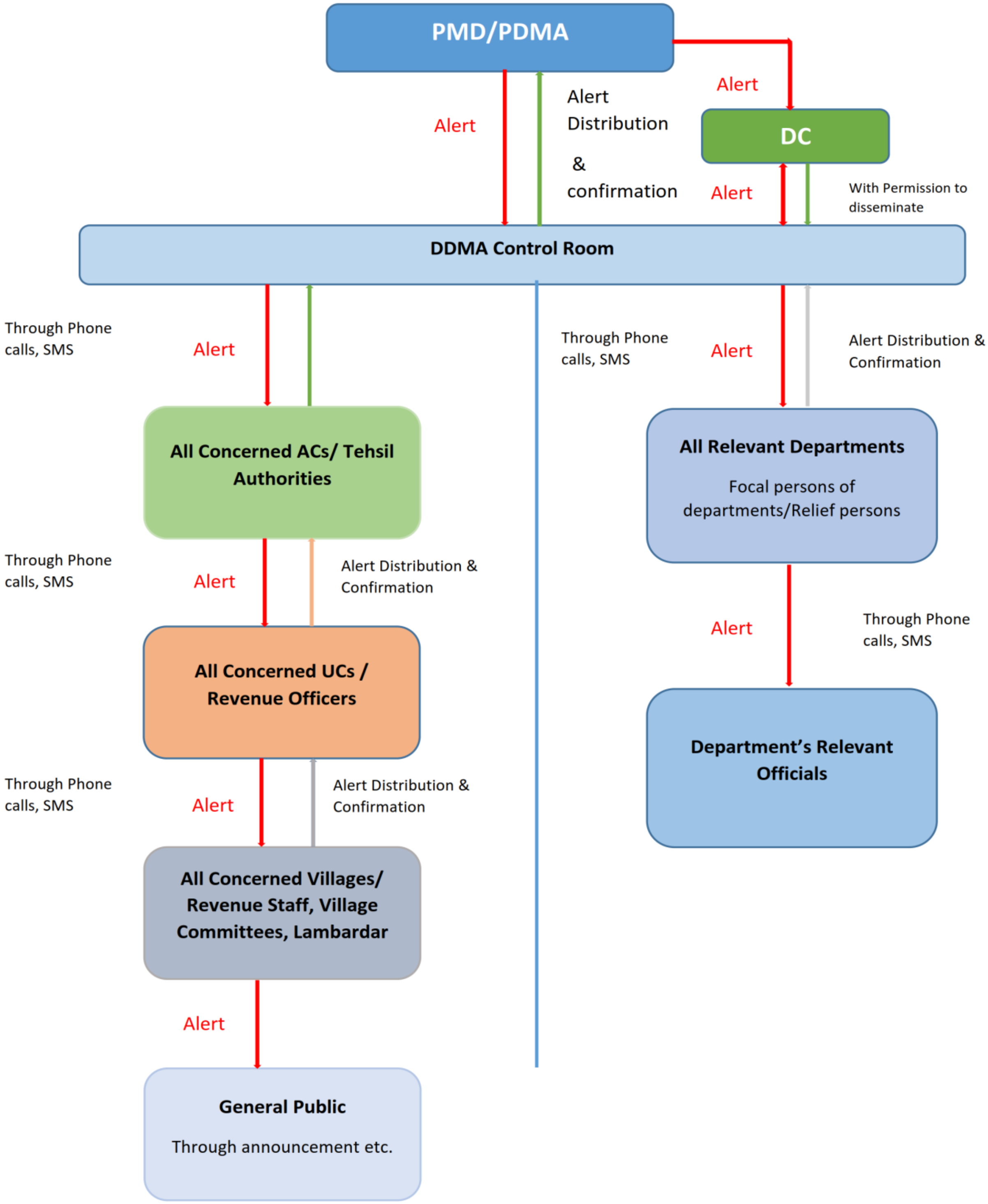
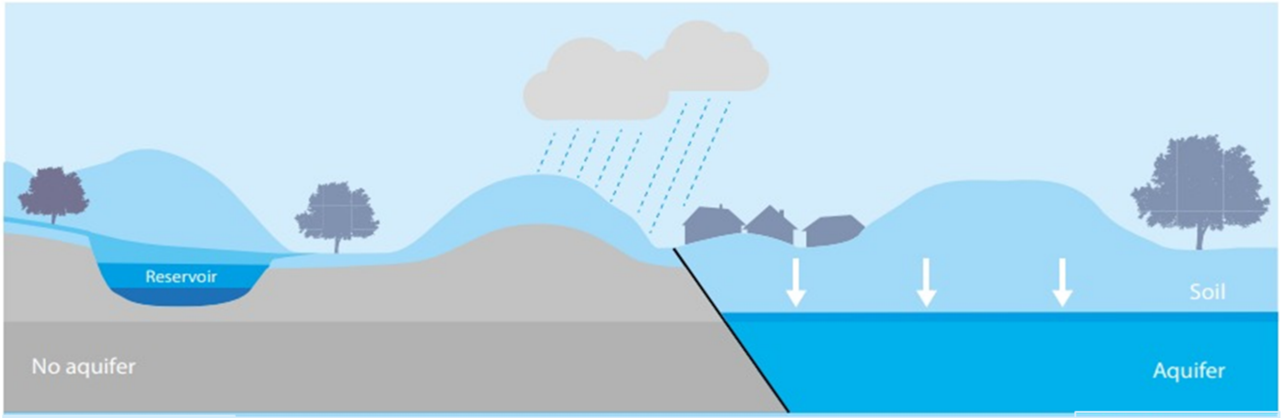


Fig. 14: Flow chart of Early Warning System Dissemination



Drought Status		Actions	Restricted Activity for you
GOOD	Water Resources are painful, no restrictions	Normal Monitoring	None
SLIGHTLY BELOW AVERAGE	Reservoir levels slightly lower than average for the time of year, increased monitoring taking place.	Extra promotion of water efficiency Enhanced leakage effort	None
BELOW AVERAGE	Reservoir levels below average for the time of year, careful management of reservoir stocks and other dry weather actions possible.	Appeals for Restrain	None
LOW	Low Reservoir levels, temporary use restrictions being considered or in place. Apply for and implement Company Drought Permits.	Temporary use ban (hosepipe ban)	Some domestic use
VERY LOW	Long-term dry condition and very low reservoir levels, non essential use restrictions being considered or in place	Non – essential use ban	Domestic and commercial use
SEVERE	Additional emergency restrictions considered.	Risk rota cuts/ standpipes	Domestic and commercial use

Fig. 15: Status of Drought along with Actions and level of responseexpected

4.3.2. Vulnerability and Impact Assessment

As the world's vulnerability to drought has increased, more attention has been focused on reducing the risks associated with its occurrence through the implementation of planning to improve operational capabilities such as climate and water supply monitoring and building institutional capacity, as well as mitigation measures aimed at mitigating the effects of drought. The goal of conducting vulnerability and impact assessment is to anticipate potential problems and potential solutions to save lives, protect assets, damage reduction and to facilitate the quick recovery from disaster.

Vulnerability and impact assessment are a critical part of the drought management plan and it has the potential to facilitate the necessary authorities to prepare for emergencies. Drought risks are a product of both the region's exposure to the event and the vulnerability of local society to drought in any region.

Cholistan may be increasingly vulnerable to water scarcity, growth and development, and a changing climate. Historical data sets from recent years have shown that this region exposed to various drought related impacts such as increased temperatures, lack of precipitation, and water scarcity issues. Drought has an impact on the country's economy at both the macro and microeconomic levels, both directly and indirectly.

Direct impacts are typically visible in declining agricultural production and heightened food insecurity among communities in the vulnerable areas; decrease of water levels in the water storages; high rate of livestock and wildlife mortality; migration of local nomads and livestock; damage to biodiversity etc. **Indirect impacts** of drought lead to the reduction in incomes for local farmers, price increases in food and fodder, reduction in purchasing capacity and slump in consumption, shrinkage of agricultural land & reduced number of livestock, rural unrest etc.

These destructive impulses have massive negative multiplier effects in the economy and society. Drought has socio-economic and environmental impacts.

Cholistan may experience variability of drought-related impacts in the future, which may be similar to those experienced in the past. The potential severity of many of these impacts could be significant depending on the magnitude and duration of the drought, climate variability trends, and as how effectively the drought mitigation and response efforts reduce the impact. Table 5 listed the overview of main drought impacts over Cholistan region.

Table 8: Drought Category and their Impacts

Drought Category	Drought impacts
Environment	Decreases in water supply and surface water and groundwater quality Ecosystem Damage: increased livestock and humans' mortality i.e., Soil erosion, decrease of vegetation cover, disease, land degradation Increased salt concentrations in water, Damages to river and wetlands life (e.g., flora, fauna, habitats)
Social	Damage to public health and safety, increase in social inequality, through larger impacts on specific socio-economic groups, stress between public administrations and affected groups Changes in the political perspectives
Economic	Decreased production in agriculture, forestry, fisheries etc. Unemployment caused by the decreased production, Damage to the tourism sector due to reduced water availability in water supply and/or water bodies Pressure on financial institutions (e.g., more risks in lending, capital decrease). Income reduction

For each of the identified sectors a likely drought impact must be quantified by using a set of appropriate indicators. For economic sectors (e.g., agriculture, power production, forestry), economic criteria are typically used. For example, impacts on agriculture can be quantified in terms of productions and losses. For the environmental impacts, the number of mortality rates are used as impact indicators.

Vulnerability is defined as the situations determined by physical, environmental, and socioeconomic factors or the processes that make a community more vulnerable to the impacts of hazards such as land degradation and desertification.

Mathematically it is represented as:

Vulnerability (V) = Exposure (E) + Sensitivity (S) – Adaptive Capacity (AC)

AC is the integration of all strengths, resources, and attributes available within the community, organization or society and can be to mitigate the impacts of disaster.

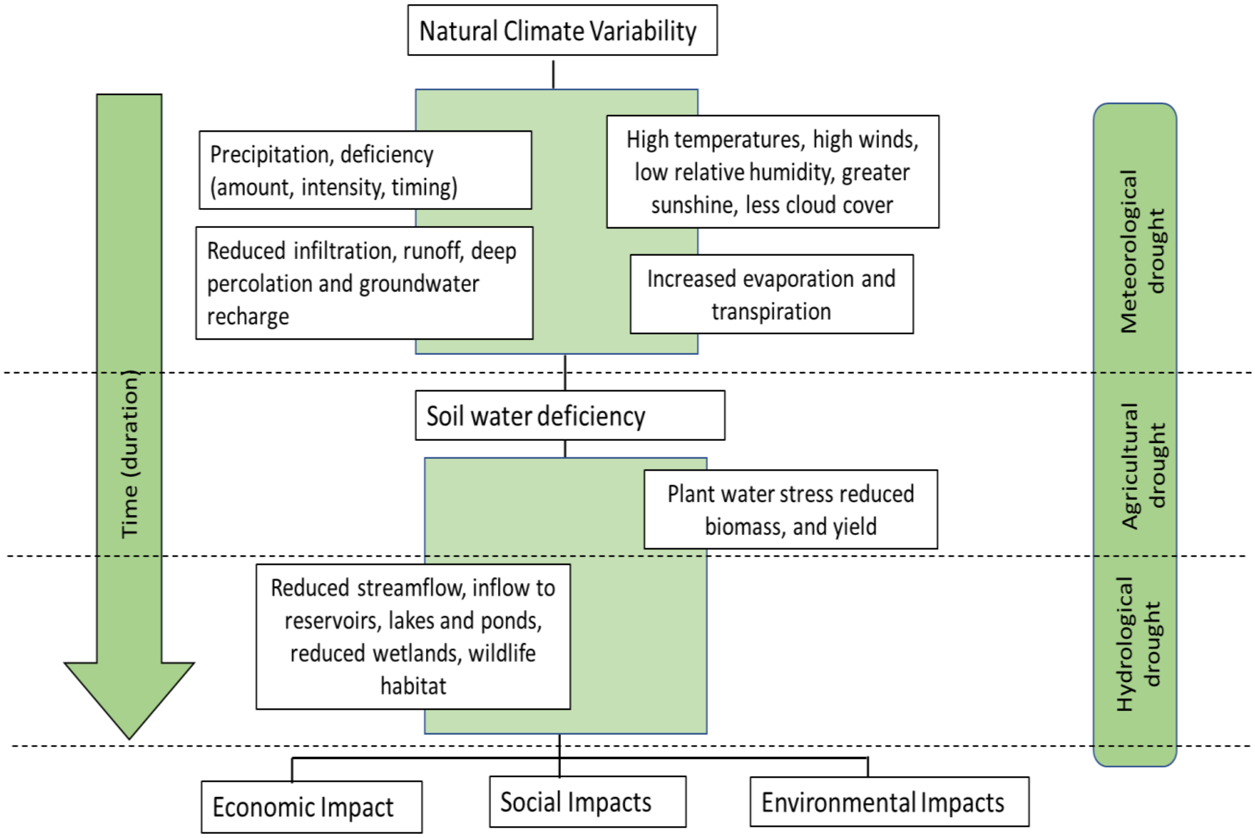


Fig.16: Drought category and its Impacts

4.3.2.1. Hazard and Risk Maps

Following are the steps to produce a hazard map:

1) Data collection,
2) Calculation and selection of indices, and
3) Creation of the hazard map

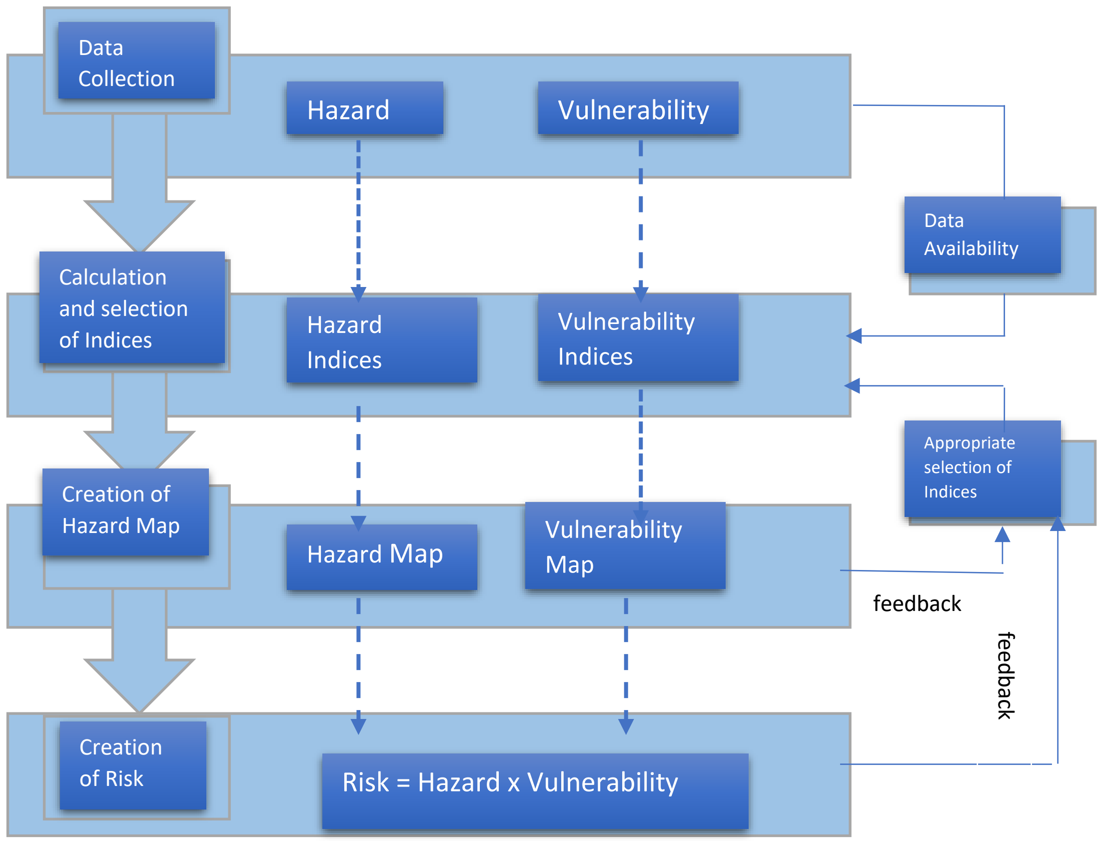


Fig. 17: Conceptual Flow Chart for creation of Hazard Map

Further, a drought risk map is derived based on the following formula

"Risk = Hazard x Vulnerability"

using the hazard map and the vulnerability indices.

Hazards and vulnerabilities make up risk. The indices for hazards and vulnerabilities are shown below. Each index is derived or calculated using basic data gathered from various sources of information

Disaster Type	Hazard Indices	Vulnerability Indices
Drought	Mean Annual Precipitation Precipitation Index Vegetation Condition Index	Population Density Crop yields

The output of vulnerability and impact assessment should include the following:

- identification of affected sectors and group
- identification of types of direct drought impacts

- assessment of expected damages caused by disaster (drought)
- ranking of the impacts i.e. identification of the prioritized impacts
- identification of potential areas prone to drought impacts, hazards and risk mapping those areas

Drought's risk and vulnerability and assessments are very critical and complex issues. This could be influenced by technical and social factors, for example, perceptions, human and technical capacities. A better understanding the risk of drought impacts will assist in proactive drought management practices that are more effective than reactive, crisis-based approaches of the past.

4.3.3. Drought Preparedness Response and Relief

PMD will monitor the following parameters that may indicate onset of drought conditions:

- Precipitation and Dry spell
- Remote sensing based Vegetative Indices
- Soil Moisture Based Indices
- Hydrological Indices

The following establish as 'early warning indicators':

- Delay in onset of Monsoon.
- Dry Spell during the Monsoon season
- Insufficient rains and skewed spatial distribution
- Absence of rising trend in reservoir levels and depletion of ground water
- Drying up of water sources in the desert areas
- Declining trend in the progress of sowing as compared to total area
- Migration of human populations and livestock
- Increase in deployment of water through tankers.

All disaster events are chaotic and dynamic, resulting in physical, emotional, and social disturbances. "Response measures are those that are implemented immediately during and after a disaster." Such measures are aimed at saving lives, alleviating suffering, protecting property, and dealing with the disaster's immediate damage. "Response operations are frequently required to be carried out in disruptive and sometimes traumatic environments. They are frequently difficult to implement and place significant demands on personnel, equipment, and other resources. '

Disaster preparedness and response capabilities should be developed at all levels of government as well as by communities. In addition to adequate evacuation routes, emergency shelters, and emergency stockpiles of food, water, and medicines, efforts must be made to ensure reliable communication systems and efficient operating procedures in disaster-affected areas.

Therefore, without systematic planning, dedicated team and organization, and operations are unlikely to succeed. Fig. 18 shows the classification of response phases.

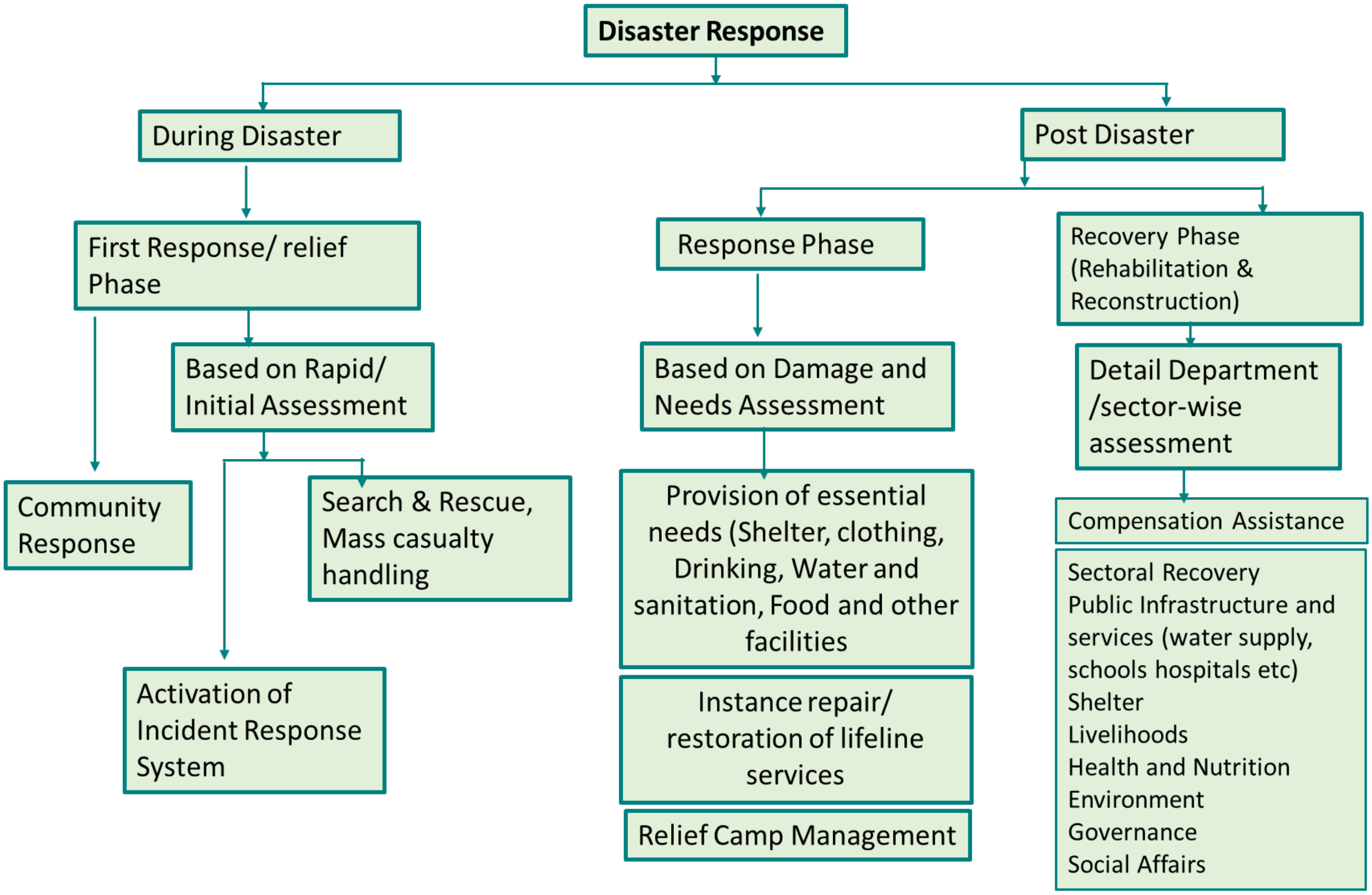


Fig. 18: Disaster Response Phases

4.3.3.1. Institutional Response

The implementation of drought response and relief measures are initiated by following the drought declaration. Because drought is a complex phenomenon, the response and relief measures frequently require sector-specific planning and extensive inter-departmental coordination. These measures must be implemented quickly and strategically in order to have the greatest impact on alleviating the hardships caused by drought for the local community.

The primary responsibility carrying out rescue, relief and recovery measures during drought conditions lies with the Cholistan Development Authority. If the requirement of resources for responding to an emergency exceeds, the local availability, then the support will be sought in the following order:

- District
- State
- International Agencies

Stakeholder participation will be sought, as will a coordinated approach at all levels between government and non-government agencies for emergency response.

4.4. Drought-Ready Communities

Drought awareness is limited and institutional capacities are inadequate for promoting public awareness and strengthening the capacities of the Cholistani people, local institutions, and all those stakeholders involved in decision-making in Cholistan.

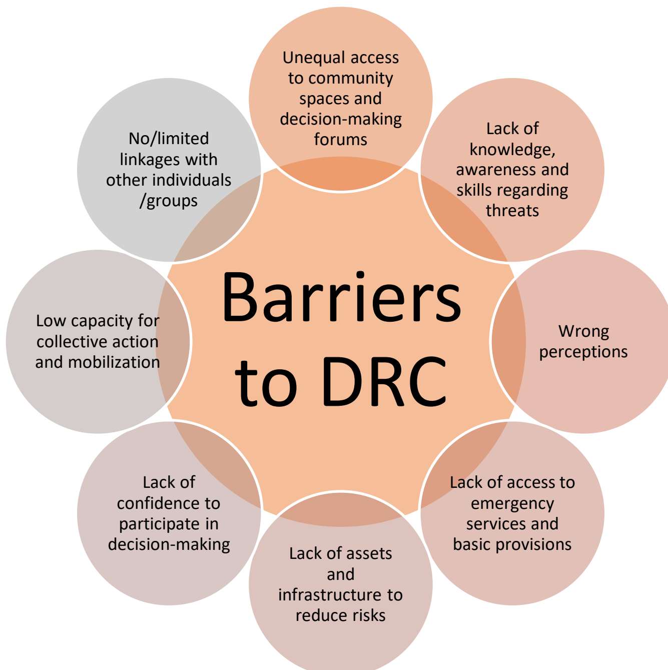


Fig. 19: Existing barriers in Cholistan with respect to Drought-Ready Community

The increasing frequency and intensity of droughts in the Cholistan are evident that a drought-ready community is essential. This section is focusing on the awareness-raising and capacity-building plan of key stakeholders of the Cholistan for effective and inclusive disaster risk reduction in the region. The plan will ensure meaningful participation and leadership of all stakeholders including the local community and vulnerable groups on drought-related risks, issues, and barriers, followed by an approach for disaster risk reduction and management. It will also provide a specific training plan for the representatives from emergency services, meteorological department, private sector, NGOs/CBOs, Cholistan Development Authority, district officers of Provincial Disaster Management Authority, Livestock, Agriculture, Forest, EPA, P&DB South Punjab, etc. These capacity-building sessions will help them to articulate and implement this drought management plan.

The plan for 'Drought-Ready Community' is as follows;

4.4.1. Pre-Risk

Droughts affect the local community either directly or indirectly depending on their severity, spatial extent, and duration along with the exclusive social and economic aspects of the community. Therefore, an activity engagement and awareness-raising process of the local community will be initiated by CDA before any potential threat of droughts. Pre-Risk awareness activities will include;

- Understanding of localized issues, vulnerabilities, and traditional adaptation practices of Cholistanis
- Sharing of potential risks to the local community (including vulnerable groups) based on drought hazard profile of previous years
- Information dissemination on drought preparedness & mitigation in local language

Information on the location of nearby tobas, kunds, hand pumps, or any other water source	Early Warning Signs and their meanings	Water Conservation and Storage Options	Information on the crops requiring less water
Food grains & fodder Storage and Food Preservation Options	Health risks management (Considering vulnerable populations)	Crisis Management Information	Traditional knowledge and practices

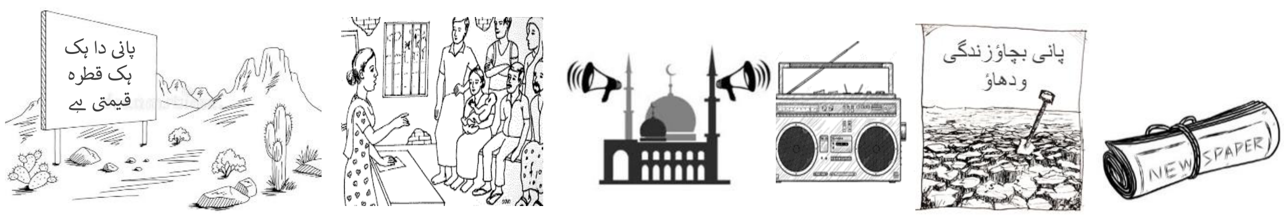


Fig. 20: Possible means of Information Dissemination

4.4.2. During Risk

To increase the drought readiness and to minimize the devastating impacts of droughts, following information will be readily available by CDA during the drought episode;

- Location of filled Tobas, Kunds, IPS, Tube wells
- Location and timing of water tankers
- Location of RO filter plants
- Location of animal shelters and water facilities
- Availability of relief materials and health camps
- Safe hygienic practices and sanitation

4.4.3. Post-Risk

After the advent of drought, it is important for CDA to arrange a review work shop to evaluate the community inclusiveness, awareness level, and participation in drought reduction and management process. This may cover following aspects;

- How well the community was prepared?
- What statistical analysis says about the loss of human and animal lives and livelihood?
- What is the status of water infrastructure?

- What areas are still underserved?
- What were the missing links and barriers?
- What were the issues raised during the drought?
- What else could be done and How?

This will enable CDA to identify the loop holes and success factor and critically propose the improvements in the existing plan and approach to develop drought-ready community in Cholistan.

4.5. Monitoring of the Plan

The NDMA will be responsible for updating and monitoring the Plan on an annual basis using drought indicators, along with DDMA. If a situation arises that necessitates a change in the Drought Management Plan, NDMA will be responsible for upgrading and/or revising the Plan with the participation of relevant stakeholders. The Plan must be revised and approved by the NDMC. Beside this micro-level monitoring and evaluation, individual projects must have their own built-Monitoring and Evaluation mechanism.

PREVENTION & MITIGATION

Due to the dearth of water resources in the region, life becomes miserable in Cholistan desert which is a vast territory, covering area of as much as 26,000 km^2, Water scarcity remains fundamental problem for human and livestock population as most of the groundwater is saline and undrinkable. Seepage water from irrigation canals & rainfall are the main sources of water in the region. As mentioned in detail in the previous section that orthodoxically water bodies which are used in Cholistan which includes Tobas and Kunds and any other such water carrying body which is dependent upon precipitation are highly unreliable and unhygienic however 20% of the total water demand is dependent upon these sources as it is considered adequate for freestyle roaming and grazing of livestock and preference of few desert dwellers for water from Tobas and Kunds. Keeping in view the afore-stated situation, there is dire need of extension of the pipeline and augmentation of Tube wells and delivery points i.e., Low-Level Reservoir (LLR). As such, following is the extension & improvement plan of water supply system in Cholistan which will help mitigate any unfortune events such as drought. Drought Prevention and Mitigation interventions are planned in two phases termed as Immediate and Long-term Plan.

Table 9: Prevention and Mitigation Strategy

Intervention Term	Planning Horizon	Strategy	Measures
Immediate	Up to year 2025 (3 Years)	▪ Drought Mitigation Measures for highly susceptible areas	▪ Rehabilitation and Repairment of Existing 6 Schemes ▪ Provision of RO Plants
Long-term	Up to Year 2050 (28 Years)	▪ Prevention Measures as a long-lasting solution	▪ Extension of Water Supply Services to the unserved hamlets in deep desert ▪ Reinforcement of Water Supply for Permanent Settlements i.e., Villages ▪ Development of Water Resources for desert area

5.1. Immediate Plan

Immediate Plan of Water Supply is focused on following and Implementation period for this immediate plan is opted as 3 years (up to 2025).

- Rehabilitation of existing water supply infrastructure
- Provision of RO Plants for severely drought affected areas

5.1.1. Rehabilitation & Repairment of Existing Schemes

Rehabilitation of current existing schemes is much needed intervention and have a pivotal role to diminish the water crisis. Rehabilitation and repair of the civil and electro-mechanical components of the existing malfunctioned assets is required in order to make them functional / operational by 2025. A very compressive & rigorous process was adopted to conclude rehabilitation interventions and are mentioned with detail in the following table.

Rehabilitation of current existing schemes is much needed intervention and have a pivotal role to diminish the water crisis. Rehabilitation and repair of the civil and electro-mechanical components of the existing malfunctioned assets is required in order to make them functional / operational by 2025. A very compressive & rigorous process was adopted to conclude rehabilitation interventions and are mentioned with detail in the following table.

Table 10: Rehabilitation of Existing schemes

Sr. #	Project	Infrastructure provided	Project Cost (Millions PKR)
1	Mirgarh to Choori	▪ Repair Tube Wells (05 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Repair / Replacement of Low Level Reservoir (LLR No's 08) ▪ Repair of Intermediate Pumping Station (IPS No's 01) ▪ Maintenance of Generator 250 Kva and Transformer	244
2	Khutri Dahr to Tufana	▪ Repair Tube Wells (01 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Replacement of Low Level Reservoir (LLR No's 07) ▪ Repair of Intermediate Pumping Station (IPS No's 01) ▪ Maintenance of Generator 250 Kva and Transformer	97
3	Kudwala to Banna Post	▪ Repair Tube Wells (10 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Repair/Replacement) of Low Level Reservoir (LLR No 11) ▪ Repair of Intermediate Pumping Station (IPS No 05) ▪ Maintenance of Generator 200 Kva and Transformer	172

4	111 DNB to Nawankot Gurara	▪ Repair Tube Wells (08 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Replacement of Low Level Reservoir (LLR No's 10) ▪ Repair of Intermediate Pumping Station (IPS No's 03) ▪ Maintenance of Generator 250 Kva and Transformer	191
5	108 DB to Bhijnot / Khalri	▪ Repair Tube Wells (11 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Replacement of Low Level Reservoir (LLR No's 15) ▪ Repair of Intermediate Pumping Station (IPS No's 04) ▪ Maintenance of Generator 250 Kva and Transformer	233
6	WS Scheme Sourian	▪ Replacement Tanks to Tube Wells (04 NF) 0.25 Cusecs ▪ Repair of Water Supply Line ▪ Replacement of Low Level Reservoir (LLR No's 16) ▪ Replacement Intermediate Pumping Station (IPS No's 07) ▪ Maintenance of Generator 250 Kva and Transformer	279
Total cost (including PST and Contingencies)			**1,222**

5.1.2. Reverse Osmosis (RO) Filtration Plant

Gigantic area of Cholistan encompass around 26,000 km^2 under its jurisdiction. Most of the area lacks drinkable water and carries high Total Dissolved Solids (TDS) in underground water which can be only be filtered through RO plants. Essence of RO plants have also been felt during April & May 2022 drought in the region of Cholistan. Officials of Cholistan Development Authority (CDA) has mentioned the need of RO Plants in below-mentioned hamlet settlements. Most of these hamlets are in Greater Cholistan and lies near Indian Border. Given these circumstances, RO plants can play a crucial role in unfortunate situations like droughts. The Urban Unit based on its GIS imagery has assessed the need of RO plants and has concluded that 31 of these 34 locations have no Water Supply scheme in 5km of their vicinity. 2 of these locations have no settlement cluster near them hence they along with 1 location where existing Canal network exists are excluded from recommendation list. However, 9 locations are added by the Urban Unit based on the unavailability of piped water supply for major settlements in the desert. Total proposed sites by the Urban Unit are 40 whereas 34 sites are shortlisted by the CDA. The proposed locations of RO with varying scope in both cases are referred herein as Option-I (Urban Unit recommendation) and Option-II (CDA recommendation).

Table 11: RO Plants Summary

Options	Scope	Cost (Million)	Total Cost (Million)
Option-I	▪ 40 RO Plants ▪ Up to 5,000 ppm (subject to Electric Resistivity (ERS) survey)	18 @ 40 RO	≈720

Recommendation by the Urban Unit	▪ LLR like platform i.e. GST (20k Gallons), water taps for human, trough for livestock with shed ▪ Solar powered ▪ RO Filtration Room ▪ Toba for livestock		
Option-II Recommendation by Cholistan Development Authority (CDA) officials	▪ 17 RO plants for 5,000 ppm TDS ▪ 17 RO plants for 35,000 ppm TDS ▪ Caterpillar Generator of 100 KVA/ 80 KW ▪ Solar powered ▪ Generator Room with integrated operator room ▪ LLR like platform i.e. GST (20k Gallons), water taps for human, trough for livestock with shed ▪ Landscape/plantation ▪ Tuff pavers on walkways ▪ Boundary wall with gate ▪ NOTE: Afore-defined scope and working done under the Option-II is initiative of CDA and has been conducted as per the direction of CDA official (Executive Engineer)	43.8 @ 17 RO & 30.4 @ 17 RO	≈1,260

4.1.1.1. The Process

In this water purification process, semi-permeable membrane is used to filter the unwanted molecules and large particles such as contaminants and sediments like chlorine, and salts, which causes high TDS and particles causing high Total Suspended Solids (TSS) in water. Reverse osmosis removes contaminants from unfiltered water, or feed water, when pressure forces it through a semipermeable membrane. Water flows from the more concentrated side of the RO membrane to the less concentrated side and in-turn produces drinkable water (permeate).

i. Prefiltration typically includes a carbon filter and a sediment filter to remove sediment and chlorine that could clog or damage the RO membrane
ii. In the next phase, water goes through the reverse osmosis membrane where dissolved particles, even too small to be seen with an electron microscope, are removed
iii. After filtration, water flows to the storage tank, where it is held until needed. A reverse osmosis system continues to filter water until the storage tank is full and then shuts off. In this case due to high water demand, GST of 20,000 Gallon is provided which will also be filled with filtered water
iv. This GST can now provide water to Human platform and to their Livestock through faucet, trough and Toba

4.1.1.2. Recommendation on the Process

Table 12: Recommendation on process

Downside of RO	Recommendation
Doesn't removes Bacteria	UV disinfection & Chlorinators should be installed with it
Water Production is less	Mixing of RO filtered water is possible and can be done with water of High TDS to setup a proportion of mixing and can be used for both Human and Livestock. Some mineral contents are fine and even beneficial to drink, but the PHED (Design Criteria 1998) recommends that the amount of TDS in water not exceed 1500 mg/l. WHO (Drinking Water Standard 1984) adopts 1000 mg/l for TDS. As such, appropriate mix ratio can be defined after testing of filtered water and as per requirement
Removes beneficial minerals like calcium and magnesium from water	As Above

4.1.1.3. Proposed Locations

Following areas of Cholistan are reported to be the most seriously affected in latest drought in 2022 and hence 34 hamlets in Cholistan desert area are shortlisted by CDA for RO plants provision.

The Urban Unit based on its GIS imagery has assessed the need of RO plants and has concluded that 31 of these 34 locations have no Water Supply scheme in 5km of their vicinity. 2 of these locations have no settlement cluster near them hence they along with 1 location where existing water supply schemes exists are excluded from recommendation list.

In addition to it, 9 locations are further added where water supply schemes are far-distanced i.e. 6 to 33kms and hence due to dire need of water, RO plant provision is suggested.

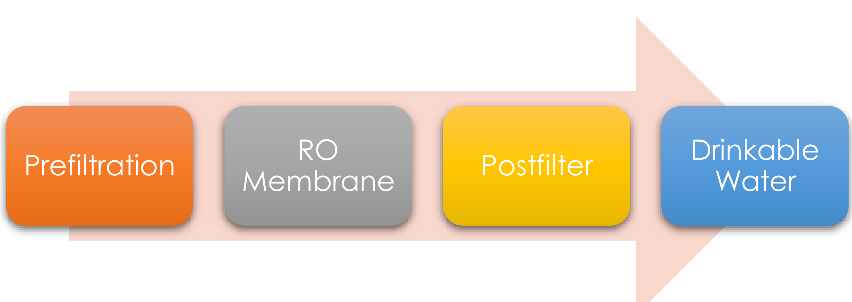


Table 13: Detail of proposed RO Plants

Sr. #	Settlement Name	Human Population	Livestock Population	Coordinate (X)	Coordinate (Y)	Option -I Urban Unit	Option-II CDA	Remarks
1	Bijnot – 1	2000	12000	71.681413	28.089981	Proposed	Proposed	Location is 16 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot and settlement Size is high
2	Bijnot – 2	2000	12000	71.681413	28.089981	Proposed	Proposed	Location is 16 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
3	Ahmed Wala	400	9000	71.898127	27.975906	Proposed	Proposed	Location is 23 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
4	Bitryan	850	15000	71.781723	28.150242	Proposed	Proposed	Location is 13 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot

5	Kheer Sar	1050	15000	71.582501	28.405197	Proposed	Proposed	Location is 6 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
6	Nawan Khu	200	6000	71.862984	27.961383	Proposed	Proposed	Location is 26 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
7	Laraan Wali	250	6000	72.597429	28.983881	Proposed	Proposed	Location is 10 km away from WS Scheme: Mirgarh to Chori
8	Saan	400	8000	71.954863	28.588177	Proposed	Proposed	Location is 15 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
9	Misri Wala	300	7000	71.754432	28.1788	Proposed	Proposed	Location is 8 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot

10	Din Garh	1600	20000	71.921366	28.975676	Proposed	Proposed	Location is 12 km away from WS Scheme: Kudwala to Banna Post
11	Wanjohar	1000	12000	72.092066	28.377246	Proposed	Proposed	Location is 20 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
12	Saans	200	8000	71.855025	28.136586	Proposed	Proposed	Location is 12 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
13	Rukan Pur	600	12000	72.044444	28.395833	Proposed	Proposed	Location not shared with the Urban Unit
14	Kurai Wala	200	8000	71.955511	28.4165	Proposed	Proposed	Location is 14 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot

15	Lakhu Wala	150	6000	72.181173	28.79067	Proposed	Proposed	Location is 13 km away from WS Scheme: Khutari Dahar to Tofana
16	Kaki	100	5000	71.410172	27.885979	Proposed	Proposed	Location is 28 km away from WS Scheme: 111/DB to Nawankot and Gurara
17	Chillan	500	8000	71.779179	28.133117	Proposed	Proposed	Location is 15 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
18	Jogi Das	200	3500	71.244217	27.911062	Proposed	Proposed	Location is 35 km away from WS Scheme: Sourian
19	14. Khoi	100	3000	71.223611	28.953611	Not Proposed	Proposed	Irrigation Network exists in the area

20	Sarwar Chowk	200	6000	70.746963	28.15511	Proposed	Proposed	Location is 4 km away from WS Scheme: Sourian but direct canal supply is posing hinderance along with on-going rehab.
21	Toba Kandaira	150	4000	70.649705	27.968596	Proposed	Proposed	Location is 6 km away from WS Scheme: Sourian
22	Dadi Karam Khatoon	300	7000	70.532075	28.036471	Proposed	Proposed	Location is 12 km away from WS Scheme: Sourian
23	Tamachi Wala	100	3000	70.20207	27.882588	Proposed	Proposed	Location is 50 km away from WS Scheme: Sourian
24	Sokhera Wala Khu	250	4500	70.675078	27.941776	Proposed	Proposed	Location not shared with the Urban Unit
25	Bachay Wala	100	3000	71.0826	27.865258	Proposed	Proposed	Location is 21 km away from WS Scheme: Sourian

26	Toba Bairseen Wala	150	4000	71.12267	27.952108	Proposed	Proposed	Location is 23 km away from WS Scheme: Sourian
27	Laraan Wali	200	6000	71.540404	27.899788	Proposed	Proposed	Location is 33 km away from WS Scheme: 111/DB to Nawankot and Gurara
28	Modi	150	4000	72.880646	29.082273	Not Proposed	Proposed	Location is 20 km away from WS Scheme: Mirgarh to Chori but no settlement is detected
29	Palwanian Wala	100	3000	72.382583	28.91871	Proposed	Proposed	Location is 12 km away from WS Scheme: Mirgarh to Chori

30	Ludhar Wala	100	4000	72.367122	29.527269	Not Proposed	Proposed	Location is 12 km away from WS Scheme: Kudwala to Banna Post to Chori but no settlement is detected
31	New Proposed Settlement - 1	-	-	71.898435	28.876073	Proposed	Not Proposed	Location is 13 km away from WS Scheme: Khutari Dahar to Tofana
32	New Proposed Settlement – 2	-	-	72.24096	28.668244	Proposed	Not Proposed	Location is 14 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
33	New Proposed Settlement – 3	-	-	71.357749	28.053383	Proposed	Not Proposed	Location is 14 km away from WS Scheme: 111/DB to Nawankot and Gurara
34	New Proposed Settlement – 4	-	-	70.847494	28.44457	Proposed	Not Proposed	Location is 14 km away from WS Scheme: Sourian

35	New Proposed Settlement – 5	-	-	71.142192	28.548153	Proposed	Not Proposed	Location is 19 km away from WS Scheme: 111/DB to Nawankot and Gurara
36	New Proposed Settlement – 6	-	-	71.947304	28.751672	Proposed	Not Proposed	Location is 9 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
37	New Proposed Settlement – 7	-	-	72.061556	29.169981	Proposed	Not Proposed	Location is 10 km away from WS Scheme: Kudwala to Banna Post
38	New Proposed Settlement – 8	-	-	71.839809	28.942127	Proposed	Not Proposed	Location is 13 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
39	New Proposed Settlement - 9	-	-	71.887151	29.01908	Proposed	Not Proposed	Location is 13 km away from WS Scheme: Kudwala to Banna Post

40	Lakhmali	300	10000	71.206389	28.722222	Proposed	Proposed	Location is 20 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
41	Janay Wala	250	6000	71.865181	28.504183	Proposed	Proposed	Location is 6 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
42	Hansi	400	7000	71.630484	28.749169	Proposed	Proposed	Location is 13 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
43	Khan garh	150	3000	71.716667	28.363889	Proposed	Proposed	Location is 9 km away from WS Scheme: 108/DB to Rasoolsar & Bijnot
						40	34	

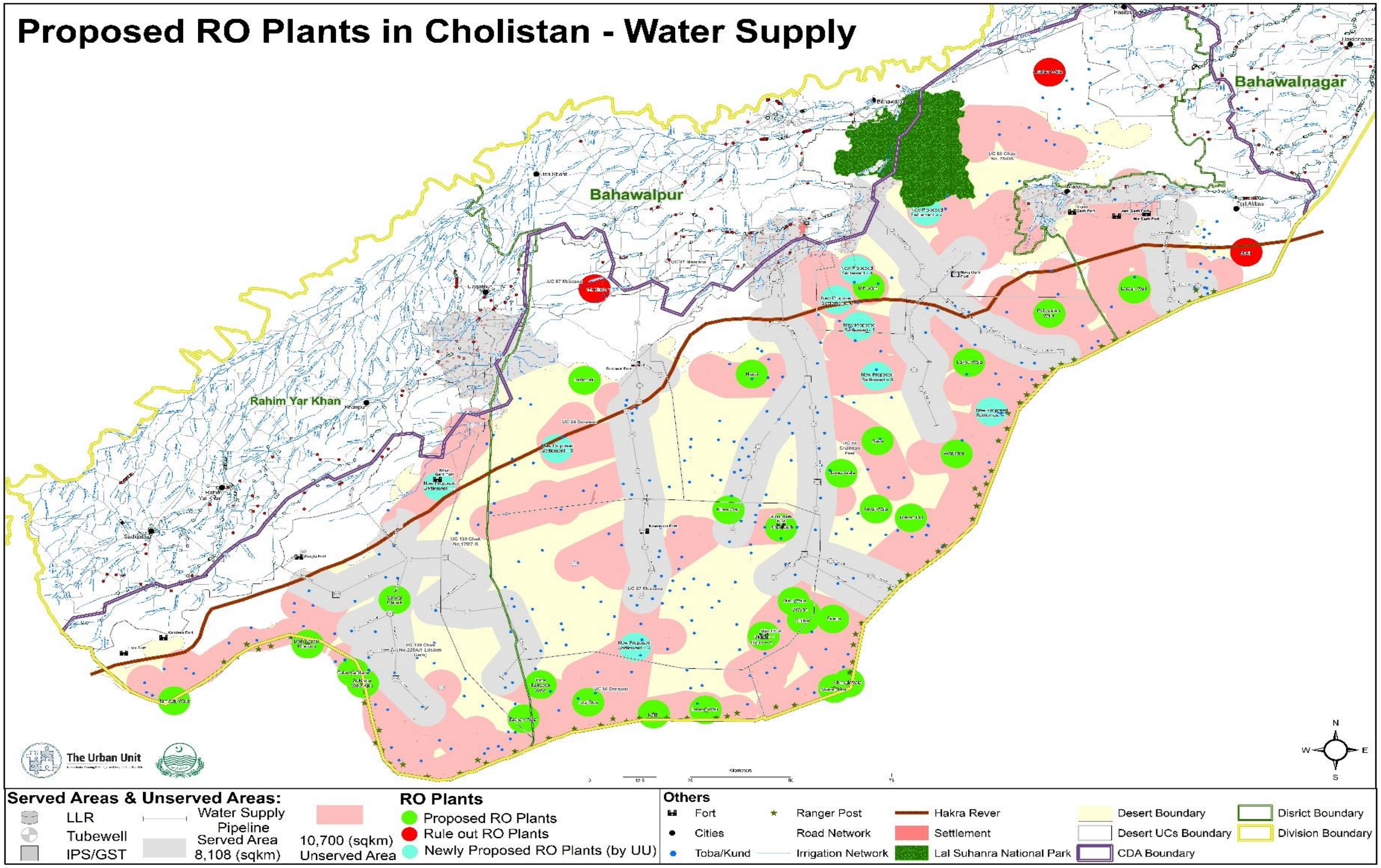


Fig. 21: GIS Map of RO Sites

4.1.1.4. Estimated Electric Load Calculations

The capacity of the RO plant, the TDS value of the water, and other factors influence the power consumption of the filtration plant. Increases in the capacity of the filtration plan or the TDS value of the water will result in an increase in power consumption. Apart from the RO filtration plant, there will be a main submersible pump to supply water to filtration plant and a 5-kW auxiliary load. Estimated load profile of individual filtration plants is given in the tables below.

Option I

In option 1, 37 RO Filtration plants of capacity 5000 LPH @ 5000 TDS are proposed by The Urban Unit along with boring pump for raw water. These filtration plants are proposed to be powered by solar system. Estimated load profile of individual filtration plants according to vendor quotation is given below.

Table 14: Option I Load Calculation (5000 ppm TDS)

Estimated Load profile for a 5000 LPH RO filtration plant @5000 TDS		
Sr. No	**RO Filtration Plants Components**	**Estimated Load (watts)**
1	RO Filtration Plants (5000 LPH, 5000 TDS)	15000
2	Raw Water Pump (7.5 hp)	5592
3	Auxiliary load (5 kW)	5000
Total Load		**25592**

Option II

In option 2, 34 RO Filtration plants of capacity 5000 LPH @ 5000 TDS and 5000 LPH @ 35000 are proposed by CDA. Out of these 34 filtration plants, 50 % would be of capacity 5000 LPH @ 5000 TDS and remaining 50 % filtration pants would be of capacity 5000 LPH @ 35000. These filtration plants are proposed to be powered by solar system and a generator as well. Load profile of these filtration plants according to vendor quotation is given below.

Table 15: Option II - Load Calculation (5000 ppm TDS)

Estimated Load profile for a 5000 LPH RO filtration plant @5000 TDS		
Sr. No	**RO Filtration Plants Components**	**Estimated Load (watts)**
1	RO Filtration Plants (5000 LPH, 5000 TDS)	15000
2	Raw Water Pump (7.5 hp)	5592

3	Auxiliary load (5 kW)	5000
Total Load		**25592**

Table 16: Option II - Load Calculation (35000 ppm TDS)

Estimated Load profile for a 5000 LPH RO filtration plant @ 35000 TDS		
Sr. No	**RO Filtration Plants Components**	**Estimated Load (watts)**
1	RO Filtration Plants (5000 LPH, 35000 TDS)	29000
2	Raw Water Pump (10 hp)	7460
3	Auxiliary load (5 kW)	5000
Total Load		**41460**

4.1.1.5. Calculation of Solar System

The assets intended to be powered by solar energy and technical estimates to meet the power requirement of the filtration plant are listed in the tables below. Solar system will provide energy to these assets for almost 5.5 hours per day.

Option 1

Table 17: Option I Solar System Calculation 5000 ppm TDS

Technical Calculations for Solar System (5000 TDS)					
Sr. No.	**RO Filtration Plants Components**	**Rough load Profile (Watts)**	**Tentative Solar System required to power RO Plant (Watts)**	**No of PV modules required**	**Annual Units (kWh) generation by Solar system**
1	Raw Water Pump (7.5 hp)	5,593	7270.6	13.5	11996.4
2	RO Filtration Plants (5000 LPH, 5000 TDS) + Auxiliary Load	20,000	24500	45.4	40425
Total			**31770.6**	**58.8**	**52421.4**

Option 2

Table 18: Option II Solar System Calculation 5000 ppm TDS

Technical Calculations for Solar System (5000 TDS)					
Sr. No.	**RO Filtration Plants Components**	**Rough load Profile (Watts)**	**Tentative Solar System required to power RO Plant (Watts)**	**No of PV modules required**	**Annual Units (kWh) generation by Solar system**
1	Raw Water Pump (7.5 hp)	5,593	7270.6	13.5	11996.4
2	RO Filtration Plants (5000 LPH, 5000 TDS) + Auxiliary Load	20,000	24500	45.4	40425
Total			31770.6	58.8	52421.4

Table 19: Option II Solar System Calculation 35000 ppm TDS

Technical Calculations for Solar System (35000 TDS)					
Sr. No.	**RO Filtration Plants Components**	**Rough load Profile (Watts)**	**Tentative Solar System required to power RO Plant (Watts)**	**No of PV modules required**	**Annual Units (kWh) generation by Solar system**
1	Raw Water Pump (10 hp)	7,460	9698	18.0	16001.7
2	RO Filtration Plants (5000 LPH, 35000 TDS) + Auxiliary Load	35,000	42700	79.1	70455
Total			52398	97.0	86456.7

RO Filtration Plant with 20,000 Gallons GST, Human Drinking platform, Shade for livestock trough & Solarization – Option - I

Fig. 22: Option I RO Filtration Plant – 3D view

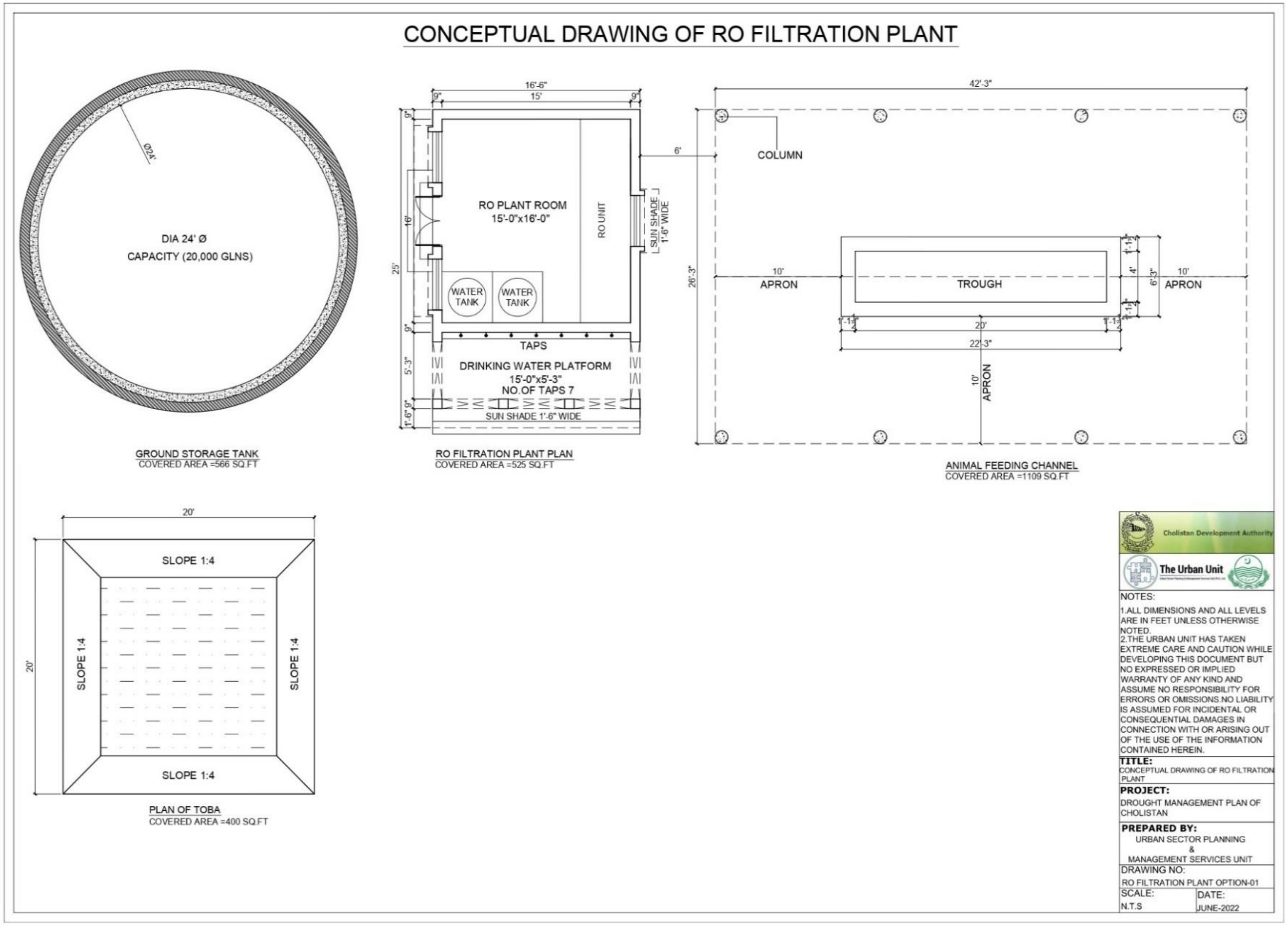


Fig. 23: Option I RO Filtration Plant – Layout Plan

RO Filtration Plant with Generator Room 20,000 Gallons GST, Human Drinking platform, Shade for livestock trough & Solarization – Option - II

Fig. 24: Option II RO Filtration Plant – 3D view

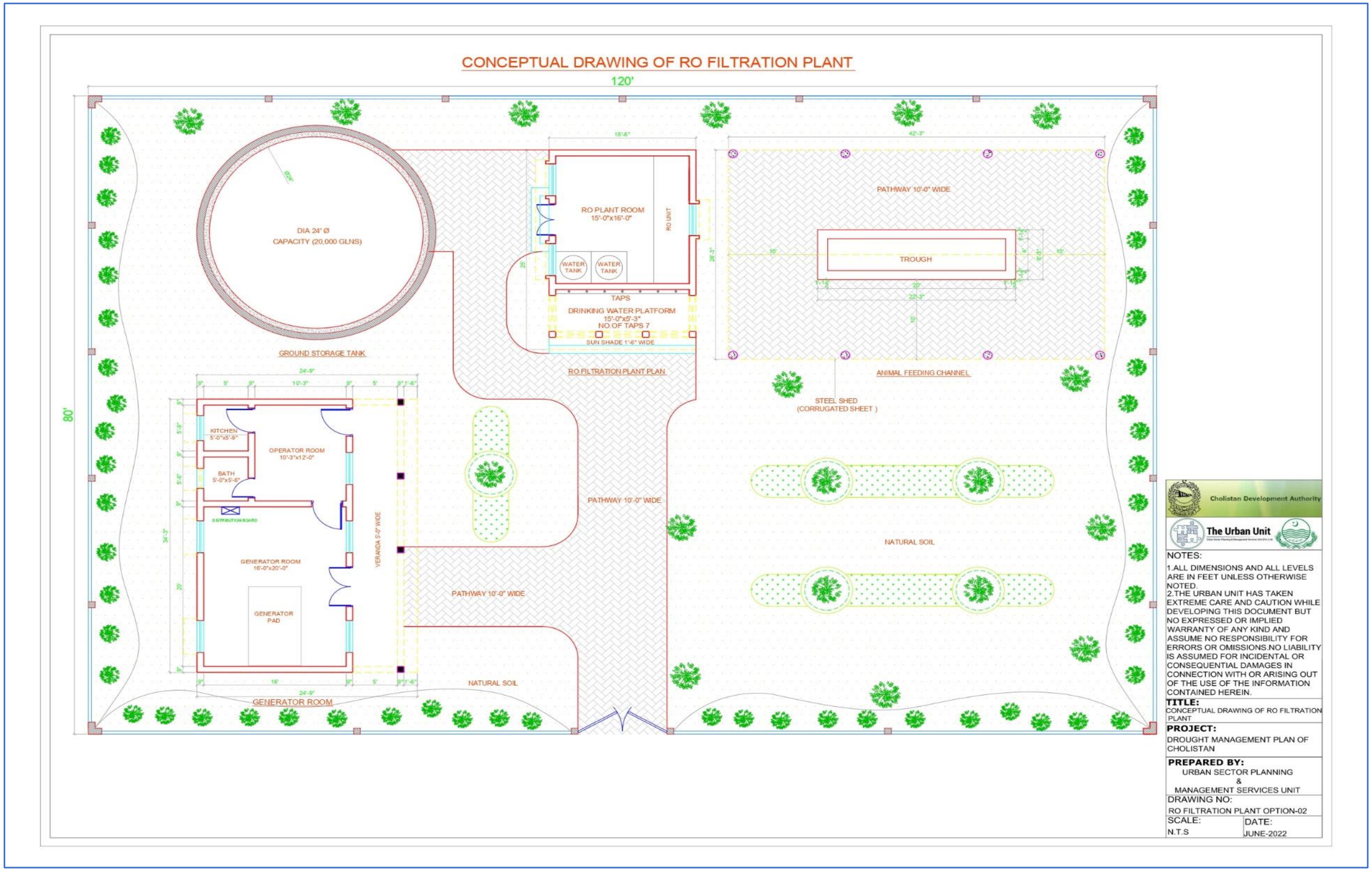
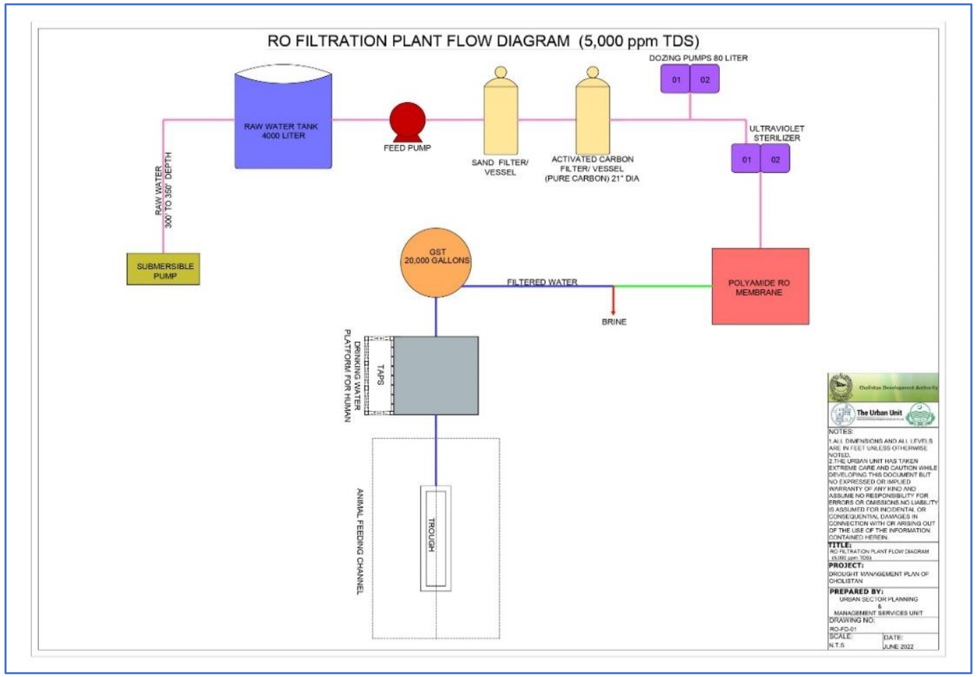
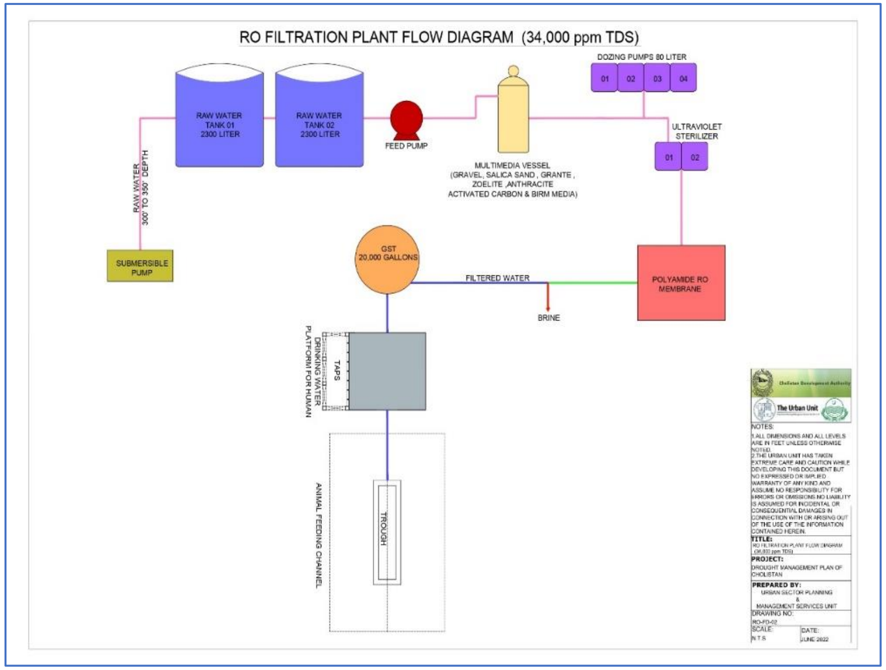


Fig. 25: Option II RO Filtration Plant – Layout Plan





(5,000 ppm TDS) RO Plant

(35,000 ppm TDS) RO Plant

Fig. 26: Filtration Process Flow Diagram

5.2. Long Term Expansion & Extension Plan

5.2.1. Water Supply Schemes Extension

Having goals of preventing and mitigating the drought and to normalize life in the desert and provide stability w.r.t. water availability in all the areas of Cholistan, the extension and expansion plan has been planned for scattered settlements residing in the deep desert or hamlets, as well as for the permanent settlements. In order for detail analysis and due to complexity of the gigantic region, and varying population density in various districts of Cholistan, Zones has been formed and interventions are further bifurcated for desert hamlets and for Chaks/Villages separately. Planning horizon set for these long-term expansions is 28 years (up to 2050) in 2022.

Detail of these four (04) Zones is described below:

Table 20: Detail of Zones

ZONING					Summation
District	Bahawalnagar	Bahawalpur		Rahimyar Khan	3
Zone Serial	1	2	3	4	4
UC (ex) name	Mir Garh	Channan Peer & 75/DB	Derawar & Meerana	Islam Garh & 178/7-R	7
CDA Existing Schemes Number	1	3	1	1	6
CDA Existing Schemes Name	• Mir Garh to Choori	▪ Kutri Dahar to Tufana ▪ Kudwala to Banna ▪ 108 DB to Rasoolsar	▪ 111 DNB to Nawan Kot/ Gurara	• Surian	6
Human population (2050)	76,691	117,044	122,069	172,826	488,630
Livestock population (2050)	810,869	2,260,231	215,758	951,585	4,238,443
Areas (km^2)	1,210	11,050	7,470	5,200	≈26,000

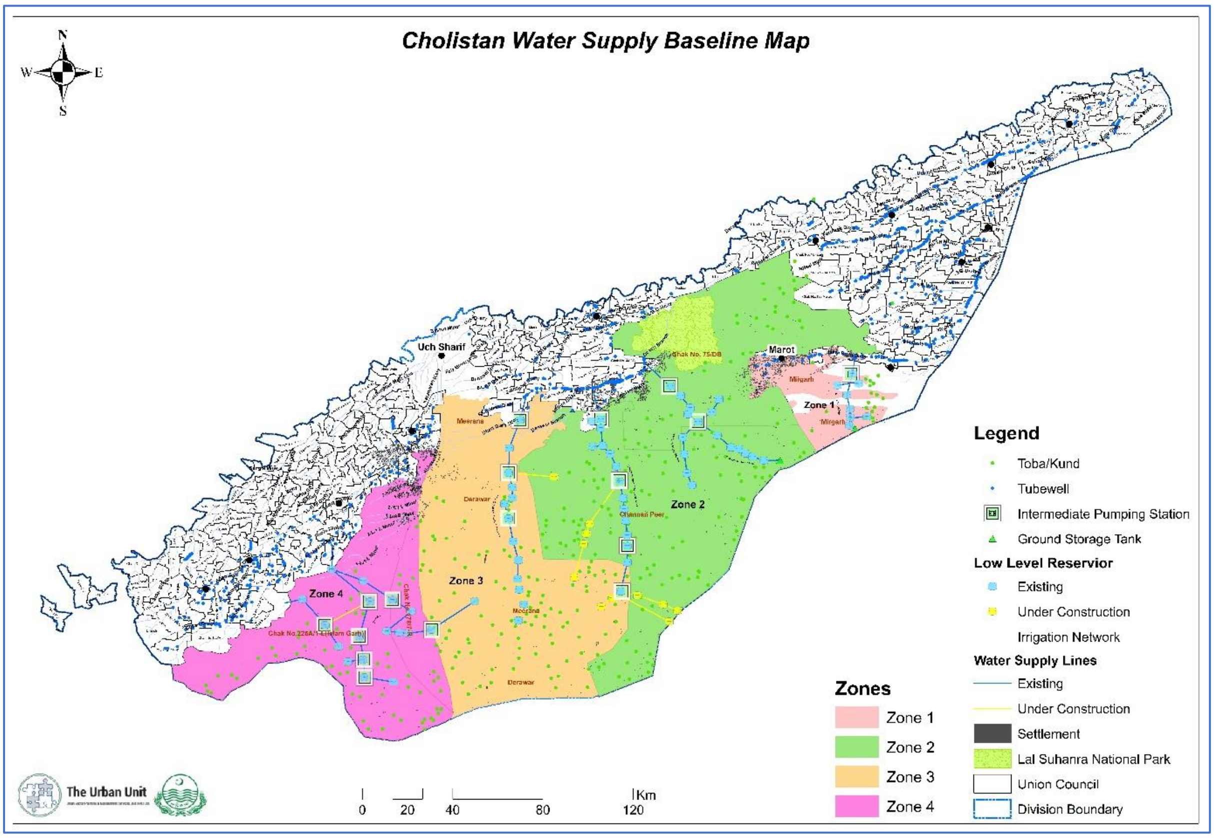


Figure 21: Water Supply Baseline Map of Cholistan

Zone – 1 (Mir Garh)

Below map shows the area which is referred to as ZONE – 1 in this report. This Zone lies in the Bahawalnagar district area under the (ex) UC known as MIR GARH.

Population Projection (Zone-1)

Detail of water demand is mentioned in the table below:

Table 21: Population projection - Zone 1

UC Name	Human population (2017)	Livestock population 2017 (CDA)	Human population 2050 (Projected)	Livestock population 2050 (Projected)
Mir Garh	40,811	264,249	76,691	810,869

Water Demand (Zone-1)

As mentioned in the table above, water demand is calculated based on aforementioned demands of both Humans and the Livestock for the Long-term planning periods (2050).

Table 22: Water Demand - Zone 1

Human Water Demand of Year 2050 (Including Tourists)	Livestock Water Demand of Year 2050	Total Water Demand in Year 2050	80% of Total Water Demand to be based on Water Supply Schemes
(M.D.D.)	(A.D.D.)	(INCLUDING 20% INFILTRATION)	(INCLUDING 20% INFILTRATION)
MGD	MGD	MGD	MGD
1.52	6.59	8.11	6.49

Intervention for deep desert area (Zone-1)

Following intervention have been made for desert areas in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand.

Table 23: Intervention desert settlements - Zone 1

Current Schemes Yield	Current Schemes Yield (After Rehab in Short Term)	Deficit	Target set to meet for desert areas	Intervention
MGD	MGD	MGD	MGD	16 Tubewells of 0.50 Cusecs provided
0.18	0.62	3.48	2.50	

Extension of Current Scheme (Zone-1)

Since this Zone (1) already possess one (1) existing scheme in the region (MIR GARH TO CHOORI). Extension of this scheme is done based on future demand of the scheme i.e. in year 2050. The year 2050 demand has been considered for the planning of extension in order to make plan cost effective and to avoid upgrading the infrastructure (i.e. Pipe Dia.) after each term. Pumps working hours can be reduced as per the demand of the region in the respective year.

Total water demand of the mentioned schemes (based on the aforementioned water demand criteria) in the year 2050 comes out to be 1.545 MGD out of which 0.62 MGD is already being provided, 12 Tubewells will be added to this existing water supply scheme in order to carter for the demand of year 2050. Extension of this scheme to new nearby unaddressed settlements is also planned which includes provision of new Tubewells (TW), Low Level Reservoir (LLR), Ground Storage Tank (GST) & Intermediate Pumping Station (IPS). These settlements are marked using LandScan of Cholistan desert. Approximate location of required infrastructure is shown in the map and can be adjusted as per the field conditions and requirement of the planning horizon period. Location of extension of the scheme is also been marked and shown in related map.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 24: Infrastructure requirement for Mir Garh to Choori – Zone 1

Infrastructure for Extension of MIR GARH TO CHOORI Scheme						
Current Yield (MGD)	Demand in 2050 (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS/GST (70,000 Gallons)	IPS/GST (100,000 Gallons)
0.62	1.54	6@0.50cusecs TW's	6	5	1	1

New Water Supply Schemes (Zone-1)

Current scheme only provides water supply for a small fraction of the total population in the area and most of the areas remains unserved for the water supply provision, as such, one (01) new scheme is planned in Medium Term Plan in order to carter for the unaddressed region.

New Scheme No. One (01) – 304/H.R. to Sand Waal Toba

This scheme is aimed at provision of water supply to the deep desert area spreading all the way to the border, plenty of settlements remains unaddressed in this region and currently extract water from the Old Hakra river bed. Scheme layout have been shown in the Map attached in the section below. Direct water supply is planned to be provided from the Hakra Canal.

Table 25: Infrastructure Requirement for New Scheme in desert – Zone 1

Infrastructure for New Scheme (#1): 304/H.R to Sand Wala Toba				
TW's	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS/GST (70,000 Gallons)	IPS/GST (100,000 Gallons)
10@0.50 cusecs TW's	13	8	1	2

This scheme is planned to be provided from 304/H.R. to Sand Wala Toba. Scheme layout have been

Intervention for permanent settlements (Zone-1)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan & Medium-term interventions are assumed to be completed and hence subtracted from the total water demand (2050).

Table 26: Intervention for Villages - Zone 1

Current Schemes Yield (After Rehab in Short Term)	Schemes Yield (Mid-term)	Deficit	Target set to meet for permanent settlemnts	Intervention
MGD	MGD	MGD	MGD	15 Tubewells of 0.50 Cusecs Provided (Out of 20 as 5 already exists in these areas)
0.62	2.5	3.37	3.50	

NEW SCHEME NO. TWO (02)

This scheme is aimed at providing water supply to the villages mentioned below however numbers shows overall requirement of these underlined areas and exact location can only be find-out after a detailed field visits and consultancies and then need-base provision. However, GIS based map is aimed at proposing them where no tube-well data was spotted in the region.

Areas considered:

Villages which are planned to be served with this scheme are:

- CHAK NO. 330/H.R
- CHAK NO. 289/H.R
- CHAK NO. 319/H.R
- CHAK NO. 327/H.R
- CHAK NO. 304/H.R
- CHAK NO. 311/H.R

Zone – 2 (Channan Peer)

Below map shows the area which is referred to as ZONE – 2 in this report. This Zone lies in the Bahawalpur district area under the (ex) UCs named as: Channan Peer and 75/DB.

Population Projection (Zone-2)

Detail of water demand are mentioned in the table below:

Table 27: Population Projection – Zone 2

UC Name	Human population (2014)	Livestock population 2017 (CDA)	Human population 2050 (Projected)	Livestock population 2050 (Projected)
Channan Peer & 75/DB	56,974	736,572	117,044	2,260,231

Water Demand (Zone-2)

As mentioned in the table above, water demand is calculated based on aforementioned demands of both Humans and the Livestock and for the Long-term planning periods (2050).

Table 28: Water Demand - Zone 2

Human Water Demand of Year 2050 (Including Tourists)	Livestock Water Demand of Year 2050	Total Water Demand in Year 2050	80% of Total Water Demand to be based on Water Supply Schemes
(M.D.D.)	(A.D.D.)	(INCLUDING 20% INFILTRATION)	(INCLUDING 20% INFILTRATION)
MGD	MGD	MGD	MGD
2.25	18.36	20.61	16.49

Intervention for deep desert areas (Zone-2)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand.

Table 28: Medium term Intervention for desert areas - Zone 2

Current Schemes Yield	Current Schemes Yield (After Rehab in Short Term)	Deficit	Target set for desert areas	Intervention
MGD	MGD	MGD	MGD	28 Tubewells of 0.50 Cusecs provided
0.8068	2.60	7.58	4.10	

Extension of Current Scheme (Zone-2)

Since this (Zone-2) already possess three (03) existing schemes in the region, named as: Kutri Dahar to Tufana, 108 DB to Rasoolsar and Kudwala to Banna and, extension of these scheme is done based on the future demand of the scheme (2050). The year 2050 demand has been considered for the planning of extension in order to make plan cost effective and to avoid upgrading the infrastructure (i.e. Pipe Dia.) after each term. Pumps working hours can be reduced as per the demand of the region in the respective year. Extension of this scheme to new nearby settlements is also planned which includes provision of new Tubewells (TW), Low Level Reservoir (LLR), Ground Storage Tank (GST) & Intermediate Pumping Station (IPS). Approximate location of required infrastructure is shown in the map and can be adjusted as per the field conditions and requirement of the planning horizon period. Location of extension of the scheme is also been marked and shown in related map.

Extension of Scheme “Kutri Dahar to Tufana”

Total water demand of the mentioned schemes (based on the aforementioned water demand criteria) comes out to be 0.842 MGD for Kutri Dahar to Tufana. Water production of 0.27 MGD is the maximum yield of the existing structure after rehab, therefore, for existing scheme of Kutri Dahar to Tufana, 1.8 MGD (from 17 seepage water Tubewells) is planned to be provided on Bahawal Canal passing from Lal Suhanra National park. The scheme will also serve settlements in CHAK NO. 75/D.B.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 29: Extension of Kutri dahar to Tufana – Zone 2

Infrastructure for Extension of KUTRI DAHAR TO TUFANA Scheme						
Current Yield (MGD)	Demand in 2050 (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS (100,000 Gallons)	IPS (200,000 Gallons)
0.27	0.842	10@0.50 cusecs TW’s	08	19	5	3

Extension of Scheme "108 DB to Rasoolsar & Bhijnot"

In year 2050, total water demand of the mentioned schemes (based on the aforementioned water demand criteria) comes out to be 1.816 MGD for 108 DB to Rasoolsar, 1.07 MGD is already being provided after rehabilitation of the existing scheme. For existing scheme named (108 DB to Rasoolsar), 1.6 MGD contribution will be made to the scheme (from 9 Tw's of 0.50 cusecs capacity) planned to be provided on Desert Branch Canal.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 30: Extension of 108 DB to Rasoolsar & Bhijnot – Zone 2

Infrastructure for Extension of 108 DB TO RASOOLSAR & BHIJNOT Scheme						
Current Yield (MGD)	Demand in 2050 (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS (70,000 Gallons)	IPS (100,000 Gallons)
1.07	1.81	9@0.50 cusecs TW's	10	14	0	3

Extension of Scheme "Kudwala to Banna"

Data of dependent humans and livestock of the Kudwala to Banna scheme was not provided by the CDA as it was launch recently but since it lies in the same region as previous schemes (Kutri Dahar to Tufana and 108 DB to Rasoolsar) so same has been applied for this scheme as well, after rehab, 1.6 MGD (from 09 seepage water TW's of 0.50 cusecs) which will be provided along Desert Branch.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 31: Extension of Kudwala to Banna Post – Zone 2

Infrastructure for Extension of KUDWALA TO BANNA Scheme					
Current Yield (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS (70,000 Gallons)	IPS (100,000 Gallons)
1.25	9@0.50 cusecs TW's	5	12	0	1

Intervention for permanent settlements (Zone-2)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand (2050).

Table 32: Interventions for villages - Zone 2

Current Schemes Yield (After Rehab in Short Term)	Medium term Intervention	Deficit	Target set to meet for desert areas	Intervention
MGD	MGD	MGD	MGD	20 Tubewells of 0.50 Cusecs provided (out of 68 as 81 of 0.25-0.50 Cusecs exists)
2.60	4.6	12.48 (3.5+8.98)	12.48	

NEW SCHEME NO. THREE (03)

This scheme is aimed at providing water supply to the villages mentioned below however numbers shows overall requirement of these underlined areas and exact location can only be find-out after a detailed field visits and consultancies and then need-base provision. However, GIS based map is aimed at proposing them where no tube-well data was spotted in the region.

Areas considered:

Villages which are planned to be served with these schemes are:

- CHAK NO. 106/D.B
- CHAK NO. 88/D.B
- CHAK NO. 67/D.B
- CHAK NO. 108/D.B
- CHAK NO. 50/D.B
- CHAK NO. 68/D.B
- KUDWALA

Zone – 3 (Derawar)

Below map shows the area which is referred to as ZONE – 3 in this report. This Zone lies in the Bahawalpur district area under the UCs named as Derawar and Meerana.

Population Projection (Zone-3)

Detail of water demand are mentioned in the table below:

Table 33: Population Projection - Zone 3

UC Name	Human population (2014)	Livestock population 2017 (CDA)	Human population 2050 (Projected)	Livestock population 2050 (Projected)
Derawar & Meerana	59,420	70,312	122,069	215,758

Water Demand (Zone-3)

As mentioned in the table above, water demand is calculated based on aforementioned demands of both Humans and the Livestock and for the Long-term planning periods (2050).

Table 34: Water Demand - Zone 3

Human Water Demand of Year 2050 (Including Tourists)	Livestock Water Demand of Year 2050	Total Water Demand in Year 2050	80% of Total Water Demand to be based on Water Supply Schemes
(M.D.D.)	(A.D.D.)	(INCLUDING 20% INFILTRATION)	(INCLUDING 20% INFILTRATION)
MGD	MGD	MGD	MGD
2.34	1.69	3.97	3.17

Intervention for deep desert (Zone-3)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand.

Table 35: Medium term Intervention – Zone 3

Current Schemes Yield	Current Schemes Yield (After Rehab in Short Term)	Deficit	Target set for desert areas	Intervention
MGD	MGD	MGD	MGD	6@0.50 cusecs TW's provided
0.4482	1.17	1.09	1.00	

Extension of Current Scheme (Zone-3)

Since this Zone (3) already possess one (1) existing schemes in the region, named as: 111/DNB TO NAWANKOT & GURARA, extension of these scheme is done based on the future demand of the scheme (2050) and extension to the unserved population in the region. The year 2050 demand has been considered for the planning of extension in order to make plan cost effective and to avoid upgrading the infrastructure (i.e. Pipe Dia.) after each term. Pumps working hours can be reduced as per the demand of the region in the respective year. Extension of this scheme to new nearby settlements is also planned which includes provision of new Low Level Reservoir (LLR), Ground Storage Tank (GST) & Intermediate Pumping Station (IPS). These settlements are marked using latest LandScan data. Approximate location of required infrastructure is shown in the map and can be adjusted as per the field conditions and requirement of the planning horizon period. Location of extension of the scheme is also been marked and shown in related map.

Extension of Scheme "111/DNB to Nawankot & Gurara"

Total water demand of the mentioned schemes (based on the aforementioned water demand criteria) comes out to be 1.047 MGD for 111/DNB TO NAWANKOT & GURARA. Water production of 1.17 MGD is the maximum yield of the existing structure after rehab, therefore, for existing scheme of 111/DNB TO NAWANKOT & GURARA, 1 MGD from 12 seepage water TW's of 0.50 cusecs on (Dera Nawab Branch) will be provided.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 36: Extension of 111/DNB to Nawankot & Gurara – Zone 3

Infrastructure for Extension of 111/DNB TO NAWANKOT & GURARA Scheme						
Current Yield (MGD)	Deficit in 2050 (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS (70,000 Gallons)	IPS (100,000 Gallons)
1.17	1.04	6@0.50 cusecs TW's provided	10	12	0	5

Intervention for permanent settlements (Zone-3)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand (2050).

Table 37: Intervention - Zone 3

Current Schemes Yield (After Rehab in Short Term)	Medium term Intervention	Deficit	Target set for permanent settlements	Intervention
MGD	MGD	MGD	MGD	6@0.50 cusecs TW's provided as none exists in the region
1.17	1.00	1.00	1.00	

NEW SCHEME NO. FOUR (04)

This scheme is aimed at providing water supply to the villages marked in the GIS Map below however numbers show overall requirement of these underlined areas and exact location can only be find-out after a detailed field visits and consultancies and then need-base provision. However, GIS based map is aimed at proposing them where no tube-well data was spotted in the region.

Zone – 4 (Islam Garh)

Below map shows the area which is referred to as ZONE – 4 in this report. This Zone lies in the Rahimyar Khan District area under the UCs named as Islam Garh and 178/7-R.

Population Projection (Zone-4)

Detail of water demand are mentioned in the table below:

Table 38: Population projection - Zone 4

UC Name	Human population (2017)	Livestock population 2017 (CDA)	Human population 2050 (Projected)	Livestock population 2050 (Projected)
Islam Garh & 178/7-R	88,181	310,106	172,826	951,585

Water Demand (Zone-4)

As mentioned in the table above, water demand is calculated based on aforementioned demands of both Humans and the Livestock for the Long-term planning periods (2050).

Table 39: Water Demand - Zone 4

Human Water Demand of Year 2050 (Including Tourists)	Livestock Water Demand of Year 2050	Total Water Demand in Year 2050	80% of Total Water Demand to be based on Water Supply Schemes
(M.D.D.)	(A.D.D.)	(INCLUDING 20% INFILTRATION)	(INCLUDING 20% INFILTRATION)
MGD	MGD	MGD	MGD
3.27	7.72	10.99	8.80

Intervention for deep desert areas (Zone-4)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand.

Table 40: Interventions - Zone 4

Current Schemes Yield	Current Schemes Yield (After Rehab in Short Term)	Deficit	Target set for desert areas	Intervention
MGD	MGD	MGD	MGD	20 Tubewells of 0.50 Cusecs provided
0.71	0.71	4.95	3.5	

Extension of Current Scheme (Zone-4)

Since this Zone (4) already possess one (1) existing schemes in the region, named as: SURIAN, extension of this scheme is done based on the future demand of the scheme (2050). The year 2050 demand has been considered for the planning of extension in order to make plan cost effective and to avoid upgrading the infrastructure (i.e. Pipe Dia.) after each term. Pumps working hours can be reduced as per the demand of the region in the respective year. Extension of this scheme to new nearby settlements is also planned which includes provision of new Low Level Reservoir (LLR), Ground Storage Tank (GST) & Intermediate Pumping Station (IPS). These settlements are marked using latest (2021) LandScan. Approximate location of required infrastructure is shown in the map and can be adjusted as per the field conditions and requirement of the planning horizon period. Location of extension of the scheme is also been marked and shown in related map.

Extension of Scheme “Surian”

Water production of 0.71 MGD is the maximum yield of the existing infrastructure, therefore major interventions are required keeping in view the demand of the area, calculated above.

Following Infrastructure has been provided in order to extend the existing scheme:

Table 41: Extension of Surian

Infrastructure for Extension of Surian Scheme (#6)						
Current Yield (MGD)	Intervention	LLR (20,000 Gallons)	LLR (30,000 Gallons)	IPS (70,000 Gallons)	IPS (100,000 Gallons)	IPS (200,000 Gallons)
0.71	20 (15+5) TW's @ 0.50 cusec	11	20	6	5	1

Intervention for permanent settlements (Zone-4)

Following intervention have been made in order to meet the targeted water demand of 2050. Rehabilitation done in the Short-term plan are assumed to be completed and hence subtracted from the total water demand (2050).

Table 42: Intervention - Zone 4

Current Schemes Yield (After Rehab in Short Term)	Medium term Intervention	Deficit	Target set for permanent settlements	Intervention
MGD	MGD	MGD	MGD	28 Tubewells of 0.50 cusecs provided
0.71	3.50	4.50	4.50	

NEW SCHEME NO. FIVE (05)

This scheme is aimed at providing water supply to the villages mentioned below however numbers shows overall requirement of these underlined areas and exact location can only be find-out after a detailed field visits and consultancies and then need-base provision. However, GIS based map is aimed at proposing them where no tube-well data was spotted in the region.

Areas considered:

Villages which are planned to be served with these schemes are:

- CHAK NO. 32/A
- CHAK NO. 46/A
- CHAK NO. 68/A
- CHAK NO. 42/A
- TALBANI
- HAYAT LAAR

Conceptual Design and Drawings

Fig. 28: 3D Design of Proposed Low Level Reservoir (LLR)

Fig. 29: 3D Design of Proposed Pump House

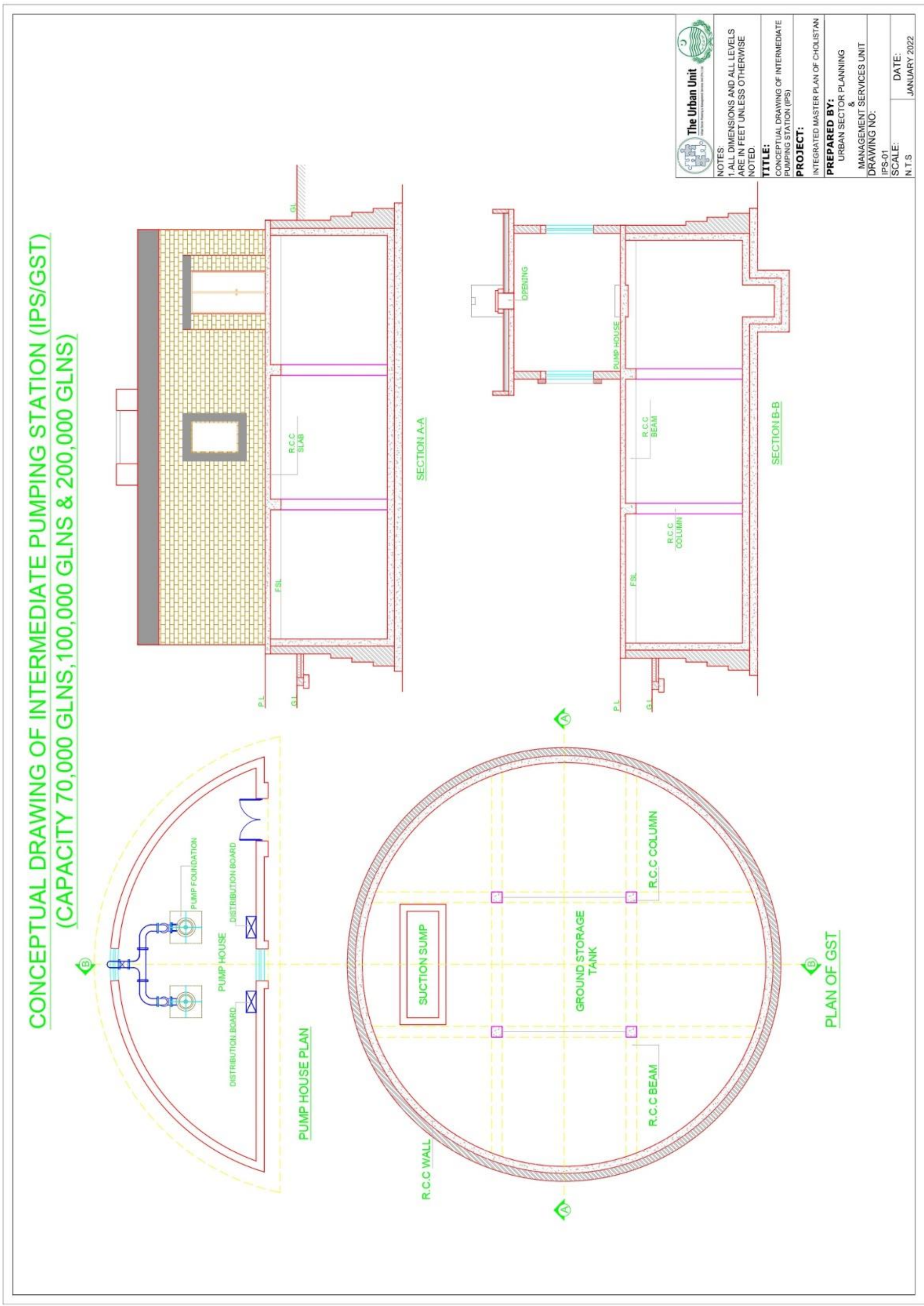


Fig. 30: Conceptual Drawing of IPS

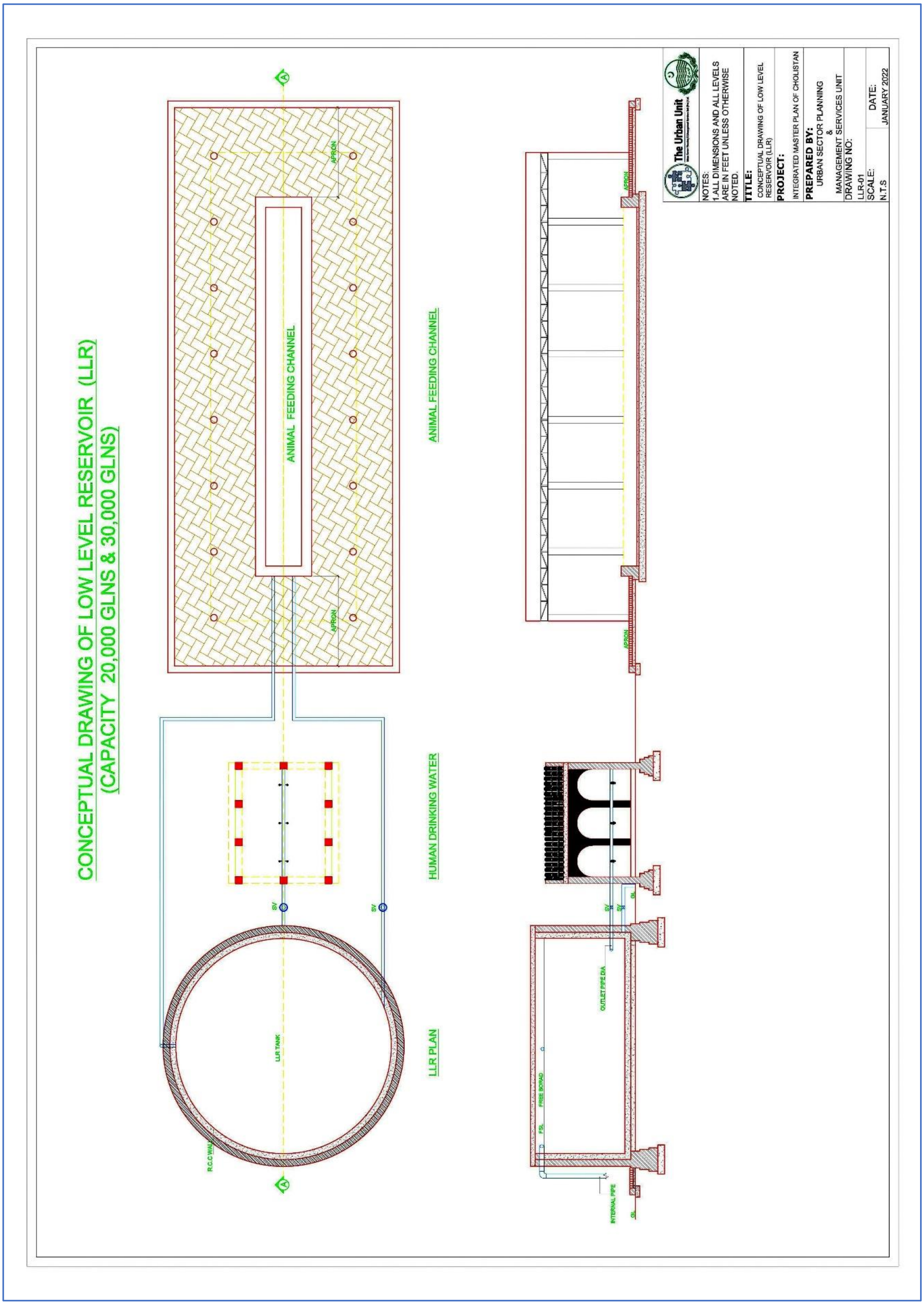


Fig. 31: Conceptual Drawing of LLR

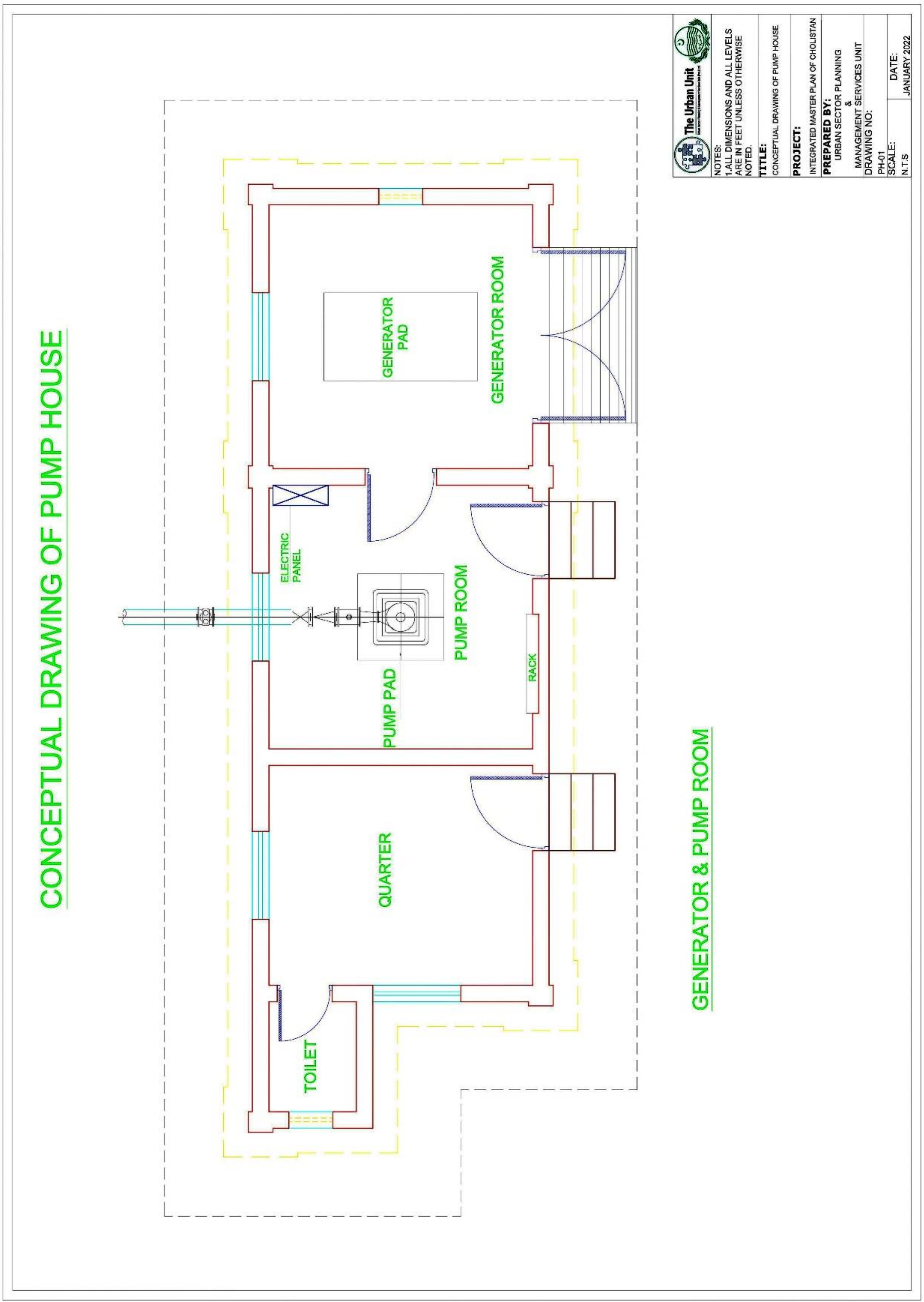


Fig. 32: Conceptual Drawing of Pump House

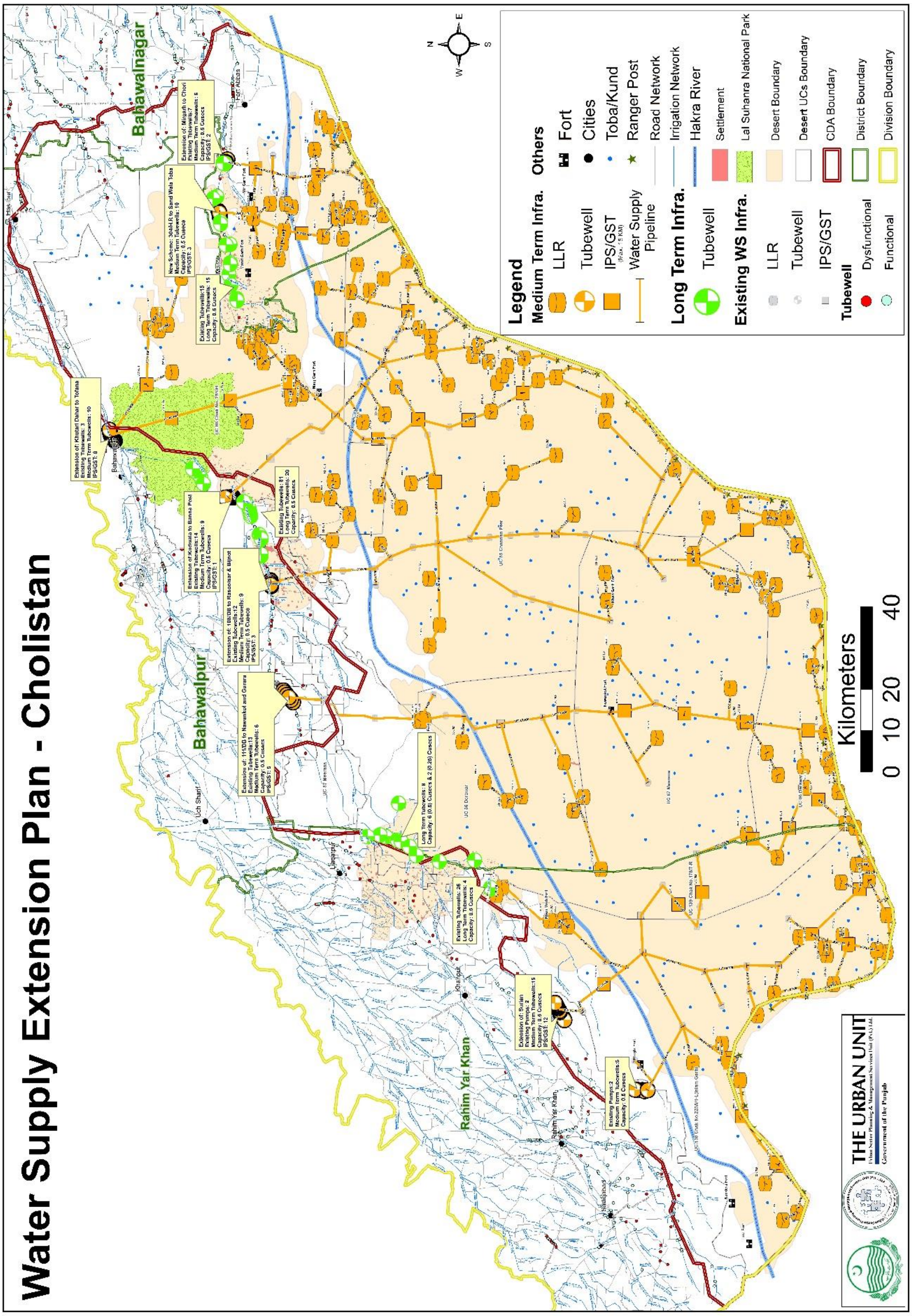


Fig. 33: Water Supply Extension and Expansion Plan Map

5.2.2. Solarization of Water Supply Schemes

Water supply system in Cholistan desert is very energy intensive due to installation of huge inductive and electro mechanical machinery, in order to tackle the head losses problems. Infrastructure is scattered throughout the desert which consists of Tube wells, Intermediate Pumping Station (IPS) and Low-Level Reservoirs (LLR). Tube wells and IPS have motors and pumps to supply the water to LLR located in remote areas, in order to power these electro-mechanical machineries huge amount of electricity is required. Tube wells are installed alongside canal which are passing in close vicinity to the electricity infrastructure. Therefore, tube wells are powered through grid electricity. But due to weak grid infrastructure, voltage drop during summer season increases reliance on generators. Intermediate Pumping Stations are located deep in the desert where electricity grid infrastructure is non-existent, hence operation depends solely on generators. It is also very difficult to supply fuel to these generators in remote areas of the desert, and significant logistic resources and human resources are required to supply the fuel to the generators. In the current situation operation expense of these water supply system is very high which is a burden on CDA resources.

SOLARIZATION OF IPS

Due to large number and scattered resources in Cholistan desert, solarization of intermediate pumping stations (IPS) have been proposed. In long term phase, electricity source of all the IPS from every water supply scheme including existing and newly proposed schemes will be converted to renewable energy i.e. Solar Energy. It is pertinent to mention here that land already available can be utilized for the installation of solar infrastructure. Tentative area requirements and assets being proposed to power by solar energy and detailed technical calculations are given below in the table. Solar system will provide energy to these assets for almost 5.5 hours per day. A 3D layout of proposed solar system and a detailed map are shown in figures given below respectively.

Table 43: Proposed Solar System for IPS (Short, Medium and Long) Term Plan

Proposed Solar System for IPS (Short, Medium and Long Term Plan)						
Sr. No.	Plans	No of IPS to be solarized	Total Solar capacity needed (KW)	Annual average units consumed by IPS @16 hours	Total Area required for Solarization of IPS (ft^2)	Annual average units generated by Solar system @5.5 hours
1	Short Term	5	565	2,438,838	28,694	1,134,238
2	Medium Term	17	996	4,311,340	77,665	1,999,470
3	Long Term	34	3,534	15,242,108	268,733	7,094,505

Conceptual Design

Fig. 34: 3D Layout design of proposed solar installation on IPS

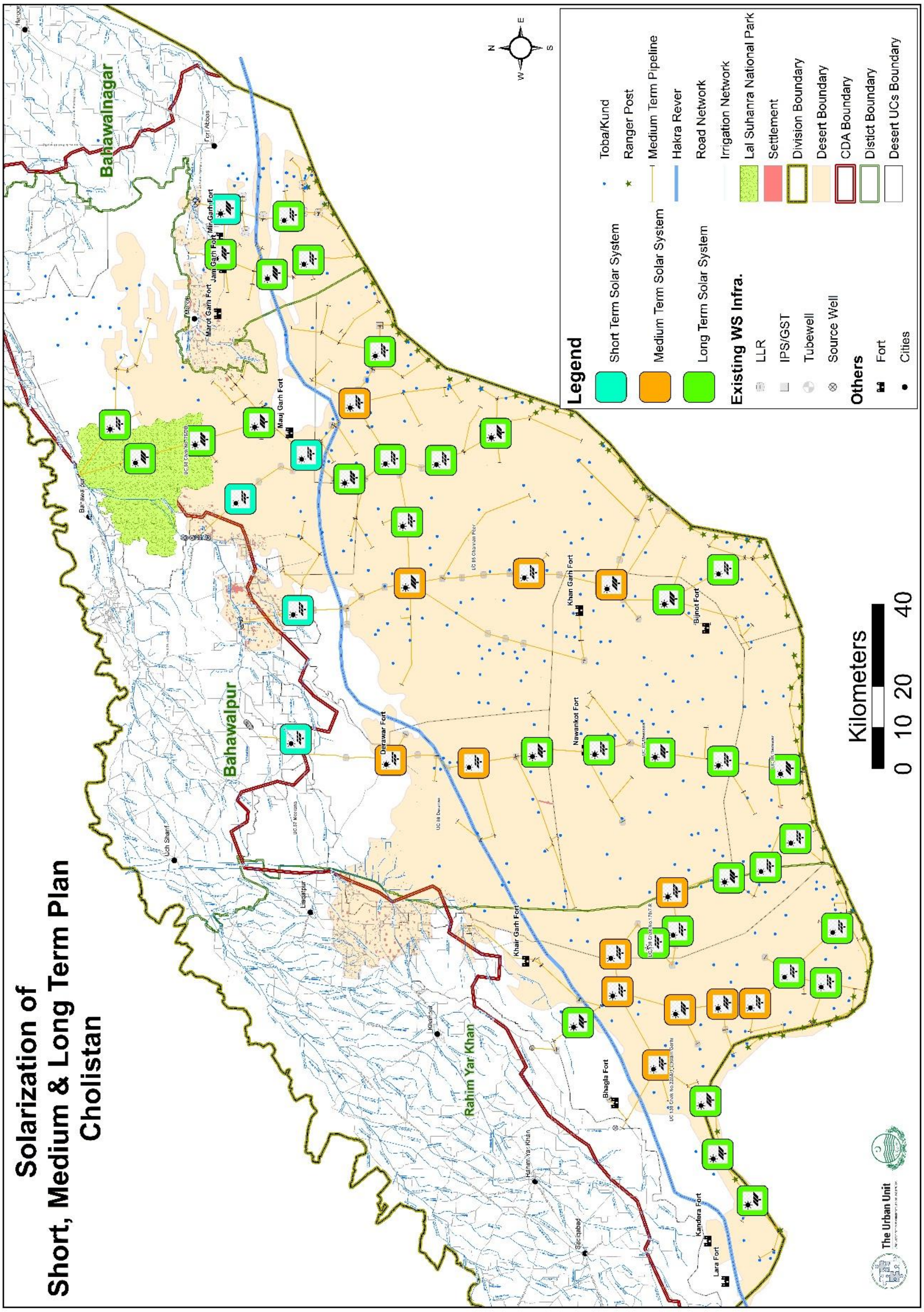


Fig. 35: Proposed IPS sites for Solarization

5.2.3. Water Resources Development

In the continuation of immediate plan for the Cholistan Water Resource Development, a long-term plan is formulated to extend the scope of work. Certainly, development of water resources in Cholistan is vital for life. Following interventions are suggested in the long-term plan

- Mini Dams
- Gabion Weir
- Recharge Well
- Desilting

5.2.3.1. MINI DAMS

Concept of mini dams is based on the scenario-based interventions. Solar system, silting basins, storage tank and separate points for human and animals. Mini dam will be properly fenced to make sure the safety of solar system and avoiding any inclusion of waste of animals in the water collection chamber. Desilting basins, will be used to desilt the surface water as it contains a large amount of silt in it. Catchment area is to be developed to garner maximum water. A GIS-based analysis is done to make sure the availability of catchment to fill the water collection chamber.

5.2.3.2. GABION WEIRS

Gabion weirs will be provided in the DCB (Ditch-cum-Bank) canal that is flowing along the Old Hakra River Bed to allow penetration of surface water into the groundwater to reduce the brackishness and increase the groundwater level. Gabions weir is a wire mesh cage or basket filled with stones. It will be useful for the construction of obstruction in the waterway. It will prolong the time of exposure to the land and will help to infiltrate more water in the groundwater.

5.2.3.3. RECHARGE WELLS

Provision of recharge wells across the old Hakra River bed to rise the groundwater level is included in the long-term plan. As per the regional survey of the Abadies of Cholistan, groundwater along the Old Hakra River Bed is depleting with the rate of 5 feet in every two years. Groundwater is only sources of potable drinking water therefore it is very important to take measures regarding conserve groundwater source. Proposed size of the recharge well is 100’ x 100’ x 15’. HDPE pipe of 8 inches diameter will be injected into the ground at the depth of 60 feet that is depth of groundwater. HDPE pipe will be extended up to 3 feet from the bed level of pond to avoid inclusion of silt in the pipe that will slower the process. A gate valve will be attached to control the flow of water for desiltation of pond. Similar to the mini dams, development of catchment area is also included for pond of recharge well as slope of Cholistan desert is not very steep to catch enough water on this larger scale.

5.2.3.4. DESILTING OF TOBAS

Seasonal desilting of tobas and mini dam is necessary to avoid the phenomenon of Choking of water body. It is obvious that process of siltation is relatively faster in the Cholistan due to sand storms and high flux of silt with water. Desiltation of water collection chamber and silting basin will keep function whole project and store maximum amount of water.

In short, all the mentioned interventions in the water resources sector will be enough to compete 20 percent of total need of water. One the key aspect of all the interventions is that these are suggested by keeping in mind all the limitations that are encountered while utilization of surface water.

Conceptual Drawings:

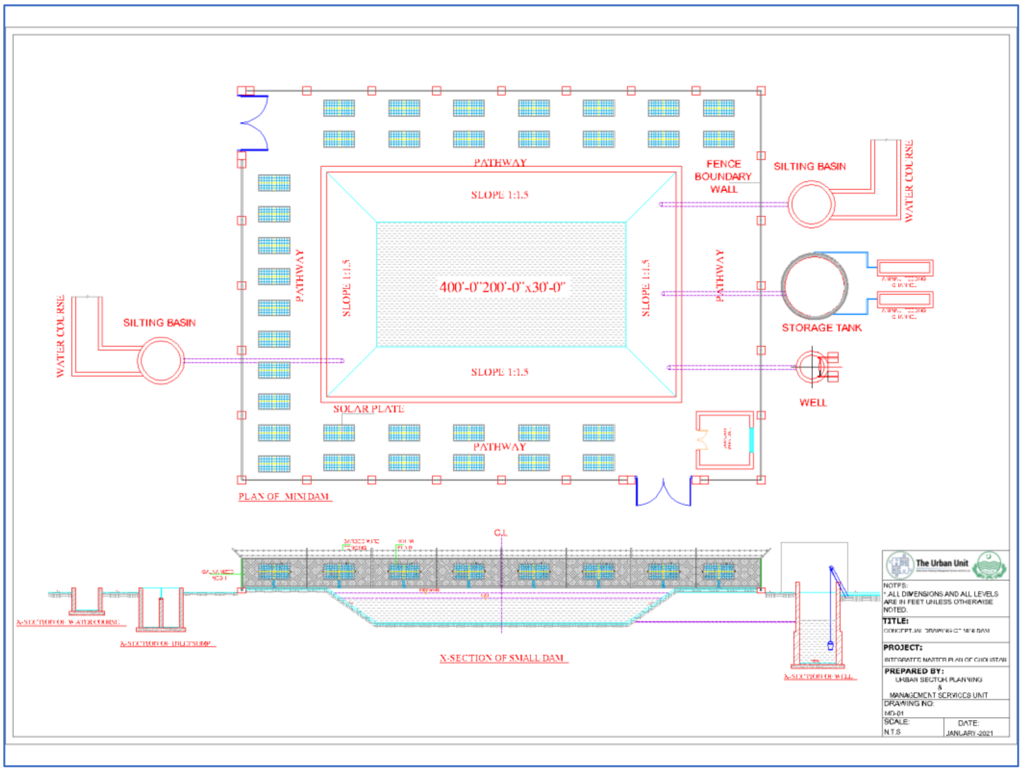


Fig. 36: Conceptual Drawing of Mini Dam

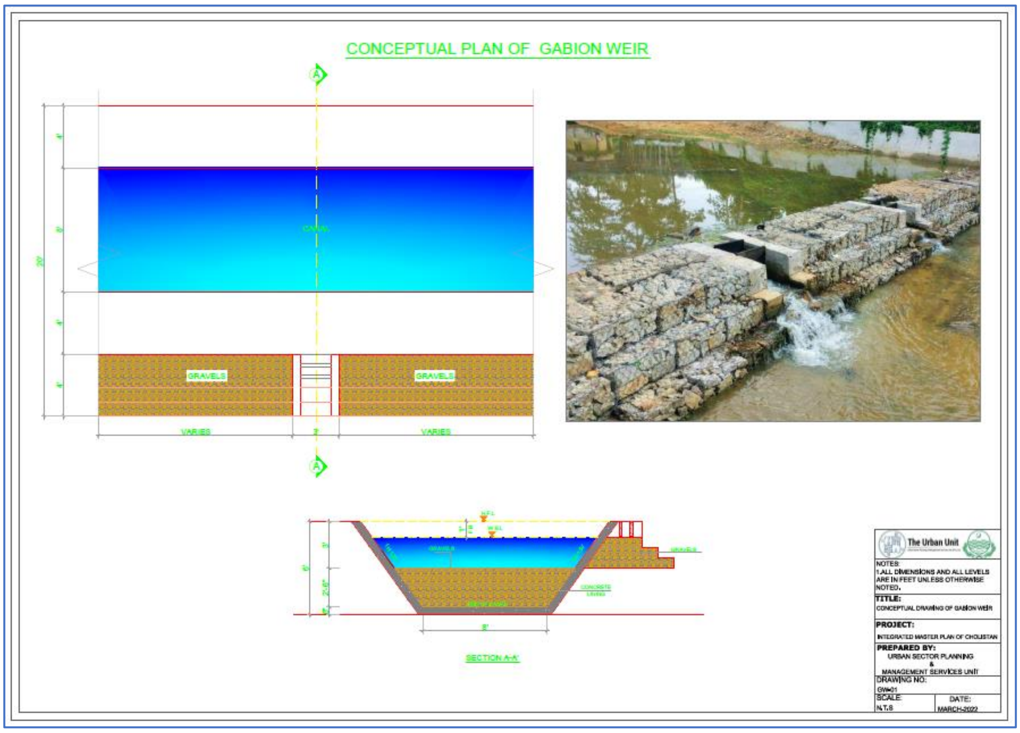


Fig. 37: Conceptual Drawing of Gabion Weir

Table 44: Water Resource Development Summary

Sr. No.	Type of Intervention	Number of Projects
1	Mini Dams	10
2	Gabion Weirs	40
3	Recharge Wells	10
4	Desilting of Water Collection Chamber	Seasonal (yearly)

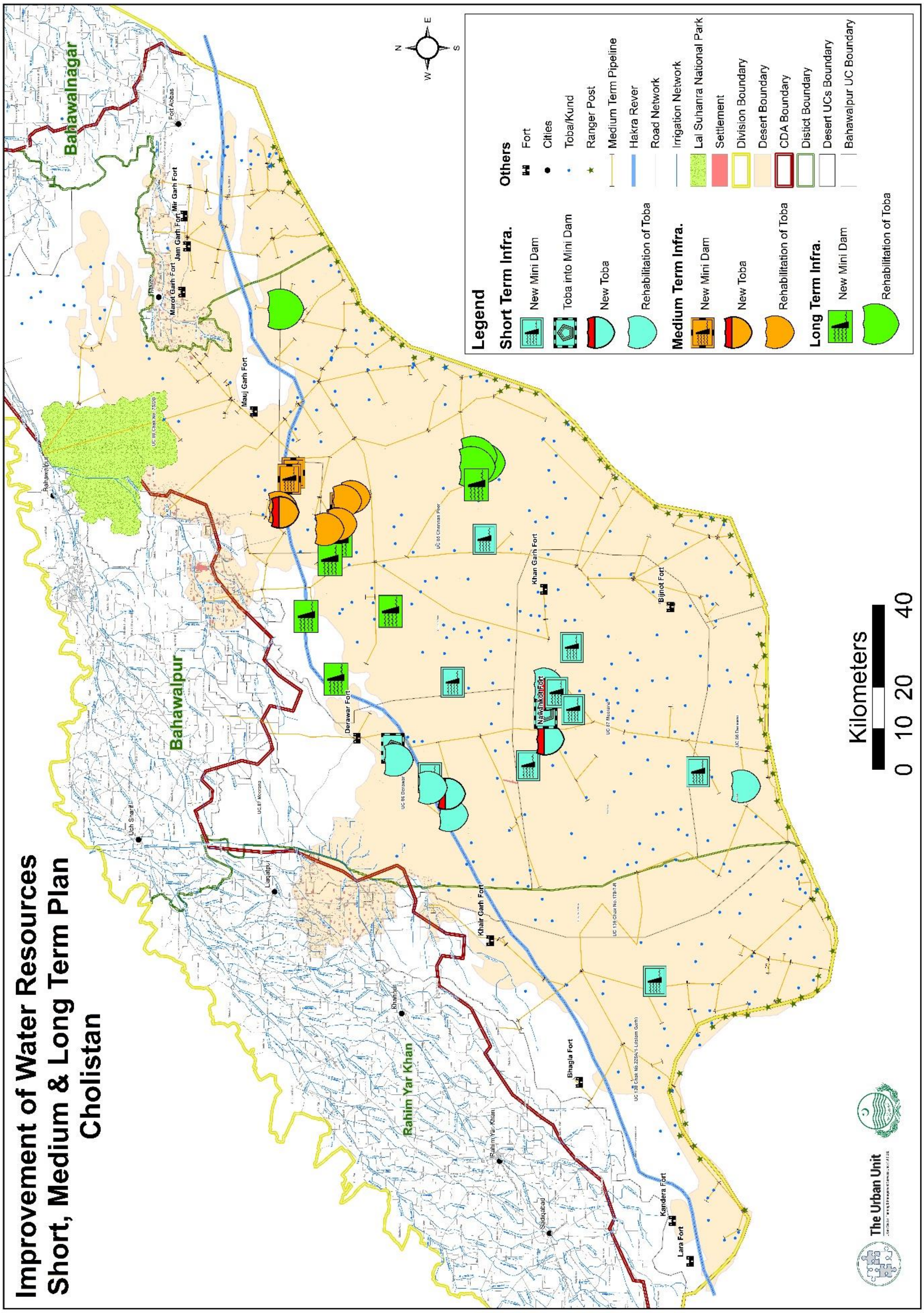


Fig. 38: Water Resource Development

5.2.4. Summary of Water Supply & Water Resource Development

Table 45: Infrastructure proposed for deep desert hamlets

Sr. #	Project	Interventions	Project Cost (Millions PKR)
1	Extension of Mir Garh to Choori Water Supply Scheme	▪ 06 @ 0.5 cusecs TW ▪ 06 @ 20,000 Gallons LLR ▪ 05 @ 30,000 Gallons LLR ▪ 01 @ 70,000 Gallons IPS/GST ▪ 01 @ 100,000 Gallons IPS/GST ▪ HDPE Pipeline	815
2	New Water Supply Scheme from CHAK 304/H.R. to Sand Wala (near Border)	▪ 10 @ 0.5 cusecs TW ▪ 13 @ 20,000 Gallons LLR ▪ 08 @ 30,000 Gallons LLR ▪ 01 @ 70,000 Gallons IPS/GST ▪ 02 @ 100,000 Gallons IPS/GST ▪ HDPE Pipeline	1072
3	Extension of Kutri Dahar to Tufana Scheme	▪ 10 @ 0.5 cusecs TW ▪ 08 @ 20,000 Gallons LLR ▪ 19 @ 30,000 Gallons LLR ▪ 05 @ 100,000 Gallons IPS/GST ▪ 03 @ 200,000 Gallons IPS/GST ▪ HDPE Pipeline	2700
4	Extension of Scheme 108 DB to Rasoolsar & Bhijnot:	▪ 09 @ 0.5 cusecs TW ▪ 10 @ 20,000 Gallons LLR ▪ 14 @ 30,000 Gallons LLR ▪ 03 @ 100,000 Gallons IPS/GST ▪ HDPE Pipeline	3665
5	Extension of Scheme Kudwala To Banna:	▪ 09 @ 0.5 cusecs TW ▪ 05 @ 20,000 Gallons LLR ▪ 12 @ 30,000 Gallons LLR ▪ 01 @ 100,000 Gallons IPS/GST ▪ HDPE Pipeline	2075
6	Extension of 111/DNB to Nawankot & Gurara Scheme	▪ 06 @ 0.5 cusecs TW ▪ 10 @ 20,000 Gallons LLR ▪ 12 @ 30,000 Gallons LLR ▪ 05 @ 100,000 Gallons IPS/GST ▪ HDPE Pipeline	2607

7	Extension of Scheme existing water supply scheme of Surian	▪ 20 @ 0.5 cusecs TW ▪ 13 @ 20,000 Gallons LLR ▪ 20 @ 30,000 Gallons LLR ▪ 06 @ 70,000 Gallons IPS/GST ▪ 05 @ 100,000 Gallons IPS/GST ▪ 01 @ 200,000 Gallons IPS/GST ▪ HDPE Pipeline	4983
8	Provision of Solar System	▪ Solar System for 56 IPS	1,346
9	Machinery Procurement for Water Supply	▪ Procurement of Automobiles, Water Bowsers, Trolleys & Loader etc. for day-to-day operations	1,256
10	Water Resources Development in Cholistan	▪ 10 Mini Dams ▪ 40 Gabion Weirs ▪ 10 Recharge Wells ▪ Desilting of Tobas	832
22.84 Billion PKR (Includes PST & Contingencies)			

Table 46: Infrastructure proposed for permanent settlement (Villages & CHAKs)

Sr. #	Project	Interventions	Project Cost (Millions PKR)
1	New Scheme for (Zone 1): ▪ CHAK NO. 330/H.R ▪ CHAK NO. 289/H.R ▪ CHAK NO. 319/H.R ▪ CHAK NO. 327/H.R ▪ CHAK NO. 304/H.R ▪ CHAK NO. 311/H.R	▪ 15@ 0.5 cusecs TW ▪ HDPE Rising Main	296
2	New Scheme for (Zone 2): ▪ CHAK NO. 106/D.B ▪ CHAK NO. 88/D.B ▪ CHAK NO. 67/D.B ▪ CHAK NO. 108/D.B ▪ CHAK NO. 50/D.B ▪ CHAK NO. 68/D.B	▪ 20 @ 0.5 cusecs TW ▪ HDPE Rising Main	268
3	New Scheme for (Zone 3) marked settlements	▪ 06 @ 0.50 cusecs TW ▪ 02 @ 0.25 cusecs TW ▪ HDPE Rising Main	170

5.3. Biodiversity Mitigation in Cholistan

In the past some years worldwide developed known country turn a blind eye to wildlife values but now trend is change to conservation and protection of wildlife according to their economics aspects, the values of wildlife are globally recognized that human being depends directly or indirectly on wild resources for best survival of life. The vital and valuable role many of these species play both to the ecology and economy of their native people. The life style of cholistani people is nomadic and relay on the livestock for their survival, Biodiversity & Livestock are assets of Cholistan desert that helps in wellbeing of local inhabitants. But ongoing water crises or water scarcity condition in cholistan desert increasing the threat of death on wildlife and livestock. One of the major effect on the ecological behavior laeds to migration of wild fauna from this natural habitat. Some of the important wild species of cholistan desert which are under threat of extinction are as follows:

- Houbara Bustard (VU)
- Great Indian Bustard (CE)
- Chinkara gazelle (LC)
- Black Buck (NT)
- Asiatic Wolf (EN)
- Desert Hare (LC)
- Steppe Eagle (EN)

Fig. 39: Biodiversity of Cholistan Desert

Fig. 40: Past and Existing Condition of Tobas

5.3.1. Mitigation and Preparedness

The conservation strategy for natural habitat is an important key to conserve the habitat and protect the native fauna and flora. Conservation and restoration of natural habitat can only be possible by the special planning and some interventions to reduce the degradation stress of natural ecological values of cholistan desert. The Some of the important planning and intervention for Cholistan desert wildlife and livestock are given below:

Grazing Pattern or Rotation Grazing:
The continuous grazing is more threaten to natural habitat destruction, grazing stress in cholistan desert is major issue of natural habitat destruction due to unplanned grazing or continuous grazing of livestock. A continually grazed pasture will take longer to recover after a drought than a pasture that has been rested because the plants are more stressed. The conservation and restoration can be done through gazing pattern, there must be planned grazing of livestock that will be helpful to restore and recover grazed area after a particular time and also benefited for wildlife of desert that get space for wildlife grazing will also available.

The rotation grazing is a grazing pattern in which large grazing area divided into different pockets or peddock to manage the grazing stress in planned way. It will helpful to lower the natural habitat destruction threat.

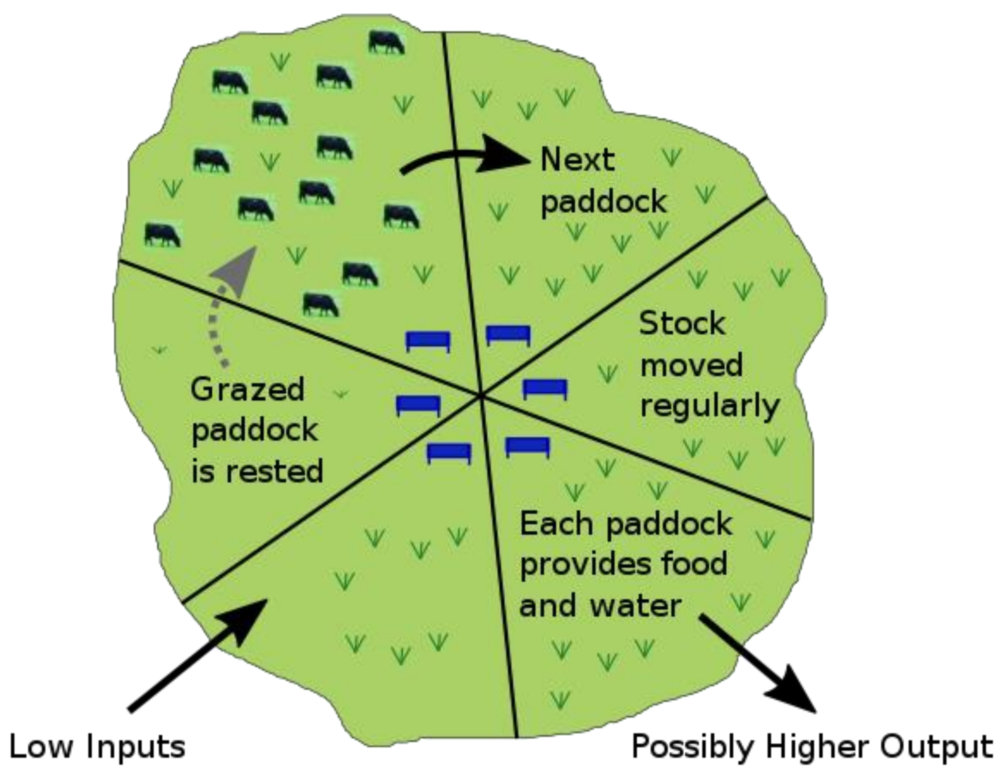


Fig. 41: Grazing Pattern of cholistan

5.3.2. Interventions:

Some of the key interventions are listed below for the conservation and restoration of natural habitat area.

- Grass field or Grass reseeding 500 Acres.
- Tree plantation or Dry Afforestation 350 Acres.

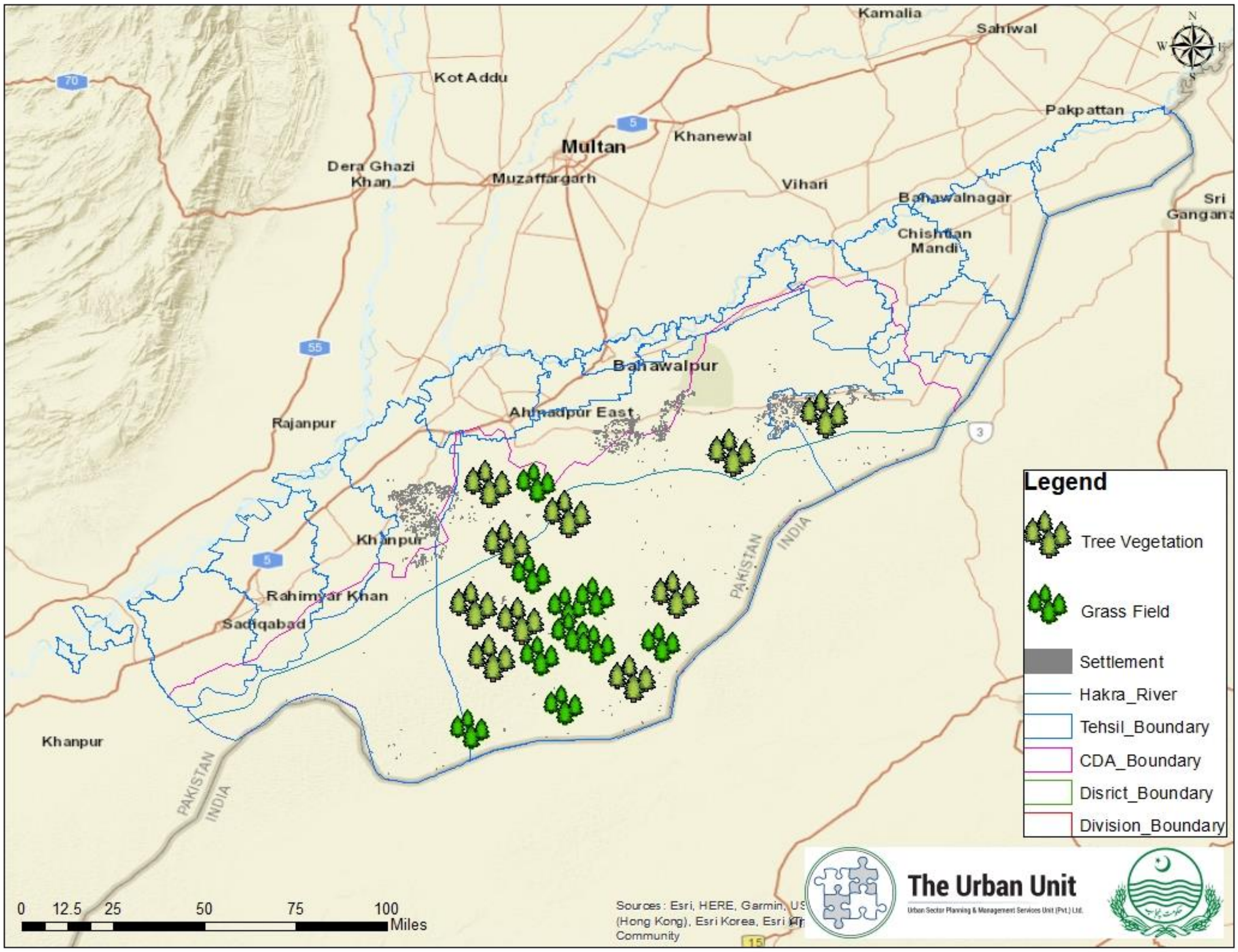


Fig. 42: Map of Vegetational Proposed Intervention in Cholistan Desert

5.3.2.1. Seed Banks

During the drought conditions, the availability of resilient seed in sufficient quantities is a major critical challenge. A plan for the production or sourcing of desirable seeds must be implemented well in advance to ensure the availability of required seed during a drought condition. Seed Banks can be set up at the most strategically advantageous locations for which adequate financial provisions will be called for.

5.3.2.2. Grass Reseeding:

Scope of work:

The native plant species are one of the natural solutions to restore the degraded habitat that is also helpful to reduce soil erosion. Native plant is able to stand in harsh and unfavorable environment, the research also proved that the native species are best habitat restoration resource of the particular region and these helps to decrease vulnerability to extreme climate conditions.

Activities:

- The reseeding of grass species at different pockets suitable for grass field.
- Reseeding of grasses to be done in 10 pockets.
- Direct or indirect seeding of grass to be done.
- Some of the important indigenous plant species suitable to reseed listed below.
    - *Brachiaria ramose (Lump)*
    - *Cenchrus ciliaris (Dhaman)*
    - *Echinochola colona (Sanawakri)*
    - *Lasiurus scidicus (Ghokra)*
    - *Panicum antidotale (Bansi)*

Fig. 43: Proposed Grasses for Cholistan Desert

5.3.2.3. Dry Afforestation or Tree Plantation

Scope of Work:

The plantation cover is key component for the stability of ecosystem as it is regulator of different biochemical cycles such as water, carbon, nitrogen etc. Plants release oxygen while sequestering carbon. Vegetation has an impact on soil development through time, resulting in a more productive soil. Wildlife habitat and food are provided by vegetation. Humans benefit from both direct (for example, timber) and indirect (for example, watershed protection) socioeconomic products and services provided by vegetation. In Desert areas only the rain water is solution to water shortage problem, rain water harvesting is best practiced method for dry land in different developing countries.

Plantation cover in cholistan desert helps to:

- Restoration of Natural habitat
- Reduced the grazing stress
- Prevent soil erosion
- Promote shelter for livestock & wildlife

Activities:

- Dry afforestation will be done at 350 acres of land in different selected pockets.
- The Afforestation should be done before monsoon rain (June to September) best for growth and development of trees.
- These are the following native flora suitable for dry afforestation:
  - *Acacia nilotica (Kikar)*
  - *A. jacquemontii (Banwali)*
  - *A. modesta (Phulai)*
  - *Azadirechta indica (Neem)*
  - *Prosopis cineraria (Jhand)*
  - *Capparis decicua (Karir)*
  - *Tamarix aphylla (Ukhan/Frash)*
  - *Ziziphus mauritiana (Beri)*

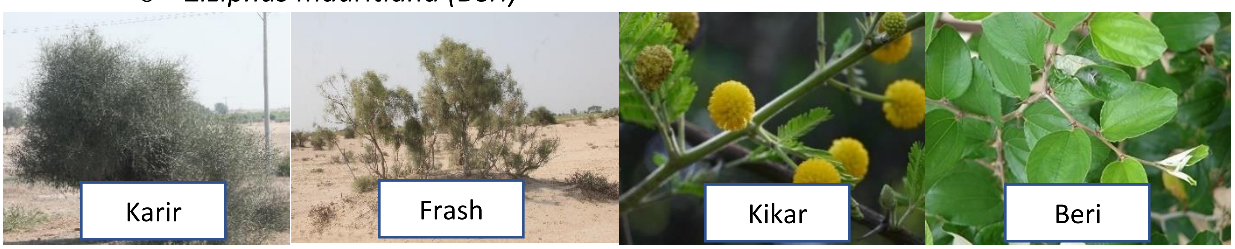


Fig. 44: Proposed Tree species for Cholistan Desert

5.3.2.4. Establishment of Automated Weather Station in Cholistan for Meteorological Parameters Monitoring

In the South East Asia, the drought monitoring system capacities and management are entirely different as they vary across and even within countries at present, the drought-monitoring systems in Pakistan, Bangladesh, Afghanistan and Nepal, are primarily on the meteorological station-based assessments, although most station networks may suffer from inconsistency in the data quality and measurements. In Pakistan, National Drought Monitoring Center (NDMC) from Meteorological Department provides drought warnings and information, mainly based on ground bases observations data.

Automatic weather observation refers to the activities involved in converting measurements of meteorological elements into electrical signals through sensors, processing and transforming these signals into meteorological data, and transmitting the resulting information by wire or radio or automatically storing it on a recording medium.

Visual observation elements including visibility, cloud cover, cloud type and present/past weather are not recorded by AWSs or monitored by a human observer who transmits the results. It measures surface temperatures, wind speed and direction, humidity, solar radiation, precipitation, atmospheric pressure and lightening intensity for a specific location through specific sensors.

Components of Automatic Weather Station:

An AWS will typically consist of a weather-proof enclosure containing the data logger, rechargeable battery, telemetry (optional) and the meteorological sensors with an attached solar panel or wind turbine and mounted upon a mast. The specific configuration may vary due to the purpose of the system.

Table 47: Components of Automated Weather Station

Solar Panel	Solar panels provide the power to run the weather stations. As these stations are located at remote stations, solar energy is the only reliable source of energy. Energy generated by the solar panels is stored in the battery.
Battery	Batteries store the energy generated by the solar panels and ensure functioning when solar energy is not available.
Enclosure	Enclosure prevents the various components of the weather station from the environmental conditions and hence, prevents them from damages.
Telemetry	Telemetry equipment is used to send the recorded data to the desired locations at the desired frequency. Besides above-mentioned sensors, some more sensors i.e., lightening sensors, snow depth sensors, soil temperatures and more may be used to acquire some other specific data of the location.
Sensors	
Thermometer	Thermometer sensors are used to measure the maximum and minimum temperature of surrounding atmosphere.
Anemometer	Anemometers are used to measure the velocity of winds. Cup type anemometers are most commonly used. The term is derived from the Greek word, Anemos which means wind.
Wind Vane	In some applications, knowing only the wind velocity is not enough, but the direction in which the wind flows is also required to be monitored. A wind vane or a weather vane is used for this purpose.
Hygrometer	A hygrometer is a device which is used to measure humidity or moisture content in the air. The first successful hygrometer was made by Johann Lambert. Different types of hygrometers function by monitoring changes in certain parameters like dew point, capacitance, and electrical resistance to find out the actual humidity.
Barometer	Pressure tendency can forecast the weather changes. Barometers are used to measure the atmospheric pressure at the given location.
Rain Gauge	The rain gauge is used to find out the rainfall at the given location.

Pyranometer	Pyranometer are used to measure the solar radiation at the given location. Depending upon the type of the Pyranometer (PV based or thermocouple-based), the bandwidth of the measurement would be decided.
Soil Moisture	Soil moisture sensors are used to collect soil moisture data at the location if this data is required.
Dust and Particulate Matters	The information of Dust and Particulate Matters (PM1, PM2.5, PM10) and various other gases (CO, O3, NO2) can be collected by using sensors accordingly.

CONCLUSION

Owing to the dearth of water supply & resources in the region of Cholistan, life becomes miserable in Cholistan especially in deep desert which encompass a vast territory. Water scarcity remains fundamental problem for human and livestock population as most of the groundwater is saline and undrinkable. Seepage water from irrigation canals & rainfall are the main sources of water in the region. As established in detail in the previous section that orthodoxical water bodies which are used in Cholistan i.e., Tobas and Kunds and any other such water carrying body which is dependent upon precipitation are highly unreliable and doesn't fulfil the very basic water quality parameters. As such, two interventions genre are proposed i.e. Mitigation and Prevention which are planned as immediate (up to 2025) and long-term (up to 2050) plan. An immediate approach is planned as to mitigate the severe effects of droughts. This includes proposal of rehabilitation of existing six (6) schemes in order to fully capacitate them to meet the high demand of dependents and provision of Reverse Osmosis (RO) filtration plants for the areas which carries high population density and does not have water supply schemes in their areas. In order to prevent water scarcity in future, water supply scheme extension & new schemes with water resource development plan is also made part of this plan as a long-term intervention spanning up-to 28 years (2050).

Annexure - A

Table: Abstract of Cost

Sr. #	DESCRIPTION OF ITEM	COST	MILLIONS
	CIVIL WORK HEAD-1		
1	Construction of Well Boring	772,549	0.773
2	Construction of Filtration Plan Room	1,457,688	1.458
3	Construction of Generator Room	1,232,104	1.232
4	Construction of Operator Room	841,155	0.841
5	Detailed of Sanitary fittings and Waste Water Arrangement	144,576	0.145
6	Construction of Animal Feeding Channel	3,081,811	3.082
7	Construction of Storage Tanks 20,000 Glns	2,664,456	2.664
8	Electro Resistivity Survey (ERS)	30,000	0.030
9	Construction of Boundary Wall with Gate 400 RFT	1,396,198	1.396
10	Allied Work	3,446,020	3.446
	SUB HEAD NO-1 AMOUNT R.S	**15,066,557**	**15.067**
	MECHANICAL WORK HEAD-2		
1	Submersible Pump of 10 HP	1,328,000	1.328
	SUB HEAD NO-2 AMOUNT R.S	**1,328,000**	**1.328**
	ELECTRICAL WORK HEAD-3		
1	Diesel Generator 100 KVA	6,142,500	6.14
2	Solar System 53 KW	8,683,082	8.683
	SUB HEAD NO-3 AMOUNT R.S	**14,825,582**	**14.826**
	REVERSE OSMOSIS PLANT (R.O PLANT) HEAD-4		
1	Reverse Osmosis Plant (R.O Plant) for Removal of TDS Upto 35000 PPM (Production Capacity 5000 Liter Per Hour's)	5,475,000	5.475
	SUB HEAD NO-4 AMOUNT R.S	**5,475,000**	**5.475**
	OPERATION AND MAINTENACE HEAD-5		
1	Operation and Maintenance (O&M) For 02 Year's	2,233,036	2.233
	SUB HEAD NO-5 AMOUNT R.S	**2,233,036**	**2.233**
	HUMAN RESOURCES HEAD-6		
1	Human Resources (HR) One Person / RO Plant For 02 Year's	960,000	0.960
	SUB HEAD NO-6 AMOUNT R.S	**960,000**	**0.960**
	TOTAL SUM OF AMOUNT HEAD 1 TO HEAD 6	**39,888,176**	**39.888**
	Add 2% Contingencies	797,763.51	0.798

	Add 2% Consultancy Charges	797,763.51	0.798
	Add 5% PST	1,994,408.78	1.994
	Add 1 % Plantation Cost	398,881.76	0.399
	Training and Awareness	100,000.0	0.1
	Automatic Weather Station (AWS)	6,000,000.0	6.0
	Total Amount R.s	**49,976,993**	**49.977**
	RO Plants 17 x G-Total Amount R.s	**752,008,883.0**	**752.009**

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